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Building-up of Railway Wheels

APPLICATION IN INDONESIA

UNIDO

Project No US/INS/93/169
Contract No 95/086

Final Report

TRANSURB CONSULT

Castolin Eutectic
Eutectic Castolin

June 1997

FINAL REPORT
ON
BUILDING-UP OF RAILWAY WHEELS

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FINAL REPORT ON BUILDING-UP OF RAILWAY WHEELS

1. INTRODUCTION

This is the final report on Building-Up of Railway Wheels for the Indonesian Railway Company PERUMKA.

This final report is a compilation of the previous reports the data of which have been updated where it was necessary. It reports on:

- the background and the objectives of the project;
- the work performed during the project and the workplan as it was carried out;
- the building-up technology;
- economic evaluation;
- the possibilities for private or public investments in this technology in Indonesia as well as in similar countries in South-East Asia;
- the evaluation of the project - Tripartite Review Meeting;
- the follow-up proposals.

The maintenance manuals of the equipment and spare parts list have been handed over to PERUMKA and PADI, local distributor for Eutectic+Castolin in Jakarta. The quality control report consists of the quality control sheets LOFC that have to be completed by the workshop staff for every built-up wheel. It is available at the shop floor.

The Contractor would like to thank UNIDO HQ, UNIDO Jakarta, PERUMKA and PADI for their assistance and continuous attention to the project.

2. BACKGROUND AND OBJECTIVES OF THE PROJECT

2.1. Background

The replacement of worn-out railway wheels is for many developing countries, like Indonesia, a heavy burden.

Without any existing domestic steelworks capable of forging new wheels, the Indonesian Railways Company PERUMKA has to buy these wheels on the international market (USD 600/unit) in hard currency.

The solution is to extend the lifetime of a wheel by building up its worn-out flanges before reprofiling.

The advantages of building-up are:

- the lifetime of a wheel can be doubled, because the reduction of the wheel diameter during reprofiling is limited to a few millimetres and the wear resistance of the wheel flanges slightly increases;

- reduction in the average maintenance/renewal cost of wheels by 38 %;

- reduction in the need for foreign currency by 40 %;

- savings in raw materials and energy consumption and therefore environment friendly;

- more labour intensive, consequently only suitable in countries with low labour cost;

- enforcement of domestic employment;

- reduction in capital immobilization in wheel stocks;

- easier supply of wheels to the workshops.

2.2. OBJECTIVES OF THE PROJECT

2.2.1. Preliminary conditions

The project is only applied on those solid wheels that meet the technical preconditions defined by the Contractor that guarantee a good build-up. At PERUMKA's request, the Contractor has also built up tyred wheels and locomotive wheels during the final mission.
All wheels with cracks were excluded from this project. These wheels with cracks are mostly the result of building up by the previous building-up technology. (See inception report)

The project has been implemented in the Manggarai workshop at Jakarta, Indonesia. It has a wheel shop that is equipped with a wheel lathe, non-destructive testing and handling equipment.

2.2.2. Objectives

At the end of the project the results should be:

a) 500 built-up wheelsets (1000 wheels), quality control of the upwelding included;
b) a fully equipped workstation for building up wheels with a capacity of 100 wheelsets per month.
c) a team of four skilled workers : one foreman and three welders, trained in building-up of wheels.

3. WORK PERFORMED DURING THE PROJECT AND WORKPLAN

3.1. SCOPE OF SERVICES

The project is conceived as a package including:

- training of skilled workers;
- supply of the workstation's equipment;
- supply of welding material for building-up of 500 wheelsets;
- building up a first batch of 1000 wheels (500 wheelsets) as a pilot project;
- technical assistance on the spot.

The overall **workplan** as executed can be found in Appendix 1.
The related **workschedule** is given in Appendix 2.

The project has been subdivided into 3 phases :

- identification phase;
- preparation phase;
- implementation phase including evaluation and follow-up proposals.

