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**Survey on Water Cooling System's Failure Analysis for Diesel Electric Locomotives**

R. K. Tyagi\* and Sukanya Borah\*\*

**ABSTRACT**

Each locomotive has an individual water cooling system, in which water is circulated by a centrifugal water pump gear driven from the engine crank shaft. A diesel engine operates efficiently when the water temperature is between 63 0C to 83 0C. In I.C. Engines, during the process of combustion gas temperature often reaches quite a high value and thus the cylinder walls, cylinder and the piston gets heated. Therefore, the water cooling system is provided to overcome seizure of piston & cylinder, loss of power, engine failure, sticking of piston rings & excessive wear of cylinder. A temperature of 85 0C for coolant is ideal. Below 70 0C condensation of acids would occur causing corrosion & rusting. If the temperature of the cooling water is not controlled it leads to either overheating or overcooling of the engine. The cooling system is provided with safety devices, which guards against high water temperature & low water level. When the temperature of water reaches a pre-determined value, an alarm bell starts ringing & simultaneously the engine is returned to the idle value. There is also a specific Maintenance procedure of the water cooling system to get the optimum output. In the present study, failure analyses of the past few years (2011-2013) have been studied thoroughly.

**Keywords:** Locomotives; Cooling System; I.C.Engines; Water Temperature; Safety Devices; Maintenance; Failure Analysis.

**1.0 Introduction**

The Diesel Electric Locomotives have Internal Combustion (I. C) Engines. Here the combustion of the fuel takes place within the cylinders of the engine. After combustion of fuel in an engine about 25 % to 30 % of heat produced inside the cylinder is absorbed by the components surrounding the combustion chamber i.e. Piston, Cylinder, Cylinder head etc. Unless the heat is taken away from them and dispersed elsewhere, the components are likely to fail under thermal stress. So, all the I.C.Engines is provided with a cooling system [1]. The ALCO design diesel locomotives running on the Indian Railway have closed circuit pressurized water cooling system [1].

The word 'Locomotive' originates from the Latin words 'LOCO' meaning 'from a place' and 'MOTIVES' means 'Causing motion'[1].

**2.0 Working of the Water Cooling System**

At first the water pump pumps the cold water from the expansion tank to the engine block. The water then exchanges heat from the various engine blocks and becomes hot. A part of the cold water also passes through the A.C Element to cool and increases the volumetric efficiency of the air sucked by turbo charger.

Now the hot water passes through the bubble collector where all the bubbles from in the hot water are extracted and sent to the expansion tank via pipes to avoid cavitations. After this the hot water passes through the radiator core where it is cooled. The cold water then passes through the lube-oil cooler and extracts heat from the hot lubricating oil. At last the water comes back to the expansion tank. This whole cycle is repeated countless no. of time till the water level in the expansion tank comes below 20 %.

\*Corresponding Author: Department of Mechanical Engineering, Amity School of Engineering and Technology, Amity University, Uttar Pradesh, Noida, India (E-mail: sukanyaborah19@gmail.com)

\*\*Department of Mechanical Engineering, Amity School of Engineering and Technology, Amity University, Uttar Pradesh, Noida, India

The cooling system is a closed system with the expansion tank vented to the atmosphere through an overflow pipe. Vent lines are provided at after-cooler, lube oil cooler, radiators, turbo-supercharger vent box & bubble collectors etc to maintain uninterrupted circulation of cooling water by eliminating the hazard of air locks in the system [2].



### 3.0 General Specifications

Diesel electric Locomotives (engine)

Total life - 36 years

ALCO (American Loco Company)

Locomotives

Maximum permissible speed of Loco = 121 km/hr Brand of locomotives used in Railway engines RR606 Mg (Lube oil) It is produced by IOCL only for Indian Railways. Fuel used: - High Speed Diesel (H.S.D) Viscosity limit = 105 - 170 centistokes @ 40 OC Fuel tank capacity = 36 liters. Water Tank Capacity = 1000-1210 liters Coolant used for Anti-Corrosion = Power cool. It is produced by Hindustan Petroleum Co. Ltd (HPCL) Horse Power Generated = 2600 Water Circulating Pump Speed = 1725 rpm. Radiator Fan full Speed = 1200 rpm. Expansion tank capacity = 155 liters No. of engine cylinders = 16 Wheel diameter = 1092 mm No. of Batteries (8.8 V each, Total 70.4 V) used = 8

### 4.0 Maintenance

Maintenance of Water Cooling System is very much important to get the optimum output. Since diesel locomotives run through I.C.Engine so temperature is a very important factor & to maintain this temperature the maintenance of the Water

Cooling System is very important. Maintenance of the Water Cooling System is done to check the crack, material defect, leakage, loose connection of all the parts of Water Cooling System.



