भारत सरकार - रेल मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

डब्ल्यू०डी०पी०$_4$ लो को मो टिव का रेखाचित्र पुस्तिका

DIAGRAM BOOK OF WDP$_4$ LOCOMOTIVE

रिपोर्ट सं० एम०पी०.मिस्ले०. -११७ (संसो.० - ०.००) ,अक्टूबर,२००१
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अनुसंधान अभिकल्प एवं मानक संगठन
मानक नगर, लखनऊ . २२६ ०११
RESEARCH DESIGNS & STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW - 226 011

WDP4 CLASS 3-PHASE (A-A-I 1-A-A) DIESEL ELECTRIC LOCOMOTIVE

BRIEF DESCRIPTION OF THE LOCOMOTIVE

The WDP4 locomotive is equipped with a turbocharged 16 cylinder 2-stroke 710 G3B diesel engine. This engine has high fuel efficiency and requires low maintenance. The fuel efficiency of this locomotive is around 11% better than the existing locomotives. This engine has many modern features like, laser hardened cylinder liners, unit fuel injectors which eliminate the problematic HP tube, Inconel valves, hydraulic valve adjuster, durable crankcase and piston structure. The diesel engine drives the main alternator.

The **main alternator TA17 is a 3-phase, 10 pole, 90 slots machine** equipped with two independent and interwoven sets of stator winding. The main alternator construction is such that it is basically two alternators in one - two sets of stator windings, permanently connected in series, work with a rotating field common to both the windings in order to provide higher alternator output voltage, which is a basic requirement of a low current high voltage alternator used on AC-AC locomotives. The main alternator converts the mechanical power of diesel engine into alternating current. The internal rectifier bank of the main alternator converts alternating current into direct current there by providing a DC power output. The DC power output from the main alternator is called the DC link voltage and is applied to the traction inverters. DC link voltage varies with the throttle position from 600 V DC at Throttle - 1 to 2600 V DC at Throttle - 8. The inverter changes DC into variable AC power. **WDP4 locomotive is provided with self load feature, capable of testing full output of the engine.**

The Main Alternator Blower and Traction Motor Blower share a common housing mounted on the front side of the auxiliary generator. Although both the blowers are mounted on the auxiliary generator shaft an internal partition separates the two blower portions. Air is drawn from the central air compartment into the alternator blower close to the auxiliary generator and pass through a duct to the main alternator air box. Air from alternator blower first cools the main alternator rectifier banks then passes internally through the alternator and companion alternator to the engine room. This creates a slight positive pressure to keep the dirt from entering the engine room.

Companion alternator CA6B is a three phase AC steady state alternator of 250 kVA rating, which is physically connected but electrically independent of the main alternator. The companion alternator rotor field is excited directly by auxiliary supply of the locomotive (74$\pm$4 V DC). It receives the excitation current from the auxiliary alternator through a pair of slip rings which are located adjacent to the slip rings of the main alternator. The companion alternator develops power whenever the diesel engine is running. The output voltage is directly proportional to the speed of rotation but varies to some extent with change in alternator temperature and load. It is used for excitation of the main alternator as well as for supply to Inertial (dustbin) blower, TCC1 and TCC2 blower motor, TCC electronic blower, 55-220 V AC for radiator fans and various control circuits. An AC auxiliary alternator of 18 kW rating is used for meeting the auxiliary and control system load.

Outside air is cleaned by Inertial (dustbin) blower, before it enters central air cabinet. In the Inertial blower there are two inertial filter panels, one mounted on either side of the locomotive. 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. The resulting clean air continues on through the smaller diameter portion of the tube where the air is again caused to swirl by internal vanes. The particles are carried to the bleed duct and the resulting clean air enters the central air compartment.

AC-AC transmission has the advantage of high adhesion and high tractive effort, maintenance free Siemens ITB - 2622 - 0TB02 3 - phase AC traction motors, high reliability and availability and higher energy efficiency. A specialty of this motor is that there is no separate stator frame resulting in reduction of weight. In braking mode, the three-phase motors act as generators and power is fed back to the DC link via the two inverters.

The Traction Motor Blower mounted on the auxiliary generator, supplies air for traction motor cooling, generator pit aspirator operation, main electrical cabinet pressurisation and traction computer cooling. Air is drawn through a movable inlet guide vane through the blower, and delivered into a duct to the traction motors. A portion of this air is diverted through a set of filters for delivery to the computer module portion of traction inverter cabinets for module cooling. Another set of filters cleans the air used to pressurise the main electrical cabinet.