3.1.1. Identification phase. (See flow chart in Appendix 3)

Period: 1st - 2nd month

Mr Decostere, maintenance expert, 12-06-95 until 30-06-95 (1st mission) and
Mr Van De Walle, welding expert, 19-06-95 until 30-06-95 (1st mission) performed the following tasks:

- introduced the project to:

HQ PERUMKA	
Mr Sjahedi Junardiono	Director of Railway Techniques
Mr Hadyir	Sudit Balai Yasa
Mr Albiner Tamba	Ind. Engineer
Mr Poedyo Soelistyo	KA Sub. Seksi Fasilitas Mesin/Pesawat
MANGGARAI Workshop	
Mr Moelyono	TKBK Manggarai Workshop
Mr Iim Abdul Hakim	UK I Manggarai Workshop
MINISTRY OF COMMUNICATIONS	
Mr Mulyadi	Land Transport
Mr Abadi Sastrodiyati Mr Bambang Sudaryono Mr Kemal Heryandri	Foreign Cooperation
PADI, Eutectic+Castolin representative	
Mr Johnny Sandakh Mr Tinjani Rupinder	

- discussed the workplan with management of the Manggarai workshop;
- designated the national project manager : Mr Drs Iim Abdul Hakim, UK I of the Manggarai Workshop;
- made a detailed expertise of the local wheel conditions (wear-out dimensions, chemical composition steel, etc.)
- surveyed the workshop facilities (availability of power supply, handling facilities, etc.);
- collected the layout of the workshop section where the workstation for building-up will be created;
- made the concept of a technology transfer programme;
- defined the list of necessary equipment and tools;
- studied a possible workshop organisation (work flow analysis) and pre-designed the work-station.

During half a manmonth at the home office following activities were done by Mr Maerten, welding expert :

- checked if the chemical composition of the solid wheels, in use at PERUMKA, allows building-up;
- drafted the welding specification procedures;
- defined the technical characteristics of the equipment to be procured.

The **inception report** was submitted to UNIDO in August 1995.

The inception report describes the implementation modalities, workplan, the Government contributions, the present situation, the expertise of the local wheel conditions (wear-out dimensions, chemical composition steel, etc.), the logistics required (workshop space, layout, power supply, handling and welding equipment, manpower, etc.) and the technical specifications of the equipment to be procured.

3.1.2. Preparation phase. (See flow chart in Appendix 4)

Period : 3rd - 15th month

3.1.2.1. PREPARATION OF THE WORKSTATION

Mr Decostere, maintenance expert, 6-11-95 until 21-11-95 (2nd mission) and Mr Iim Abdul Hakim, national project manager carried out the following tasks:

- designed the workstation (floor space, electric power and gas supply, compressed air, transportation means, location of the new equipment, etc.);

- planned the preparation of the workstation;

- selected the skilled workers.

Further on the national project manager started and monitored the preparation of the workstation by PERUMKA.

The list of the preparative works by PERUMKA and their status on 31/01/96 are given in Appendix 5. This was verified by Mr Decostere during his third mission.

3.1.2.2. PROCUREMENT AND SUPPLY OF THE EQUIPMENT

Based on the technical specifications in the inception report UNIDO Purchasing Unit started the procurement of all necessary equipment and tools.

The equipment was ordered by UNIDO on 20 February 1996.

The procured equipment was verified and tested by the Contractor prior to packing and shipping to the project location at the supplier's workshop on 17 April 1996.

The equipment was shipped to Jakarta on 30 April 1996 where it arrived on 25 May 1996.

Due to administrative reasons, the entrance of the equipment with tax exemption was delayed. It finally arrived at the Manggarai Workshop on 30 July 1996. For this reason, Mr Decostere, maintenance expert, had to interrupt his 3rd mission (10-06-96 until 21-06-96).

The maintenance expert and the two welding experts arrived at the project site on 26 August 1996 where they:

- checked the condition of the equipment and welding material at the project site;
- selected wheelsets for building-up.

Mr Decostere, team leader, made **the progress report**. The progress report consists of a statement confirming that all facilities were ready for operation (milestone) and the updated workplan for the implementation phase.

This progress report was submitted to UNIDO in September 1996.

3.1.3. Implementation phase. (See flow chart in Appendix 6)

Period : 15th - 22nd month

The implementation phase started on 26 August 1996 (milestone) when the facility was ready for operation and the equipment had arrived.

3.1.3.1. INSTALLATION OF THE EQUIPMENT AND START OF THE PRODUCTION.

Mr Decostere, maintenance expert, 26-08-96 until 20-09-96 (4th mission),
Mr Maerten, welding expert, 26-08-96 until 20-09-96 (1st mission) and
Mr Van De Walle, welding expert, 26-08-96 until 4-10-96 (2nd mission)
performed the following tasks :

- installed the equipment of the workstation;
- built up a prototype CC wheel;
- defined the procedure for selecting of the wheels ready for build-up and registration of the built-up wheels;
- defined the working method for preparing of the wheel flanges on the wheel lathe before building-up;
- adjusted the turning table to make it suitable for all wheel axle diameters and wheel types;
- defined the welding procedure specifications;
- defined the procedure for quality control and reporting;
- started the series production;
- trained the supervisor, welders and maintenance staff;
- extended the project with KRL wheels on demand of PERUMKA;
- gave a demonstration to:
    - Mr Sjahedi, Technical Director PERUMKA;
    - Mr Hasnain Country Director UNIDO;
    - PERUMKA Workshop staff of Surabaya, Yogyakarta and Tegal;
    - PADI local distributor of Castolin-Eutectic.