#### 4.1. Maintenance schedule

**T-15(15 DAYS) [for P.S.B.], T-20(20 DAYS) [for R.S.B]:-** Sample of water is tested & if necessary cooling water is replaced. In water pump telltale hole and in after cooler telltale hole leakage of water is checked and necessary action is taken. Radiator core is cleaned with compressed air.

**M-2 (2 MONTHS):-** Turbocharger water return pipes are checked for cracks and water or oil leakage from telltale hole of water pump is checked and the pump is replaced if leaking. All parts of the system are checked for any other leakage. Operation of radiator fan is checked.

**M-4 (4 MONTHS):-** Hot engine alarm switch is checked.

**M-12 (12 MONTHS):-** Renew of water and oil seal assembly if necessary, after is removed and cleaned, flexible water connectors to the cylinder heads are checked for any cracks and damages, Expansion tank water level is checked. Water Cooling System is flushed with suitable cleaning solution and refilled.

**M-24 (24 MONTHS):-** Radiators are cleaned and tested, Radiator fan is removed and reconditioned, the Water Cooling System is flushed with suitable cleaning solution and refilled, water hoses are examined and renewed if necessary.

**M-48 (48 MONTHS):-** Radiators are removed from locomotives and cleaned and tested, radiator fan drives are renewed and reconditioned if necessary.

**5.0 Tests Related to Water Cooling System**

1. **Magnetic Particle Inspection Dry Test:** - It is a test for determining cracks in the components made up of magnetic material. Here component is put into magnetic field and then iron powder is sprayed over it. The region where the iron powder gets stuck indicates the presence of cracks.
2. **Hardness Test:** - In the shed Rockwell and Vickers hardness test machines are present where hardness numbers of various components are checked and compared with the standard values.
3. **Dye Penetrate Test:** - It is attest to find cracks in the different components like water pumps, radiator fans etc. Here first the surface of the component is cleaned and then red dye penetrate is sprayed over the surface. After the developer is sprayed over the surface, the region where there is crack, it turns white. This is how the cracks become visible.
4. **Blue machining test:** - It is a test for determining the matching of two components. Here one face of the component is painted with blue colored paint and then the face is allowed to touch other face and according to the impression, necessary actions are taken [3].

The cooling system is provided with safety devices, which guards against high water temperature & low water level. When the temperature of water reaches a pre-determined value, an alarm bell starts ringing & simultaneously the engine is returned to the idle value.

**High temperature alarm switch:** - Engine is protected against high temperature by a switch which sounds an alarm & on the same locomotives returns the engine to idle temperature when the water outlet temperature reaches 185 OF.

**Low water level switch:** - When the water falls below 1 inch from the bottom of the expansion tank, the LWLS connected to it shuts down the engine through the governor. Warning alarm & lamp indication also comes into the driver's cabin.

**Thermostat:** - It is a temperature control device. We have seen that heat is generated in the engine & it needs to be controlled. A thermostat is used for this.

**Role of Laboratory:** - Corrosion inhibitors are widely used with cooling water to ensure protection of components from corrosion & cavitation erosion. [3]

**7.0 Objective:**

To analyze the failure records of the past few years of the diesel electric locomotives

**6.0 System Safety**

**Survey for the Period from 01/01/2011to 31/05/2013**

Sr. No.	Sub Assembly group	Loco	Date	Primary Cause Secondary Cause	Remarks Against P/Cause & S/Cause
1	Radiator Fan Turret/Blades Broken/Damaged	14970	26/01/2013	Defective Material	Radiator Fan All Blade Broken. Loco No. 14970 Failed On 26/01/13 At 09:55 Hrs. Over APDJ Due To Reported Cause Of Radiator Fan All Blades Broken. Loco Arrived In Shed On 28/01/12 At 03:30 Hrs As Dead Attached. On Visual Checking Of Lab/NGC The Fracture Of 4 Nos. Blade Are Fresh Crystalline In Nature. The Surface Of One Blade Shows Patches In The Fracture Area Which Has Started From The Surface.
	<b>Water System</b>				
2	Siphoning Out Of Water Due To Overheating/ Hot Engine	14836	26/01/2011	Mismanagement By Crew	Water Leakage & Water Nil In Head Light Side Tank Loco No 14836 Failed On 26/01/2011 At 09:46 Hrs Over MB/N 1. Engine Lube Oil Level Found 40 Liters Mark 2. Water In Exp Tank Only 4". 3. Water Pump Pr. Checked Found