The locomotive has two inverters TCC1 and TCC2. The output converter, a pulse width modulated (PWM) inverter, is responsible for providing the variable frequency and the variable terminal voltage for the three-phase motor. The main alternator feeds electrical power to the DC link via two series connected diode rectifiers. Two identical PWM inverters TCC1 and TCC2 with GTO and their capacitors are connected electrically to the DC link via isolating switches. There is one traction inverter for each parallel set of three traction motors, which are responsible for supplying power to them. A protective circuit based on GTO is connected to the DC link to protect the inverters against any over-voltages. The TCC blower defuses heat produced by losses generated in TCC.

An electronic blower in each TCC cabinet driven by its own 3-phase AC motor draws the air from central air compartment in across the modules and expels it across the R2 snubber resistor. This air is used for cooling and pressurising in some parts of the inverter cabinet. This air keeps dirt from contaminating areas containing DC link capacitors, gate units and traction computers. The TCC blower motor is a dual speed 3-phase AC induction motor. It operates as a series-Y wound machine for lower speed (only low speed configuration is used on WDP4 locomotives). Power for the motors is taken from the companion alternator through the main contacts of TCC1SS and TCC2SS. EM2000 exercises control of the blower contactors at the request of the TCC via RS-485 serial link.

Radiator Cooling Fan Motors are of the inverted squirrel cage induction type and are integral part of the cooling fan assembly. Each cooling fan (total two per locomotive) is driven by a two-speed AC motor, which in turn is powered by the companion alternator. Cooling fans are powered through contactors, which are controlled by the EM2000 program. Each fan motor circuit consists of one slow-speed and two fast-speed contactors that are located in the AC cabinet.

The WDP4 locomotive is equipped with a microprocessor based computer control system. It provides fault detection of components and systems, it contains 'self tests' to aid in trouble shooting locomotive faults. It has basic features like, significant reduction in number of control modules, better fault detection of components, memory archive and data snap shot. The **microprocessor EM2000 is the locomotive control computer**. EM 2000 utilises "Flash PROM" memory. It is a 32 bit computer based on Motorola 68020 microprocessor running at 16 MHz with a math co-processor communication through RS-232 serial cable / port. EM 2000 controls the main locomotive functions based on inputs from two traction computers. This system is equipped with a diagnostic display system in the cab to provide an interface between the maintenance personnel and the computer. The computer is programmed to monitor and control locomotive traction power, record and indicate faults that have been incorporated into EM 2000 system. **One of the special features of the locomotive is that, it is provided with event recorder, which downloads various parameters for EM 2000 for later use.**

The locomotive is equipped with KNORR/NYAB CCB(computer controlled braking) 1.5 system. This system is an electro-pneumatic microprocessor based system with 30A CDW type desktop controls. The overall purpose of using a computer (microprocessor) to control the air brake system is to eliminate as many of the electrical and mechanical devices as possible, there by reducing periodic maintenance, simplifying trouble shooting, fault diagnostics etc. It allows greater reliability and flexibility for future system upgrade.

WDP4 locomotives are provided with a special feature called blended brake. The purpose of blended brake system is to maximize the use of dynamic braking. This is accomplished by causing dynamic braking to go its maximum value whenever blending is requested. Once the amount of asking brake effort is determined, the maximum amount of dynamic brake effort is determined from the flat top portion of dynamic brake curve. The amount of dynamic brake effort present at that time, then determines how much air brake cylinder pressure must be applied to complement the dynamic brake effort. This becomes the air brake cylinder reference value, which in turn, maintains the asking locomotive brake effort.

Each unit of the Dynamic Brake Grid Blower Assembly consists of fan assembly powered by a 36 HP series wound DC motor. During dynamic braking, a portion of the current (rectified DC) from the traction motors is shunted around one of the resistor grids and used to power the grid blower motor. Air driven by the grid blower drives grid heat to atmosphere.

