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No.SD.Genl.3

Date.28.03.2019

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3. Northern Railway, Baroda House, New Delhi -110 001
4. N.E.Railway, Gorakhpur-273 001 (UP)
5. N.F.Railway, Maligaon, Guwahati -781 011 (Asam)
6. Southern Railway, Park Town, Chennai -600003 (TN)
7. S.C.Railway, Rail Nilayam, Secunderabad -500 371 (AP)
8. S.E.Railway, Garden Reach, Calcutta -700 043 (W. B)
9. Western Railway, Church gate, Mumbai -440 020 (MH)
10. North Western Railway, Jaipur-302006 (Rajsthan)
11. East Central Railway, Hajipur-844101 (Bihar)
12. East Coast Railway, Bhubaneshwar -751017(Odisha)
13. North Central Railway, Allahabad-211001 (UP)
14. West Central Railway, Jabalpur - 482001 (MP)
15. South Western Railway, Hubli - 580023 (Karnataka)
16. South East Central Railway, Bilaspur - 495004 (Chhatishgarh)

Sub.: Diagram book of WDG5 (5500 HP) diesel electric locomotive.

Newly prepared diagram book for WDG5 (5500 HP) diesel electric locomotive for Freight service is issued as details given below:

Diagram Book of WDG5 (5500 HP) AC – AC traction for freight diesel electric locomotive report no. MP.MISC – 304 (Rev 0.00) March' 2019.

DA : As above

28/3/19

(Vijay Kumar Goel)
Jt. Director/Motive Power
for Director General/MP/RDSO

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
भारत सरकार - रेल मंत्रालय

डब्ल्यूडीजी5 (5500एच.पी) डीजल इलेक्ट्रिक लोकोमोटिव. एसी–एसी कर्षण मालगाड़ी की रेखाचित्र पुस्तिका

DIAGRAM BOOK OF WDG5 (5500 HP) AC – AC TRACTION FOR FREIGHT DIESEL ELECTRIC LOCOMOTIVE



रिपोर्ट सं.एमपी.मिस्ले- 304 (संशो.–0.00),मार्च'2019
Report No.MP.MISC- 304 (REV. – 0.00), March'2019

MOTIVE POWER DIRECTORATE
चालन शक्ति निदेशालय

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WDG5 (5500 HP) 3-PHASE AC-AC TRACTION FREIGHT DIESEL ELECTRIC LOCOMOTIVE

ITRODUCTION

On Indian Railways, scenario of freight movement will be undergoing a sea change in the near future. IR is contemplating to lay exclusive movement of heavy haul goods trains. It is also planned to upgrade speed of freight trains up to 100 Km/h.

To meet the above requirements, Motive Power of the diesel locomotive has to be improved further. Indian railways have decided to go in for more powerful, state of the art WDG5 (5500 HP) diesel electric locomotives, with a view to haul heavier loads and at higher balancing speed.

BRIEF DESCRIPTION OF THE LOCOMOTIVE

GENERAL

The WDG5 (5500 HP) diesel electric locomotive is equipped with a turbocharged 20-cylinder 2-stroke710 G3B diesel engine. This engine has 4 to 5% fuel efficient better than the existing locomotives. This engine has many modern features like, air start (pneumatic), Electronic fuel injection, high efficiency turbo supercharger, green technology for fuel efficiency & reduced emission capable, fiberglass bag type 184 day air filter, increased lube oil cooler capacity, 10filter element lube oil, separate engine jacket water & after cooler water & flooded type cooling system for rapid cool the engine. The locomotive is equipped with Automatic electronic start/stop system to further harness fuel saving in the freight operations. This system enables stoppage of engine idling when the locomotive is stopped for long duration. Fuel capacity of this locomotive is 7500 liters.

This locomotive has also used to several new advanced technologies such as, functionally integrated railroad electronic (FIRE) radial brake grids, tread brake unit, Computer Controlled Brake II Generation (CCB2.0), inverter driven auxiliary equipment (for higher reliability & energy efficiency), user friendly driver console among other state of art technologies which is TFT screen based integrated driver display on analogous gauges and K glass (25t certified) wheel journal bearings.

The locomotive has been designed to setup new standard of crew comfort & safety. It implements EN12667 compliant collision protection, provides cabin air conditioning & for heated ventilation, crew toilet & visual TFT based operator display and an ergonomically designed driver seat & locomotive is longer than WDG4, it provides better visibility through enlarged Maximum Moving Dimension (MMD), elimination of blower duct & a raised radiator profile.

This locomotive has been designed to run up to maximum operating speed of 100 Km/h on BG routes of Indian Railways for freight service. The primarily aimed of improving the throughput with higher balancing speed. The locomotive will be able to achieve 100 Km/h speed on level tangent track with 59 BOBRN wagon trailing load. It can also start the same load on 1 in 150

gradient. The tractive effort limiting switch has been provided in the driver cab of the locomotive & may be operated by the crew at the time of requirement.

ENGINE SYSTEM

AIR INTAKE & EXHAUST SYSTEM:

1. TURBO SUPERCHARGER:

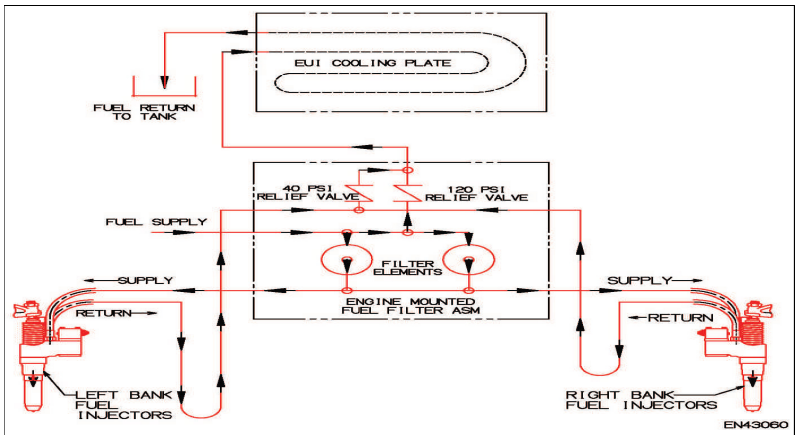
The turbocharger assembly is primarily used to increase engine horsepower and provide better fuel economy through the utilization of exhaust gases.
The turbocharger has a single stage turbine with a connecting gear train. The connecting gear train is necessary for engine starting, light load operation, and rapid acceleration. Under these conditions, there is insufficient exhaust heat energy to drive the turbine fast enough to supply the necessary air for combustion, and the engine is actually driving the turbocharger through the gear train assisted by exhaust gas energy. When the engine approaches full load, the heat energy in the exhaust, which reaches temperatures approaching 1000°F (538°C),is sufficient to drive the turbo-charger without any help from the engine. At this point, an overrunning clutch in the drive train disengages and the turbocharger drive is mechanically disconnected from the engine gear train.
Main component of turbocharger are doweling assembly, turbine wheel, Gear drive- assembly, impeller, turbine Blades, sun gear, exhaust duct, turbine inlet scroll, nozzle ring, etc.
Exhaust manifolds-Main function is to collect exhaust gases from engine and remove them with minimum restriction and provide it to turbocharger for utilizing energy. Main component of EMF are exhaust chamber (rear, intermediate & front), Turbo screen adaptor, expansion joint and gasket.

2. FUEL OIL SYSTEM:

DESCRIPTION:

In operation, fuel from the fuel tank is drawn up by the fuel pump through a suction strainer and primary fuel filter for delivery to the engine mounted filter. It then passes through the filter elements to the engine fuel supply lines and injector inlet filter at each cylinder into the injector. A small portion of the fuel supplied to each injector is pumped into the cylinder, at a very high pressure, through the needle valve and spray tip of the injector. With EMDEC controlled engines, the quantity of fuel injected by the Electronic Unit Injector (EUI) is determined by its integral solenoid operated poppet valve which is controlled by the master Electronic Control Module (ECM). The excess fuel not used by the injector flows through the injector, serving to lubricate and cool the working parts. The fuel leaves the injector through the return fuel filter. This filter protects the injector in the event of a backward flow of fuel into the injector from the return fuel line. From the return fuel filter in the injector, the excess fuel passes through the fuel return line in the manifold to the relief valve inlet of the engine mounted fuel filter. This valve restricts the return fuel, maintaining a back pressure on the injectors. The fuel continues down through the return line to the fuel supply tank.

EMDEC FUEL SYSTEM:



EMDEC Fuel Flow Schematic Diagram

The engine mounted filter assembly incorporates a number of different features for the EMDEC system. Fuel exiting the filter assembly manifold runs through a network of steel and/or reinforced flexible hose fuel lines which connect the fuel distribution block of the assembly manifold to the left bank and right bank engine fuel manifolds. Return fuel is routed by the network back through the distribution block to the ECM "cooling plate(s)" at either the sides or front of the engine, and through the fuel return section of the filter assembly manifold. A second fuel return line from the distribution block, with a 241 KPa (35 psi) pressure relief valve, may be used on some applications to relieve excess pressure during engine idle conditions.

