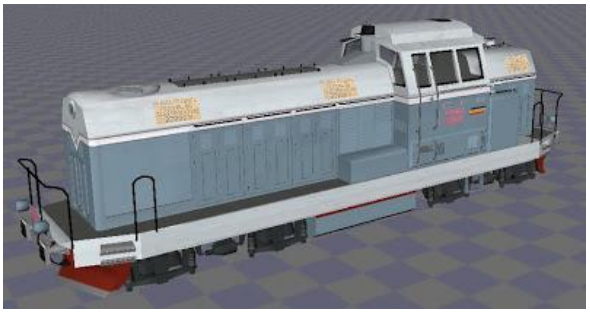
ANGLO BELGIAN CORPORATION

AGEFENERGY

PARTENER ABC IN ROMANIA

STUDY REGARDING THE REFURBISHMENT OF THE ROMANIAN LOCOMOTIVES WITH ABC ENGINES



REFURBISHMENT LOCOMOTIVE LDH1250
WITH ABC ENGINE
6DZC-750-178
1065KW(1448HP)/700RPM

REFURBISHMENT LOCOMOTIVE LDE1250
WITH ABC ENGINE
6DZC-1000-176
1405KW(1910HP)/1000RPM

REFURBISHMENT LOCOMOTIVE LDE2100
WITH ABC ENGINE
8DZC-1000-176
1875KW(2545HP)/1000RPM

CONTENT

1. Overview.

Nowadays, there are numerous refurbishments globally regarding Diesel traction at locomotives and railcars.

The causes of such an activity are applied for numerous railway vehicles are multiple, complex, so in the followings they will be mentioned very shortly:

- *High fuel and oil consumption of the old conception and construction engines in comparison with the new Diesel engines.*

Practically, lowering the fuel consumption is up to 20% and the oil consumption is up to 60%. This differences are reflected in the transportation costs, which finally leads to the loose of the competition for those companies whom rolling stock is equipped with old conception and construction Diesel engines.

- *High maintenance costs of the old conception and construction Diesel engines in comparison with the actual Diesel engines.*
  Practically, the maintenance time interval between two intervention has grown up to 2-3x, in some cases even up to ... 6x! Regarding the service maintenances interval, it has grown up to 3-5x. For the above mentioned we can also add the reduced cost and lower qualified labour necessary for the new type Diesel engines in comparison with the old conception and construction Diesel engines. This differences are reflected in the transportation costs, which finally leads to the loose of the competition of those companies whom rolling stock is equipped with old conception and construction Diesel engines.

- *Growing difficulties regarding the acquirement of the spare parts necessary for the maintenance of old conception and construction Diesel engines.*

Compleiton of the production of a Diesel engine type is usually coupled with the compleiton in very short time of the spare parts production, consumption parts and components, both by the engine producer and both by the numerous orizontal providers. There are freqvent cases when the suppliers are abolished or completely reprofiled. This aspect are reflected in the transportation costs, which finally leads to the loose of the competition for those companies whom rolling stock is equipped with old conception and construction Diesel engines

- *Limited capacity of the railway industry to produce new railway vehicles according to the request of the railway operators.*

Railway transportation presently involves a massive developement globally. Furthermore promoting the new construction rolling stock, the prolongation of the life cycle of the existent vehicles is also needed. To fulfill the request of the growing railway trafic, on the existent railway vehicles must be done a ‚general overhaul' with it's modernisation. This

‚treatment' is applied for thoose vehicles which are characterized with a robust construction and easy adaptability of mechanical parts, which permits a good service condition for the next 15-20 years or even more. In Diesel traction, modernization firstly means the refurbishment with a new engine coupled with all the necessities for the engine optimal functioning. At the client request, modernization can be made at transmissions and at auxiliary devices (some of these are necessary).

- *Reduced costs for the engine refurbishment in comparison with the price of a new vehicle*

Internationall achievements proves that the refurbishment process including the necessary auxiliary devices of a Diesel rail vehicle necesitates max.65% of the value of a new rail vehicle from the same class and same power rate. In fact, if these percentage is exceeded, the new rail vehicle acquisition is preferred.

This study is intended to present an alternative refurbishment/modernisation unit of the Diesel locomotives with romanian construction (LDH1250, LDE1250, LDE2100), having ABC - Anglo Belgian Corporation Diesel engines.

The presented study was done after a complex analysis of all the aspects regarding the refurbishment/modernisation of the Diesel rail vehicles with romanian construction, respectively:

- Utilization of Diesel engines with high performance regarding the fuel and oil consumption, emissions, life cycle, maintenance and explitation costs (life cycle cost –LCC) and expecially the adaptaility for the romanian Diesel locomotives.

- Utilization of a single Diesel engine family for all three Diesel engine locomotives, as a continuation of a positive experience registered at CFR with Diesel engine from the Sulzer LDA 28 family.

- Improving the working conditions for the working personnel of the locomotive

- Unifying as much as possible of the components used in the refurbishment/modernisation process of the three romanian Diesel locomotives.

- Improving the traction performances of the romanian Diesel locomotives up to the possible limits.

- Implementing the electronic comands units, monitorization, protection and diagnosis to the board of the romanian Diesel locomotives.

2. Introduction.

Today, Diesel locomotives having new construction of refurbished/modernized are equipped with two type of Diesel engines, respectively:

- **Fast Diesel Engines**, which are working mainly at speeds between 1500÷1800rot/min.

In this category takes part at this moment:

- Diesel MTU engines– family ,,4000'';
- Diesel Caterpillar engines– family ,,3500'' and,,C175'';
- Diesel Cummins engines – family ,,QSK'';
- Diesel General Electric engines– family GE P616;
- etc.

This category of Diesel engines has penetrated in large scale into the railway traction about 30 years ago, most of the cases coming from military naval applications. Their fast spread is due to their three major qualities:

- Nominal power(kg/kW) is extremely high, about 2 times in comparison with slow Diesel engines;
- Weight reduced about 2÷2,5 times in comparison with the slow Diesel engines;
- Reduced dimensions about 2 times in comparison with slow Diesel engines.

