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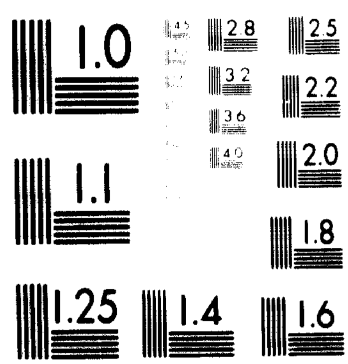

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FINAL REPORT

UNIDO Project No. IS/ROM/71/806

Contract No. 74/36

May 27, 1975

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1.) Survey of Travel Activities

In connection with the above project two visits to the Project Area were made with several experts of AVL participating.

First visit from January 15 to January 28, 1975

Participants Dipl.Ing. H. Oberth, Chief Engineer Design
Dr.-Ing. M. Rankl, Chief Engineer Research & Development

Second visit from February 24 to March 10 with participants and schedules as follows:

Ing. W. Kunzfeld, Diesel Injection Systems
from February 24 to March 5, 1975

Dipl.Ing. H. Oberth
from February 24 to March 10, 1975

Dipl.Ing. P. Claaßen, Engine Laboratories and Instrumentation
from March 3 to March 7, 1975

Visits were made to the ICPET Institute Bukarest and to factories in Sinaia and Brasov. Observations and conclusions are summed up in the following paragraphs.

2.) Summary

Diesel engines with an output ranging from 500 to 40.000 HP are manufactured under licences obtained from several companies in Europe and the USA. Enclosures 1 to 10 contain a complete listing and technical data of the engines. In paragraph 3A details of these engines are described.

Large 2-stroke and 4-stroke marine and stationary engines (Encl. 1 to 8) are made in the U.C.M. factory in Resita under licence from M.A.N. (Fe. Rep. of Germany). This represents a complete family of two-stroke Diesels supplemented by the two larger engines of the M.A.N. 4-stroke program. These engines and spare parts are identical with the products of the parent company and of many other licences of M.A.N. all over the world. This is considered as an advantage regarding development towards reliability, operating performance and servicing.

Locomotive engines are manufactured in another U.C.M. factory in Resita under licence from ALCO, USA. Data are given in Encl. 9. This represents an older design which is continuously developed to keep up with increased demands on rated output.

Another 4-stroke engine, Type LDA with 280 mm bore and 360 mm stroke, has been produced by still another factory of U.C.M. in Resita under licence from SULZER, Switzerland. Production of this model line was discontinued to be replaced by the ALCO engine mentioned above, but fabrication of spare parts for SULZER engines continues at this plant.

Engines licenced from MAYBACH (Fed. Rep. of Germany) are manufactured in the factory "23rd August" in Bucarest. These are prechamber engines being in production for many years. The power ratings and the speed range of these engines are not satisfying todays requirements of the Romanian users of Diesel engines. Obviously these engines should be replaced by a new engine concept. Such a newly designed engine might become the first indigenous Romanian engine in this power range. A principal action program is suggested for the design and development of such a new engine concept. This program includes participation of personnel and facilities of the Institute ICPET. The proposed schedule (Encl. 11) also includes the additional training of ICPET personnel in the engineering of internationally competitive Diesel engine.

The suggested engineering program is based on the cooperation between ICPET and AVL Austria which would take over the responsibility for the design concepts, the main structural features as well as the initial analysis, research and development.

Engineering activities and installation of facilities should start simultaneously at ICPET in order to enable this organisation to gradually take over more development work and prototype testing.

The investments needed to prepare ICPET for efficient experimental work on high output Diesel engines are described in section I.

3.) Statement of Work performed in Accordance with the UNIDO Contract

A) Survey of Diesel powerplants operated in the Project Area, consisting of imported powerplants, of engines manufactured under licence and of indigenous developments.

A survey was compiled in the Project Area listing and describing Diesel engines which are either imported, or manufactured under foreign licence or manufactured as indigenous products. Encl. 1 to 10 describe the engine programme in the range of more than 500 HP output being manufactured in Romania. This survey also contains engines which are in the programme but not yet in production.

The engines manufactured under various licences apparently satisfy the quality requirements which were established by the licensor. Many power plant components and auxiliary equipment are also manufactured under licence in Romania, i.e.:

Turbochargers	-	BBC and CAV
Injection Equipment	-	R. Bosch
Vibration Dampers	-	Holset
Piston Rings	-	Goetze
Hydraulic Transmission	-	Voith

The engines with the power range under consideration in this Project Area are used for railroad and marine propulsion, for transportable generator sets and in oil drilling operations. To a lesser extent they are used for stationary power generation.

B) Evaluation of the Economy and of the Quality of Engines operated in Romania.

The engine types whose data are listed in Encl. 1 to 8 and which are to be manufactured in the U.C.M. plant in Resita, consist of the complete 2-stroke program of stationary and marine engines of M.A.N. The program is supplemented by two of the larger models of the M.A.N. 4-stroke medium speed models.

The licence contracts were concluded a short time ago so that at present preparatory work for production is still in progress. To this purpose three new shop buildings are under construction. High performance and numerically controlled machine tools are installed in one of these new shops. The other two buildings will contain the engine assembly and the test stands. The plant should be operative by the end of 1975.

Production of parts and components has been started in those workshops which do already exist.

Production of the medium speed 4-stroke engines Type V 40/54 with an output from 3000 to 8000 HP as well as of the low speed 2-stroke engine, Type KSZ 90/160 with an output ranging from 19.000 to 23.000 HP is planned to be started in 1976.

The marine engine program of M.A.N. is licenced all over the world. This is of a particular advantage with seagoing vessels because identically designed spare parts are stocked and available throughout the world. This form of organisation ensures that the engines are beeing kept up-to-date by the parent factory.

The turbocharger for these engines as well as forgings are manufactured in the factory I.M.G.B. in Bucarest.

In the Encl. 9 the engines built according to the licence of the firm ALCO, Auburn/N.Y., USA. are listed. For this engine family a new factory was built in Resita within the enterprise U.C.M. Production has been started shortly so that no durability experience is yet available. These engines are locomotive engines, the concept of which is several years old. ALCO, however, attempts to develop the engines continuously to the latest technical standard. For this purpose, the 8-cylinder V-engine was thoroughly investigated on the AVL test stands from the beginning of 1972 to the end of 1974.

The SULZER engine Type LDA (280 mm bore and 360 mm stroke) has been manufactured under licence since 1958 in Resita. This engine series has run out of production and was replaced by the above mentioned ALCO engine. The factory produces at present spare parts of the SULZER engines.

In Encl. 10 a further engine series according to the licence of MAYBACH, Friedrichshafen (Fe. Rep. of Germany) is shown. The engines are produced in the factory "23rd August" in Bucarest. These are pre-chamber engines which were developed in the 1950's. The engines MB 936 Db and MB 820 Db are still included in the sales program of the firm M.T.U. (successors of MAYBACH) under the designation of 493 TY 60 resp. 493 TY 70.

As increased performance is required for the field of applications of this engine family in Romania, a direct injection system was developed for this engine by the Institute ICPET, which is used in the engines of the Types 500 6 SA to 5012 SR (Encl. 10). As the pre-chamber engine had been designed for low cylinder pressures, the compression ratio had to be reduced from 1 : 16,5 to 1 : 13,5 when changing to direct injection. Only in this way, the peak pressure could be limited. Such a low compression ratio for engines of 175 mm bore, however, causes blue and white smoke problems.

This engine series does therefore not satisfy any longer the requirements of the future.

It is therefore planned to replace this series of engines by new ones. These should have an output of up to 2000 HP and be operable also at an increased speed of 1800 rpm. These would be the first indigenous constructions and developments of engines of this size which would be independent from foreign trade restrictions.

C) Analysis of the Thermodynamic Data, especially of Turbo-charged Cycles and of Inter-Cooling Methods, emlpoyed in Engines operated and recently produced in Romania.