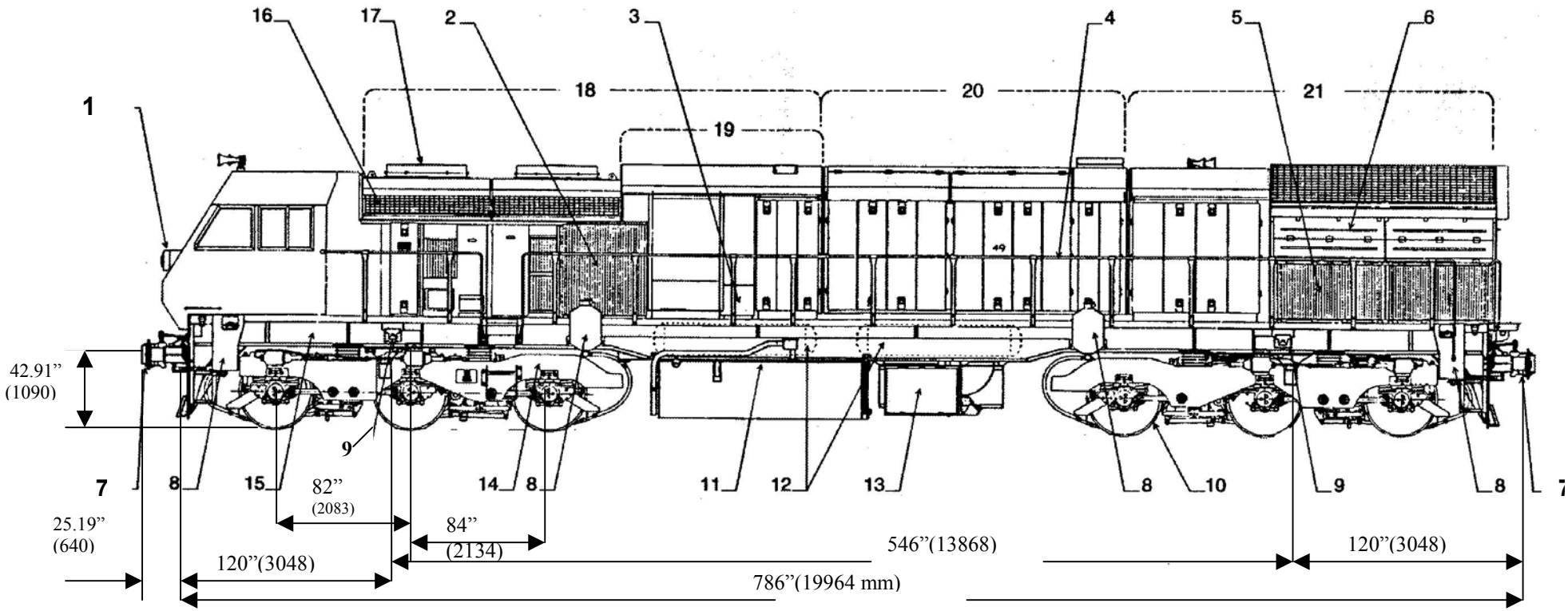
There are two SIBAS 16 traction control computers. Each computer is dedicated to one inverter. SIBAS 16 is a 16-bit computer based on an INTEL 8086 microprocessor running at 5.6 MHz. The TCC receives data via RS-485 serial link from the locomotive computer EM2000. The bi-directional bus carries data such as how much power for traction the TCC must develop as well as other information to control activation of devices like blowers and heaters. In addition to the RS-485 data, information constantly gets fed back into the TCC, to monitor various things such as status of relays and temperature of various components, voltages and currents. Based on this feed back data and information received via RS-485 serial link, the programs stored in the TCC work to drive the TCC as well as to protect it in the event of faulty operating conditions.

The WDP4 locomotive is equipped with a **high adhesion HTSC (High Tensile Steel Cast) truck or bogie**. The bogie assembly supports the weight of the locomotive and provides the means for transmission of power to the rails. The HTSC bogie is designed as a powered 'bolsterless unit'. Although the bogie or truck frame itself is rigid, the design allows the end axles to move or "yaw" within the frame. This movement will allow the wheels to position themselves tangent to the rails on curves for reduced wheel and rail wear. Axles 1 and 3 can move or kink a little bit to negotiate a curve from 0-8 degree deflection, increases the tractive effort and improves the rolling resistance. Traction loads are transmitted from the truck or bogie to the locomotive underframe through the carbody pivot pin assembly. **Each bogie is equipped with two unidirectional AC traction motors for better adhesion characteristics**. The motors are geared to the driving axles, which in turn apply rotational force to the rails through the wheels. The driving force is transmitted to the bogie through tractive rod attached to the journal-bearing adapter in the frame. From the truck / bogie frame the driving force is transmitted to the locomotive carbody through the carbody pivot pin.

Each locomotive is an independent power source. Several units may be combined for multiple operation to increase the load capacity.

The WDP4 locomotive has been designed on the 'platform' concept which means that the layout and the mounting of equipment is arranged in such a manner that retrofitment of equipment developed in future on existing locomotives as well as equipment changes/upgradation of the existing design of the locomotive can be implemented without any major change in the underframe, structure and even layout.