Having in provision Diesel engines, high power locomotives construction were possible, (max.4300HP), achieving high speeds, (max.220km/h), for towing services of the passanger railcars, with low axle load(19÷20t), having the Bo-Bo axle formula!

- **Slow Diesel engine**, which are wokring mainly at speed between 900÷1100rot/min.

In this category takes part at this moment:

- Diesel General Motors engines – family ,,710'';
- Diesel Caterpillar engines– family ,,3600'';
- Diesel General Electric engines – family 7FDL;
- Diesel ABC engines– family DZC;
- etc.

This category of Diesel engines opened the era of Diesel traction in railway transportation in the interwar period. They have developed and has been perfectioned in continuity achieving today the greatest share on the board of the Diesel locomotives. Their production continues even today because of their advantages in comparison with the fast Diesel engine:

- life cycle about 2÷3 higher;
- reduced wear;
- simplicity in construction;

For the locomotives made for towing cargo railcars, which does not involve

problems about the weight on the axle, which can be ‚heavy', the same Diesel engines are the optimal solution.

The achievements in this field are remarkable:

- the most powerfull Diesel-electric locomotive: 6500HP equipeed with Caterpillar 3616 Diesel engine;
- The most powerfull Diesel-Hydraulic locomotive: 4900HP equipped with ABC 16DZC Diesel engine.

In the followings a short proposal for refurbishment/modernization for the the romanian Diesel locomotives will be presented.

The main goal is the prolongation of the life cycle of the romanian Diesel locomotives with 15÷20 years, or even more.

The robust construction of the mechanical parts, (chassis, gearbox, bogie), submitted for the general overhaul, adaptations and reinforcements necessary for the implementation of the new components, is the warranty for the succes of the refurbishment/mdernisation of the romanian Diesel locomotives.

To support this affirmation, the compensation of the mass of the locomotive, (considering that the new parts are easyer than the original ones) will be done involving the supporting structure reinforcement where weak points are present and not by balasting.

From the tehnico-economical market research of the Diesel engines, the Diesel DZC family engines has been choosen, produced by *ABC – Anglo Belgian Corporation*.

The main argument for sustaining of this proposal is the calculus of the costs of the exploitation delivered by *ABC – Anglo Belgian Corporation.*

LOCOMOTIVE TYPE	**LDE1250**	**LDE2100**	**LDH1250**
LIFE CYCLE COST			
Number of working years:		20 years	
Operating hours per year per engine:		6000 hours/year/engine	
Total operating hours per engine:		120000 hours/engine	
Fuel cost [€/h/engine]	104.75	141.00	76.93
Oil cost [€/h/engine]	0.87	1.10	0.72
Spare parts cost [€/h/engine]	2.88	3.67	2.63
Maintenance work cost [€/h/engine]	0.43	0.50	0.40
Total cost of work [€/h/engine]	**108.93**	**146.27**	**80.68**

3. Presentation of ABC- ANGLO BELGIAN CORPORATION

ANGLO BELGIAN CORPORATION, hereafter ABC, is the European leader in the construction of semi-slow Diesel engines. The company conceive and construct engines for maritine applications, railway applications, backups and heating plants – turnkey solutions on all the continents.

ABC was founded in 1912 by a group of Belgian entrepreneurs, immediately after the validation of the first compression ignition engine by Rudolf Diesel.

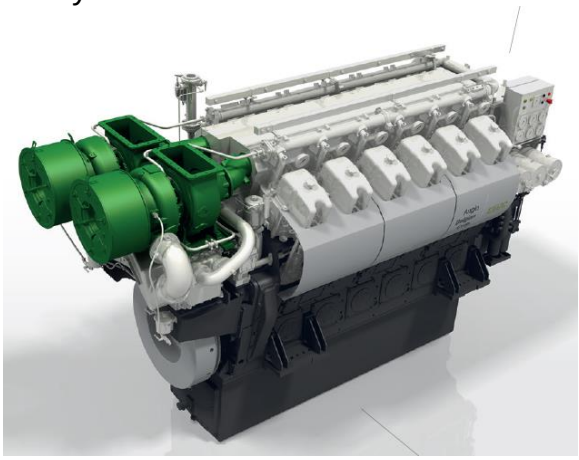
An important step in the evolution of ABC was their accession into OGEPAR group in 1985, a powerfull holding in engineering and metal processing industry. Today ABC is more than a engine manufacturer; ABC develops and innovates permanently in the maritime, railway and power generation fields.

ABC improves day by day their engine quality and reliability taking part in the competition for durable improvements in the field of reducing emissions. All ABC engines are designed for continous use in severe conditions with an easy and fast maintenance.

For more than 100 year, ABC is a viable partner in the locomotive refurbishments. Their acumulated experience allow them to propose feasible solutions even in the complex projects.

ABC engines are designed for use in the most severe conditions. Engines from the DZC family are the most robust and most reliable in the market. In extreme conditions, these engines have won their users confidence whom activity depends on the performances of the Diesel-electric or Diesel-hydraulic locomotives.

The DZC engines family (in-line engines; 6/8DZC and V engines; 12/16DZC) are reknowed for their reduced necessity for maintenance (large maintenance intervals – 3000h) and of course for their low fuel consumption respecting the stringent emission limits. Assuming all, it offers a maximum life cycle with minimum costs.