As described under 3.) A) and 3.) B) all the engines produced in Romania are manufactured under licence. The licensors are well-known Western engine manufacturers. In the technical literature there are detailed publications about most of these engine types. A thermodynamic analysis and an analysis of the turbocharging and intercooling process would have to be based on these publications. For such an analysis comprehensive measurement results are required which could not be obtained in Romania from the licenced engines. Under these circumstances we do not think that these analyses would be useful as they would not cover the Romanian but only the original Western products.

D) Survey of the Research and Development Potential in the Project Area, Including Equipment and Methods suitable for Comparative Analysis of Indigenous and Foreign Designs and Products.

There exist three national Institutes in Romania, dealing with research and development in the field of mechanical engineering. These are:

1.) ICPAT in Brasov:

This Institute mainly deals with chassis for tractors and trucks as well as with the engines belonging to them. Their main activity consists in adjusting the engines for the various applications.

2.) ICPET in Bucarest:

All new engines (vehicle- and medium-sized engines up to approximately 2000 HP) are to be developed in this Institute. ICPET also has departments for the development of turbochargers and different laboratories for engine engineering and research.

3.) "Research- and Development-Institute for Energetical and Hydrotechnical Installations" in Resita:

This Institute deals with large marine-engines, marine-power sources and water turbines.

Since the subject UNIDO-Contract asked to concentrate mainly on medium-sized engines, we centered our discussions on the ICPET-Institute in agreement with the Romanian government agencies.

Besides some relatively well-equipped dynamometer test-stands and a bigger single cylinder test engine the ICPET Institute has different laboratories:

a) Laboratory for injection
b) Laboratory for gasdynamical proceedings
c) Laboratory for the formation of mixture and fuel
d) Laboratory for heat-exchange problems
e) Laboratory for stress analysis and material examinations

From different meetings held with several experts, we observed a high standard of theoretical knowledge. Quite sophisticated work on gasoline- and diesel-engines with performances up to approx. 400 BHP was carried out. Improvements leading to an impressive reduction of fuel consumption and toxic exhaust gas emissions were developed on existing gasoline engines.

Because of these successes the ICPET Institute is to be enlarged and transplanted into a new building complex. In this complex, generously sized buildings for engine dynamometer test stands, several laboratories and workshops are planned. The Romanian government intends to concentrate in the ICPET Institute all the research work in the domain of internal combustion engines up to 2000 HP.

The goal of this concentration is to develop engines of this power range independent from foreign licences. We think this attempt is reasonable. Since the Romanian engine production has reached an adequate standard with the possibility of offering competitive products in all foreign markets. Licence contracts, however, usually restrict such an effort of worldwide export business. Furthermore an indigenous development provides the possibility to consider existing production installations and tooling when planning a new engine.

E) Survey of the Technology of Fuel Injection, Fuel Atomisation and Combustion. Evaluation of the present Status in the Project Area and Recommendations for Research and Development.

As already mentioned in paragraph D), at the ICPET Institute there exist special laboratories for examination of these problems.

The injection laboratory is equipped with a Bosch test-stand, as well as with additional self-made test-stands. At these stands spray-formation and spray distribution can be filmed and analysed. Moreover pressure traces can be registered in order to define and study injection rates.

A mathematical model was developed which allows to evaluate the injection-equipment design with an analoge-computer. The model considers the diameter of the nozzle holes, the dimension of the plungers, the retraction volume, the line pressures as well as the elasticity and the dimensions of the injection lines. The staff shows a high theoretical knowledge and has developed new ideas for which several patents have been granted.

To fulfil the task imposed by the institute, the laboratory would have to be extended in order to be able to work on larger injection pumps with plunger-diameters up to 16 mm and more. The institute's enlargement for work on medium-sized engines requires the equipment for the examination of cooled nozzles and double-wall injection lines.

The examination of air flow through inlet and exhaust ports is carried out in the laboratory for gas dynamics. The swirl of the intake air is measured photoelectrically using a propeller. Furthermore, the velocity profile is measured inside the inlet and outlet ports and the flow-coefficient is optimized at a given swirl rate. Computer programs to find the best camshaft profile and valve timing are available.
A computer program for gas exchange processes of highly-boosted engines is beeing developed. This laboratory, however would have to be supplied with several new instruments permitting the measurement of larger air-volumina.

The laboratory's engineers should be given the opportunity to study other already existing computer programs in order to enable them to critically examine their own programs. There are several research departments which specialize on the investigation of gas dynamics. An exchange of views and experiences would be beneficial to both parties.
The combustion processes of medium-sized engines are examined on a single-cylinder test engine. This test-stand should definitely be modernized. We would recommend the purchase of a modern single-cylinder engine with thermostatical oil-temperature control, mass-balance and the possibility to test higher maximum cylinder-pressures. Modern single-cylinder test engines are designed to withstand combustion pressures up to 200 atm thus allowing to evaluate combustion prodesses with a BMEP of up to approx. 25 bar.

One other laboratory deals with fuel and air mixture control for carburettor-engines.

This laboratory obtained rather impressive results with regard to the reduction of the specific fuel consumption and the toxic emissions of exhaust gases. In this field various patents were applied for. As this group of engines does not fall within the UNIDO-task subject to this contract, we do not discuss this laboratory any further in this report.

Problems of heat exchange always exist with internal combustion engines. A special laboratory at ICPET deals with this problematic field. With highly-boosted engines the problems of piston- and cylinder-head-cooling are in fact of great importance.

Piston temperatures with a running test engine (175 mm Ø x 205 mm) were already measured with instrumentation developed by ICPET.

An expansion of this laboratory for future tasks would be absolutely required.

F) Study of the Available Potential for Design and Quality Control. Suggestions for Projects to be carried out in National Institutions for Engineering Education and Training.

In the field of construction of internal combustion engines there are some experiences with smaller vehicle-engines in the Institute ICPET. A lack of specific know-how exists, however, in the field of the construction and the development of locomotive and medium speed engines.

As mentioned under paragraph B), a new family of engines for the use in locomotives, stationary power units and in oil drilling equipment is planned to be constructed and developed. It is recommended that this project should be accomplished by ICPET in cooperation with a competent institute such as AVL. This way ICPET would be provided with both the required know-how and an excellent training opportunity for its staff of engineers.

AVL has prepared a schematic time schedule (Encl. 11), showing the different activities suggested in connection with such a project.

As it can be seen from this schematic presentation, it would be possible for a designer of ICPET to participate, right from the start, in the basic engine design study and to be trained this way.

The preliminary design concept of the engine would then be discussed with the engineers at the manufacturing works, in this case the factory "23rd August".

On this occasion, existing production equipment and tooling would be thoroughly examined, to see if they are useable, without changes, for the production of the new engine. Should this not be feasible, the drawings would be re-examined for possible design changes in order to adapt them to the existing manufacturing facilities.

The results of these investigations and discussions would be shown in a final design study. The preliminary work should be carried out in the engineering department of AVL, so as to permit our extensive experience to be incorporated in the design.
After completion of the overall design, the various subassemblies would have to be designed. This work could be accomplished within a short time at AVL in the presence of two designers of ICPET.
Detail drawings are made in accordance with final assembly layouts.
At this point, parts of the work could be turned over to the engineering department of ICPET.
All major parts, such as the crankcase, the cylinder-head, the piston and the connecting rod, should also be designed at AVL with ICPET-designers again participating in the work. All other detail drawings could be made at ICPET. The AVL staff would still be responsible for the checking of all the drawings.

This method of training on a practical example of a modern engine would permit the conveying of experiences and know-how.

The necessary strength calculations, needed for the design, could be carried out by means of programs which already exist at AVL. We would give the participating designers of ICPET an insight into these programs.

Various investigations could be performed in AVL's Stress Laboratory in which ICPET engineers would be able to participate. At the same time, parallel examinations could be carried out in the Material and Stress Laboratory of the Institute ICPET.
Special problems, concerning the supply of materials and/or the coordination of material specifications according to Romanian sources, could be carried out at ICPET.
Moreover, durability, wear and similar problems could be investigated. Various stress measurements on heavily loaded engine parts would have to be made on the running engine. Such investigations could also be done by the ICPET Institute.