					<p>Idle-1.7 Kg Cm<sup>2</sup>, 8th Notch 3.0Kgcm<sup>2</sup>.</p> <p>4. No Water Found In Engine Lube Oil.</p> <p>5. Engine Hydraulic Test Done Found Normal.</p> <p>6. Water Topped In Expansion Tank And Found Water Siphoning From No Crew.</p>
3.	Radiator Element Tubes Cracked/Leaking	14840	03/02/2011	Defective Material	<p>Heavy Water Leakage From L/S Radiator Core. Loco Arrived NGC D/Shed As Dead Attached On 03/03/11 At 12.45 Hrs. Water In Expansion Tank On 4" L/S Radiator Core Found Leakage From Inside Tube. Loco Left Side Radiator Core 01 Tube Found Crack. Water Seen Came Out From Left Side Tube Of Radiator Core During Starting. New Radiator Core Fitted</p>
4.	Water Jumper (Inlet Elbow) Cap Screw Sheared Off	14969	19/02/2011	Defective Material	<p>Water Leakage From Cyl No.1 Water Jumper Pipe Joint Loco No. 14969 Failed On 19/02/11 At 23:30 Hrs. Over LKO Due To Reported Cause Of Water Leakage From Cyl No.1 Water Jumper Pipe Joint.</p>
5.	Radiator Element Tubes Cracked/Leaking	14840	02/03/2011	Defective Material	<p>Heavy Water Leakage From L/S Radiator Core. Loco No 14840 Failed On 02/03/2011 At 13.20 Hrs Over MXN Due To Reported Cause Of Heavy Water Leakage From L/S Radiator Core. Loco Arrived NGC D/Shed As Dead Attached On 03/03/11 At 12.45 Hrs. Water In Expansion Tank On 4" L/S Radiator Core Found Leakage From Inside Tube. Loco Left Side Radiator Core 01 Tube Found Crack. Water Seen Came Out From Left Side Tube Of Radiator Core During Starting. New Radiator Core Fitted By GP/D/Shed During POH On 14/08/09 .Radiator Core Service Life 01 Year 06 Months. Radiator Core SL No:- M.B.I.H 1157211. TPL:-8601 09/04/42. This Is A Case Of Material Failure Fitted On14/08/09 At POH/ KGP.</p>
6.	Any Other Defect Not Listed Above.	17625	17/03/2011	Bad W/S By Ngc Shed	<p>Water Leakage From Armour Joint. Loco No 17625 Failed On 17/03/2011 At 23.00hrs Over GHY Due To Reported Cause Of Water Leakage From Armour Joint. Loco Arrived In Shed On 18/03/2011 At 05.30 Hrs. Incoming Water Levels Checked 9" No</p>

					External Leakage Found. Water Pump Pressure Checked Idle Pressure 0.5 Kg/Cm2 & 2.8 Kg/Cm2 On 8th Notch. Unusual Sound From Water Pump On Idle. Cool Down Time 4 Min 25 Sec. During Temperature Rise Up Water Symphonic From Tank No-1 On 8th Notch. Suspected Air In The System Come Water Out From Exp Tank. After Water Topping Up to 11 Inch, Again Checked Everything Found Normal. Equalizing Pipes Of Exp Tank Are Checked Found Ok. Radiator Core Cleaned. Water Pump Changed Due To More Back Lash.
7.	Flexible Hoses Damaged/ Leaking	14764	02/06/2011	Defective Material	Water Shortage, Internal Water Leakage. Loco No. 14765 Failed On 03/06/11 At 23.52 Hrs At KES UMB/NR Due To Reported Cause Of Water Shortage, Internal Water Leakage. Loco Arrived In Shed As Working On 22/06/2011 At 20.30 Hrs On Arrival Loco Checked Found Turbo Accumulator To Water Suction Pipe Hose New Fitted At LDH Shed. Failed Hose Found Burst Near Water Suction Pipe Side Near Adopter. Premature Failure Of Hose. Service Life 08 Months. Date Of Hose Fitment: - 22/10/10 During M12 Sch. Make Of Hose: - Local Make. As Per Lab Report, "The Turbo Accumulator To Water Suctions Pipe Hose Found Burst From Inside Portion. Wire Burnt Found May Be Due To Long Use." This Is A Case Of Defective Material.
8.	Any Other Defect Not Listed Above.	14856	09/06/2011	Miscellaneous	Water Leakage From Water Return Pipe. Loco No. 14856 Failed On 12/06/2011. At 06.30 Hrs Over Roza/NR Due To Reported Cause Of Water Leakage From Water Return Pipe. Loco To Be Pushed IZN Shed. Loco Arrived In Shed As Working On 21/06/2011 At 12.20 Hrs.
9	Flexible Hoses Damaged/ Leaking	13010	03/07/2011	Defective Material	Water Leakage From Water Delivery Pipe Loco No. 13010 Failed On 03/07/2011 At 05:10 Hrs Over DGA/SEE Due To Reported Cause Of Water Leakage From Delivery Pipe. Loco Push To SPJ Shed. Loco Arrived In Shed As Working On 14/07/2011 At 13:45 Hrs.
10	Water Pump	17839	09/08/2011	Bad W/S By	L/Side Radiator Core Water Leakage