ABC references in locomotive refurbishments:

Diesel Electrical locomotive **U15, ONATRA**
6DZC, 1150KW(1560HP)

Diesel Hidraulic locomotive **HLD77**, **SNCB-NMBS**
6DZC,1150KW(1560HP)

Diesel Electric locomotive **6005,SNCB-NMBS**
6DZC, 1350KW(1800HP)

Diesel Hydraulic locomotive**VOITH MAXIMA 40cc** (the most powerfull hydraulic mono-engine locomotive)
16VDZC, 3600KW(4900HP)

Engine family DZC
Emissions IIIA according to Directive 97/68CE

Cycle: 4	Cycle: 4
Cylinders: in-line 6-8	Cylinders: in V 12-16
Bore: 256mm	Bore: 256mm
Stroke: 310mm	Stroke: 310mm
Cylinders: -6 cylinders 95.7 litre -8 cylinders 127.6 litre	Cylinders: -12 cylinders 191.5 litri -16 cylinders 255.2 litri
Compression ratio: 12.1:1	Compression ratio: 12.1:1
Injection: direct/mechanic/ a pump per cylinder	Injection: direct/mechanic/ a pump per cylinder
Mean effective pressure: 18.8bar (at 1000 rpm)	Mean effective pressure: 18.8bar (at 1000 rpm)
Piston speed:10.3m/s (at 1000 rpm)	Piston speed: 10.3m/s (at 1000 rpm)

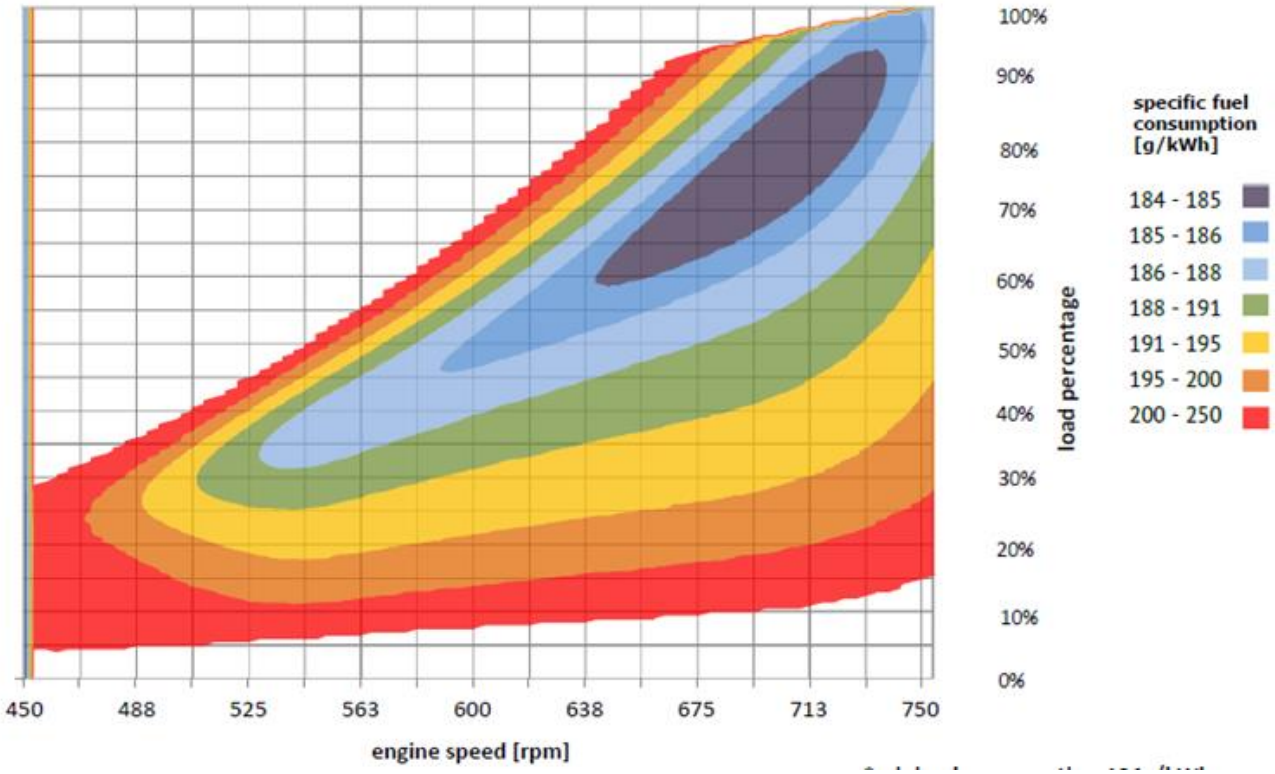
Engine type		rpm	Engine power (ISO 3046 – I)	
			kW	HP
6 DZC-720-181		720	1032	1402
6 DZC-750-179		750	1065	1447
6 DZC-900-166		900	1194	1622
6 DZC-900-188	*	900	1350	1834
6 DZC-1000-166		1000	1326	1802
6 DZC-1000-176		1000	1405	1910
6 DZC-1000-188	*	1000	1500	2038
8 DZC-720-181		720	1376	1870
8 DZC-750-179		750	1420	1929
8 DZC-900-166		900	1592	2163
8 DZC-900-188	*	900	1800	2446
8 DZC-1000-166		1000	1768	2402
8 DZC-1000-176		1000	1875	2545
8 DZC-1000-188	*	1000	2000	2717

Engine type		rpm	Engine power (ISO 3046 – I)	
			kW	HP
12 DZC-720-181		720	2064	2804
12 DZC-750-179		750	2130	2894
12 DZC-900-166		900	2388	3245
12 DZC-900-188	*	900	2700	3668
12 DZC-1000-166		1000	2652	3603
12 DZC-1000-176		1000	2800	3805
12 DZC-1000-188	*	1000	3000	4076
16 DZC-720-181		720	2752	3739
16 DZC-750-179		750	2840	3859
16 DZC-900-166		900	3184	4326
16 DZC-900-188	*	900	3600	4891
16 DZC-1000-166		1000	3536	4804
16 DZC-1000-176		1000	3750	5095
16 DZC-1000-188	*	1000	4000	5435

*For special applications

4. Refurbishment LDH 1250HP.

In the case of the Diesel hydraulic locomotive of 1250HP, changing the power (for increasing it) is insignificant. This fact is imposed by the hydraulic transmission TH2 limited capacity to overtake the Diesel engine power.
From the ABC Diesel engine family, it has been chooosen the 6DZC-750-178 with 6 cylinders in-line, with 1065kW (1448HP) at 750rot/min. In this case, the hydraulic transmission will suffer no modifications for the new Diesel engine.
In the below picture the specific fuel consumption is presented in function of the load of the adopted engine, confirms the special fuel consumption.