G) Study of factors which improve performance, economy and reliability:

Regular examination and further development of manufactured engines is absolutely necessary so as to keep them to the latest state of engineering. The institute's expansion should eventually provide the possibility of carrying out such work for all Romanian engine manufacturers centrally in the Institute ICPET. Single engines, out of the series produced in Romania, should be tested regularly at certain intervals to ascertain their quality and performance.

This type of inspection is already being done from time to time. Enlargement of the institute's instrumentation would provide the facilities needed for the testing of locomotive engines, oil field drilling units and medium speed engines. The thermal and mechanical loading of the different parts should be examined. The specifications for the development of a turbocharger for Romania should be based on the requirements of the engine. The automation of durability tests, endurance test programs etc., developed by the International Railway Association ORE, would be of great advantage.

An additional task would consist in the investigation of cost reduction possibilities in the manufacture of engine parts by selecting suitable but lower cost materials or more efficient machining methods, etc.

For this purpose, some parts may have to be re-designed.
Other additional tasks would consist in the standardization of auxiliary units and the utilization of Romanian domestic products.

H) Advice on specific procedures for the testing of functional models:

In our proposed work plan (Encl. 11) we also suggest that certain dynamometer testing should be performed by competent institutes such as AVL so as to assure the best training of ICPET engineers.
For instance, the final development of inlet and exhaust ports of the cylinder head would be made on the actual engine on the test stand. On this occasion, AVL's development techniques could be demonstrated to the ICPET engineers participating in this work.

It is advantageous to perform the basic development of the combustion system, the injection equipment and the valve mechanism on a single cylinder test engine.
The piston profile and cooling could also be determined on the single cylinder test engine. Since the 6-cylinder prototype engine is planned to be turbocharged, the single cylinder engine would be tested with simulated pressure charging using a compressor. The pressures and the quantity of the inlet air would be regulated according to turbocharger-characteristics.

The shorter assembly time and the smaller number of test parts required for a single cylinder engine, considerably reduce test cost and time requirements when development is performed on such an engine.

To permit the construction of a single cylinder engine, the design of the cylinder head, the piston, the cylinder-liner and the valve mechanism with camshaft would have to be done ahead of the other design work described in paragraph F).
Foundry patterns and castingscould be produced from these detail drawings and machined at AVL. Two AVL basic units would have to be assembled from these parts. These basic units are single-cylinder crank-casesdesigned specifically for development work and are kept on hand for

quick availability. Utilizing basic units, which have been produced in advance, substantially reduces the time required for the procurement of single cylinder test engines. It is proposed to use two test engines rather than just one so that simultaneous work could be carried out at AVL in Graz and at ICPET in Bucarest. An engineer from ICPET would be welcome to participate in the work at AVL so that AVL's experience could be transmitted directly to ICPET.

Furthermore, ICPET's engineers could study and experience the test techniques and instrumentation utilized during modern single cylinder engine development. Some time afterwards the second engine should be put in operation at ICPET, so that the results from the first engine could be applied by ICPET and own ideas put to test.
All results of the single cylinder engine tests would continuously be transmitted to the design departement. There, the drawings for the 6-cylinder prototype engine would be corrected in accordance with these results.

The manufacture of cores and core boxes for the prototype engine as well as the production and machining of all engine parts could be carried out in Romania.

The completed multi-cylinder engine could be tested at ICPET in Bucarest. The test results could be discussed at the test facility from time to time by engineers of AVL and directives could be worked out for the continuation of the tests. It is suggested that two multi-cylinder engines are made. One of these would have to be used for turbocharger matching, the second for endurance tests to ascertain wear resistance and reliability. As shown in the schedule, an engine requires a development period of approximately 4 years from the initial design study to the series production.
Obviously this development period could be adhered only if the various phases would be started according to schedule.
To this purpose, single cylinder engine development is suggested to be already in progress while multi-cylinder detail drawings would be completed and while prototype engine parts would be made.

The approach described above would result in a considerable time saving since all experiences obtained from the single cylinder development could immediately be incorporated in the very first multi-cylinder prototypes.

The suggested time schedule is based on two fully equipped test stands being available at the ICPET Institute.

I) Preparation of neutral specifications for the equipment which is expected to be required for testing:

After the various discussions with members if ICPET and the inspection of the installations, the following recommendations are made for the different laboratories:

1.) Engine test stands:

As mentioned in paragraph E), various more or less fully equipped engine test-stands exist already. The Institute will be provided with a new building complex, including a structure for new engine test-stands with approx. 600 m^2 floor space. At present, however, no test facilities exist for engines in the 500 to 2000 HP range. Several discussions have shown that it is advisable to establish such a test stand as a "Model Test Stand" which could serve not only as model for other ICPET test-stands, but would provide the entire engine industry with a sample for improving their production test installations.
The first phase consists of dynamometer work on engines of up to 500 HP. The test stand should be equipped so as to permit computer-controlled operation after subsequent enlargement. During an additional development phase, the instruments should be completed so far as to enable the development of a supercharged engine with a performance of 2000 HP.

The test stand itself should consist of:
One test stand desk fully equipped with control-, regulating-, measuring- and indicating instruments. The data which ought to be measured are mentioned in Encl. 12 to 15.

An automatic regulating and controlling installation according to Encl. 16 and 17 for

a) automatic fuel temperature adjustment
b) heat exchanger for the engine's cooling water
c) installations for the pre-heating of the cooling water
d) installations for engine lubrication prior to starting

1 performance dynamometer according to Encl. 18
1 exhaust gas measurement device according to Encl. 19

Prior to the installation of the test-stands, the advice from AVL or from other qualified specialists should be sought on the following items:

Construction of the foundation;
Dimensioning of the engine's air supply and exhaust gas removal;
Ventilation and heating of the test stand room;
Noise damping;
Water supply;
Fuel supply for different kind of fuels;

2.) Injection laboratory:

This laboratory now has the following equipment:

3 older types of injection test stands system Bosch
1 indicator for rate of injection
1 nozzle spray testing device

The system of measuring the rate of injection, now used by ICPET, provides, in our opinion, only approximate values. The test stands system Bosch are out of date.
Therefore, the following instrumentation is recommended:

One modern pump test stand, with 20 HP drive, to allow large block pumps, for the planned engine performance of 2000 HP, to be examined.

One measuring device for the determination of the flow coefficient of the injection nozzle, sizes "S" and "T". This instrument is to be capable of measuring the flow coefficient at pressure differentials up to 100 atm.

One nozzle drilling machine for making experimental nozzles.

One nozzle test stand for the examination of opening pressures and spray characteristics. The instrumentation must be provided with an exhaust device for the elimination of the fuel haze.

One special microscope for inspecting the needle seat in the nozzle body and the sack.

The existing line pressure measuring devices employ transducers which have large trapped volumes, making them incapable of providing exact data.

The following electronic instrumentation is recommended:

An Injection Analyzing System, capable of accurately measuring and displaying:

Injection line pressures, simultaneously on 8 channels.

In addition:
Pump housing pressure;
Relief valve lift;
Internal nozzle holder pressure;
Injection needle lift;
Pump camshaft angular position.

3.) <u>Stress Laboratory</u>:

Static and dynamic stresses in engine parts can be measured by the following instrumentation:

a) Strain gauge instruments:
Strain gauges measure the strain on actual and model parts under static and dynamic load and at temperatures up to 500 °F (260 °C). Strain gauge measurements are very exact if the location and the direction of the maximum principal stresses are known.

a1) Manual (automatic) Switching and Balancing Unit
for about 50 strain measuring points. By applying this instrument the strain at up to 50 different locations on a part can be measured consecutively with a single amplifier.

a2) Two Amplifiers with a carrier frequency of 5000 Hz for strain gauge measurements with indicator.

a3) Dual Beam Storage Oscilloscope with single trace and dual trace amplifier and dual time base. This instrument is necessary for the observation and documentaion of strain gauge measurements on parts under dynamic load (firing engine).

a4) UV-Recorder. This instrument is used for the documentation of strain gauge measurements on parts under dynamic load, if the strain on a great number of points is to be measured.

b) Stress Coat Instruments

For applying the stress coat, only one calibrator is needed as the material is supplied in spray cans. With this method it is possible to find the location of maximum stresses and their direction. By applying Stress Coat approximate values of stress magnitudes can be predicted. This information is used to determine the proper installation of strain gauges.

c) Photo Elastic Instrumentation

c1) Photo Elastic Coating Method:
Reflection Polariscope with manual or digital compensator, Strobe Light and Camera.
The photo elastic coating technique is a stress analysis method which does not require a model. Strain distribution on actual parts and structures of any size and shape, under

actual operating conditions (static and dynamic), is obtained with this method. The actual maximum strain is measured with fair accuracy. This method is also used to find the location and the direction of suitable strain gauge application points.

c2) Two and Three Dimensional Photo Elastic Method:
This method measures stress and strain existing at any point in a flat two-dimensional or a sliced three-dimensional photo-elastic model of actual engine parts.
Fir instance: This method is used to establish the stress magnitude on connecting rod surfaces and at bolt holes. It is the only method permitting stress measurement in and near threaded holes, small fillets, etc.