	Drive Gear Failed/Loose On Shaft/Key Worked Out			Shop	<p>Loco No. 17839 Failed On 09/08/11 At 07:20 Hrs Due To Reported Cause Of L/Side Radiator Core Water Leakage. Loco Arrived In Shed On 09/08/11 As Dead Attached. As Per Repair Book "Loco Shut Down At KYQ Station Due To Low Lube Oil And Hot Engine Indication." On Arrival Loco Checked Found Water Nil In Water Expansion Tank. Water Topped And Water Pressure Checked Found .5 On Idle And Higher Notch. Water Pump Removed And Found Impeller Is Free. Water Pump Removed And Following Observation Noticed.</p> <ol style="list-style-type: none"> <li>1. Impeller Got Rubbed With Water Pump Housing And Damaged</li> <li>2. Water Pump Housing Inside Damaged Due To Rubbing With Impeller</li> <li>3. Taper Split Sleeve Got Loose On Impeller.</li> <li>4. Impeller Key Missing.</li> <li>5. Key Groove On Pump Shaft Worn Out As Well As Key Groove On Impeller Also Worn.</li> <li>6. Castle Nut On Shaft Found Intake And Tight</li> <li>7. Drive Gear And Shaft Nut In Take And Ok. Tapper Split Sleeve Got Loose On Shaft Caused Loosing Of Impeller, Resulting Touch With Water Pump Casing And Damaged The Both.</li> </ol>
11	Flexible Hoses Damaged/ Leaking	17579	2/9/2011	Overdue Schedule	Water Shortage. Loco No. 17579 Failed On 02/09/11at KIR Div. Due To Reported Cause Of Water Shortage. Loco Arrived In Shed As Working On 03/09/11 At 23:10 Hrs. On Arrival Loco Checked Found All Water Jumper Hose Found Leakage.
12	Dresser Joints/Clamps/ Bolts Loose/Broken	14762	15/09/2011	Overdue Schedule	Water Leakage Through Cylinder Head Loco No. 14762 Failed On 15/09/11 Over N.E.Rly Due To Reported Cause Of Water Leakage Through Cylinder Head. Loco Arrived In NGC On 18/09/11 As Dead Attached. During Shed Investigation Found Incoming Water Level 5 ". Engine System Preurerisation Done And Noticed Water Leakage From Water Tank Equalizing Pipe 1/2 Armour Joint. This Is A Case Of BWM By NGC. Loco Was Running M2 Overdue Schedule Since 12/09/11.