For a good functioning of the Diesel engine, a new adequatly dimensioned cooling turret will be delivered.

Also related to the cooling we have to mention that a new heat exchanger for the oil of the transmission has to be implemented. This is with a modern design, with the construction in ‚plates'. The cooling capacity of these will be superior to actual one, thereby the increase of the lasting traction force is possible – this aspect is usefull in applications of type ‚heavy manouver'.

The most important change will be done at the auxiliary devices
With respect to the ‚board energetics' we can mention the followings:

- Working voltage:
  - 24V cc;
  - 3 x 400V, 50Hz;
  - 220V, 1~ 50Hz

- Electric sources at the board:
  - batteries 240Ah;
  - synchronous three-phase generators of power 50kW, 3 x 400V, 50Hz hydraulic driven;
  - external plugs 220V, 1~ 50Hz –25A, 3 x 400V, 50Hz-63A.

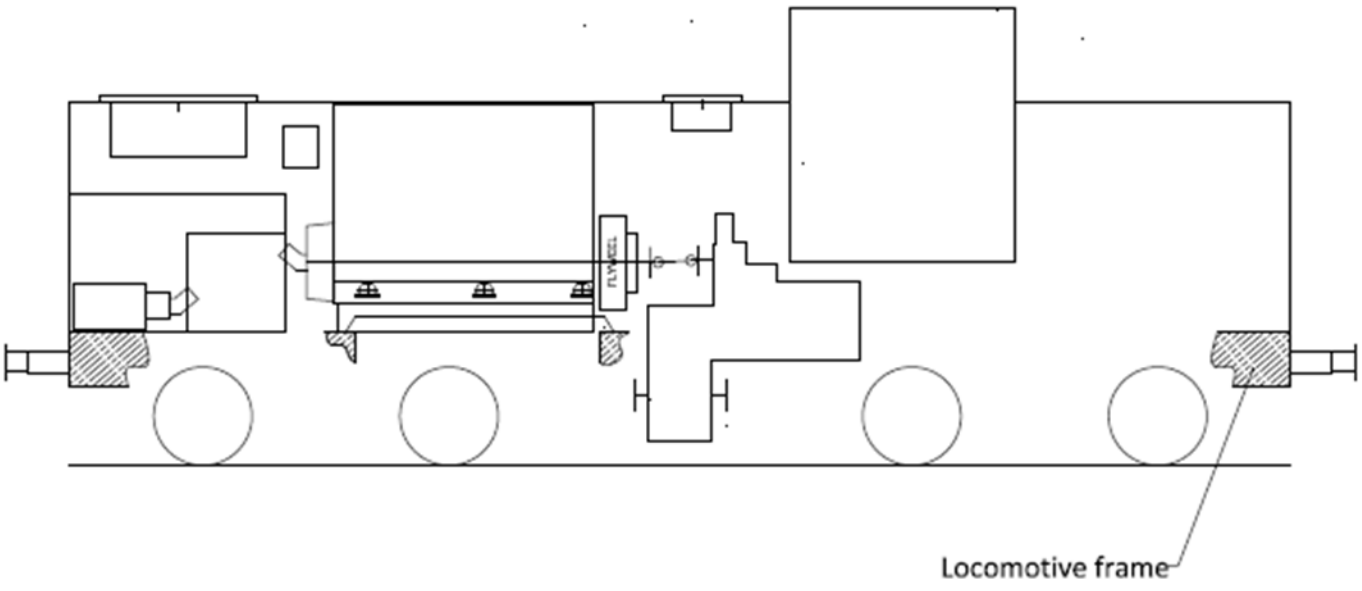
Auxiliary services with alternative current includes the following aggragates:

- Air compressor, power cca. 22kW, type ,,screw'', driven by an asynchronous three-phase motor with short-circuited rotor, with assisted start by a converter working in between 0÷50Hz;
- Air conditioning for the driver room;
- Preheating/Maintaining warm of the Diesel engine;
- Other consumers: front windows with electric heating, driver cabine floor electric heating, fridge, electric stove, microvawe oven, water heater etc.

With direct curent consumption are the following consumers:

- Command circuits
- Signaling and lights;
- Electronic equipment;
- External plugs, etc.

Taking into account the important modifications which should take place during the refurbishment, the reconstruction of the driver's cabine and the hood is also imposed, according to instalation of the new agregates.
For the beformentioned we can add: monitoring equipment, protection and diagnosis, on board computer, modern driving desk, ergonomic chairs, etc.
In the below picture we can see the layout drawing of the locomotive with the ABC traction equipment.