Equipment:

c2.1 Transmission Polariscope with a filter diameter of about 500 mm and with white and monochromatic light source.
This equipment is necessary for obtaining the fringe pattern of a loaded 2-dimensional model or of slices of a three-dimensional photo-elastic model in which the stress is frozen.

c2.2 Microscope with a polariscope equipment. This microscope is needed for obtaining the maximum fringe order in small fillets or in threaded fasteners.

c2.3 Photo-elastic Oven with temperature regulation, with a temperature range from 0° to 200°C for casting, annealing and stress-freezing photo-elastic models.

c2.4 Oven with temperature regulation from 0° to 100°C. This oven is used for preserving the models and the slices of 3-dimensional models without time edge effect.

c2.5 Camera for documentation of the fringe pattern in black and white and in colour. This camera must have a lens with a great focal distance.

d) Hardeness test machine

This instrument is used for the rapid testing of the strength of materials.

e) Hydropulser with a mean load range from 0 to 40 000 kp and a dynamic load range of ± 30 000 kp.
This machine is necessary for carrying out stress analyses on engine parts under static and dynamic conditions.

J) Recommandations for Continued Technical Assistance in Development Projects of Diesel Engines as Required in Romania:

The work, started with the suggested project, should be continued towards the completion of the instrumentation of the different ICPET Institute Laboratories, with help of subsequent SIS projects. During these projects, informative trips for training purposes in the area of measuring techniques should be considered. Such training should be organized by the instrument manufacturers.
AVL in Graz could conduct an adequate training program, covering their line of instruments and related devices.

The schedule in Encl. 11 shows that it is proposed to conduct the training in design methods and in the use of instruments concurrently.

Full participation in the complete design process as well as in the development of a new engine series would be the best way for conveying experience, know-how, empirical design data, etc., from AVL to the client's personnel. In this way, idle time would not occur, as shown by the Schedule.

Alternatively, the complete project could also be devided into several SIS projects.

The schedule shown in Encl. 11 was set up not only on the basis of observations made during visits to ICPET, but also to fully utilize

AVL's extensive experience with projects of a similar nature. Obviously, the schedule could be modified in some respects, for instance if it should become desireable for ICPET to take on additional phases of the complete program.

K) Outline of Program for Acquisition of Advances Know-how:

Our visits to various manufacturing facilities have convinced us that the Romanian Industry has reached a very high technical level. Therefore, it possesses the basic ability and knowledge to develop and manufacture an engine with over 500 HP of its own design.

The advantages inherent in the manufacture of indigenous designs are well known. To mention only a few:

Un-restricted export to all parts of the world;
Elimination of licence fees;
Product adaptability to market requirements;
Full utilization of existing production facilities;
Up-to-date design and possibility of up-grading such designs to keep in step with technological developments;
Application and utilization of locally produced accessories, parts, ancillary equipment, etc.

Conducting one's own development, however, would imply accepting the responsibility for the quality and soundness of the design and the product. Frequently, licences are obtained for the purpose of avoiding such responsibility. Also, sometimes a manufacturer may lack confidence in his own engineering ability and/or may argue that a product, made under licence from a well-known licensor, is easier to sell.

It is our conclusion, that, in order to free the Romanian Industry from being tied to foreign licensors, it would be primarily required that the ICPET Central Development Laboratory have modern equipment, that its engineers acquire up-to-date technological knowledge and experience and that such knowledge be continuously up-dated on all progress made elsewhere in the respective fields.

So as to make Romanian products better known in the world market and, thus, to make them more competitive, prospective buyers have to be made aware of the abilities of Romanian engineers and the technical knowledge possessed by them. To this end, these engineers should be given the opportunity to participate in international congresses and donferences of engineers, such as CIMAC, FISITA and SAE. The engineers should be encouraged to present reports on their own developments and findings at such engineering conventions.

This would not only give them confidence in their own ability but would also enhance their image in the market place.

Expansion of the Institute, in a well-guided and properly planned manner, may well be the starting point for the development if a truly native Romanian Diesel Engine Industrie, eliminating dependence on foreign licensors.

Dipl.Ing. J. Greier
Executive Vice President

Dr. M. Rankl
Manager, Engine Develop. Dept.
Team Leader

Ship Engines Family V/40/54
produced by UCM RESITA, ROMANIA

Engine Types		R6V40/54	R740/54	R8V40/54	R9V40/54
Bore	mm	400	400	400	500
Stroke	mm	540	540	540	540
Output	HP	2440-3350	2850-3900	3255-4450	3660-5000
Speed	rpm	300-430	300-430	300-430	300-430
Number of Cylinders		6L	7L	8L	9L
Displacement	dm^3	407	476	543	611
Mean eff. Pressure	kgf/cm^2	16,8/18	16,8/18	16,8/18	16,8/18
Output per 1 l displacement	HP/l	5,98-8,20	5,98-8,20	5,98-8,20	5,98-8,20
Fuel Consumption	g/HPh	153+5%	153+5%	153+5%	153+5%
Stroke		4-str.	4-str.	4-str.	4-str.
Cycle		dir.inj.	dir.inj.	dir.inj.	dir.inj.
Boost pressure	at	1,57-1,84	1,57-1,84	1,57-1,84	1,57-1,84
Cooling		water	water	water	water
Weight	kgf	53800	60900	68200	74700
Specific weight	kgf/HPh	22,0-16,0	21,4-15,6	21,0-15,3	20,4-14,9

Engine Types		V5V40/54	V6V40/54	V7V40/54	V8V40/54	V9V40/5
Bore	mm	400	400	400	400	400
Stroke	mm	540	540	540	540	540
Output	HP	4070-5600	4880-6700	5700-7800	6570-8900	7380-1000
Speed	rpm	300-430	300-430	300-430	300-430	300-430
Number of Cylinders		10V	12V	14V	16V	18V
Displacement	dm^3	679	814	952	1086	1222
Mean eff.Pressure	kgf/cm^2	16,8/18	16,8/18	16,8/18	16,8/18	16,8/18
Output per 1 l displacement	HP/l	5,98-8,20	5,98-8,20	5,98-8,20	5,98-8,20	5,98-8,2
Fuel Consumption	g/HPh	153+5%	153+5%	153+5%	153+5%	153+5%
Stroke		4-str.	4-str.	4-str.	4-str.	4-str.
Cycle		dir.inj.	dir.inj.	dir.inj.	dir.inj.	dir.inj
Boost pressure	at	1,57-1,84	1,57-1,84	1,57-1,84	1,57-1,84	1,57-1,84
Cooling		water	water	water	water	water
Weight	kgf	70900	83200	95200	107700	119100
Specific weight	kgf/HPh	17,4-12,7	17,0-12,4	16,7-12,2	16,4-12,1	16,1-17,9