13	Water Jumper (Inlet Elbow) Cap Screw Sheared Off	14842	23/09/2011	Defective Material	Heavy Water Leakage From R/S No 8 Water Jumper. Loco No. 14842 Failed On 23/09/11 At MLDT Due Reported Cause Of Heavy Water Leakage From R/S No 8 Water Jumpers.
14	LEAKAGE/ BREAKAGE AT BUBBLE COLLECTOR	14837	18/10/2011	OVERDUE SCHEDULE	Water Leakage From Bubble Collector Joint. Loco No. 14837 Failed On 18/10/11 At 23:15 Hrs. Over NJP Due To Reported Cause Of Water Leakage From Bubble Collector Joint. Loco Arrived In Shed As Dead Attached On 21/10/2011 At 00:10 Hrs. Loco Is Running T2 Over Due Schedule Since 16/10/11.
15	Any Other Defect Not Listed Above.	14843	29/01/2012	Not Finalization	Heavy Water Leakage From Jumper Joint Of Cylinder No-4. Loco Arrive NGC/D/Shed On 09/02/12 At 19.45 Hrs As Working.
16	Riser Pipe/ Header Cracked/ Damaged	14861	13/02/2012	Defective Material	LWS Pick Up Low Water Level 3" & Auto Shut Down, Water Riser Leakage. Loco No 14861 Failed On 13/02/12 At 13:45 Hrs Over WR/ADI Due To Reported Cause Of LWS Pick Up Low Water Level 3" & Auto Shut Down, Water Riser Leakage. Loco Made Fit By VTA/D/Shed By Replacing The Water Riser. Loco Arrived NGC/D/Shed On 29/02/12 At 08:20 Hrs. On Arrival Repair Book Was Checked But Pages From 15/02/12 Were Available Only. Defective Water Riser Was Not Found Along With Loco. This Is A Case Of Defective Material (Over Aged).
17	Any Other Defect Not Listed Above.	14931	13/02/2012	Bad W/S By Ngc Shed	Heavy Water Leakage From L/Side Bubble Collector. Loco Pushed To BGKT/D/Shed. As Per Telephonic Information, "Loco L/S Bubble Collector Adopter Heavy Water Leakage Which Was Rectified By Tightening And Made Fit On Date 14.02.12 At 23.30 Hrs As Working. Loco Arrived In Shed On 01/04/12 At 17:15 Hrs. As Working. On Shed Arrival Bubble Collector Adopter Joint Checked And Found No Water Leakage. Loco L/S Bubble Collector Adopter Heavy Water Leakage Which Was Rectified By Tightening.
18	Water Pump Oil Seal Leaky/Damaged, Tell-Tale Hole Leaking	14857	29/05/2012	Bad W/S By Ngc Shed	Water Pump Leakage From Tale Tall Hole. Loco No. 14857 Failed On 29/05/12 Over Mgsloco Arrived NGC Shed As D/A On 31/05/12 At 21:30 Hrs. Loco Arrived NGC Shed As D/A

					On 31/05/12 At 21:30 Hrs. On Arrival Water Topped And Starting Checking Done. During Starting Checking, Observed Water Leakage From Water Pump Tell Tale Hole Continuously. Water Pump Removed, Hydraulic Testing Done And Found Water Leakage From Water Seal. Water Pump Disassembled And Found Retainer Ring For Water Seal Spring Got Stuck Up With Water Pump Shaft End Because Of Which For Which Water Pump Water Seal Got Free From Its Spring Force Resulting In Water Leakage From Mating Surface.
19	Flexible Hoses Damaged/Leaking	13000	03/06/2012	Not Finalization	Water Leakage From After Cooler Riser Pipe / Loco Push To JMP Shed.* AC Element Changed During Last Schedule*. Loco Arrived In Shed As D/A On 05/06/2012 At 17:30 Hrs. Loco Arrived NGC/D/Shed On 05/06/2012 At 17.30 Hrs As D/A During Shed Observation Found AC Element Inlet Rubber Hose Pipe Got Punctured Vertically. Water Leakage From After Cooler Riser Rubber Pipe As Pipe Got Punctured Vertically. Make- Soni, DOC. 11/06, PL No. 11459438 Visually It Is Observed That The Outer Rubber Cover Ruptured Of Approximately 9 Cm Length Horizontally. It Is An Over Aged Material Fitted During POH Schedule At KGP Workshop. Due To Over Age The Self Life Of Rubber Was Lost Which Effected On Polymerization & Generate Micro Crack On The Surface & Subsequently Generate.
20	Flexible Hoses Damaged/Leaking	13006	04/06/2012	Overdue Schedule	Turbo Super Charger Water Out Let Pipe Burst. ODS Loco Arrived NGC/D/Shed On 05/06/2012 At 19.45 Hrs As D/A. During Shed Observation Found AC Element Inlet Rubber Hose Pipe Got Punctured Vertically. Water Leakage From After Cooler Riser Rubber Pipe As Pipe Got Punctured Vertically. Make- Soni, DOC. 11/06, PL No-11459438. Visually It Is Observed That The Outer Rubber Cover Ruptured Along Horizontally Of Approximately 15 Cm Length. It Is An Over Aged Component. AC Element Inlet Rubber Hose Pipe Got Punctured Vertically As Over Aged Material Fitted During POH