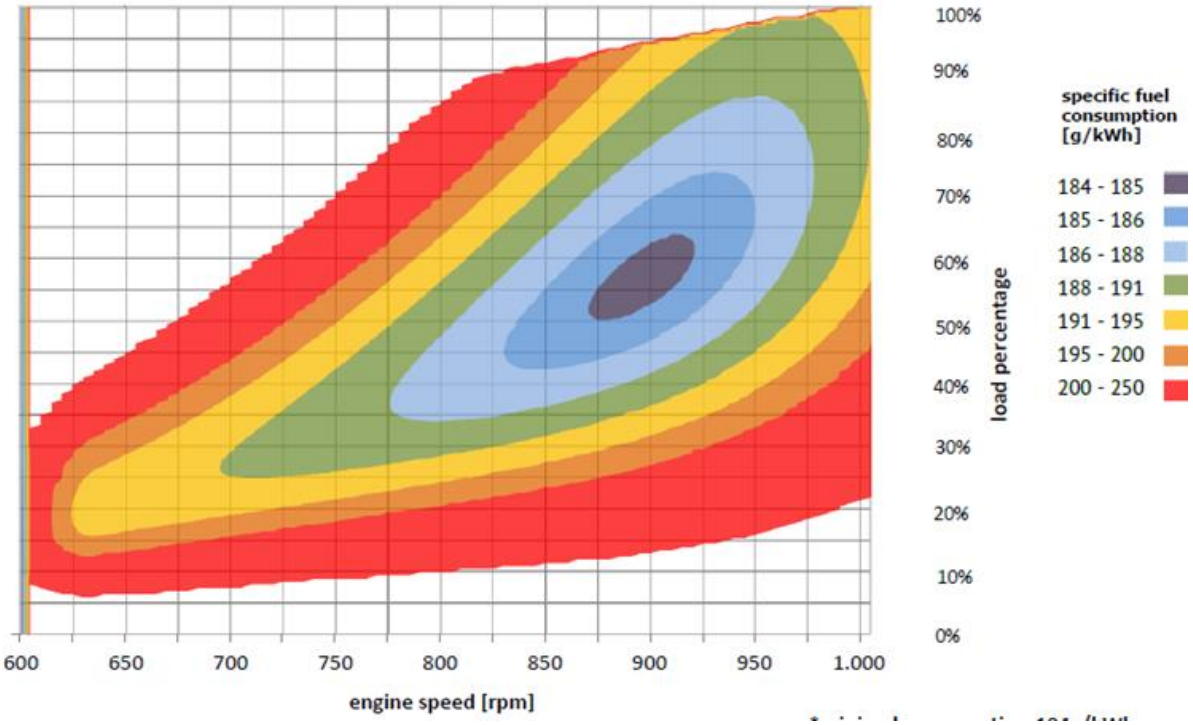


ABC delivery kit consist of:

-ABC engine, type 6DZC-750-178, power 1065KW(1447HP)/700RPM, emission level IIIA, electronic starting (24V),
-Alternator for auxiliary consumers - hydrostaticly driven 50KVA,
-Elastic support for mounting on the locomotive platform,
-Flexible coupling for driving the hydrodinamic coupling,
-PTO on the crankshaft with flexible coupling for driving the tandem hydrostatic pump,
-Engine cooling system (low and high temperature circuit),
-Locomotive cooling system (low and high temperature heat exchanger, ventilator, hydrostatic syistem, hydrostatic motor for driving the auxiliary alternator, hydrostatic fan for the cabine)
-Heat exchanger for the transmission cooling
-Diesel engine monitoring unit

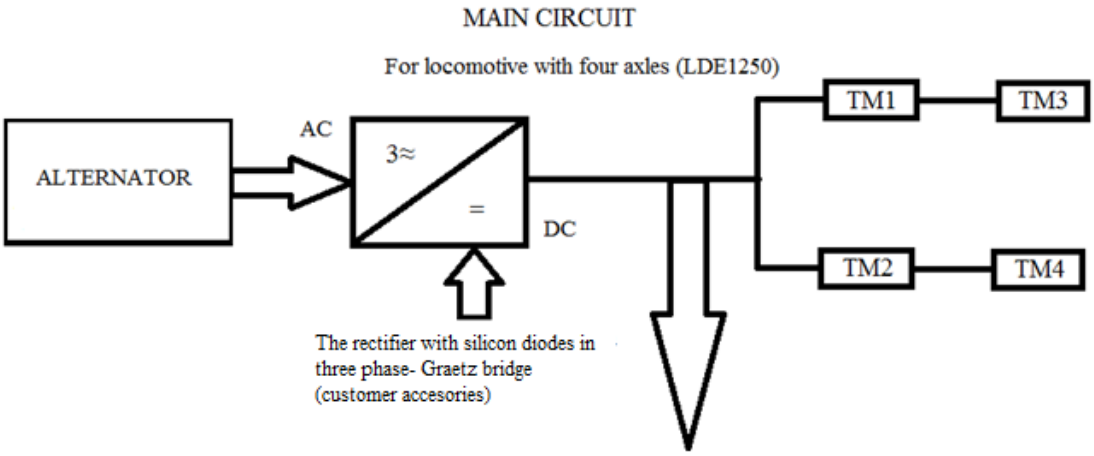
5. Refurbishment LDE 1250CP.

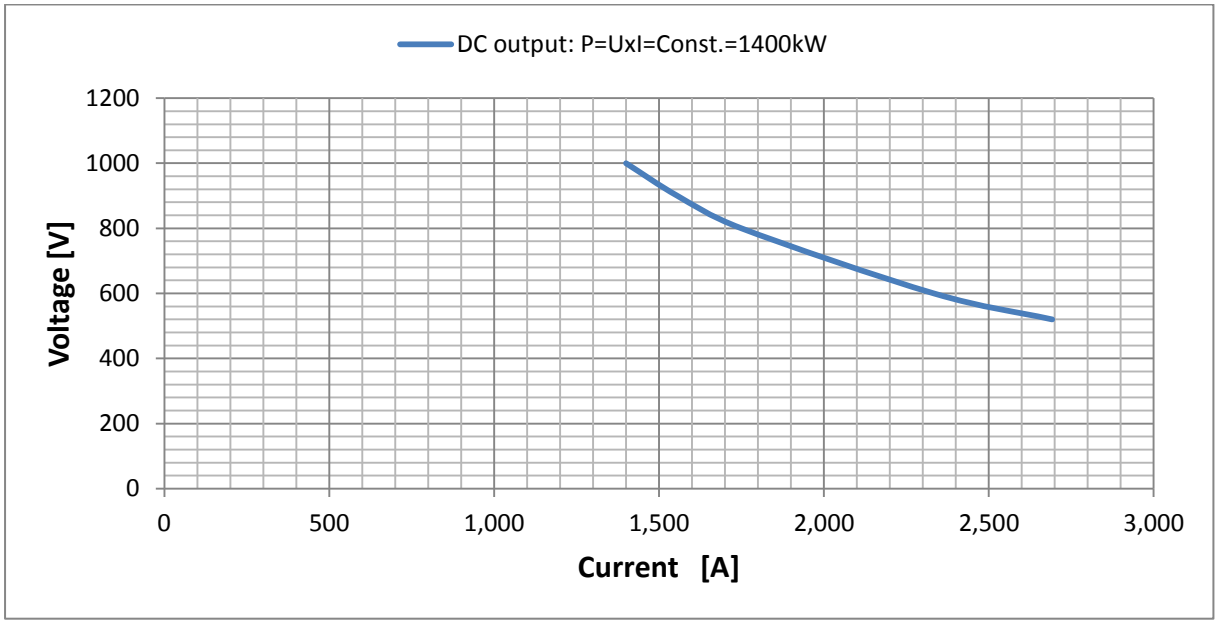
The refurbishment of the Diesel electric locomotive of 1250CP implements a series of modifications which are extremely important and beneficial:



- The mentioned power can be used by the four existing traction motors GDTM 533. A locomotive with this power, along the basic applications, respectively medium and heavy manouvers, can be also used ‚on road' in towing freight trains of reduced or medium weight, with high speed.
- Using the electric transmission alternative current – direct current, instead of the old one, namely direct current – direct current. ABC delivers genset having the assembly of two three phase synchronous alternators, respectively the one pirmary and the auxliliary. The advantages of this tehnical solution are well known in

comparison with the old transmission: increasing reliability, increasing overall efficiency, decreasing maintenance costs etc.
In the picture below a general layout is presented from electric transmission.





At the client's request an alternative current-alternativ current transmission is also available, although the costs for the refurbishment/moderisation is about 60% higher than for the refurbishment/modernisation with the alternative current – direct current solution.

- Electronic driven auxiliary services with short circuited asynchronous motors. This will increase the reliability, decrease the costs for maintenance, improving the energetic balance.

Along the above mentioned, we can mention that the cooling turret , the compressor and other equipments will be the same with the ones on the Diesel hydraulic locomotive of

1250HP.
Taking into account the important modifications which should take place during the refurbishment, the reconstruction of the driver's cabin and the hood is also imposed, according to instalation of the new agregates.

For the beformentioned we can add: monitoring equipment, protection and diagnosis, on board computer, modern driving desk, ergonomic chairs, etc.

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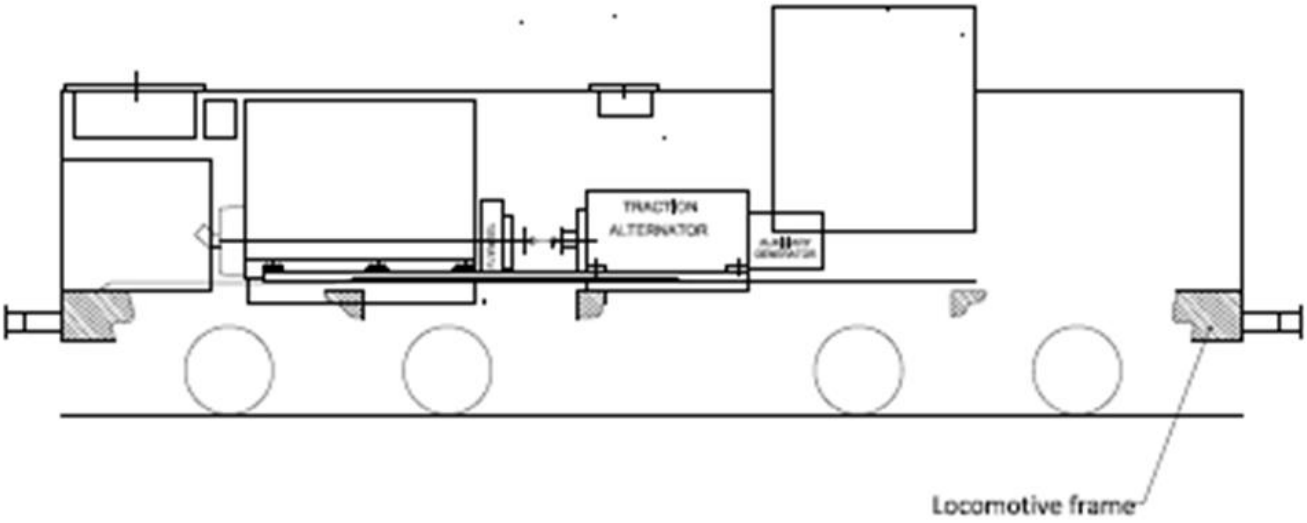
The preliminary calculus, shows that the approximative parameters for towing of the Diesel electric locomotive of 1250 HP for refurbishment/modernisation are:

- Acceleration traction force..... .....cca. 230kN;
- Lasting traction force.....cca. 150kN;
- Lasting speed.....cca. 26km/h.

In the below picture the schematic layout of the locomotive with ABC traction equipment is presented.