EMDEC SYSTEM:

The EMDEC system is an electronic engine speed control and fuel management system. It is designed to provide optimal control of critical turbocharged engine functions which affect fuel economy, smoke, and emissions. The system also provides the capability to protect the engine from serious damage resulting from extreme operating conditions, such as high engine temperatures or low oil pressure.

The major "on engine" sub-systems of EMDEC include:

(A) The Electronic Control Module(s) (ECM)
(B) The Electronic Unit Injectors (EUI)
(C) Engine Sensors
(D) Wiring Harnesses (External, Injector, Sensor and Power)

3. LUBRICATING OIL SYSTEM

The engine lubricating oil system used on 20-cylinder engines combines the three systems (main lubricating system, piston cooling system and the scavenging oil system) into one system using a single high capacity oil pump. This pump assembly mounts on the lower right side of the accessory drive housing and is driven by the accessory drive gear. The pump "scavenges" oil from the engine oil pan through the supply manifold and strainer assembly, and then pumps it through the off-engine lube oil filter and cooler assemblies. Oil is returned to the engine through a "Y" branch manifold which divides it proportionally between the main lubricating oil system and the piston cooling oil system. The pump is driven from the accessory gear train at the front of the engine.

MAIN LUBRICATING OIL SYSTEM:

The main lubricating oil system supplies oil under pressure to most of the moving parts of the engine. Oil is pumped into the main oil manifold which is located above the crankshaft, and extends the length of the engine. Maximum oil pressure is limited by a relief valve in the passage between the pump and the main oil manifold. Oil tubes at the center of each main bearing frame conduct oil from the main manifold to the upper half of the crankshaft bearings. Drilled passages in the crankshaft supply oil to the connecting rod bearings, damper, and accessory drive gear at the front of the crankshaft. Leak-off oil from the adjacent main bearings lubricates the crankshaft thrust bearings.
Oil from the main lube oil manifold enters the gear train at the rear of the engine, at the idler gear stub shaft bracket. Oil passages in the stub shaft bracket distribute the oil. One passage conducts oil to both the right and left bank camshaft drive gear stub shaft brackets and to a manifold connected to the turbocharger oil filter. After passing through the filter, the oil enters the return line in the manifold and flows back to the idler gear stub shaft. A passage in the idler gear stub shaft bracket directs lube oil to the upper and lower stub shaft bearings. Filtered oil enters the turbocharger oil system from the upper idler gear stub shaft.

An oil passage in the turbocharger filter head, parallel to the filter output line, is connected to a passage in the turbocharger oil manifold. On governor controlled engines, an oil pressure line is connected between the manifold passage and the low oil pressure device in the governor. On EMDEC controlled engines, a sensor is used to detect low oil pressure directly at the manifold passage or connected to it by an oil pressure line.

Oil enters the hollow bore camshafts from the camshaft drive stub shafts. Radial holes in the camshaft conduct oil to each camshaft bearing. An oil line from one camshaft bearing at each cylinder supplies oil to the rocker arm shaft, rocker arm cam follower assemblies, hydraulic lash adjusters, and the injector rocker arm button. Leak-off oil returns to the oil pan through passages between the top deck and the oil pan. Passages in the turbocharger conduct oil to the turbocharger bearings, idler gear, planet gear assembly, and auxiliary drive bore. Considerable heat will remain in the metal parts of the turbine when the engine is shut down, and if the oil supply to the turbocharger was shut off suddenly, this heat would penetrate the turbocharger bearing area. To prevent possible overheating of the turbocharger, oil is automatically supplied to the turbocharger after stopping the engine. Protection is provided against a hot oil condition by a thermostatic valve (on governor controlled engines) or a sensor (on EMDEC controlled engines).

Filters for WDG5 Locomotives –

INERTIAL FILTERS :

There are two inertial filter panels, one mounted on either side of the locomotive, are made up of a series of tubes designed to produce a cyclonic action. Outside air is drawn rapidly through the tubes which contains specially designed vanes that induce a spinning motion to the contaminated incoming air. Dirt and dust particles, because they are heavier than air are thrown to the outer wall of the tube and carried to the bleed duct where it is removed by the scavenging action of the Inertial blower and expelled through the roof of the locomotive and the resulting

clean air enters the central air compartment (Ref.- Inertial Filter R.H. (DLW Part No. 17456710) & Inertial Filter L.H. (DLW Part No. 17456708)).

Engine Intake Air Filters :

Additional filtration is required for air used by the engine. The engine intake air filters uses six nos. fiberglass bag filter elements (Ref.- Secondary Filter Casing Asm. (DLW Part No. 17049039)).

Lube oil filters:

The purpose of lube oil filter element to remove particulate matter from the engine lube oil prior to delivery to the engine. These lube oil filter elements are paper type and seven nos. of these filter elements are used in lube oil filter housing assembly (Ref.- Lube Oil Filter Asm (DLW Part No. 17455637, Drg. No. 40170081)).

Turbocharger Oil Filter:

The turbocharger oil filter, provides additional protection for the high speed bearings and other lubricated areas of the turbocharger, by filtering the oil just before it is admitted to the turbocharger. The filter element is of the disposable (spin-on) type that mounts directly to an adapter on the filter head assembly (Ref.- 710 series engine maintenance manual (20 – cylinder EMDEC controlled engine)).

Soak Back Lube Oil Filter:

To ensure lubrication of the turbocharger bearings prior to engine start, and the removal of residual heat from the turbo after engine shutdown, a separate lube oil pressure source is provided. An AC (or DC) electric motor driven pump draws lube oil from the oil pan, pumps the oil through a soak back filter. (Ref.- 710 series engine maintenance manual (20 – cylinder EMDEC controlled engine)).

Fuel Filter:

The purpose of fuel filter element is to remove foreign material contaminants from engine fuel oil. One no. Fuel filter element (5 micron) is used in fuel oil filter assembly (Ref.-.Fuel Filter Element (5 Micron), DLW Part No. 16050629, Drg. No. 40106208).

Water Cooling System

The engine cooling system consists of engine driven centrifugal water pumps, replaceable inlet water manifolds with an individual jumper line to each liner, cylinder head discharge elbows, and an outlet manifold through which cooling water is circulated. The centrifugal water pumps are mounted on the accessory drive housing and are driven by the accessory drive gear (on 8,12,16 and 20-cylinder engines). A similar representative illustration of the 20-cylinder engine and separate aftercooler cooling systems is shown in next Figure 1 & 2.