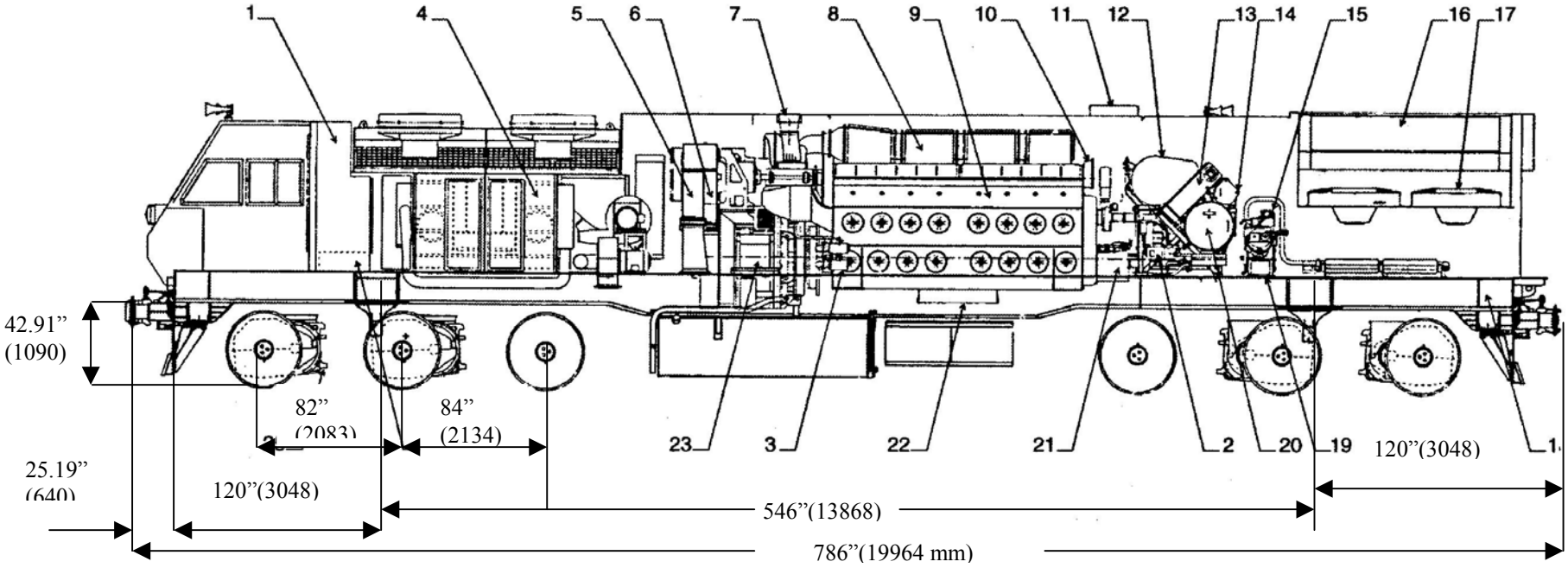
10 locomotives of 4000hp GT46PAC with 710 – G3B fuel-efficient engine, were supplied by GM / USA and were put on line.



1) Head Light
2) Inertial Filter Air Inlet
3) Starting Fuse and Battery Knife Switch
4) Handrails
5) Cooling System Air Inlet
6) Radiator and Fan Access
7) Coupler "E/F" Type
8) Sanding Box (8)
9) Jacking Pads (4)
10) Wheels (6)
11) Fuel Tank
12) Compressed Air System Main Reservoirs
13) Battery Box
14) Trucks (3 axles 2 motors HTSC type) Qty.2
15) Underframe
16) Dynamic Brake Grids
17) Dynamic Brake Fans (2)