Enclosure

Ship Engines Family V 52/55
produced by UCM RESITA, ROMANIA

Engine Types		R6V52/55	R7V52/55	R8V52/55	R9V55/55
Bore	mm	520	520	520	520
Stroke	mm	550	550	550	550
Output	HP	5060-6000	5905-7000	6750-7200	7600-9000
Speed	rpm	375-430	375-430	375-430	375-430
Number of Cylinders		6L	7L	8L	9L
Displacement	dm^3	701	819	935	1052
Mean eff. Pressure	kgf/cm^2	16,2-17,92	16,2-17,92	16,2-17,92	16,2-17,92
Output per 1 l displacement	HP/l	7,22-8,57	7,22-8,57	7,22-8,57	7,22-8,57
Fuel consumption	g/HPh	152+5%	152+5%	152+5%	152+5%
Stroke		4-str.	4-str.	4-str.	4-str.
Weight	kg	78000	88000	97000	106000
Specific weight	kg/HPh	15,4-13,0	14,9-12,6	14,4-12,1	13,9-11,8

Engine Types		V5V52/55	V6V52/55	V7V52/55	V8V52/55	V9V52/5
Bore	mm	520	520	520	520	520
Stroke	mm	550	550	550	550	550
Output	HP	8440-10000	10120-12000	11810-14000	13500-16000	15200-1800
Speed	rpm	375-430	375-430	375-430	375-430	375-430
Number of Cylinders		10V	12V	14V	16V	18V
Displacement	dm^3	1168	1402	1638	1870	2104
Mean eff.Pressure	kg/cm^2	16,2-17,92	16,2-17,92	16,2-17,92	16,2-17,92	16,2-17,92
Output per 1 l displacement	HP/l	7,22-8,57	7,22-8,57	7,22-8,57	7,22-8,57	7,22-8,57
Fuel consumption	g/HPh	152+5%	152+5%	152+5%	152+5%	152+5%
Stroke		4-str.	4-str.	4-str.	4-str.	4-str.
Weight	kg	106000	121000	138000	153000	162000
Specific weight	kg/HPh	12,5-10,6	12,0-10,1	11,7-9,8	11,3-9,6	10,6-9,0

Enclosure 3

Ship Engines Family KZ 57/80 F

produced by UCM RESITA, ROMANIA

Engine Types		K5Z57 F80	K6Z57 F80	K7Z57 F80	K8Z57 F80
Bore	mm	570	570	570	570
Stroke	mm	800	800	800	800
Output	HP	3750-4500	4500-5400	5250-6300	6000-7200
Speed	rpm	187-225	187-225	187-225	187-225
Displacement	dm^3	1020,5	1224,6	1428,7	1632,8
Number of cylinders		5L	6L	7L	8L
Mean eff. pressure	kg/cm^2	8,8	8,8	8,8	8,8
Output per 1 l displacement	HP/l	3,67-4,40	3,67-4,40	3,67-4,40	3,67-4,40
Stroke		2-str.	2-str.	2-str.	2-str.
Cycle		dir.inj.	dir.inj.	dir.inj.	dir.inj.
Compression ratio		10,8	10,8	10,8	10,8
Weight	kg	124000	144000	171000	192000
Specific weight	kg/HP	31,0	26,7	27,2	26,7

Engine Types		K9Z57 F80	K10Z57 F80	K12Z57 F80
Bore	mm	570	570	570
Stroke	mm	800	800	800
Output	HP	6750-8100	7500-9000	9000-10800
Speed	rpm	187-225	187-225	187-225
Displacement	dm^3	1836,9	2041	2450
Number of cylinders		9L	10L	12L
Mean eff. pressure	kg/cm^2	8,8	8,8	8,8
Output per 1 l displacement	HP/l	3,67-4,40	3,67-4,40	3,67-4,40
Stroke		2-str.	2-str.	2-str.
Cycle		dir.inj.	dir.inj.	dir.inj.
Compression ratio		10,8	10,8	10,8
Weight	kg	211000	230000	269000
Specific weight	kg/HP	26,1	25,6	24,9

Ship Engines Family KZ 60/105E
produced by UCM RESITA, ROMANIA

Engine Types		K5Z60/E 105	K6Z60/E 105	K7Z60/E 105	K8Z60/E 105	K9Z60/E 105
Bore	mm	600	600	600	600	600
Stroke	mm	1050	1050	1050	1050	1050
Output	HP	3935-5000	4720-6000	5510-7000	6295-8000	7085-9000
Speed	rpm	130-167	130-167	130-167	130-167	130-167
Number of Cylinders		5L	6L	7L	8L	9L
Displacement	dm^3	1484	1780,8	2077,6	2374,4	2671,2
Mean eff. pressure	kg/cm^2	8,56/9,18	8,56/9,18	8,56/9,18	8,56/9,18	8,56/9,18
Output per 1 l displacement	HP/l	2,65-3,37	2,65-3,37	2,65-3,37	2,65-3,37	2,65-3,37
Stroke		2-str.	2-str.	2-str.	2-str.	2-str.
compression ratio		10,8	10,8	10,8	10,8	10,8
Weight	kg	171000	202000	231800	258500	281300
Specific weight	kg/HPh	34,2	33,7	33,1	32,3	31,3

Ship Engines Family KZ 70/120E produced by UCM RESITA, ROMANIA

Engine Types		K5Z70/E 120	K6Z70/E 120	K7Z70/E 120	K8Z70/E 120	K9Z70/E 120	K10Z70/E 120
Bore	mm	700	700	700	700	700	700
Stroke	mm	1200	1200	1200	1200	1200	1200
Output	HP	6500-7000	7800-8400	9100-9800	10400-11200	11700-12600	13000-1400[illegible]
Speed	rpm	130-150	130-150	130-150	130-150	130-150	130-150
Number of cylinders		5L	6L	7L	8L	9L	10L
Displacement	dm^3	2310	2772	3234	3696	4158	4620
Mean eff. pressure .	kg/cm^2	9,1-9,75	9,1-9,75	9,1-9,75	9,1-9,75	9,1-9,75	9,1-9,75
Output per 1 l displacement	HP/l	2,82-3,03	2,82-3,03	2,82-3,03	2,82-3,03	2,82-3,03	2,82-3,03
Stroke		2-str.	2-str.	2-str.	2-str.	2-str.	2-str.
Cycle		dir.inj.	dir.inj.	dir.inj.	dir.inj.	dir.inj.	dir.inj.
Compression ratio		10,8	10,8	10,8	10,8	10,8	10,8
Weight	kg	350000	275000	312000	350000	395000	423000
Specific weight	kg/HP	33,6	32,7	31,9	31,3	30,6	30,2

Ship Engines Family KZ 78/155 F
produced by UCM RESITA, ROMANIA

Engine Types		K5Z78/F 155	K6Z78/F 155	K7Z78/F 155	K8Z78/F 155	K9Z78/F 155	K10Z78/F 155
Bore	mm	780	780	780	780	780	780
Stroke	mm	1550	1550	1550	1550	1550	1550
Output	HP	8170-9500	9810-11400	11440-13300	13080-15200	14710-17100	16350-19300
Speed	rpm	105-122	105-122	105-122	105-122	105-122	105-122
Number of cylinders		5L	6L	7L	8L	9L	10L
Displacement	dm^3	3703	4443,6	3184,2	5924,8	6665,4	7405
Mean eff. pressure	kg/cm^2	9,45	9,45	9,45	9,45	9,45	9,45
Output per 1 l displacement	HP/l	2,21-2,56	2,21-2,56	2,21-2,56	2,21-2,56	2,21-2,56	2,21-2,56
Stroke		2-str.	2-str.	2-str.	2-str.	2-str.	2-str.
Cycle		dir.inj.	dir.inj.	dir.inj.	dir.inj.	dir.inj.	dir.inj.
Compression ratio		10,95	10,95	10,95	10,95	10,95	10,95
Weight	kg	323000	383000	4[illegible]3000	495000	543000	603000
Specific weight	kg/HP	34,0	33,6	33,3	32,6	31,7	31,4