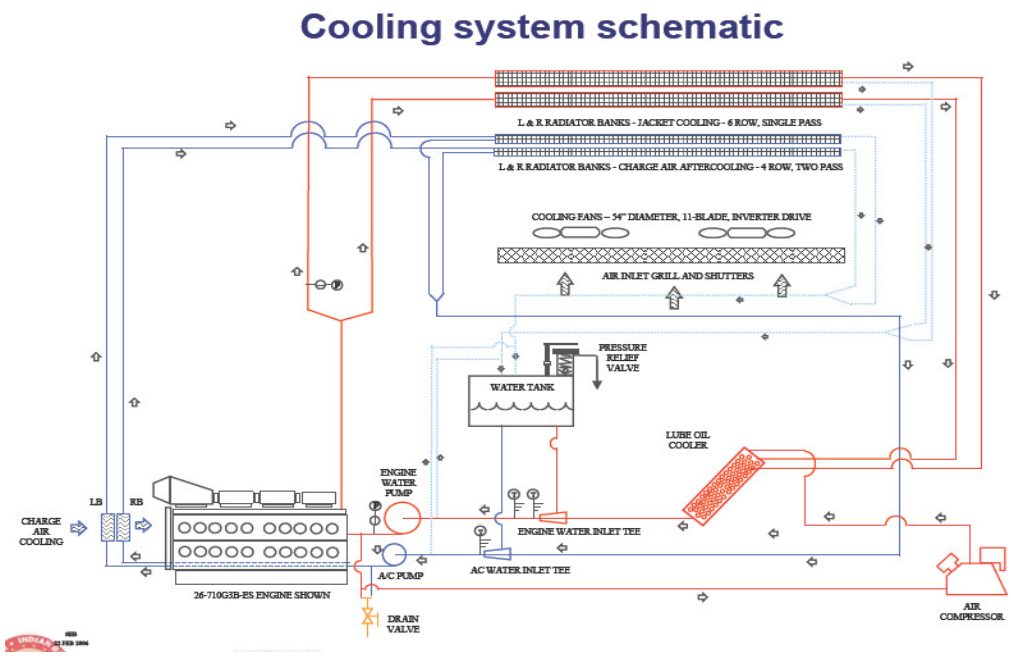


Fig.-1 Typical Water Cooling System Schematic

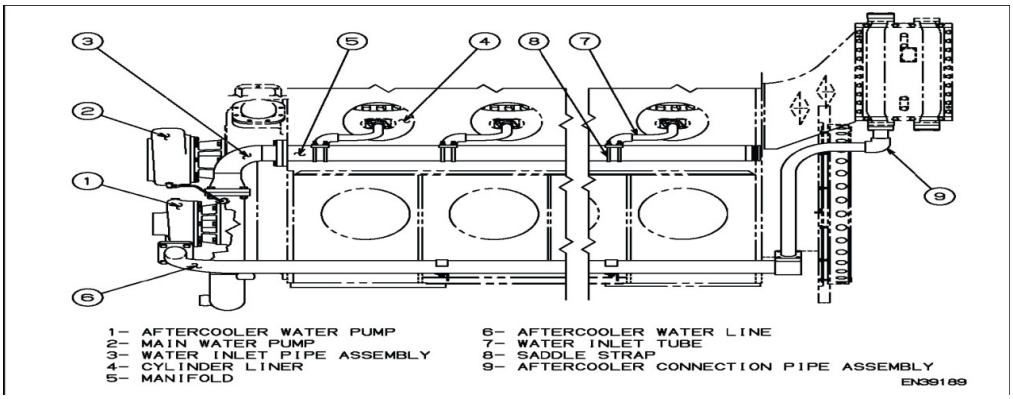


Fig -2 Typical Separate After Cooling System Piping

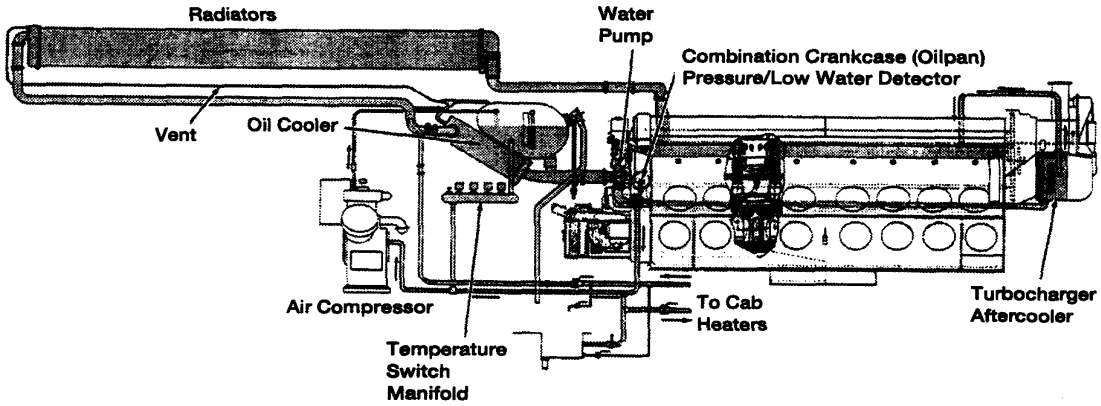


Fig - 3 Cooling system Schematic Diagram

Each liner is individually supplied with coolant from the water manifold through a water inlet tube assembly. A deflector is used at each liner water inlet to divert the water and prevent direct impingement on the inner liner wall. Water enters the cylinder head through 20 discharge holes at the top of the liner. A counterbore around each hole accommodates a heat dam and a water seal. A water discharge elbow is bolted to each cylinder head to provide a water passage to the water discharge manifold which extends along the top of the crankcase.



Fig. -4 Coolant Flow through Power Assembly

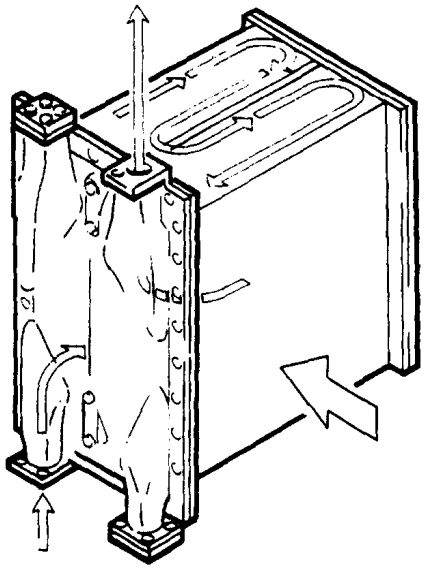


Fig. -5 Four Pass Aftercooler

Cooling water is circulated in a counter-flow direction through each aftercooler, which is located at the banks of the turbocharger air discharge duct, to cool the air before it enters the engine air box. The engine (and aftercooler) discharge water flows through an external cooling system to dissipate the heat taken up in the engine. This system consists of a water tank, water level gauges, temperature gauges, radiators, and connecting piping.

EMD in partnership with Young Radiator has developed a four pass aftercooler which recycles the water through the cooler before discharge to provide a higher cooling capacity. The cores have been equipped with four connection flanges to allow for the application of any four pass core to either the right or left engine bank and keep the coolant pattern the same between banks.

Coolant from the power assemblies and the aftercoolers is collected in the main water chamber in the top center of the engine. From the engine, water is directed out the 'Y" pipe to the radiator assemblies. Electrically driven cooling fans move air through the radiators which absorb heat from the coolant. Water temperature control is facilitated by the use of temperature switches that control fan and shutter operation. Coolant systems also use temperature sensors, and fan and shutter control is handled by a microprocessor unit.

The coolant returns from the radiators to the lube oil cooler where it absorbs some of the excessive heat from the lube oil. The cooler consists of a radiator section mounted in a steel tank.

From the cooler, the coolant goes back to the aspirators to repeat the cycle. When the engine is first started, coolant is drawn from the expansion tank as there is no return from the radiators at this point. When there is sufficient return flow, the water level in the tank stabilizes.

Note that part of the water from the engine mounted pumps is piped to the air compressor. There are no valves in the line, thus cooling will be provided whenever the engine is running. Upon leaving the air compressor, water is piped back to the water tank for re-circulation

Cooling System Pressurization

On most newer systems, the cooling system is pressurized to increase the boiling point of the coolant, prevent cavitation at the water pumps during high transient temperature conditions, and to provide uniform cooling throughout the operating range of the diesel engine. The expansion tank has a pressure cap that regulates system pressure at 20 psi (138 kPa) depending on engine requirements.

Operating Water Level

An operating water level instruction plate on the water tank is provided next to the water level sight glass. The instructions indicate minimum and maximum water lever with the engine running or stopped. The water level mark should not be permitted to go below the applicable "low" water level mark.
Progressive lowering of the water in the gauge glass indicates a water leak in the cooling system, and should be reported. Normally, there should be no need to add water to the cooling system, except at extended intervals.

COOLANT:

The coolant is circulated through the engine to transfer heat from the engine components to the radiators. Engine coolant is composed of water and corrosion inhibitor. Engine coolant must meet four basic requirements:

- adequately transfer heat energy through the cooling system
- not form scale or sludge deposits
- prevent corrosion inside the cooling system
- can't deteriorate seals or gaskets in the cooling system

WATER:

The water use in the cooling systems of EMD engines should be processed by softening, de-ionizing, or distillation to make it suitable for cooling system use.

Water Pump : Description

The two engine cooling water pumps (one on 8 cylinder engines) are self draining centrifugal pumps, which rotate in the opposite direction of the engine crankshaft. The pump drive shaft is supported by two permanently sealed grease lubricated ball bearings which require no maintenance.

Low Water Shutdown.

The cooling system is protected against low water situations by the engine protective device. The operation of this device is covered in the chapter Engine Safety devices.

EPD - ENGINE PROTECTION DEVICE

Low Water & Crankcase Pressure Protection-A low water detecting portion of the EPD, balances water pressure against airbox pressure. When water pressure falls, the device dumps oil from the governor supply line, causing an engine shutdown.

While there is no air box pressure when an engine is shut down, there is spring pressure. This spring pressure must be acted against by water pressure in order to keep the device latched in. On certain devices the static water pressure working against spring pressure will not keep the device latched in when the engine is shut down. This is not necessarily an indication that the device is defective. It is merely necessary to reset the device immediately after engine start.

Radiators:

Two radiator equipped with after cooler separate water cooling system. The radiator are having 200” length and 45” width core with 10 row tube stacked configuration. 6 row tube single pass for engine water cooling upper side of the radiator and 4 row for separate after cooling with two pass one for water in and another for water out at each radiator lower side. At one each screens are provided to trap debris larger than 0.06”in diameter at water inlet to radiator. The same should be removed and cleaned annually

Water tank

Two water tank arrangements possible, Flooded cooling system -small hood mounted tank - water fill from roof, Drain back system –larger tank on equipment rack -water fill on rack

Cooling System Pressure cap

20-lb pressure cap will seal the fill neck connected to the water tank, Water and corrosion inhibitor, in solid or liquid form, can be added through the fill neck. The changing periodicity of the Pressure cap should be annually.