CLASS	TYPE	GAUGE	SERVICE
WDP4	A-A-I	1676mm	PASSENGER

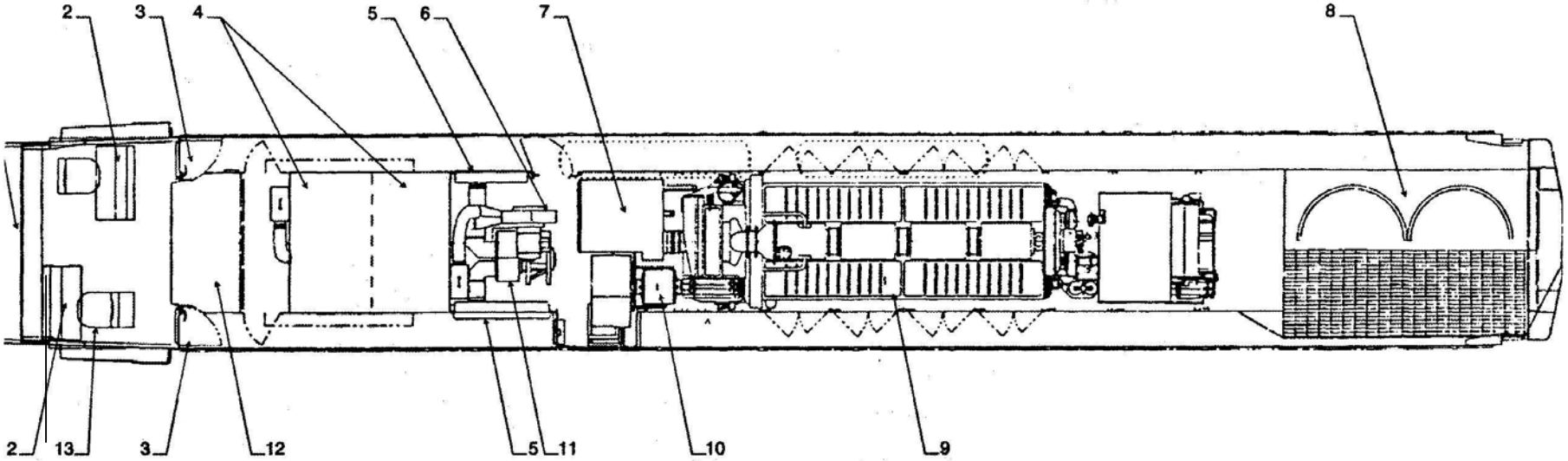
Equipment location
Figure – 1



1) Electrical Control Cabinet
2) Fuel Pump
3) Engine Starting Motors
4) Traction Control Cabinet
5) Traction Motor Cooling Air Blower
6) Main Generator/Companion Alternartor Blower
7) Engine Exhaust Stack
8) Engine Exhaust Manifold
9) 16-710G3B Diesel Engine
10) Governor
11) Engineroom Vent
12) Engine Water Tank
13) Lube Oil Cooler
14) Primary Fuel Filter
15) Air Compressor
16) Radiators
17) AC Radiator Cooling Fans (2)
18) Draft Gear
19) Air Compressor Air Filter
20) Lube Oil Filter Tank
21) Lube Oil Strainer
22) Lube Oil Sump
23) Main Generator/Companion Alternator
24) Electrical Control Cabinet Air Filter Box
25) Traction Motors

CLASS	TYPE	GAUGE	SERVICE
WDP4	A-A-I	1676mm	PASSENGER

Equipment location
Figure – 2



1) Air Brake Rack
2) Engineers Control Console
3) Cab Door
4) Traction Control Cabinets
5) Inertial Air Filters
6) TCC Electronics Blower
7) Engine Air Filter
8) Radiators
9) Engine
10) AC Auxiliary Generator
11) Inertial Filter Dust Bin Blower and Motor
12) Electrical Control Cabinet
13) Cab Seat

CLASS	TYPE	GAUGE	SERVICE
WDP4	A-A-I	1676mm	PASSENGER

Equipment location
Figure – 3

DIFFERENCES BETWEEN GT46 PAC (WDP4) & GT46 MAC (WDG4)		
Sl. No.	**GT46 PAC / WDP4**	**GT46 MAC / WDG4**
1.	Max. speed – 160 Km/h	Max. speed – 100 Km/h
2.	Axle load – 19.5 T	Axle load – 21T
3.	Max. Tractive effort – 27550 Kg.	Max. Tractive effort – 53000 Kg.
4.	A-A-I I-A-A Bogie	CO – CO Bogie
5.	Two traction motors in each bogie	Three traction motors in each bogie
6.	Siemens traction motor ITB – 2622 - 0TB02 • *Gear ratio : 17/77* • *Max. power – 765 kW,* • *Max. speed – 3776 rpm*	Siemens traction motor ITB – 2622 - 0TA02 • *Gear ratio : 17/90* • *Max. power – 630 kW,* • *Max. speed – 3320 rpm*
7.	Traction Motor Blower ▪ *Air flow requirement – 1.2 m³/s* ▪ *Cfm - 12450* ▪ *Static pressure – 14.3 inch w.g.* ▪ *BHP – 65*	Traction Motor Blower ▪ *Air flow requirement – 1.0 m³/s* ▪ *Cfm - 17550* ▪ *Static pressure – 16.5 inch w.g.* ▪ *BHP – 125*
8.	Blended brake is provided to optimize use of Dynamic brake.	Dynamic Brake only.
9.	Event recorder ♦ *Event recorder down loads various parameters / signals from EM 2000 and stores for later use / analysis.*	Not provided