In Appendix 7, you can find the letter of Mr Hasnain, Country Director of UNIDO, in which he certifies the readiness of the workstation and the start of the training.

Appendix 8 shows the statement of Mr Iim A. Hakim, Local Project Manager, and Mr Decostere, Team Leader about the acceptance of the equipment and consumables and the good functioning of the installation.

Mr Decostere, team leader, drafted **the quality control report.** The quality control report notifies on the process flow chart, the welding procedure specifications, the recording of production, the quality control and the responsibilities of each party.

The quality control report was submitted to UNIDO in October 1996.

3.1.3.2. Study tour of Mr Iim Abdul Hakim, National Project Manager.

Because Eutectic+Castolin has the company PADI as local distributor in Jakarta, it was not necessary for Mr Maerten (Castolin Benelux) to participate in the TPR meeting at the end of the project. On that meeting, Eutectic+Castolin was represented by Mr Tinjani, technical advisor Eutectic+Castolin, and Mr Johnny Sandakh, Manager PADI.

Therefore, UNIDO agreed upon a study tour to Belgium for Mr Iim Abdul Hakim, National Project Manager and to cancel the third mission of the welding expert from Castolin Benelux. The purpose of this study tour was to make Mr Iim familiar through a number of lectures and field visits with :

- the main methods of spare parts reconditioning by welding, hard surfacing and thermal spraying;
- the selection criteria of a rational method for parts reconditioning;
- the selection of the applied welding materials;
- the applications at the Belgian State Railways;
- the applications carried out by Eutectic+Castolin in other industries,

in a way that he can define other applications in spare parts reconditioning at PERUMKA and assist the Contractor in organizing a so-called "show-room" for advanced reconditioning technologies during the implementation of the current project.

The time schedule and contents of the study tour can be found in Appendix 9.

3.1.3.3. Demonstration of the technology and economic evaluation.

Mr Decostere, team leader, 06-01-97 until 24-01-97 (5th mission),
who replaces Mr De Greef as industrial economist, performed the following tasks :

- gave a demonstration of the technology for the benefit of the concerned authorities and (eventually) potential investors from the private sector. See Draft Final Report;
- assessed the possibilities for private or public investments in this technology in Indonesia as well as in similar countries of South-East Asia;
- wrote **the draft final report** that consists of an economic evaluation, an assessment concerning investment and development opportunities.

The draft final report was submitted to UNIDO in February 1997.

Mr Maerten, welding expert, 13-01-97 until 24-01-97 (2nd mission), performed the following tasks :

- assisted Mr Decostere in organising a seminar together with PADI, local distributor Eutectic+Castolin, on various welding techniques of spare parts reconditioning;
- gave further assistance to PERUMKA for building-up of wheels at the Manggarai workshop.

3.1.3.4. Evaluation and follow-up proposals

Mr Decostere, team leader, 14-04-97 until 30-04-97 (6th mission) carried out the following tasks :

- evaluated the project implementation;
- conducted final discussions with all authorities concerned - TPR meeting on 24 April 1997;
- planned follow-up activities in a round table discussion attended by PERUMKA and Government authorities - TPR meeting on 24 April 1997 and during a meeting with Mr Koensabdono, Kasubdit Balai Yasa and Mr Bambang, Kepala Bidang Traksi at HQ PERUMKA, Bandung on 29 April;
- finalised **the final report.**

The final report was submitted to UNIDO in June 1997.

Mr Van De Walle - 24-03-97 until 25-04-97 (3rd mission)

performed the following tasks :

- supervised the on-going project in Manggarai and give further assistance for this matter;
- trained an additional welder;
- built up tyre wheels and locomotive wheels and drafted the welding procedure specifications;
- gave demonstration of the technology to the participants of the TPR meeting.