Cooling system drain

Drain valve located in engine compartment in the pit between the engine and equipment rack

Cooling system flexible couplings and hoses

Cooling system contains flexible couplings and hoses in several places to take up relative motion between large components (e.g. between radiators and oil cooler)

ELECTRICAL MACHINES

(A) Traction & Companion Alternator

The diesel engine drives (rotates) the Generator Assembly, which comprises of Traction Alternator and Companion Alternator and Rectifier Assemblies in a single housing. The traction alternator converts diesel engine mechanical power into alternating current electrical power. Internal rectifier banks in the main generator assembly convert traction alternator output alternating current (AC) to direct current (DC)

1. Traction Alternator (TA20MBF)

It consists of two interwoven but electrically isolated stator windings excited by a common rotating field. The stator winding #1 three phase output is connected to traction rectifier bank #1 which resulting DC output (DC link) is applied to IGBT inverter #1 (bogie #1).The stator winding #2 three phase output is connected in the same manner to the traction rectifier assembly #2 and the IGBT inverter #2 (bogie #2).

2. Companion Alternator (CA9E)

It consists of two isolated stator windings with a common rotating field winding. From companion alternator stator#1, 400VL-L AC, 500A, 346 KVA (at 904RPM i.e TH8) is provided to locomotive blower motors and cooling fans; and 200VL-L AC, 80A, 28 KVA (at 904RPM i.e TH8) is provided through its half tap winding for excitation of traction alternator field via chopper. The companion alternator stator #2 output (275 VAC in 8TH) is connected to Auxiliary Power Convertor (APC – phase controller) which produces the low voltage DC power (72-78 VDC) required for control system, battery charging, and companion alternator excitation, thus eliminating the need for an auxiliary generator.

3. Rotor Assembly

The rotating field of **TA20MBF** consists of series connected field pole coils (10 pole electrically connected to slip rings#3 and #4) which are bolted to a drum type spider. The spider connects to the shaft which is supported by a bearing mounted in the end housing of the main generator assembly. AC output from **TA20MBF** is of frequency range 16.7 to 75.3 Hz for speed range 200 to 904 RPM. The 16 pole companion rotor of **CA9E** is coupled to main alternator rotor. Series connected field pole coils of companion rotor are electrically connected to slip rings#1 and #2. AC output from **CA9E** is of frequency range 26.7 to 121 Hz for speed range 200 to 904 RPM. The other end of the complete rotor assembly is supported through coupling by engine crank shaft.

The two Rectifier assemblies and Slip Ring assembly are located in the **Air Box** which forms a part of Generator assembly. Rectified traction alternator output is rated 1650 Amps continuous and 2700VDC maximum.

4. Traction Alternator and companion Blower

The Main generator blower has provided cooling air to traction & companion alternator & then provide pressurization on the locomotive carbody. The blower has pulled initial filtered air from inertial compartment. The blower is fitted in above the engine air filtered and will force air through a transition duct that will connect to the generator air box. The air will circulate through the generator & then discharge in to the locomotive carbody to provide a sight positive pressure to the engine room. The blower has operated in one mode: power mode via a single winding 4-pole motor. Blower has controlled via a circuit breaker & will always be running when the locomotive is running.

(B) **Traction Motor**

1. **The traction motor** is a three phase, asynchronous type 4 poles force cooled electrical machine. Its stator winding is star connected. The motor converts electrical power into mechanical power to the shaft. It has very simple & extremely rugged, almost unbreakable construction i.e. squirrel cage rotor. Use of AC traction motor in AC-AC transmission has the advantage of high adhesion and high tractive effort, maintenance free, high reliability & availability and higher energy efficiency. In dynamic braking mode, the three-phase motors act as generators and power is fed back to the DC link via the two inverters and gets dissipated in BDR grids.

2. Traction Motor Blower

The traction motor blower is provided to supply the necessary cooling air to the phase module (quantity 6) & the traction motors. The blower has pulled unfiltered air in through a screen and pass the phase module cooling fins & will dump into a plenum. Plenum is directly connected to the inlet of the blower assembly. The blower will then force the air down, into the underframe plenum. Cooling air is distributed to traction motors through traction motor inlet openings. The air will pass through TM's & escape to the ambient beneath the locomotive end.

C) Other Electrical Machines

1. Radial Dynamic Braking Hatch Assembly.

It consists of fan, fan motor & radial resistor assembly. The radial resistor dissipated the heat developed from the kinetic energy of locomotive during dynamic braking. 54" diameter fan has been used to cool the resistor with blowing air on it. The fan is driven by a DC motor power from one of the 4-quadrant resistor.

2. Electrical locker blower / Dustbin Blower

The electrical locker blower has provided cooling air to the cabinet mounted electrical component. The blower has pulled air from inertial filter compartment. The air has drawn through a carbody mounted inertial filter assemblies on the main generator compartment. The blower will force air thru a hose connection to the E/Locker filter box, where the air will undergo a secondary filtration. The air will then split off into different path throughout the locker & cool various component , such as the APC,EM2000 & Aux inverters.

The dustbin blower has scavenged dirty air from inertial filters & exhaust dirty air through the roof. Blower has pulled dirty air from the inertial filter-dustbins & discharge that dirty air through the roof to the outside ambient.

3. Radiator Cooling Fan Motors

Radiator Cooling Fan Motors are of the inverted squirrel cage induction motor type and are integral part of the cooling fan assembly. Each cooling fan (total two per locomotive) is powered by inverter through companion alternator.

AC –AC TRANSMISSION SYSTEM

Electrical locker:

The GT Locker / Electrical locker replaces the ECC1, ECC2, ECC3, TCC1 and TCC2 cabinets with a single cabinet while retaining the functionality. The Electrical locker will comprise of the Control Cabinet and the Inverter cabinet which will be supplied as a single welded unit and pre-wired and tested. The Electrical locker will have lifting locations identified to handle the unit as an assembly and to be decked on the locomotive. The Electrical locker will be applied above the underframe, behind the cab and will be welded to the underframe. Essential building blocks of the E-Locker will be similar to that on a WDG4 locomotive, however the same are packaged into a single cabinet instead of 5 cabinets reducing the cabling and eliminating components as required by use of latest technology.

The AC Traction system consists of the Locomotive Control Computer, IGBT based Traction Inverters, various sensors for Current, Voltage, Temperature, Pressure, Speed and other allied equipment like relays, breakers, indicators, etc.

The Electrical locker will incorporate following major components of control system-

The locomotive control computer EM-2000 (similar to that used on a WDG4 locomotive):

EM2000 is a 32-bit computer based on Motorola 68020 microprocessor running at 16 MHz with a math coprocessor and Communication through RS-232 serial cable/port. The traction control computer receives data from EM2000 via RS-485 serial link. The bi-directional bus carries data such as how much power for traction the inverter must develop as well as other information to control activation of devices like blowers and heaters. In addition to the data via RS-485 link, traction control computers continuously provide feedback information to monitor various parameters such as status of relays and temperature of various components, voltages and currents. Based on this feedback data and information received via RS-485 serial link, the programs stored in the traction control computers work, to drive the inverter as well as to protect it in the event of faulty operating conditions. Traction converters are controlled by traction control computer & braking system is controlled by CCB with interface from EM-2000. The traction control computers also provide failure detection and protection for inverters and also provide EM2000 with fault information to be displayed and archived in the memory for further analysis.

Auxiliary Power Converter (APC)-

The control system provides a supply of 74VDC up to 32 kW, irrespective of the variation in engine speed. This power is obtained from the companion alternator. This is accomplished by

an APC which replaces the Auxiliary Generator and the Battery Charging rectifier on WDG4 .With the implementation of the Auxiliary Power Converter (APC), the Auxiliary Generator, Digital Voltage Regulator (DVR) and Battery Charging Assembly is now eliminated. The APC is a modular unit located on the back inside wall of the electrical locker. The power to the APC is taken from one of the variable Voltage/Frequency Companion Alternator windings. Input to the APC is a three phases, alternating current with both frequency and voltage proportional to locomotive engine speed. It provides:

Low voltage circuit power (74vdc system, maximum of 31Kw)

- Battery charging voltage
- Companion alternator excitation

The Inverter Cabinet portion

The Inverter Cabinet portion of the E-Locker contains the following equipment:

- Auxiliary inverters for:
  - Engine cooling fans
  - Truck blower motors
- Main Generator Field Supply Chopper-

It provides rectified and regulated current to the traction alternator as requested by the locomotive control system computer (EM2000)

- APC Phase Controller
- Contactors
- Battery Charge Resistor
- 6 Phase Modules

FIRE (Functionally Integrated Railroad Electronics) Display:

Two FIRE display screens are provided on each control console. They replace the conventional analog gauges & indicators on the control stand. Also, the display screens serve as the driver/operator interface to the locomotive.

The Functionally Integrated Rail Electronics (FIRE) system is an electronic system that is used to both interconnect and host locomotive command and control functions. The FIRE computers integrate and manage the overall locomotive control. These command and control functions include the following:

1. It provides the user an interface to access the locomotive's functional subsystems.
2. It routes communications between functional subsystems that do not communicate directly with each other.
3. It systematically integrates and coordinates the overall operation of the locomotive's functional subsystems (In other words, they internally assimilate the system functions into the FIRE system itself).