MAIN PARTICULARS OF WDP4 LOCOMOTIVE

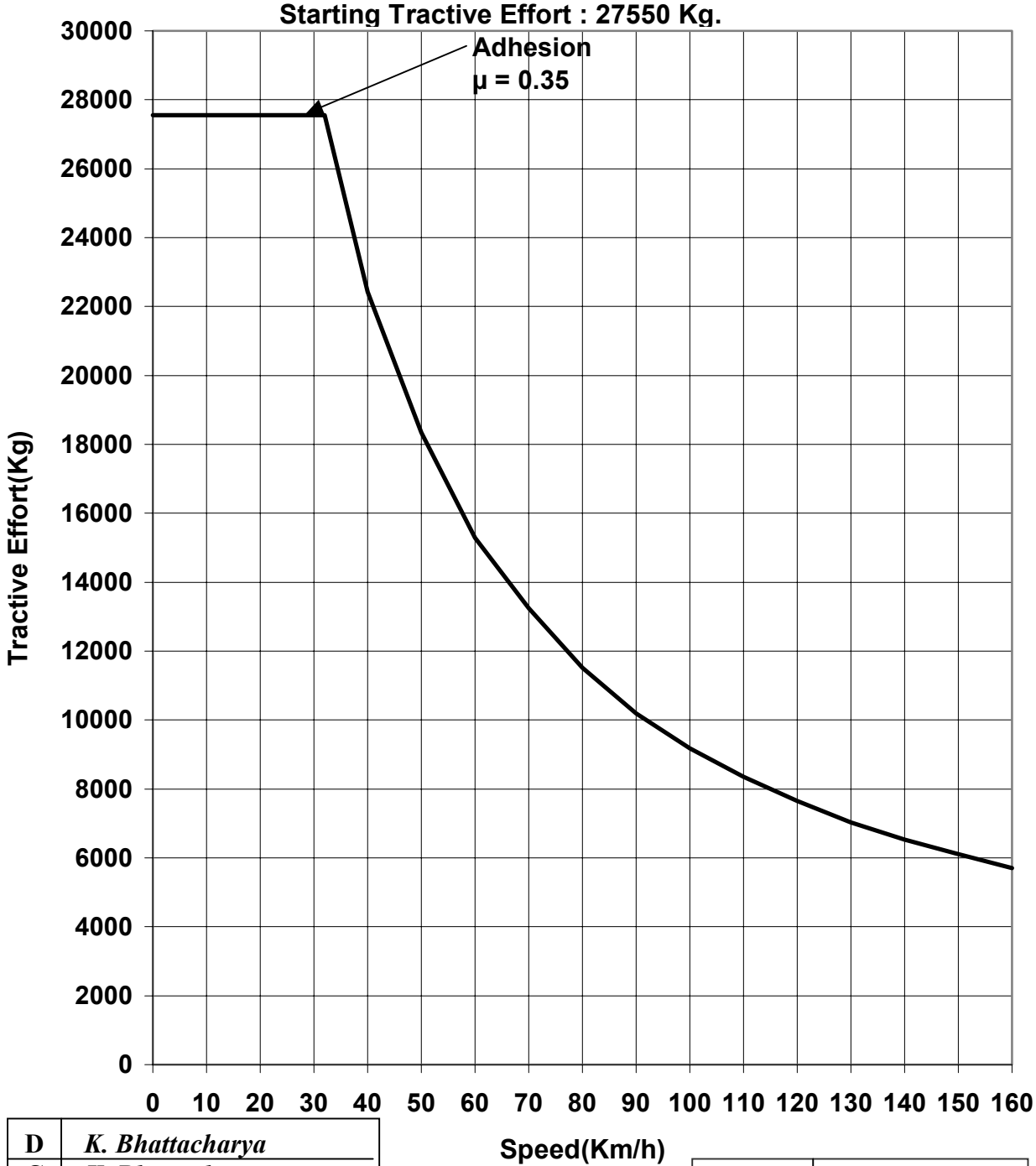
GENERAL		Injection System	
Weight of loco in Working Order (T)	117.0	Type	Direct unit injector
Adhesive weight in Working Order (T)	78.0	Displacement / cyl.	11635 cm²
Axle load (T)	19.5	**Turbo Supercharger**	
Wheel dia (new) Driving mm.	1092	Make and type	EMD Model G
Tractive effort (Kg.), Maximum	27550	Weight of turbocharger	953 Kg.
		TRANSMISSION (ELECTRICAL)	
Speed (Km/h) Maximum	160	**Alternator**	
		Make and type	GM TA-17
Transmission	Electric	Number per locomotive	One
ENGINE		Maximum speed	904 rpm
		Max. Voltage	2600 V DC
Make and type	710 G3B	Max. continuous current	1250 A DC
No./Loco	One	**Companion Alternator**	
Governor	Woodward	Make and type	CA 6B
Weight of engine (dry)	17963 Kg.	Max. Voltage	230 V AC
Number of cylinders	16	Frequency at 904 rpm	120 Hz
Cylinder formation	45 degree V type	Max. power	250 kVA
Bore and stroke in mm	230.19 x 279.4	Unit weight(TA & Comp. alternator assly.)	8709 Kg approximately
Mean piston speed m/sec	8.38		
BMEP at rated output	11.23	**Traction motor**	
Compression ratio	16 : 1		
Lube oil sump capacity	1073 Litre	Make and type	Siemens ITB - 2622 - 0TB02
Lube oil pan, from bottom to top dipstic	371 Litre		
Horse Power		Number per locomotive	Four (2 in parallel per bogie)
AAR condition	4132 CV	Continuous voltage / Nominal rating	2027 V AC / 638 kW
At Site (47^{o}C – 600m)	4012 CV	Maximum speed	3776 rpm
Input to traction	3780 CV	Gear ratio	77 : 17
RPM		Suspension	Axle hung / tapered roller bearing
Rated	904	Unit weight(with pinion, gear & gear case)	3016 Kg.
Idle / Low idle	269 / 200	**AUXILIARIES**	
Cooling system		**Auxiliary generator**	
Water Pump type	Centrifugal	Make and type	GM, 5A – 8147
Water pump capacity	3785 l/m at 900rpm	HP absorbed	18 kW
No. of radiator fans	Two	Rating	74 V DC, 904 rpm
Fan drive	AC motor		
Fan power	113.4HP		

