सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION

FOR

DESIGN AND DEVELOPMENT OF HIGH EFFECTIVENESS LARGE AFTER COOLER FOR DLW BUILT 16 CYLINDER 3100/3300/3600 HP ALCo DLW ENGINES OF INDIAN RAILWAYS

Specification No. TS/ED/ 2012/68

Engine Development Directorate
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Manak Nagar, Lucknow- 226 011(India)

1. INTRODUCTION

Research Designs and Standards Organization (RDSO) under Ministry of Railways at Lucknow is the central research organization of Indian Railways (IR) and headed by Director General, RDSO. Director General is assisted by Additional Director General, Sr. Executive Directors and Executive Directors, heading different directorates. RDSO has various directorates for smooth functioning including Engine Development Directorate (EDD). EDD is engaged in design and development of railway traction diesel engines and has CAD centre, engine simulation and computer centre, dedicated engine test cells, fuel injection lab, instrumentation lab and other facilities to carry out diesel engine development work.

EDD has taken up various projects in the area of reduction of fuel consumption, reduction of exhaust emissions & lower air manifold temperature for ALCo DLW diesel locomotives of Indian Railways. As part of the ongoing efforts to reduce fuel consumption and harmful exhaust emissions from ALCo DLW diesel locomotives of IR, it is planned to develop a high effectiveness large after cooler (Charge Air Cooler-CAC) for these engines.

2. SCOPE OF THE PROJECT

1. It is planned to design, develop and procure a prototype high effectiveness, large after cooler suitable for DLW built 16 cylinder 3100/3300/3600 HP AlCo DLW engines of Indian Railways.
2. High effectiveness large after cooler being proposed for development should be compatible to work with various make turbochargers presently being fitted on ALCo DLW make 16 cylinder diesel engines. In addition it could also be used with the Miller Cycle timing based Turbocharger planned to be fitted on ALCo DLW engines in future.
3. High effectiveness large after cooler shall be compatible with the engine coolants being used on diesel locomotives of Indian Railways.
4. The material proposed by successful bidder will be cleared for manufacturing of prototype after its testing as per ASTM D-1384 in M&C Lab of RDSO.

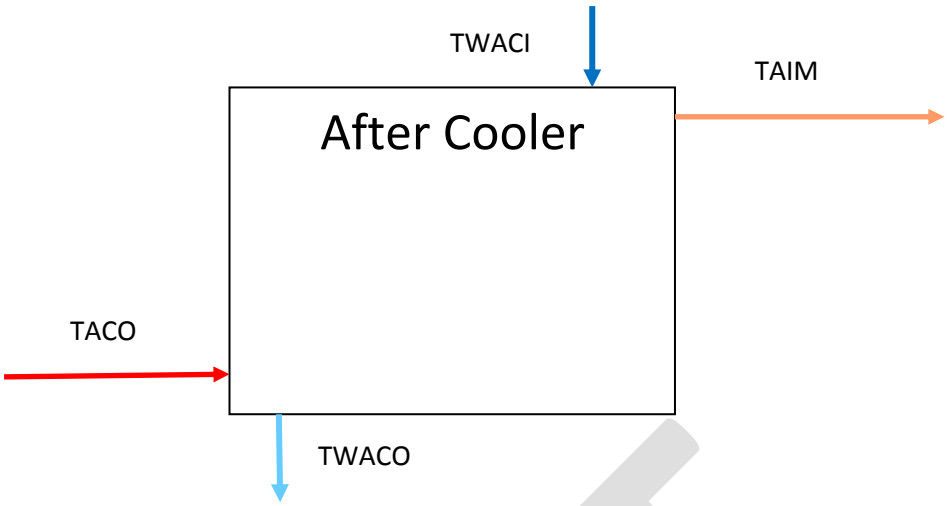
3. ACCEPTANCE CRITERIA

Following minimum broad objectives are required to be met: -

a) The effectiveness of the after cooler should be more than 90% throughout the operating range.
Effectiveness is defined as below: -

Effectiveness (%) = (TACO-TAIM) x 100/ (TACO-TWACI)

Where
TACO- Temperature intake air compressor out (after cooler in)
TAIM- Temperature engine intake air -after cooler out (Inlet to air manifold)
TWACI- Temperature water inlet to after cooler



b) The after cooler should be capable to withstand charge air pressure of 6 bar (Absolute).
c) The after cooler material must be compatible to work with IR approved coolant HP Power KOOL RR with expected after cooler life of minimum twelve years. The material used for after cooler must be corrosion resistant for coolant Ph value from 7 to 11.
d) Complete interchange-ability with the existing after cooler. It means easy fitment in existing after cooler housing without any modification in locomotive piping.
e) Weight of the offered after cooler should be comparable to the weight of the existing shell and tube type after cooler.