In addition to the command and control functions, the FIRE system is capable of integrating any combination of functional subsystems. For example, FIRE can perform command and control functions with a physically separate electronic air brake function. FIRE is not required to

support either the sensors, or the actuators required for a particular function. However, it can allow user to communicate with the various systems using the network connections.
The FIRE System serves in three main capacities:
1. Provides Operator/Maintenance Personnel with an interface with locomotive subsystems.
2. Completes a communication link between locomotive subsystems.
3. Replaces some devices such as crew alerter, speed indicators, air gauges, EOT devices, load meter, push-to-test type warning lights.
The FIRE system includes / has a built-in locomotive event recorder system. The locomotive event recorder collects and records locomotive operation data and events in accordance with railroad requirements and railroad operating rules. There are two preferred methods for downloading the FIRE event recorder:

1. PC Card Download
2. Laptop Serial Download

Event recorders do not stop recording while downloading is in progress and can be downloaded during locomotive operation.

EMDEC (Electro-Motive Diesel Engine Control)

EMDEC Engine EUI System consists of:

- Interface module: It acts as a bridge between ECM & Controller i.e. EM-2000 or test bed controller.
- Dedicated power supply: Supplies power to all the modules of the EMDEC. It provides 24V, 23A DC supply to ECMs and Interface Boards.
- EMDEC Computers

BATTERIES

The locomotives have 10 NiCad batteries connected in series providing 64 volts.

WDG5 locomotives are provided with some special features –

- Crash Hardened Memory- An additional Crash Hardened Memory (CHM) module will also be provided which performs the same functions of the Event recorder built into FIRE. However, the CHM module as the name indicates is designed to be robust and retain data and withstand conditions even if the locomotive is in an accident.
- Electronic fuel gauge-Provides digital signal, Provides value for FIRE and Enables fuel usage history.

BOGIES

The WDG5 locomotive is equipped with two High Tensile Cast Fabricated (HTCF) bogie assemblies. The bogies support the weight of the locomotive and provide the means for transmission of power to the rails. The rigid steel fabricated frame, utilizes a bolster-less secondary suspension system. All longitudinal traction and braking loads generated are transferred from the bogie assembly to the locomotive under-frame through the car-body

linkage system. The bogie is designed to provide high reliability, long overhaul cycle and extended maintenance intervals.

WDG5 locomotive car body weight is transferred directly to bogie frame through four rubber compression spring assemblies located at corner positions formed on the bogie frame where the longitudinal beams and cross beams intersects. Bogie frame is supported on twelve soft primary coil springs kept on journal bearing adaptor. Each bearing adaptor have two coil springs which are designed to improve ride quality and equalization of wheel set loads for operation over the track. Centre pivot does not bear any load and is used only for transfer of traction and braking forces. All longitudinal traction and braking forces transferred from bogie assembly to locomotive under-frame through the car body linkage system.

The damping at the primary stage has been provided by hydraulic dampers fitted between each bearing adaptor and the bogie frame. Two lateral dampers are provided at each end of bogie at secondary stage to supplement the damping provided by the rubber springs. These dampers are fitted between the bogie frame and the locomotive under-frame to limit the lateral motion for stability at higher speed. Primary traction rod is fitted between bearing adaptor and bogie frame to transmit traction between bogie to wheel set. Axle boxes are fitted with taper roller bearings with integrated bearing adopters. The journal bearing adaptor serve to position the journal bearings and primary coil springs between the bogie frame & axle to transmit vertical loads.
Axle-hung, nose link suspended lightweight AC traction motors are used to convert electrical energy into locomotive tractive effort. All traction motor nose positions are oriented to the same side of each axle within the bogie frame.

Unitized tread brakes acting on one composition brake shoe per wheel provide the braking power for the locomotive. The tread brake units are compact and have integrated slack adjuster that compensates the full amount of wheel wear as well as brake shoe wear.

Brake System related with Bogie

Information related to Tread Brake Unit (TBU) is as under:

- Tread Brake Unit (TBU) has been provided on each wheel of bogie with Brake Head & K-Type composite Brake Shoe.
- Flexible Type Tread Brake Units has been fitted on middle axles of each bogie.
- TBU has been provided with integrated spring applied and air released parking brakes on one wheel of end axles of each bogie.
- TBU has been fitted with integrated slack adjuster to compensate brake shoe and wheel wear.
- For description of TBU, refer to the manufacturer's document i.e. for M/s Knorr - Bremse make Tread Brake Unit refer TBU's PEC7 Manual (B-B000.25) Rev.12 - 16.06.2011- en.
- Brake rigging and brake ratio are as per drawing no. SK.VL-756

UNDERFRAME

WDG5 locomotive is a platform type locomotive. All the hoods are designed to transfer the equipment load to the underframe. The underframe structure carries all the equipment such as Cab, E- locker, inertial hood, engine hood, cooling hood, dynamic braking hood, air compressor, equipment rake, air reservoirs blowers, sand batteries, cables, pipes,& all other equipments etc. These loads are transfer to bogie. The carbody has two slip joints at both ends of the engine hood.

The underframe structure has been built with two depth of underframe 475 mm at end & 620mm in the middle of underframed. Underframe section that serves as the main load carrying member for locomotive. Special features are given below:

- High strength light weight underframe
- 400 KN buff load capacity
- Anti climbing feature
- NC 390 draft gear
- Light weight- Carbody occurs doors for ease of maintenance
- 7500 liters fuel tank with fuel fill adaptor on each side.
- Electronic fuel gauge & cab FIRES screen display.

BRAKING SYSTEM

The locomotive is equipped with computer controlled braking (CCB-II) system as per RDSO specification no. MP.0.01.00.24 (Rev.01) Jan'2010.This system is an electro-pneumatic microprocessor based system. The CCB-II system conforming to UIC requirements and during operation and diagnoses any fault and communicates to the system for logging and display. The advantage of CCB-II is as under:

- Ease in Maintenance – all Valves mounted on front of panel only
- Valves modularized into 6 LRUs (Line Replaceable Unit)
- Simplifies maintenance tasks- (Allows replacement of LRUs with just one wrench)
- CCB II is a network-based, electronic air brake system with substantially reduced wiring viz-a-viz CCB1.5 (earlier version of the system) system thereby reducing wiring related faults.
- Includes flow sensing. Digital Display on Fire Screen
- Integrated with EMD FIRE screens on locomotive
- Includes crew advisory on EBV (Electronic Brake Valve) display
- Fully potted electronic modules.
- High Temperature HNBR Rubber used for o-rings
- FLASH programmable from PTU (Portable Test Unit)
- Includes Real Time Clock in EBV (Electronic Brake Valve)
- Can be used with Backup DBVs (Driver Back Up Valve) in case of CCB II failure up to 15 km/h speed
- Overhauling Periodicity Increased up to 8 years
- Rredundancy features

The complete information related to brake system is as under

- Dynamic brake has been provided in the locomotive.
- Automatic Emergency Brake (AEB) and Restricted Air Penalty brake Switch (RAPB): AEB restricts the speed of locomotive to a preset value, which is useful in ghat sections. RAPB switch is provided in the cab to enable AEB feature.

MISCELLANEOUS EQUIPMENT

AUTO ENGINE START/STOP SYSTEM (AESS):

The WDG5 locomotives are equipped with the Auto start system. When the Auto Start system is properly set up (locomotive not in active service, etc), it automatically stops the diesel engine in order to save diesel fuel & to reduce noise and emissions. Following the automatic stop, the properly set up system automatically restarts the engine, if and when necessary, to prevent cold-engine starting problem, engine coolant freezing damage & weak batteries.

Set Up Auto Start

The system set up as follows:

1. Stop the locomotive
2. Set the throttle handle in IDLE position
3. Center the reverser
4. Apply the locomotive brake

Engine shut down set up

If auto start is ENABLED, the engine will automatic shut down when all following conditions are met :

1. Engine has been running for at least 20 Minutes
2. Main Reservoir air pressure is above 120 psi
3. Locomotive battery charging current is low enough
4. Locomotive battery voltage is high enough

ELECTRONIC FUEL GAUGE:

The locomotive is equipped with a microprocessor based fuel level monitoring system. The system uses the “Bubble Method” for measuring the fuel level in the locomotive fuel tank. The principle of this method is to force a controlled airflow through a pipe mounted inside the fuel tank. The backpressure is the measured & compared to the tank’s geometry & fuel density. A fuel level is then calculated & provided to the two Digital Fuel Level Display units. Compressed air is piped from the No.1 Main reservoir air to the fuel link control box mounted under car body on right side of the locomotive. The input air is filtered the metered & output to the sense pipe mounted in the fuel tank.

INVERTER FOR BABY COMPRESSOR:

The WDG5 locomotive has Air start system which employs air compressor & auxiliary inverter. Inverter for auxiliary air compressor is used for driving baby compressor. The inverter has following control & display:

From Panel controls

- DC Input Circuit Breaker – Normally ON
- Output RCD/MCB - Normally ON
- RESET/ON/OFF switch

SPEED POTENTIAL

In order to establish the speed potential of WDG5 locomotive on track maintained to other than C&M-I, Vol.-I standard, detailed oscillation trials have been conducted over BE – MB section of Northern Railway up to maximum test speed of 110 Km/h. The test results as contained in RDSO report no. MT-1242/F, Rev.0 amendment Nil, dated 08-04-2013, indicate that WDG5 locomotive has exhibited satisfactory riding quality and stability characteristics up to a maximum test speed of 100 km/h with new & worn wheel profile on straight track, station yard & 1º/2º curve on track maintained to other than C&M-I, Vol.-I standard.