Ship Engines Family KSZ 90/160 produced by UCM RESITA, ROMANIA

Engine Types		K6SZ90/ 160	K7SZ90/ 160	K8SZ90/ 160	K9SZ90/ 160	K10SZ90/ 160
Bore	mm	900	900	900	900	900
Stroke	mm	1600	1600	1600	1600	1600
Output	HP	14940-17400	17430-20300	19920-23200	22410-26100	24900-29000
Speed	rpm	105-122	105-122	105-122	105-122	105-122
Number of Cylinders		6L	7L	8L	9L	10L
Displacement	dm^3	6108	7126	8144	9152	10180
Mean eff. pressure	kg/cm^2	10,5	10,5	10,5	10,5	10,5
Output per 1 l displacement	HP/l	2,44-2,85	2,44-2,85	2,44-2,85	2,44-2,85	2,44-2,85
Fuel consumption	g/HPh	152+5%	152+5%	152+5%	152+5%	152+5%
Stroke		2-str.	2-str.	2-str.	2-str.	2-str.
Compression ratio		10,48	10,48	10,48	10,43	10,48
Weight	kg	610000	685000	770000	840000	920000
Specific weight	kg/HPh	35,1	33,7	33,2	32,2	31,7

Ship Engines Family KSZ 105/180

produced by UCM RESITA, ROMANIA

Engine Types		K6SZ105/180	K7SZ105/180	K8SZ105/180	K9SZ105/180	K10SZ105/180	K12SZ105/180
Bore	mm	1050	1050	1050	1050	1050	1050
Stroke	mm	1800	1800	1800	1800	1800	1800
Output	HP	20400-24000	23800-28000	27200-32000	30600-36000	34000-40000	40800-480[illegible]
Speed	rpm	90-106	90-106	90-106	90-106	90-106	90-106
Number of cylinders		6L	7L	8L	9L	10L	12L
Displace-ment	dm^3	9348	10906	12464	14020	15580	18700
Mean eff. pressure	kg/cm^2	10,9	10,9	10,9	10,9	10,9	10,9
Output per 1 l displace-ment	HP/l	2,18-2,57	2,18-2,57	2,18-2,57	2,18-2,57	2,18-2,57	2,18-2,5[illegible]
Fuel consump.	g/HPh	150+5%	150+5%	150+5%	150+5%	150+5%	150+5%
Stroke		2-str.	2-str.	2-str.	2-str.	2-str.	2-str.
Cycle		dir.inj.	dir.inj.	dir.inj.	dir.inj.	dir.inj.	dir.inj.
Compression ratio		10,46	10,46	10,46	10,46	10,46	10,46
Weight	kg	895000	1015000	1140000	1255000	1368000	1615000
Specific weight	kg/HP	37,3	36,3	35,6	34,9	34,2	33,6

Enclosure 9

Locomotive Engines Family 228,6/266,7 - ALCO
produced by UCM RESITA, ROMANIA

Engine Types		ALCO 251L6	ALCO 251V8	ALCO 251V12	ALCO 251V16	ALCO 251V18
Bore	mm	228,6	228,6	228,6	228,6	228,6
Stroke	mm	266,7	266,7	266,7	266,7	266,7
Output	HP	2080	1725	4056	5070	6074
Speed	rpm	1100-1200	1100-1200	1100-1200	1100-1200	1100-1200
Number of Cylinders		6L	8V	12V	16V	18V
Displacement	dm^3	65,7	87,5	131,5	175	196,7
Mean eff. pressure	kg/cm^2	18,7	17,7	18,7	18,4-21,7	18,9
Output per 1 l displacement	HP/l	23,2-30,9	19,7	23,1-30,8	22,6-28,9	23,2-30,8
Stroke		4-str.	4-str.	4-str.	4-str.	4-str.
Compression ratio		11,5	11,5	11,5	11,5	11,5
Weight	kg	10400	11550	15050	19140	21800
Specific weight	kg/HPh	6,83	6,7	4,94	4,84-3,78	4,77

Locomotive Engines Family 175/205

produced by UZINA "23. August" , Bucuresti, Romania

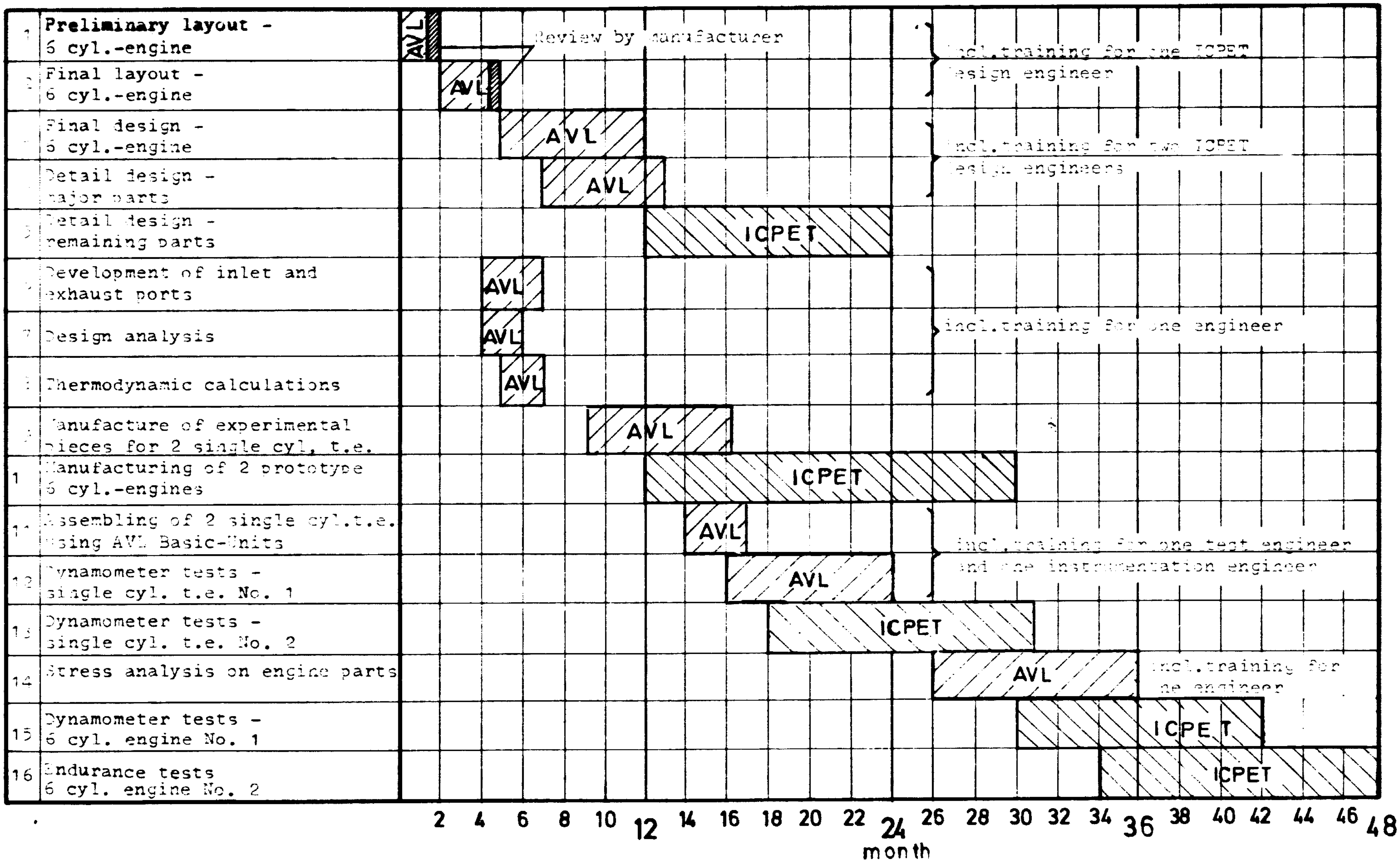
Engine Types		MB 836B	MB 836Bb	MB 836Db	MB 820B	MB 820Bb	MB 820Db
Bore	mm	175	175	175	175	175	175
Stroke	mm	205	205	205	205	205	205
Output	HP	350	500	550	700	1100	1200
Speed	rpm	1500	1500	1500	1500	1500	1500
Number of cylinders		6L	6L	6L	12V	12V	12V
Displacement	dm^3	29,6	29,6	29,6	59,2	59,2	59,2
Mean eff. pressure	kg/cm^2	7,6	10,65	11,3	7,6	11,15	12,3
Output per 1 l displacement	HP/l	11,83	16,9	18,6	11,82	18,6	20,3
Fuel consumption	g/HPh	170	170	168	168	166	165
Stroke		4-str.	4-str.	4-str.	4-str.	4-str.	4-str.
Cycle		prechamb.	prechamb.	prechamb.	prechamb.	prechamb.	prechamb.
Weight	kg	1935	2135	2375	2700	3040	3200
Specific weight	kg/HPh	5,7	4,38	4,3	3,3	2,7	2,6

Engine Types		5006SA	5006SR	5012SA	5012SR
Bore	mm	175	175	175	175
Stroke	mm	205	205	205	205
Output	HP	600	750	1200	1500
Speed	rpm	1500	1500	1500	1500
Number of cylinders		6L	6L	12V	12V
Displacement	dm^3	29,6	29,6	59,2	59,2
Mean eff. pressure	kg/cm^2	12,1	15,2	12,1	15,2
Output per 1 l displacement	HP/l	20,3	25,3	20,3	25,3
Stroke		4-str.	4-str.	4-str.	4-str.
Cycle		dir.inj.	dir.inj.	dir.inj.	dir.inj.
Weight	kg	3300	3480	4910	5250
Specific weight	kg/HPh	5,5	4,65	4,1	4,5

ENCL.