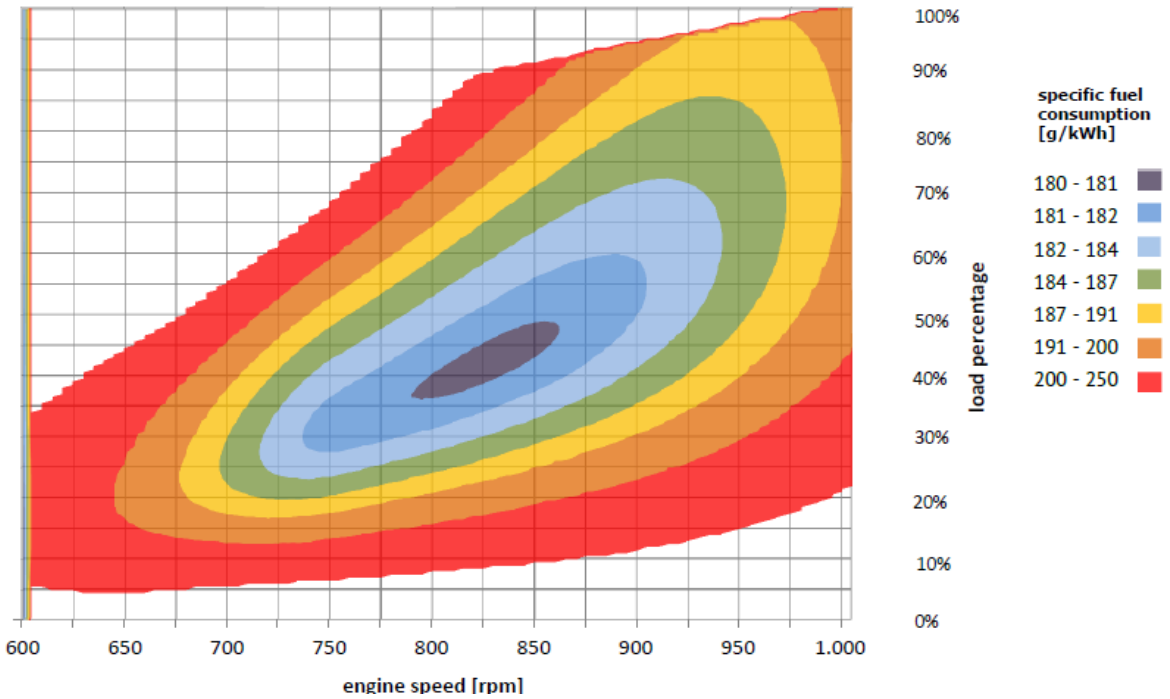
ABC delivery kit consist of:

-ABC engine, type 6DZC-1000-176, power 1405KW(1910HP)/1000RPM, emission level IIIA, electronic starting (24V),
-Traction alternator HITZINGER, two bearings, excitation control system
-100KVA auxiliary lternator in the same shaft with the traction alternator
-Elastic support for mounting on the locomotive platform,
-Flexible coupling for driving the alternator,
-PTO on the crankshaft with flexible coupling for driving the tandem hydrostatic pump,
-Engine cooling system (low and high temperature circuit),
-Locomotive cooling system (low and high temperature heat exchanger, ventilator, hydrostatic syistem, hydrostatic motor for driving the auxiliary alternator, hydrostatic fan for the cabine)
-Diesel engine monitoring unit

6. Refurbishment LDE 2100CP.

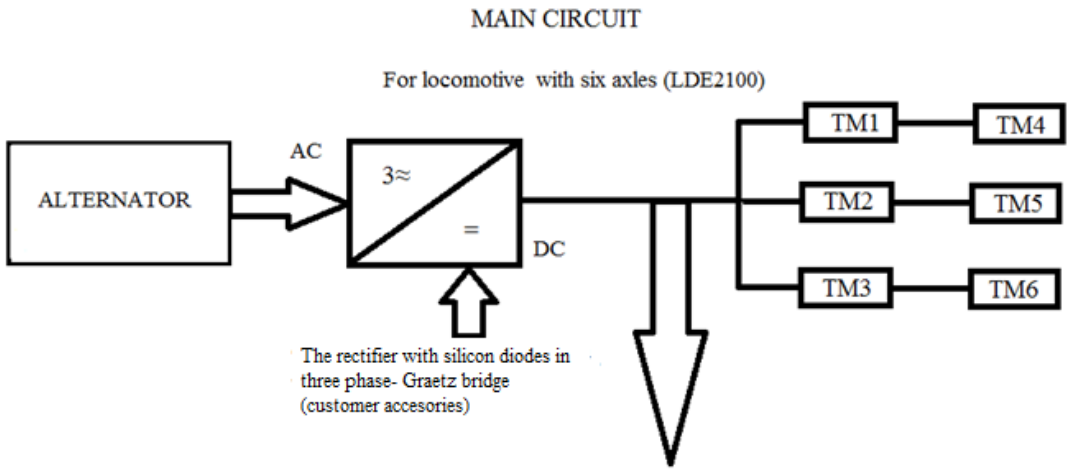
The refurbishment of the Diesel electric locomotive of 1250CP implements a series of modifications which are extremely important and beneficial:

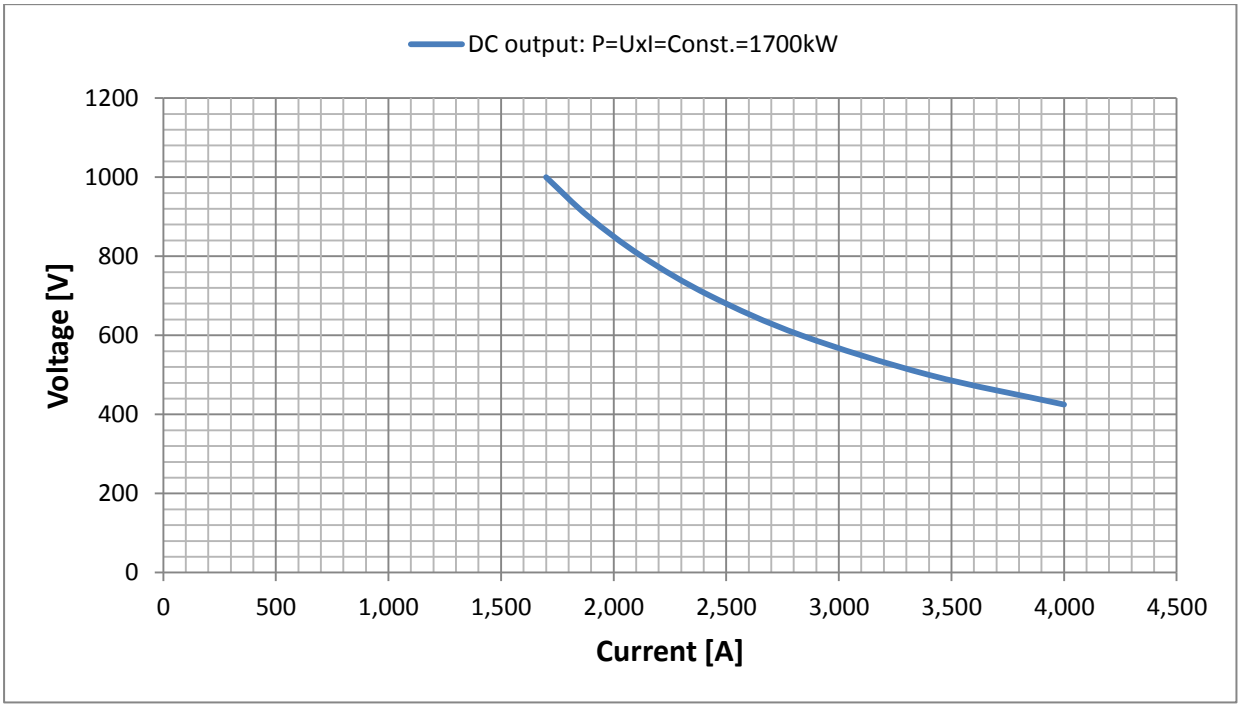
- Increasing the Diesel engine power, using from ABC Diesel engine family, type 8DZC-1000-176 with 8 cylinders in line with the following performances 1875kW (2545HP) at 1000rot/min. In the below picture the specific fuel consumption is presented in function of the load of the adopted engine, confirms the special fuel consumption