Based on the satisfactory trial results, it is certified that single/double headed WDG5 class of locomotives may be permitted to run up to a maximum speed of 90 km/h on BG track of Indian Railways.

HAULING CAPACITY, BALANCING SPEED & ACCELERATION CHARACTERISTICS

Load chart for freight services:

The load charts are drawn considering the **standard 59 loaded BOXN wagons having capacity (CC+8+2t) i.e. 5400 tonnes** which is the current limitation imposed by loop length.

To assist Railways to decide loads under adverse conditions also, it has now been decided to include **two sets of load charts for diesel-electric locomotives for freight services i.e.** one based on the dry rail condition (standard conditions) and the other for adverse conditions taking into consideration the wet rail condition.

Assumptions for haulage capacity:

The following assumptions have been considered while computing / calculating haulage capacity of diesel electric locomotives for goods services:

- The load charts are applicable for dry rail conditions as well as wet rail conditions with different gradients.
- The load charts are based on designed value of adhesion on dry rail conditions. The adhesion values in case of **wet rail condition** is likely to drop maximum by 20% as compared to dry un-sanded condition as per RDSO Report no. TFC - 77, January '2002.
- The Load chart has been calculated on the basis of 5% ageing factor & no acceleration reserve.
- No de-rating factor has been considered in computing haulage capacity.

- Specific starting resistance of loaded BOXN / BCN wagon has been taken as 4 kg/t on main line service.

Balancing speed & acceleration characteristics:

Zonal Railways have reported that the RDSO table for balancing speed and acceleration characteristics of diesel locomotive is outdated. It does not take into account the prevailing speeds and loads of trains. It is necessary that to standardize the balancing speed as well as acceleration characteristics of all diesel locomotives on current scenario, so as to assess the time loss accurately.

Based on the above, balancing speed of locomotive on level tangent track with loaded 59 BOXN (CC+8+2t) & 44 BCN (CC+8+2t) is 91 Km/h & >100 Km/h respectively. A comparison of balancing speed for all diesel locomotives is also enclosed.

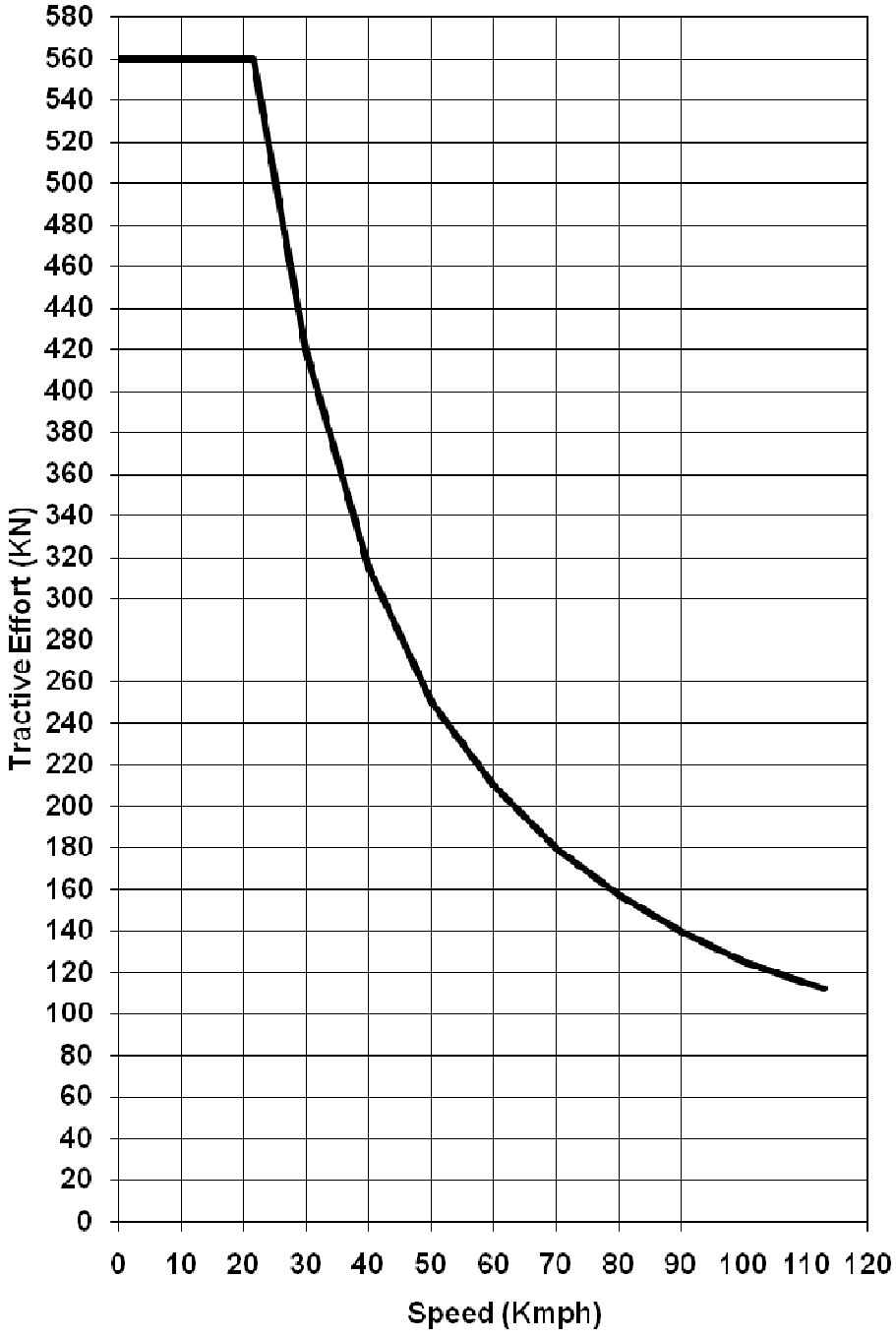
Similarly, acceleration characteristics of WDG5 locomotive for loaded 59 BOXN (CC+8+2t) & 44 BCN (CC+8+2t) has been calculated.

Note:

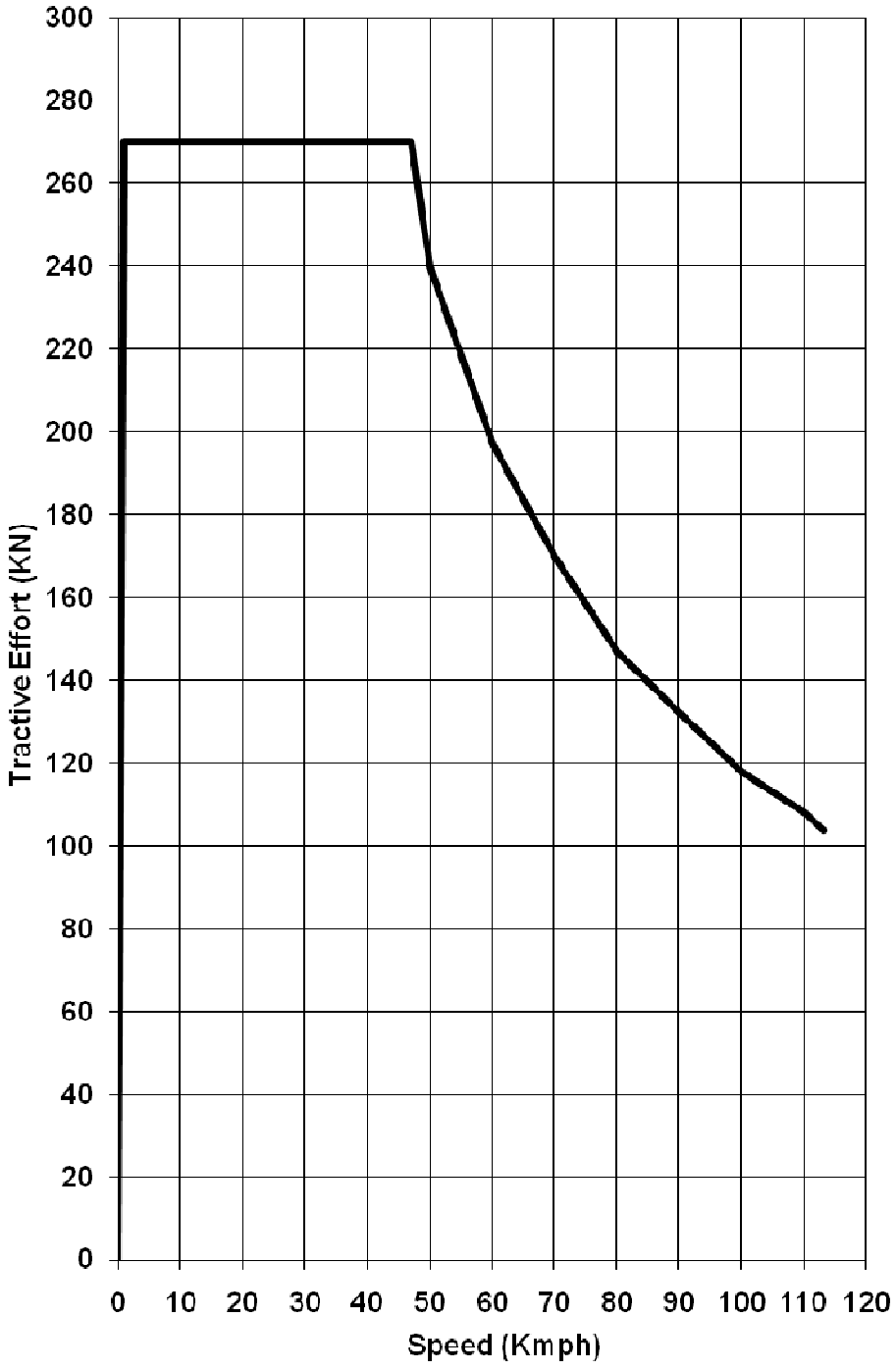
The values indicated in load charts, balancing speed & acceleration characteristics have been derived through theoretical computer simulation software and may be used as guidelines only. Although, every care has been taken while simulating / calculating data and analyzing it but it is difficult to arrive at actual results since practical conditions are always different from theoretical ones assumed. Any errors, omissions & suggestions for further improvement of this report will be thankfully acknowledged and included in the next revision.