					Schedule At KGP Workshop
21	Any Other Defect Not Listed Above	14841	15/06/2012	Bad W/S By Ngc Shed	Unusual Sound From Rad.Room. Loco Arrived In Shed As Dead Attached. After Arrival Found Radiator Fan 2 Nos. Blade Broken And One Tie Rod Connecting Nut & Bolt Drop Down. Lube Oil Leakage In Radiator Room. Due To Drop Down Of Tie Rod Bolt And Which Created Slagness In The Radiator Fan, Caused Damaged.
22	Water Leakage Due To Cracks In Rigid Pipes	14841	27/06/2012	Defective Material	Water Leakage In Compressor Room. Loco No. 14841 Failed On 27/06/12 At 03:15 Hrs At NGC Yard Due To Reported Cause Of Water Leakage In Compressor Room. Loco Arrived In Shed On 27/06/12 At 03:15 Hrs. During Shed Investigation It Was Found That Water Leakage From A/C Element Inlet Pipe 2-1/2 " Victaulic Joint Grove Due To 1.5 Mm Size Blow Hole In The Pipe. Water Leakage From A/C Element Inlet Pipe 2-1/2 " Victaulic Joint Grove Due To 1.5 Mm Size Blow Hole In The Pipe. During Pipe Observation Found 1.5 Mm Size Blow Hole In It. This Is Due To Defect In Material. The Pipe Was Old And Cover In Self Life.
23	Victaulic Gaskets Leaking/ Perished	14759	14/07/2012	Bad W/S By Ngc Shed	Turbo Water Inlet Pipe Leakage. Loco Arrived At NGC Shed On 16/07/12 At 15: 13 Hrs. As Dead Attached. Loco Starting Checking Done And Found Drop By Drop Water Leakage At 2-1/2" Victaulic Joint Near Partition Wall At Exp. Room (AC Element Inlet Pipe From Radiator. Room). After Victaulic Coupler Dismantling, Victaulic Gasket Found Partially Cracked At Seat Area. Modification Of This Pipe Line Was Done During Lube Oil Cooler Conversion From Conventional Cooler To PTLOC During M48 Sch On 14/06/12. As This Victaulic Joint Is At The Edge Of The Partition Wall, There Is Very Less Accessible Area For Gasket Fitment. During Fitment Of Gasket By Technician Gasket Partially Over Pressed And Crack Developed In Letter Stage Of Loco Running. Gasket Make: - ARL, MFG Date: - 08/10, Victaulic Gasket Is Partially Cracked At Seat Area As During Fitment Gasket Partially Over Pressed.

24	Flexible Hose Joints Defective/Leaking	14910	13/08/2012	Defective Material	Turbo Hose Pipe Joint Water Leakage. Loco Arrived In Shed As Dead Attached On 13/08/12 18:30 Hrs. Loco Starting Checking Done And Found Water Drop By Drop Leakage From L/S AC Element Water Outlet No 20 Hose. Water Leakage Found From Back Side Of Hose Fitting.
25	Universal Shaft Needle Bearing Worn/Seized	16006	15/08/2012	Defective Material	Hot Engine And Auto Shut Down. Loco Arrived In Shed As D/A On 17/08/12 12:30 Hrs. As Per Lab Report," Bearing Assembly Of The Failure Journal Cross Seized In Service And Got Damage Itself. This May Have Attributed To Journal Cross Fracture At Two Location On Opposite Tip Which Are Battered At The Surface Due To After Effect. This Breakage May Have Further Fractured The Sleeve Yoke Of The Universal Shaft On Opposite Site."
26	Water Pump Shaft Cracked/Failed	14844	01/11/2012	Defective Material	Water Throwing From Water Tank. Water Level Of Water Tank Only 6 ".Loco No. 14844 Failed On 01-11-12 Over BSB/NE At 18:11 Hrs. Due To Reported Cause Of Water Throwing From Water Tank. Loco Arrived In Shed On 06-11-12 At 14:00 Hrs As Dead Attached. On Arrival Water Pump Pressure Checked Found .5 Kg/Cm/Sq On Idle And 8th Notch. Water Pump Removed And Found Water Pump Shaft Broken. As Laboratory Report It Was Found That The Water Pump Casing Groove Is Completely Worn Out. The Groove Adjacent Impeller Contact Circumference Area Shows Not Much Appreciable Wearing. The Shaft (Modified With Sleeve System) Has Fractured Into Two Pieces At One End Of The Fitted Sleeve. The Worn Out Groove Deficiency Fitment May Lead Stress Imbalances At The Shaft And Stress Concentration At The Fractured Location Due To Sleeve. The Fracture Surface Shows Presence Of Branch Marks, Which Is Indicative Of A Progression Cracking With Rotation In Service. This Is A Case Of Material Failure.
27	Radiator Element Tubes Cracked/Leaking	16578	05/12/2012	BAD W/S BY DMW	Water Leakage From Bubble Collector Loco Arrived In Shed On 10-12-12 At 09:30 Hrs. As Dead. During Shed Investigation It Was Found That