- The mentioned power can be taken by the six existing traction motors GDTM 533.
- Using the electric transmission alternativ current – direct current, instead of the old one, namely direct current – direct current. ABC delivers genset having the assembly of two three phase synchronous alternators, respectively the one pirmary and the auxliliary. The advantages of this tehnical solution are well known in comparison with the old transmission: increasing reliability, increasing overall efficiency, decreasing maintenance costs etc.

In the below picture the schemtic layout of the electric transmission is presented





At the client's request an alternative current-alternativ current transmission is also available, although the costs for the refurbishment/moderisation is about 60% higher than for the refurbishment/modernisation with the alternative current – direct current solution.

- Electronic driven auxiliary services with short circuited asynchronous motors. This will increase the reliability, decrease the costs for maintenance, improving the

energetic balance.

Taking into account the important modifications which should take place during the refurbishment of the locomotive, in order to position the engine and the cooling turret delivered by ABC, the reconfiguration of the ‚equipment room' is imposed.

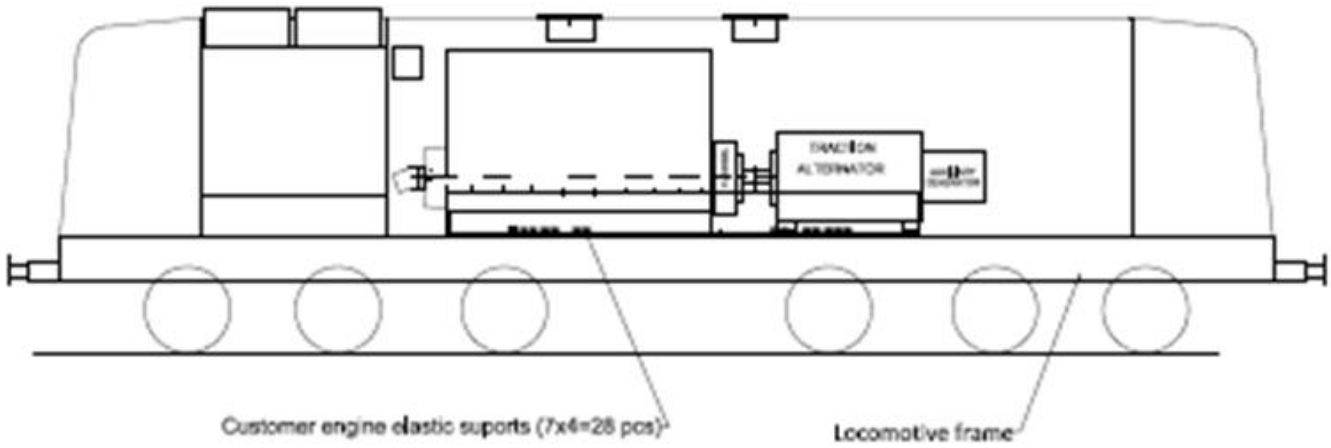
For the beformentioned we can add: monitoring equipment, protection and diagnosis, on board computer, modern driving desk, ergonomic chairs, etc.

Along the above mentioned, we can add that a series of eqipment are common with the Diesel electric locomotive of 1250HP (fans, rectifiers, convertors etc.) the other equipments will be the same with the ones on all three Diesel locomotives (compressor, cabine, etc.).

The preliminary calculus, shows that the approximative parameters for towing of the Diesel electric locomotive of 2100 HP for refurbishment/modernisation are:

- Acceleration traction force..... .....cca. 330kN;
- Lasting traction force.....cca. 220kN;
- Lasting speed.....cca. 25km/h.

In the below picture the schematic layout of the locomotive with ABC traction equipment is presented.



ABC delivery kit consist of:

-ABC engine, type 8DZC-1000-176, power 1875KW(2550HP)/1000RPM, emission level IIIA, electronic starting (24V),
-Traction alternator HITZINGER, two bearings, excitation control system
-100KVA auxiliary alternator in the same shaft with the traction alternator
-rigid frame mounting of the engine and alternator, flexible support of the frame in the locomotive platform on elastic supports according to the initial solution,
-Flexible coupling for driving the alternator,
-PTO on the crankshaft with flexible coupling for driving the tandem hydrostatic pump,
-Engine cooling system (low and high temperature circuit),
-Locomotive cooling system; complete cooling module with radiator for low and high temperature heat, hydrostatic system, 2 hydrostatic fan for the engine cabine)
-Diesel engine monitoring unit