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Tractive Effort Vs Speed characteristics (AAR condition)
5500 GHP WDG5 Diesel Electric Locomotive
Input to traction : 5206 HP
Gear ratio : 20:91, Wheel Dia. : 1054 mm (HW)
Starting Tractive Effort : 560(KN) or 57085 Kg
Locomotive weight : 133.8 T



Dynamic Braking Characteristics of
WDG5 (5500 HP) Diesel Electric Locomotive
Gear Ratio: 91/20, wheel dia: 1054 mm (HW)

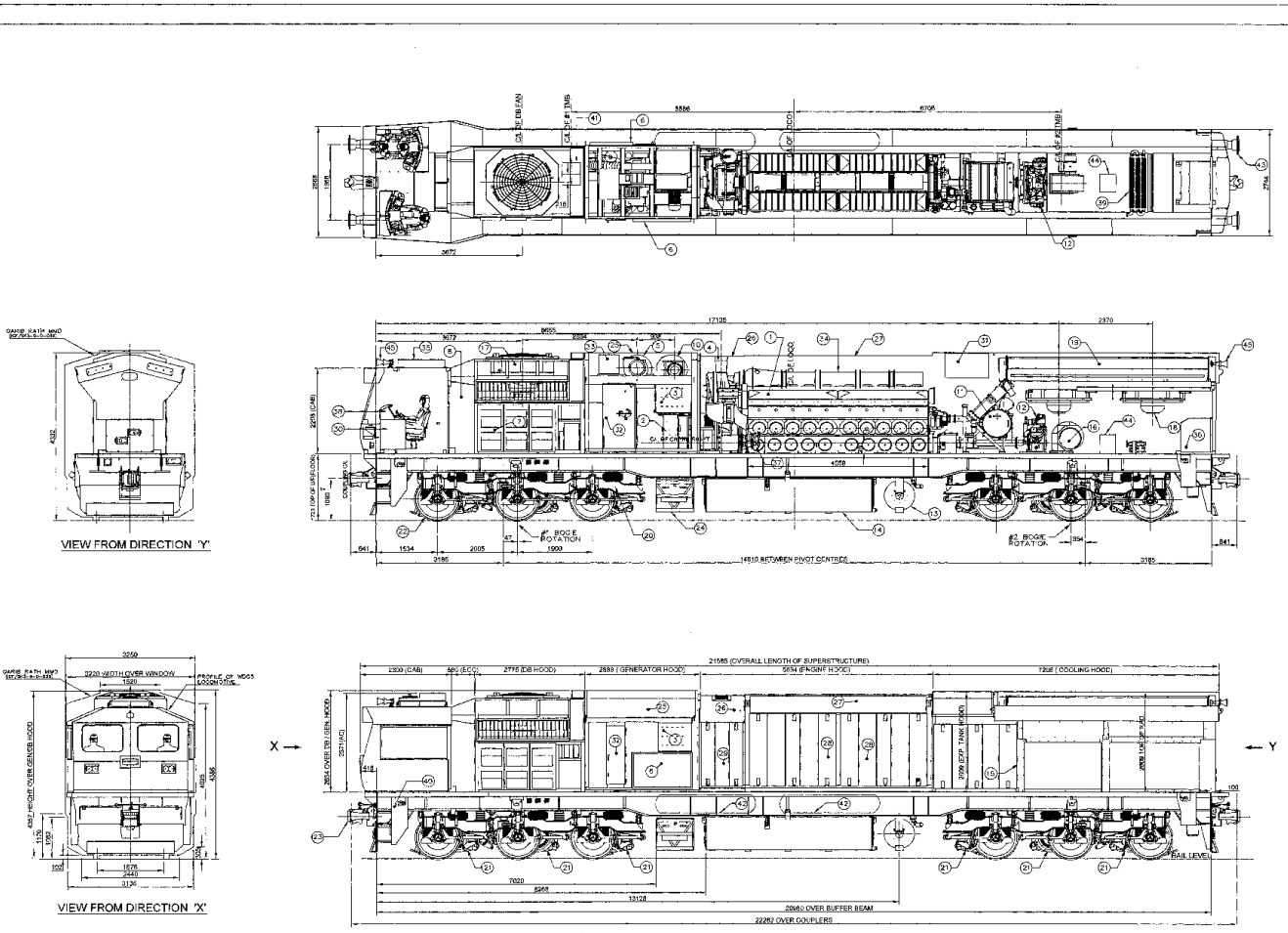


MAIN PARTICULARS OF WDG5 (5500 HP) LOCOMOTIVE

GENERAL		**Injection System**	
Weight of loco in Working Order (T)	133.8	Type	Electronic unit injector
Adhesive weight in Working Order (T)	133.8	Displacement / cyl.	11635 cm²
Axle load (T)	22.3	**Turbo Supercharger**	
Wheel dia (new) Driving mm.	1092	Make and type	EMD Model G
Tractive effort (KN), Maximum	560	Weight of turbocharger	953 Kg.
Continuous TE (KN)	405	**TRANSMISSION (ELECTRICAL)**	
Speed (Km/h), Maximum	105	**Traction Alternator**	**EMD**
Continuous Speed (Km/h)	30.6	Make and type	EMD TA20 MBF
Transmission system	AC – AC traction	Number per locomotive	One
ENGINE		Maximum speed	904 rpm
Make and type	20-710G3B-ES	Max. Voltage	2700 V DC (Rectified)
No./loco	1	Max. continuous current	1650 Amps (Rectified)
Governor	Electronic Control Module	**Companion Alternator**	
Weight of engine (Dry)	21318.8 Kg	Make and type	EMD CA 9E
No. of Cylinders	20	Max. Voltage	400 V
Cylinder formation	45 Degree V type	Frequency at 904 rpm	121 Hz
Bore & Stroke in mm	230.19 x279.4	Max. power (Output)	400 KVA
Compression Ratio	16:1	Unit weight (TA &Comp.alternator assly.)	8618 Kg (Appr.)
Lube oil sump capacity	1596 litre	**Traction Motor**	
Lube oil pan, from bottom to top dip stick	1”-1.2”	**Make**	**EMD**
Horse Power		Type	A2921-6
AAR condition	5500 hp	Number per locomotive	6
Input to traction (THP) (47^{o}C – 600m)	5206 hp	Maximum Power (KW) / speed (RPM)	645 KW/2675 rpm
RPM		Gear ratio	20:91
Rated	954	Suspension	Axle hung
Idle / Low idle	269 / 200	Motor, Complete weight	2386 Kg

Cooling system (Pressurized)		**AUXILIARIES**	
Water Pump type	Centrifugal	**Auxiliary Generator**	
Water pump capacity	1235 liters	Auxiliary Generator has been replaced by APC (Auxiliary power converter)	
No. of radiator fans	2	Rating	74 V DC, 904 rpm
Fan drive	Individual inverter	**CONTROL SUPPLIES**	
Fan power		**Fuel tank (Detachable)type**	
BATTERIES		Number per locomotive	One
Make and type	Total capacity	Fuel Capacity	7500 litres
Number of cells	10	**Sand**	
Arrangement	2 series connected 5 cell Ni-Cadmium Shaft-Nife SRX1500P batteries	Number of sand boxes / Locomotive	**8**
Voltage	64 VDC	Total capacity	283 liters (10 cubic ft)
Capacity	155 AH	**COMPRESSED AIR SYSTEM**	
Head light	200W,30V PAR- 56Standard bulb	Air brake	KNORR/NYAB CCB-II-IR
BRAKES		Control system	Microprocessor controlled
Locomotive	Air, Hand, Dynamic Brakes fully Blended with Automatic Brakes.	**Air compressor**	
Train	Pure air brake system.	Model	WLN A9BB
System	KNORR/NYAB CCB-II-IR	Type	Two stage, 3 Cylinder
Brake Rigging		Coolant	Engine Coolant
Type	Single 355.6 mm(14”)	Displacement at 904 RPM	7.19 cubic meter/min (254 CFM)
Shoe material	Composite		
Cylinder Quantity	4 per truck		