3.2. GOVERNMENT CONTRIBUTIONS

The government, through its railway company has contributed to the project as follows:

- the project was implemented in the PERUMKA Workshop of Manggarai (Jakarta) that serves as the pilot workshop. This workshop was selected based on a number of considerations including location aspects, condition of the workshop, availability of skilled manpower and equipment like a wheel shop equipped with a wheel lathe, non-destructive testing equipment and wheelset handling equipment;
- workshop space as well as storage space for wheelsets under process were available;
- the infrastructure of the workstation was prepared according to the design of the Contractor
  - floor space;
  - electric power, LPG, oxygen and compressed air supply;
  - crane bridge.
- the transport of the wheelsets selected for building-up from site to the wheel lathe and from the wheel lathe to the workstation and vice versa was provided;
- at the start of the implementation phase (month 15), 20 wheelsets were available for building-up. Initially, it was stated that, during implementation, approximately 80 wheelsets per month should be available for building-up. This was not the case due to a lack of coaches entering for overhaul, tyre and cracked wheels that were excluded. At the end of the project, only 152 wheelsets could be built up;
- 152 instead of 500 solid wheelsets checked and selected were reprofiled on a wheel lathe according the Contractor's instructions;
- supply of electric power, oxygen, LPG and compressed air;
- skilled manpower (one foreman and three skilled welders) were assigned to the project on a full-time basis in order to receive training and apply the building-up technique during the implementation phase.

4. BUILDING-UP TECHNOLOGY

4.1. EQUIPMENT

4.1.1. Technical specifications of the equipment

The technical specifications of the equipment have been updated according to the equipment that has been procured. See Appendix 10.

4.1.2. Project's equipment

The list of the equipment and consumable is given in the table below.

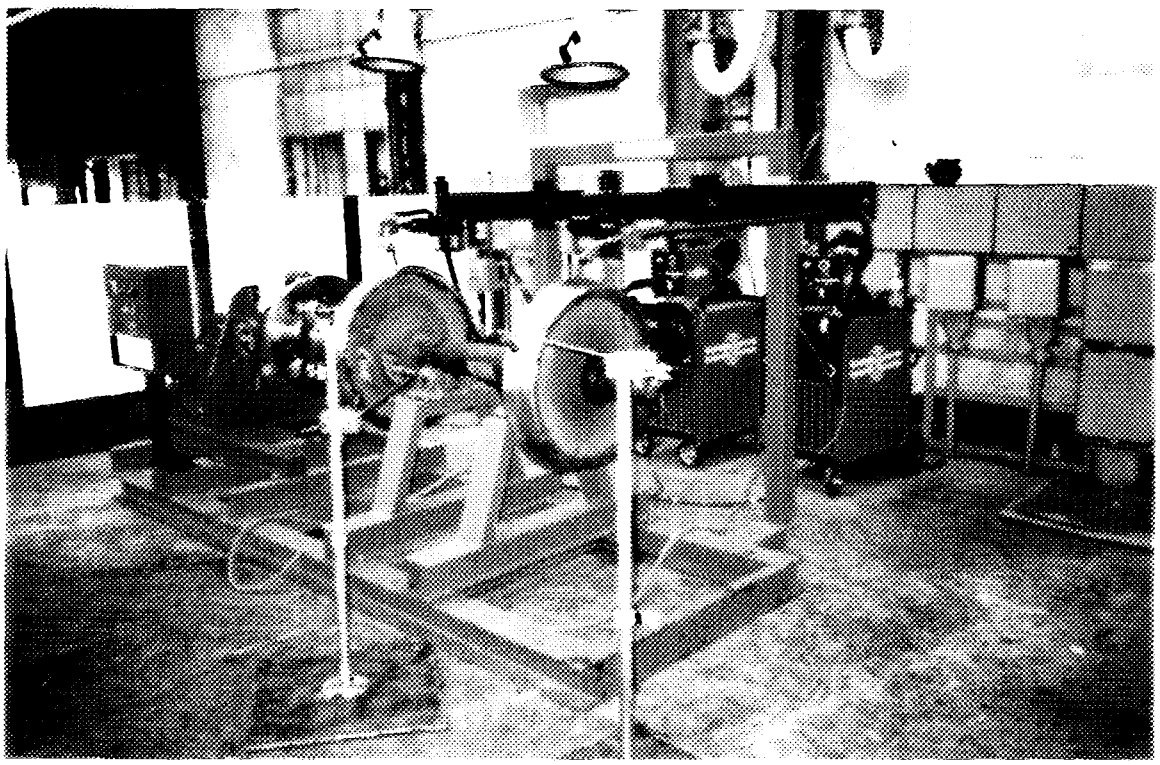
1. Consumable	Quantity
Welding wire Teromatec 3205 ∅ 1.6 mm	5000 kg
Vermiculite insulation material	60 sacs of 100 litres
2. Equipment	
Turning table including supports	1 pcs
Support wheels	1 set
Welding power source incl. wire feeder 448 RDS	2 pcs
Welding torch 97620	2 pcs
Welding torch support system	1 pcs
Fume extractor	1 pcs
Digital thermometer	2 pcs
Pneumatic weld flux scalers	2 pcs
Spare part kit	
■ Contact tips ∅ 1.6 mm	100 pcs
■ Contact tip holder	10 pcs
■ Shielding nozzle with insulating sleeve	10 pcs
■ Complete spare torch Super Handy	1 pcs
■ Helicoidal liner 3 m for torch Super Handy	4 pcs
■ Wire feed rollers ∅ 1.6 mm for AN 3205	8 pcs
■ Interconnecting cable for wire feeder	1 pcs
■ Regulator circuit welding source	2 pcs
■ Wire spool holder with braking device	2 pcs