4. OTHER REQUIREMENTS

1. Mass flow rate of charge Air will be maximum 5.72 Kg/s.
2. Maximum values of TACO & TAIM are expected to be 190 & 75 degree centigrade respectively for all three configurations of 16 cylinder ALCo Engine.
3. Maximum water flow rate in after cooler is 586.9 l/m (approx.).
4. Same turbocharger and after cooler combination will be used for 3100, 3300 & 3600 HP ALCo Engine.

5. PERFORMANCE TEST ON RDSO ENGINE TEST BED

1. Performance of engine fitted with High effectiveness large after cooler shall be validated on the test bed of ALCO engine at Engine Development Directorate, Research Designs & Standards Organization (RDSO), Lucknow, India. Heat Dissipation Conformance Test and thermal effectiveness shall be carried out of one prototype sample of after cooler on ED Dte test bed. Performance shall meet the stipulated requirements.
2. No other component besides large after cooler is proposed to be changed to achieve the desired performance.
3. The ALCO engine will be run at the predetermined speed and load points during the test as per Annexure 4. Optimization will be done under the identical conditions and combination of components. The engine will be loaded by hydraulic dynamometer controlled by AVL test commander. For calculation of corrected horsepower and brake specific fuel consumption, ALCO formula will be used. Performance parameters will be recorded in direction of descending order of load and speed.
4. Detail of data acquisition system of the test bed is at Annexure 5.
5. Performance tests on RDSO Engine Test beds shall be carried out for a period of maximum two months after complete assembly.

6. PERFORMANCE TEST ON LOCOMOTIVE

After the validation of the system performance on ALCO engine test bed at Engine Development Directorate, RDSO, the system would be fitted on ALCO-DLW diesel locomotive. After proving out the performance requirement on the locomotive, its maintainability and reliability under field conditions (Reliability Verification Testing) would be jointly monitored by RDSO and the manufacturer for 6 months. All problems noticed during this period shall be logged and a satisfactory solution shall be found.

7. DELIVERABLES

The requirement envisages inclusion in the offers, separately, of the following deliverables:-

a) One number high effectiveness large after cooler with adaptation parts if any.
b) One complete set of Specifications, material test reports, User manual, spare parts catalogue, including detailed dimensioned drawings of the interfacing dimensions except the proprietary design details.
c) Full technical support and update for a period of minimum two years after successful installation and commissioning.

8. RELIABILITY REQUIREMENTS

The expected reliability goal established for the engine after coolers is a failure rate not exceeding 0.1% during service period of 24 months.

9. PREVENTIVE MAINTENANCE

The proposed large after cooler shall be so designed that it is maintenance friendly. The manufacturer shall specify the preventive maintenance schedule required. Care shall be taken by the manufacturer to ensure that these schedules match the existing locomotive schedules, and least possible work content in these schedules shall be preferred.

10. ENVIRONMENT CONDITIONS

The after cooler shall be designed to tolerate continuous operation at coolant conditions of 5 bar and 110º C. The after cooler shall withstand coolant temperature pressure cycles throughout its life. These cycles will have a maximum frequency of 15 cycles per hour at the 1.4 bar- 4.9 bar range and a maximum rate of water temperature change of 20 deg C per minute. The after cooler will be exposed to occasional coolant temperature of 135 deg C for 20 minutes at a nominal frequency of 10 times per year. The after cooler shall be designed to tolerate continuous operation at air-side conditions of 4 bar (gauge) and 220° C.

Annexure-I

ENGINE DATA – 16 CYLINDERS DLW BUILT 251-B ALCo ENGINE

1.	Application	Rail traction diesel (Indian Railways, Broad gauge) 3100,3300 HP, 3600 HP
2.	Engine type	DLW built 251-B engine
3.	No. of cylinders	16
4.	Configuration	'V'
5.	Cycle	4 stroke
6.	Bore	9"(228.6 mm)
7.	Stroke	10.5"(266.7mm)
8.	Compression ratio	11.75:1
9.	Ratio of con rod length to crank radius	4
10.	Fuel injection (at full load)	
	Spill port closing	22.0 degree CA BTDC
	Duration of injection	Approx.34 degree CA
	Pumps	17 mm plunger dia, 20mm stroke
	Nozzles	0.35 mm dia. 9 holes, 157-degree spray angle, 90-degree tip angle.
11.	Firing order	1R 1L, 4R 4L, 7R 7L ,6R 6L, 8R 8L, 5R 5L, 2R 2L, 3R 3L
12.	Valves (4 valve head) Air inlet open	72 degrees CA before TDC
	Air inlet close	48 degrees CA after BDC
	Exhaust open	66 degrees CA before BDC
	Exhaust close	66 degrees CA after TDC
	Valve dia	7.62 cm
	Max. valve lift	2.04 cm
	Port diameter	7.40 cm
13.	Turbocharger	One per engine
14.	After cooler	Single water-cooled.