Comparative data of WDG5 & WDG4 locomotive			
S.no	**Feature**	**WDG5**	**WDG4**
1.	Horse Power (HP)	5500	4500
2.	Gross weight / axle load (t)	134 / 22.3	126 / 21
3.	Length over couplers (mm)	22262	21246
4.	Max. height (mm)	4382	4264
5.	Max. tractive effort (KN)	560	540
6.	Max. braking effort (KN)	270	270
7.	Balancing speed with 5400 t trailing load (km/h)	91	82
8.	Engine	EMD,20 cylinder	DLW,16 Cylinder
9.	Brake system	CCB2	CCB1.5
10.	Alternator	EMD, TA-20CA-9	EMD, TA-17CA-6
11.	Start system	Pneumatic	Battery
12.	Driver's display	TFT, As per AAR	Conventional Gauges
13.	Radiator fan drive	Individual inverter	Companion alternator
14.	Air conditioner	Dayton Phoenix + Toilet	-
15.	Emission control	EFI & split cooling	Nil
16.	72 V supply	Solid state drive	Auxiliary generator
17.	TM Blower	Two inverter driven	Single, mechanical driven
18.	Traction Motor	EMD traction motor • Type EMD A 2921-6 • Gear ratio : 20:91 • Max. power – 645 kW, • Max. speed – 2675 rpm • Air flow – 1.23 m^3/sec • Stall torque : 10811 Nm • Weight – 2386 Kg	Siemens traction motor • Type ITB – 2622 - 0TA02 • Gear ratio : 17:90 • Max. power – 630 kW, • Max. speed – 3320 rpm • Air flow – 1.0 m^3/sec • Stall torque : 9470 Nm • Weight – 2120 Kg



REF NO.	DESCRIPTION
45.	HORN
44.	AUX. AIR COMPRESSOR(BABY)/INVERTER
43.	SIDE BUFFERS
42.	MAIN AIR RESEVOIRS
41.	#1 TRACTION MOTOR BLOWER
40.	SAND BOXES F/B & O/B
39.	FINNED AFTER COOLER
38.	FIRE SCREENS (X4)
37.	ENGINE START MOTORS (AIR START)
36.	AIR BRAKE RACK CCB2-IR
35.	AIR CONDITIONER
34.	EXHAUST MANIFOLD
33.	FRESH WATER TANK (TOILET)-300 LTR.
32.	TOILET COMPARTMENT
31.	EXPANSION TANK
30.	CONTROL STAND
29.	GENERATOR ACCESS DOORS
28.	ENGINE ACCESS DOORS
27.	REMOVABLE ENGINE HOOD SECTION
26.	REMOVABLE SILENCER/ TURBO HATCH
25.	REMOVABLE INERTIAL FILTER HATCH
24.	BATTERIES - NICAD SRX1500P
23.	COUPLER - E TYPE
22.	WHEELS (43")
21.	TRACTION MOTORS (A2921-6)
20.	BOGIE HTSC FABRICATED(3AXLE/3 MOTOR)
19.	RADIATORS-200" LONG
18.	COOLING FANS-54"
17.	DYNAMIC BRAKE GRIDS-RADIAL
16.	#2 TRACTION MOTOR BLOWER
15.	ENGINE ROOM PARTITION
14.	FUEL TANK (7500 LTR.)
13.	AIR START RESERVOIR
12.	AIR COMPRESSOR- SHAFT DRIVEN
11.	EQUIPMENT RACK
10.	GENERATOR BLOWER
9.	INVERTER
8.	ECC
7.	TCC
6.	INERTIAL FILTER
5.	DUST BIN/TCC BLOWER
4.	ENGINE EXHAUST SILENCER
3.	ENGINE AIR FILTER
2.	GEN/ALT (TA20-CA9)
1.	ENGINE 20-710G3EBS

D	Sd/-
C	Sd/-
DO	Sd/-
APPD.	Sd/-
DT.	12.04.2010

NOTE:-
1. DIMENSIONS ARE IN MM
2. NOT TO SCALE

ALT	NO.OF PLACES	REF. NO.	DESCRIPTION	ALT.NOTE NO	SIGN	DATE
B	-	-	DRAWING REVISED	L2-1026		SEPT.2011

APPLICABLE FOR: WDG5 CLASS LOCO

GENERAL ARRANGEMENT

SCALE :- NTS | REF. EMD's GA DRG. NO.40169997 | FIRST ISSUED

INDIAN RLYS. R.D.S.O. (M.P)

DRG. NO. SK.DL - 4744

SUPERSEDES

SUPERSEDED BY

HAULAGE CAPACITY (FRIEGHT)										
Loco: WDG5 (5500)			**Track condition : Dry Rail**					**Weight of loco : 133.8 T**		
Trailing load in tonnes at Km/h on tangent track										
BOXN/BCN Wagons and other casnub bogie air brake stocks										
GRADE	**START**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
LEVEL	**5400**	5400	5400	5400	5400	5400	5400	5400	5400	5190
1/500	**5400**	5400	5400	5400	5400	5400	4925	4020	3330	2780
1/400	**5400**	5400	5400	5400	5400	5360	4325	3555	2960	2485
1/200	**5400**	5400	5400	5300	4080	3260	2670	2230	1880	1605
1/150	**5210**	5210	5210	4145	3200	2570	2115	1770	1500	1285
1/100	**3940**	3940	3940	2870	2225	1790	1475	1240	1055	905
1/50	**2240**	2240	2005	1450	1120	896	735	615	520	440

HAULAGE CAPACITY (FRIEGHT)										
Loco: WDG5 (5500)			**Track condition : Wet Rail**					**Weight of loco : 133.8 T**		
Trailing load in tonnes at Km/h on tangent track										
BOXN/BCN Wagons and other casnub bogie air brake stocks										
GRADE	**START**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
LEVEL	**5400**	5400	5400	5400	5400	5400	5400	5400	5400	5190
1/500	**5400**	5400	5400	5400	5400	5400	4925	4020	3330	2780
1/400	**5400**	5400	5400	5400	5400	5360	4325	3555	2960	2485
1/200	**4935**	4935	4935	4935	4080	3260	2670	2230	1880	1605
1/150	**4140**	4140	4140	4140	3200	2570	2115	1770	1500	1285
1/100	**3125**	3125	3125	2870	2225	1790	1475	1240	1055	905
1/50	**1765**	1765	1765	1450	1120	896	735	615	520	440

Balancing speed of locomotives with various trailing load for freight service

Section : Level tangent track

Load : (CC+8+2t) = 5400 t

Type of Wagon	Axle load (t)	Length (MM)	No. of wagon	Balancing speed (Km/h)										
				WDM2 (2600 HP)		WDG3A (3100 HP)		WDM3D (3300 HP)		WDG4 (4000 HP)		WDG4D (4500 HP)		**WDG5 (5500 HP)**
				Single	Multi	Single	Multi	Single	Multi	Single	Multi	Single	Multi	**Single**
BOXN	**22.9**	**10713**	**59**	57	81	64	90	67	92	76	104	82	110	**91**
BOXNEL	25	10713	**58**	56	80	63	88	66	91	74	101	79	108	**89**
BOYEL	25	11929	**53**	59	83	66	91	69	94	78	104	82	111	**93**
BOXNHL	22.9	10963	**58**	58	82	65	91	68	93	77	105	83	112	**94**
BCNA	**22.82**	**14450**	**44**	68	92	75	104	78	108	87	117	94	124	**>100**
BCNHL	22.9	10963	**58**	59	83	66	91	69	94	77	105	82	111	**94**
BCNHS	22.82	14450	**44**	68	92	75	104	78	108	87	117	94	124	**>100**

Acceleration characteristics of WDG5 locomotive

Load : 59 BOXN (CC+8+2t) = 59 x 91.6 = 5400 t

Section : Level tangent track

Speed (km/h)	0	10	20	30	40	50	60	70	75
Time (Min)	0	0.61	1.15	1.74	2.52	3.63	5.18	7.38	8.42
Dist (Km)	0	0.05	0.18	0.43	0.88	1.72	3.14	5.52	7.01

Load : 44 BCN (CC+8+2t) =44x 91.28 = 4016 t

Section : Level tangent track

Speed (km/h)	0	10	20	30	40	50	60	70	75
Time (Min)	0	0.44	0.82	1.25	1.81	2.59	3.63	5.03	5.97
Dist (km)	0	0.04	0.13	0.31	0.64	1.22	2.18	3.69	5.00