					Radiator Core Tube Leakage. The Loco Was RB Done At DMW/PTA In Mar'2012. The Loco Was Transferred From Maurali To NGC/D/Shed In July'2012. This Is A Case BWM By DMW/PTA.
28	Radiator Element Tubes Cracked/Leaking	17579	31/12/2012	DEFECTIVE MATERIAL	Water Leakage From L/S Radiator Core, Middle Portion Heavy Leakage Loco Arrived In Dead Attached On 02-12-12 At 23:45 Hrs. On Arrival Of The Loco Water Topped And Found Loco Left Side Radiator Core Inside Tube Leakage. This Is A Case Of Premature Failure Of Radiator Core Tube. The Radiator Core Was Last Fitted During POH At KGP On 28/04/12. Radiator Core Make - Gasket & Diesel Pvt. Ltd., Baroda, Type P.P.I, 0304 SL No. 74.01.110. This Is A Case Of Defective Material.
29	Any Other Defect Not Listed Above.	14860	09/03/2013	NO LOCO DEFECT	Water Leakage From Radiator Core. Loco Arrived In Shed On 04/04/13 At 2:00 Hrs. As Dead Attached. As Per Information Of SSE/RTM/Diesel Shed, Make Up Pipe And Vent Pipe Of Cooling System Was Chocked. The Same Was Cleaned And Rectified At RTM/D/Shed. On Arrival Of The Loco Incoming Water Level Found 8 Inches. Loco Starting Checking Done, But No Any Leakage Noticed. This Is A Case Of No Loco Defect.
30	Impeller/Pump Housing Cracked	18576	18/04/2013	BAD W/S BY NGC SHED	Water Blow Out. Loco Arrived NGC/D/Shed On 19.04.13 At 02.30 Hrs. After Arrival Of The Loco Water Topping And Starting Checking Done. After Starting Checking Water Pump Circulating Pressure Checked And Found Nil. Water Pump Removed & Found Impeller Worked Out From Shaft. Split Pin For Castle Nut Broken And Missing. Castle Nut Got Loose. Water Pump Shaft – New (Modified), Shaft DOC- 15.5.12, Impeller – Serviceable, Water Seal – New Leak Proof L/Oil Seal – New, Key Impeller – Serviceable, Water Pump Last OVH – 30.06.12/NGC
31	Water Pump Bearing Seized/Failed	16087	03/05/2013	BAD W/S BY NGC SHED	Hot Engine Loco Arrived In Shed On 08/05/13 At 09:55 Hrs. On Arrival Loco Checked Found Water Pump Seized.

## 8.0 Results & Discussions

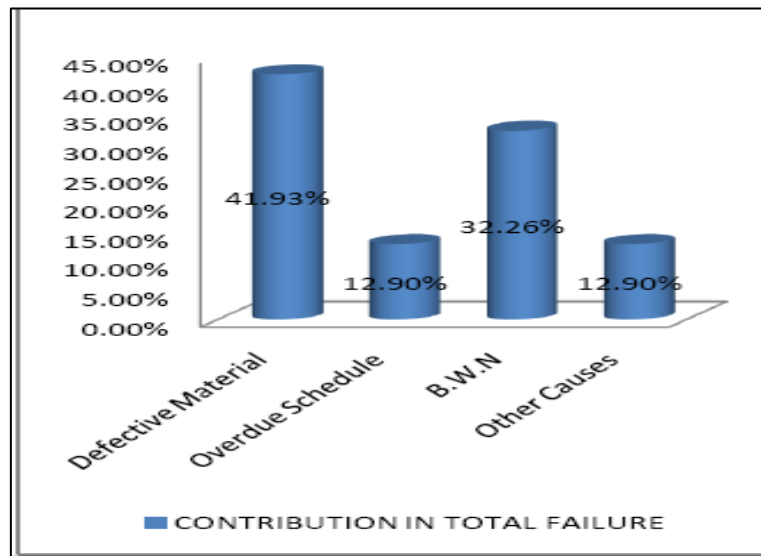
While going through the failure record of past few years (2011-2013) I have found many scopes for the reduction of the failures. But for doing that I had to analyze the records thoroughly.