NOTE: These figures are indicative and can be used only for approximate guidance

Annexure-II

ENGINE PERFORMANCE DATA AT FULL LOAD- 16 CYLINDERS DLW BUILT 251-B ENGINE (MECHANICAL FUEL INJECTION SYSTEM) AS AVAILABLE AT RDSO TEST BED-

1.	Engine speed	1050 rpm	1050 rpm	1050 rpm
2.	BMEP	14.25 bar approx.	15.75 bar approx.	17.17 bar approx.
3.	Turbo inlet temperature	485ºC (approx.)	500ºC (approx.)	535ºC (approx.)
4.	Average cylinder head exhaust temperature	415ºC (approx.)	415ºC (approx.)	415ºC (approx.)
5.	Max. Ambient temp. Expected	55ºc	55ºc	55ºc
6.	Vacuum at compressor air intake		400 mm H2O-g approx.	550 mm H2O-g approx.
7.	Compressor outlet pressor	1.60 bar-g approx	1.82 bar-g approx.	2.20 bar-g approx
8.	Pressure drop across after cooler	0.1 bar approx.	0.1 bar approx.	0.12 bar approx.
9.	Inlet manifold pressure (engine air gallery)	1.55 bar approx.	1.77 bar approx.	2.02 bar approx.
10.	Exhaust pressure before turbine	1000 mm of Hg approx	1000 mm of Hg approx.	1120 mm of Hg approx.
11.	Turbine outlet pressure (Exhaust)	440 mm H2O g approx. on engine test bed	440 mm H2O g approx. on engine test bed.	640 mm H2O g approx. on engine test bed.
12.	Maximum cylinder pressure	1800 psi.	1850 psi.	1950 psi.

NOTE: These figures are indicative and can be used only for approximate guidance

Annexure-III

TYPICAL INDIAN RAILWAY OPERATING DUTY CYCLE FOR DIESEL LOCOMOTIVES

NOTCH	FREIGHT SERVICE %	PASSENGER SERVICE %
Idle	60	49
1st	3	6
2nd	5	7
3rd	3	5
4th	4	4
5th	4	7
6th	5	5
7th	6	5
8th	10	12

Extracted from RDSO report no.-MP-Misc. – 204, Feb. - 2008

Annexure-IV

OPERATING POINT AT VARIOUS NOTCHES FOR ALCo 251B ENGINE

NOTCH		3100 HP		3300 HP		3600 HP	
	RPM	LOAD (N)	POWER (HP)	LOAD (N)	POWER (HP)	LOAD (N)	POWER (HP)
8 th	1050±3	21600±50	3100	22997±50	3300	25065±50	3600
7th	950±3	19082±50	2500	20316±50	2640	22163±50	2880
6th	850±3	16018±50	1870	17029±50	1980	18577±50	2160
5th	750±3	13826±50	1430	14475±50	1485	15971±50	1620
4th	650±3	10616±50	950	11135±50	990	12147±50	1080
3rd	550±3	8138±50	615	8773±50	660	9570±50	720
2nd	450±3	5471±50	330	5361±50	330	5848±50	360
1st	350±3	2984±50	145	3336±50	165	3760±50	180
Idle	350±3	2131±50	105	2131±50	105	2131±50	105

NOTE: These figures are indicative and can be used only for approximate guidance

Annexure-V

DATA ACQUISITION SYSTEM OF ALCo ENGINE TEST BED

(a) AVL test commander, capable of real time only measurements on 176 channels, controls the engine. The test commander controls the dynamometer coupled to the diesel engine. Different parameters like speed, load, torque, power, temperature and pressure at various critical location of engine are measured and recorded. The test commander operates on "Window NT" operating system with "PUMA 5" engine monitoring and testing software.

(b) The high-speed data acquisition system (HSDA) of M/s AVL is used to measure online high-speed parameters of engine such as Cylinder pressure, Fuel line pressure, Injector needle lift etc.

(c) AVL frequency based fuel balance measures the online Brake Specific Fuel Consumption and rate of fuel flow. Fuel leak-off is measured separately. The rate of leak off amount is subtracted from the rate of fuel flow to get the exact consumption of fuel.