PROJECT "RAILWAY-ENGINE IN ROMANIA"

18-cylinder-engine - 20.. HP at 1… rpm approx.



Computer-compatible equipments for measuring stationary states of gas (Test stand for Diesel engines)

Encl.No.12

item	measured variable		measuring point: naturally aspirated Diesel engine 8-cylinder	measuring point: highly supercharged Diesel engine 12-cylinder	number of measuring points: initial stage of construction	number of measuring points: ultimate stage of construction	measuring range	accuracy of measurement max. tolerance of reading
1	air temperature	t_o	engine test stand	engine test stand	1		0 to +60°C	1%
2	psychometric air temper.	Δt_o	engine test stand	engine test stand	1		0 to +20°C	1%
3	barometric air pressure	B	engine test stand	engine test stand	1		650-800 torr	± 0.5torr
4	air temperature	t_1	before air is entering measuring section	before air is entering measuring section	1	2	0 to +60°C	1%
5	differential pressure	Δp	air diaphragm or Venturi tube	air diaphragm or Venturi tube	-	2	0 to -500mm WC	±0.5 mm WC
6	pressure loss	Δp	gas meter	-	1	-	0 to -50mm WC	± 1 mm WC
7	air volume	Q	gas meter	-	1	-	< 35cu.m/min.	1%
8	air temperature	t_1'	-	air before entering compressor	-	2	< 50°C	1%
9	air pressure	p_1'	-	air before entering compressor	-	2	0 to -500mm WC	± 1 mm WC
10	air temperature	t_1''	-	air before entering heat exchanger	-	2	< 200°C	1%
11	air pressure	$\Delta p_1''$	-	air before entering heat exchanger	-	2	3 kgf/sq cm	1%
12	air temperature	t_2	air before entering intake manifold	in equalizer vessel	1	2	0 to 100°C	1%
13	air pressure	Δp_2	air before entering intake manifold		1		0 to -500mm WC	±0.5 mm WC
14	air pressure	p_2	-	in equalizer vessel		2	3 kgf/sq cm	1%
15	exhaust gas temperature	t_3	in exhaust manifold nearby cylinder head	in exhaust manifold nearby cylinder head	8	12	0 to 900°C	1%
16	exhaust gas temperature	t_3'		in exhaust pipe before entering turbine		4	0 to 900°C	1%
17	exhaust gas pressure	$\Delta p_3'$		in exhaust pipe before entering turbine		4	3 kgf/sq cm	1%
18	exhaust gas temperature	t_4		behind turbine	1	2	0 to 900°C	1%
19	exhaust gas pressure	p_4		behind turbine	1	2	0 to 500mmWC	±1 mmWC

Computer-compatible equipments for measuring stationary states of cooling water, fuel and lubricating oil (Test stand for Diesel engines)

Encl.No. 13

item	measured variable		measuring point: naturally aspirated Diesel engine 8-cylinder	measuring point: highly supercharged Diesel engine 12-cylinder	number of measuring points: initial stage of construction	number of measuring points: ultimate stage of construction	measuring range	accuracy of measurement max. tolerance of reading
20	cooling water temperature	t_{we}	before ingoing the engine		1 1 for heat balance	1 1	0 to + 100°C	1% 1‰
21	cooling water temperature	t_{wa}	behind engine's outlet		1 1 for heat balance	2 1	0 to +100°C	1% 1‰
22	quantity of cooling water	Q_o	before ingoing the engine		1	1		1%
23	cooling water temperature	$t_{we1,2}$		before ingoing intercooler	-	2	0 to +100°C	1%
24	cooling water temperature	$t_{wa1,2}$		behind intercooler	-	2	0 to +100°C	1%
25	cooling water temperature	t_{we3}	before ingoing the oil cooler		1	1	0 to +100°C	1%
26	cooling water temperature	t_{wa3}	after oil cooler		1	1	0 to +100°C	1%
27	lubricating oil temp.	t_{oil}	in the oil pan		1	1	0 to +150°C	2%
28	lubricating oil pressure	p_{oil}	behind oil filter		1	1	0 to 10 kgf/sq.cm	2%
29	fuel temperature	t_{k1}	before ingoing the fuel consumption measuring equipment		1	1	0 to +50°C	2%
30	fuel temperature	t_{k2}	before ingoing the injection pump		1	1	0 to +100°C	2%
31	fuel temperature	t_{k3}	behind injection pump		1	1	0 to +100°C	2%
32	fuel pressure	p	before ingoing the injection pump		1	1	0 to 6 kgf/sq.cm	2%
33	fuel pressure loss	Δp	at the fuel filter		1	1	0 to 2 kgf/sq.cm	2%

Computer-compatible equipments for determination of engine's operating data(Test stand for Diesel engine)			Encl.No.14
item	pcs.		accuracy of measurement max. tolerance of reading
34	1	<u>Gravimetric Fuel Consumption Measuring Equipment</u> Suitable for Diesel engines with outputs up to 500 hp, facility for alternative output ranges up to 2000 hp. Consisting of measuring and control devices;excess fuel is fed back into the measuring vessel. Additional equipment for attenuating pulsations of the excess fuel.An overhead fuel tank will be designed and built by equipment 's manufacturer according to customer's specifications.	± 3‰
35	1	<u>Smoke Meter</u> Measures blackening degree of the exhaust gases discharged by Diesel engines;suitable for tests of two exhaust systems.Consisting of measuring und control units.Blue and white constituents of the exhaust gas must not falsify measurement. Reading in terms of SZ-Bosch units.	±0.15 of full scale
36	1	<u>Smoke Meter for continuous measurements(Opacity Meter)</u> Measures continuously the opacity of exhaust gas. Meets requirements established by Europcan Commission (ECE-Rule No.24).	±0.15/m in the range of 0 to 3/m
37	1	<u>Blow-by for continuous measurements</u> Suitable for continuous measurements and recording of instantaneous values of the leak gas quantities escaping via crank case;including limit value contact for alarm facilities. Version for engines up to 500 hp Measuring range : 40 up to500 litres/h	±5%
38	1	<u>Gravimetric Oil Consumption Measuring Equipment</u> Automatic oil consumption measuring unit permitting determination of the consumption rate (employing gravimetric method)with engine running. Version for engines up to 500 hp Configurations: according to our specifications.	
39	1	<u>Automatic Equipment for Measuring Beginnung of Delivery/Injection</u> Measuring equipment for the automatic determination of the beginning of injection pump delivery/injection. Measured values traced by means of a pressure transducer,a linear displacement transducer(needle lift) and a pulse pick-up(TDC-mark)are handled and displayed by the "Angle Calculator" module. Measuring range: 0 - 50° crank angle	± 0.3° crank angle

				accuracy of measurement max.tolerance of reading
40	1	**Gas Meter** Suitable for measurements of air consumption,complete with an equalizer vessel preventing air pulsation and an electrical device counting the air quantities. Maximum allowable pressure loss: 30mm WC at maximum rate of air flow of an engine having an output of 500 hp.		± 0.5%