Though I don't have much knowledge about the railway locomotives, but still I have tried my best to analyze the records which is described as follows –

**From line failure we have found out**

<b>Cause</b>	<b>Contribution In Total Failure</b>
Defective material	41.935 %
Overdue schedule	12.903 %
B.W.N/ mismanagement by crew	32.258 %
Other causes	12.90 %

**Line Failure**



41.9 % of line failure is due to defective materials which should be an important matter of concern for the railway authorities. It is very necessary to check the materials of the components on the very time it was supplied and only then it should be put to used in the locomotives. The main reasons for defective material are –

- Design deficiency
- Compositional deviational from the standard
- Manufacturing defects.

It is seen that almost 12.9% of line is due to overdue schedule i.e. the components which were

meant to be replaced as per schedule were not replaced. For example in many locomotives items like water pump, extension tanks, Victaulic joints and water jumpers are not maintain according to schedule for which leakage, loose of joint of joint and other failures occurs.

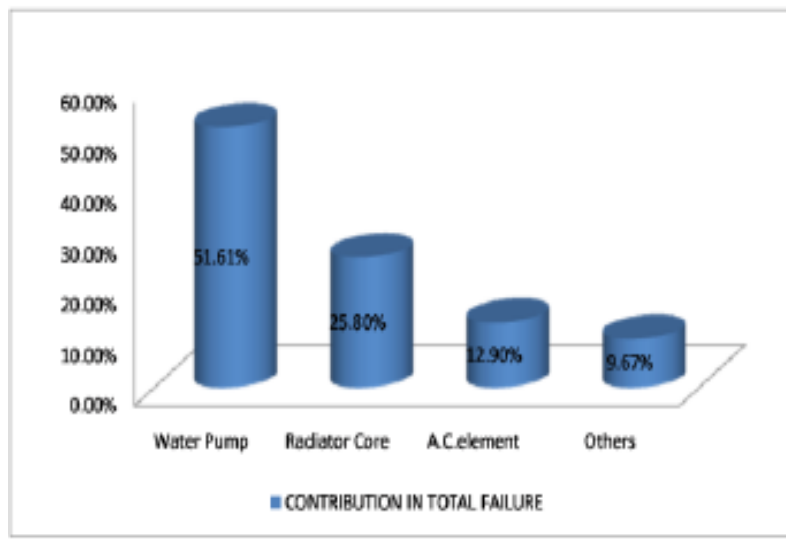
32.2% of the failures are due to B.W.N. This may be because of the negligence & lack of knowledge of the technicians.

Water leakage from telltale hole of water pump, loose of nut, water leakage from radiator core are the failures which are because of B.W.N but this are the failures which should not have been occurred.

**From shed failure data we found that**

Components Of W.C.S	Contribution In Total Failure
Water Pump	51.61%
Radiator Core	25.8%
A.C. element	12.9%
Others	9.677%

**Shed Failure**



It is quite clear from the above table that almost half of the W.C.S failures are of the water pump failure. It is also found that the radiator cores suffer many failures. So, proper maintenance of the radiator core is required. I have done a very brief analysis on the failure records but even then i could find so many flaws in the maintenance of the W.C.sytem.

I am quite sure that a proper detailed analysis of the failure records done by the specialists on the various components will find out many more of flaws which will definitely help to improve the overall performance of the shed.

**9.0 Conclusion**

From the failure analysis we find that most of the failures is because of defective material and this type of failures occurs in items like water jumper, water pump, vent pipe, extension tank, A.C. Element, Radiator fan etc. So, it should be brought under the notice of the manufacturer so that they can take necessary actions for better quality of the items. For that proper study, proper design, proper equipment and proper is required.

Another most important reason for failure is overdue schedule so the authority should be strict regarding the maintenance.

For that proper records should be present and regular inspection is required. It is better to use new components to replace older ones timely.

"Bad Workmanship (B.W.N)" is another cause of failure. This may be due to the ignorance or due to the lack of knowledge. In the whole training period i have notice that many technicians have good practical knowledge but not much of theoretical knowledge. So, there must be a proper platform especially for the workers where they can get both practical and theoretical knowledge.

The failure material should be kept for further testing so that the actual cause of failure can be known and suggestions can be taken from the experts.

From the failure analysis it was found that water pump, radiator core, AC. element, expansion tank etc. are the core components of Water Cooling System where frequently failure occurs. So, the maintenance of these should also be frequent. Experts should be available for each part of the items.

It is vital to control the temperature of the water. Regular inspection should be done for the same

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