MAIN PARTICULARS OF WDP4 LOCOMOTIVE

Exciter		**COMPRESSOR**	
Make and type	GM, CA - 6B	Make	Knorr CCB equipment
HP absorbed	250 kVA	Type	WLNA 9BB, two stage, 3 cyl.
Rating	250 V AC, 904 rpm	Displacement at 900 rpm	7.19 m^3 / Min at 900 rpm
Unit weight	647 Kg	Lube oil capacity	9.98 litres (2.64 US gallons)
BATTERIES		Weight	1043 Kg
Make and type	SURRETTE, 16 CH-25 Unitized	**TRACTION CONTROL COMPUTER**	
Number of cells	10	Model	SIBAS 16
Arrangement	2 series connected 5 cell Ni-Cadmium Shaft-Nife SRX1500P batteries	Make	Siemens
Voltage	72.5 VDC	SIBAS 16 is a 16-bit computer based on an INTEL 8086 microprocessor running at 5.6 MHz. Each computer is dedicated to an inverter(total 2 converters (TCC1 and TCC2)	
Capacity	500AH (8 Hr)	**LOCOMOTIVE COMPUTER**	
Head light	250W, 32V	Model	EM 2000
BRAKES		Make	GM
Locomotive	Air, Hand, Dynamic Brakes fully Blended with Automatic Brakes.	EM 2000 is a 32 bit computer based on Motorola 68020 microprocessor running at 16 MHz with a math co-processor communication through RS-232 serial cable / port. EM 2000 controls the main locomotive functions based on inputs from two traction computers.	
Train	Pure air brake system.		
System	KNORR/NYAB CCB equipment.	**TRACTION INVERTERS (TRACTION CONTROL CONVERTERS TCC1 & TCC2)**	
CONTROL SUPPLIES		Model	1GE 420 050 9010.00MB74
Fuel tank (detachable)		Type	Voltage source inverter with Gate Turn-Off thyristors.
Number per locomotive	One	Rating	1430 kW
Total capacity	4000 litres	Quantity	2 (One per bogie / truck)
Sand			
Number of boxes / Locomotive	8		
Total capacity	0.028m^3 Box (1.0 cubic ft. / box)		

Tractive Effort Vs Speed characteristics
4000 HP WDP4 Diesel Electric Locomotive

One Traction Alternator type TA17
Four Traction Motor type ITB 2622
Gear ratio : 17:77, Wheel Dia. : 1054mm(Half Worn)
Starting Tractive Effort : 27550 Kg.