No.	Qty	Description		accuracy of measurement max.tolerance of reading
41	1	<u>Automatic Temperature Regulating Equipment</u> For recooling of excess fuel coming from injection pump to the Fuel Consumption Measuring Equipment and regulating regulating temperature of fuel before feeding the injection system. Recooling temperature=temperature of coolant + $5^{\circ}C$ Range of temperature regulation= $t_{1,2}$ up to $50^{\circ}C$ t_1: temperature of fuel in central tank t_2: temperature of fuel behind recooling system Suitable for engine versions up to 500 hp.		± $1^{\circ}C$
42	1	<u>Heat Exchanger for recooling of engine coolant</u> and regulating temperature in the same range covering 70 up to $90^{\circ}C$. Versions suitable for engines up to 500 hp.		± $1^{\circ}C$
43	1	<u>Preheating Installation</u> (in addition to item No.) The coolant if fed via a boiler by means of a time switch to preheat the engine when not used.Simultaneously the coolant is circulated by an injector (See the sketch).		
44	1	<u>Start Oil Pump</u> An externally driven lubricating oil pump,suitable for a 500 hp Diesel engine,increases the pressure in the lubricating system up to 2 kgf/sq.cm;followed by releasing of starting process. Complete with valves and lubricating oil lines.		

45	1	<u>Engine Speed Measuring Equipment with Digital Indication</u> A pulse generator disc having 100 pulse marks is fitted to the engine shaft. The pulse generated in a magnetic pickup is fed to a digital counter. The counter has a built-in time base of 0,6 sec., thus permitting direct indication of speed in rpm. The counter features a 4-digit display, a crystal controlled time base and a BCD-output for connection to a computer.
46	2	<u>Turbo Charge Speed Measuring Equipments</u> An electronic counter having a 6-digit display indicates the turbo charger speed. Depending on the type of turbo charger used, a magnetised nut is fitted to the turbo charger shaft. An inductive pickup provides 1 pulse/rev., which in conjunction with a time basis of 6 sec. permits indication of the charger speed to an accuracy of 10 rpm.
47	1	<u>Pressure Transducer Calibrating Device with Electric-Motor Drive</u> A measuring equipment for recalibrate the High Pressure Indicating Equipment.
48	1	Set <u>Adapter</u> for mounting the following pressure transducers: 40 DP 500 k 40 DP 1200 k 7 QP 2500 a 8 QP 10 000 12 QP 250 ck furthermore one set of special adapter for mounting the pressure transducer 7 QP 2500 a.

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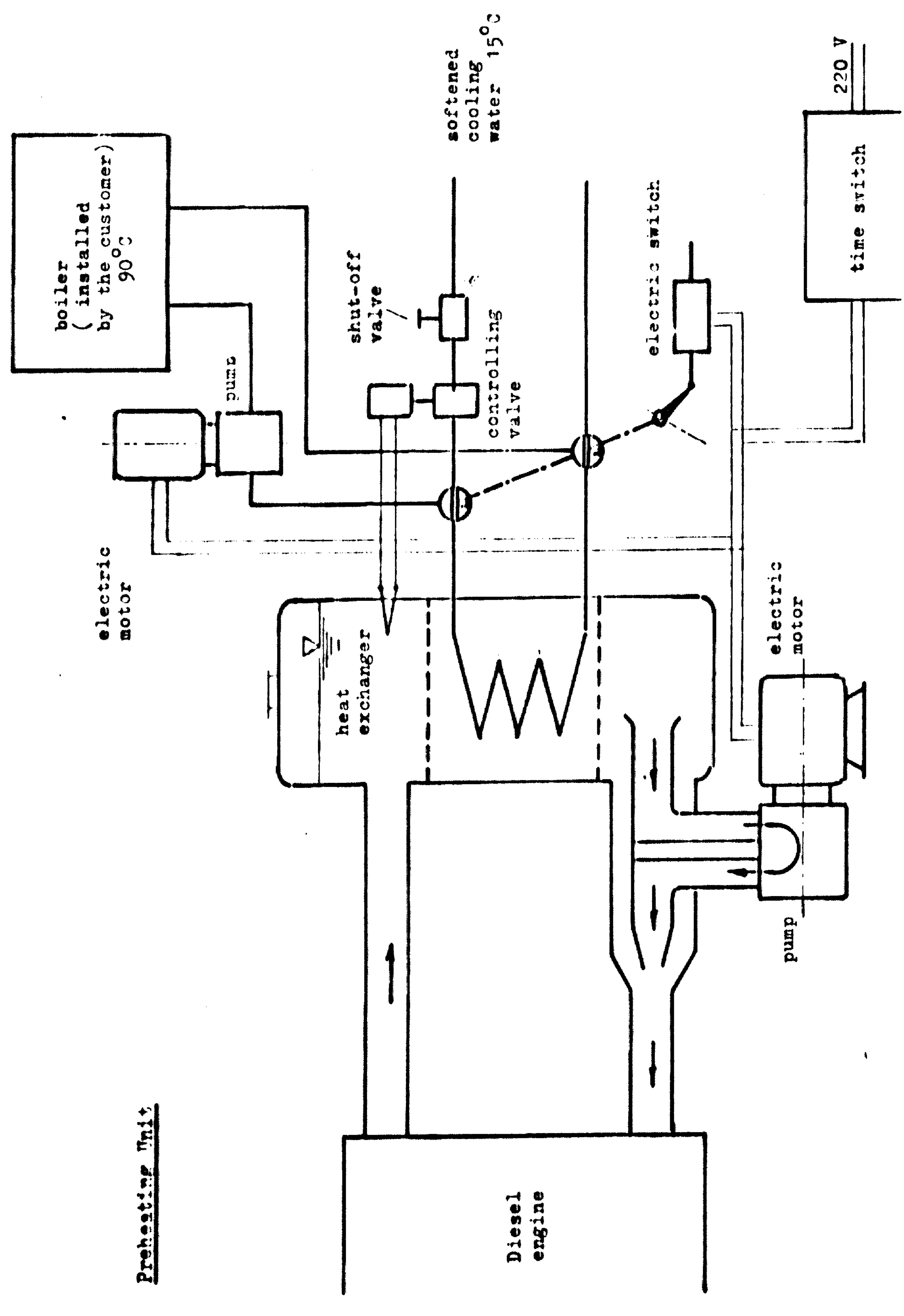

Computer-compatible equipments for determination of engine's operating data (Test stand for Diesel engine)

Encl.No. 18

item	pcs.		accuracy of measurement max. tolerance of reading
49	1	**Eddy Current Dynamometer** As Type W 780 manufactured by Carl Schenck, complete with Torque Measuring Equipment. Suitable for measuring power of Diesels with rated output of 500 hp and a speed range covering 0 up to 4000 rpm; complete with control unit providing exciter current supply, preselecting and automatic control of the dynamometer characteristics with reference to speed(n), torque (M) and (n,const.). Supplementary equipment: test units, proper drive shaft (elastic construction) and protective cover.	0.4 % of full scale

Computer-compatible equipments for determination of engine's operating data (Test stand for Diesel engines)

Encl.No.19

item	pcs.			accuracy of measurement max. tolerance of reading
50.	1	<u>Exhaust Gas Analyzer System</u> Compact, self-contained, remotely controllable and computer-compatible unit, which permits continuous measurements and digital display of the concentrations of HC, CO and NOx. Meets legal regulations of exhaust gas analysis issued by the USA, the EC member countries and Japan. Features negligible zero drift, long term stable calibration curves, low interference (cross sensitivity), insignificant pressure dependence and minimum maintenance. Measuring ranges: <u>HC</u> 0 - 10 ppm 0 - 100 ppm 0 - 1000 ppm 0 - 10000 ppm <u>CO</u> 0 - 1000 ppm 0 - 5000 ppm <u>NO</u> 0 - 1000 ppm 0 - 5000 ppm $\underline{CO}_2$ 0 - 5 % 0 - 20 % $\underline{O}_2$ 0 - 5 % 0 - 20 %		± 2 % of proper full scale

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