D	*K. Bhattacharya*
C	*K. Bhattacharya*

Appd.
S. Srinivas/Dir/EM
Dt. Sept.2001

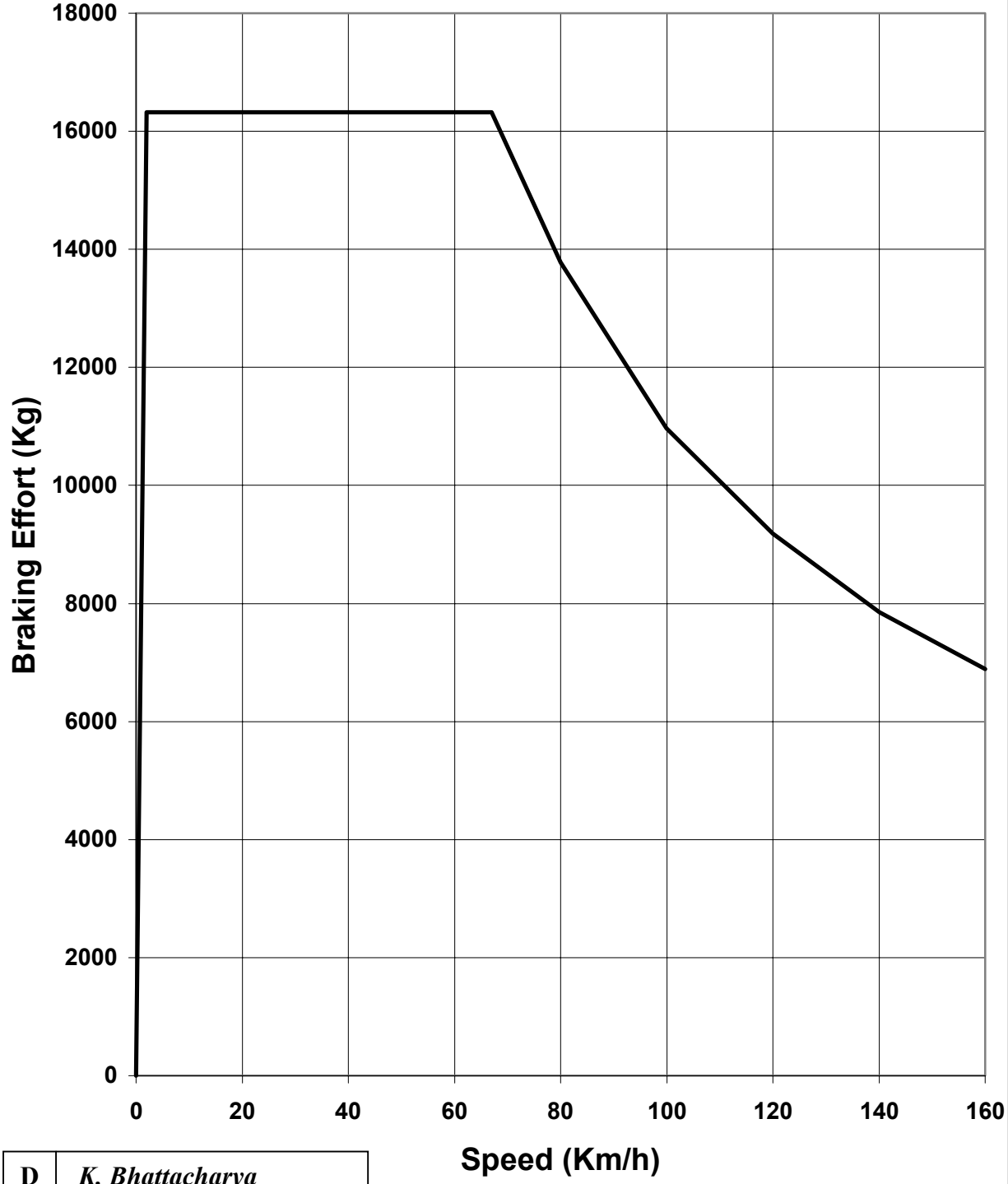
RDSO (MP)	GDP - 1121 (Rev - 0.00)

DYNAMIC BRAKING CHARACTERISTICS

OF

4000 HP WDP4 LOCOMOTIVE

One Traction Alternator type TA17
Four Traction Motor type ITB 2622
Gear ratio : 17:77, Wheel Dia. : 1054mm(half Worn)



D	*K. Bhattacharya*
C	*K. Bhattacharya*

Appd.
S. Srinivas/Dir/EM
Dt. Sept.2001

RDSO (MP)	GDP - 1122 (Rev - 0.00)

HAULAGE CAPACITY (PASSENGER)																
LOCO:- WDP4 (4000 HP)					Track condition: Dry rail						WT OF LOCO : 117 t					
Trailing load in tonnes at Km/h on tangent track, ICF stock (with 0.005m/sec² acceleration reserve)																
GRADE	SPEED(KM/H)															
	START	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
LEVEL	4125	4125	4125	4125	4125	4125	3080	3055	2370	1950	1550	1270	1060	875	715	570
500	3130	3130	3130	3130	3130	2885	2310	1890	1510	1280	1040	870	740	620	510	415
400	2950	2950	2950	2950	2950	2600	2095	1720	1380	1175	960	800	685	575	475	385
200	2285	2285	2285	2285	2195	1725	1410	1175	955	820	675	570	490	415	345	275
150	1980	1980	1980	1980	1770	1400	1150	960	785	675	560	470	405	345	285	230
100	1560	1560	1560	1560	1270	1005	830	695	565	490	405	340	295	245	200	160
50	925	925	925	835	650	515	420	350	280	240	-	-	-	-	-	-