A complete set of maintenance manuals and the spare parts list have been given to :
- Mr Iim Abdul Hakim, Local Project Manager and UKI of the Manggarai Workshop;
- Mr Tinjani, Technical Advisor Eutectic+Castolin, PADI Jakarta.

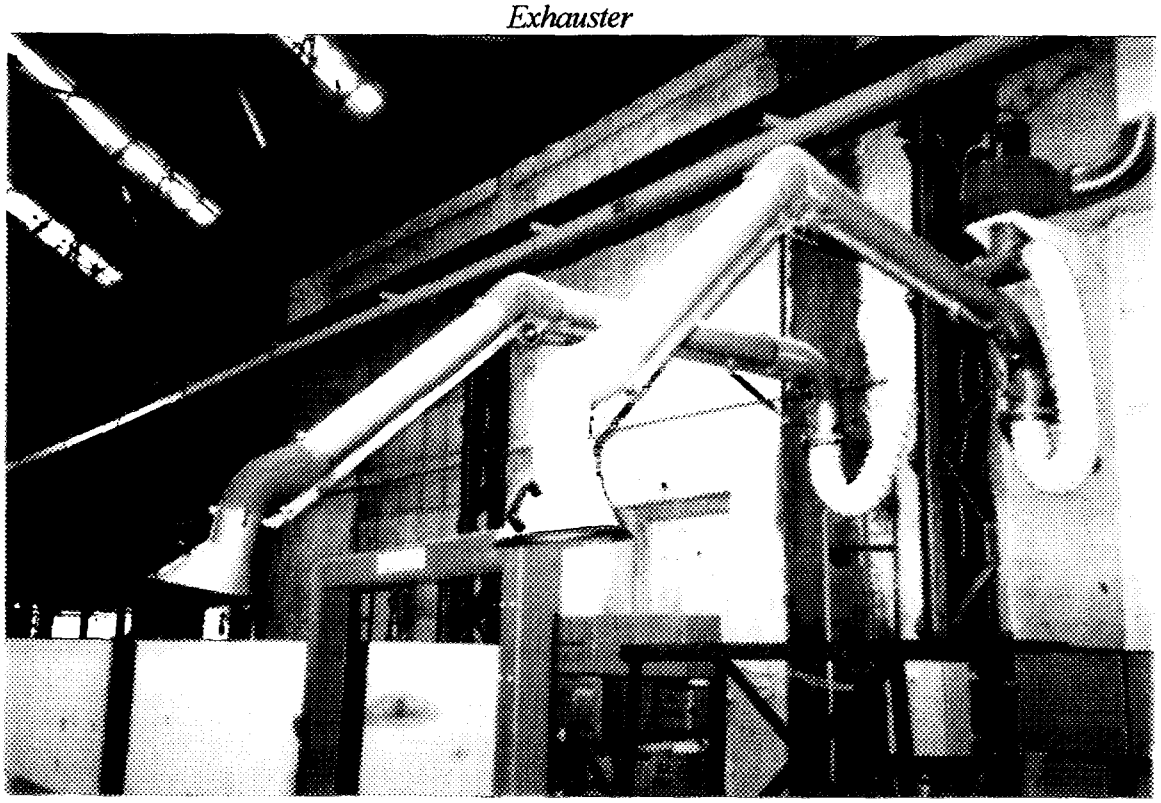
4.2. WORKSTATION

The layout of the workstation is given in Appendix 11. The next photographs show the workstation :

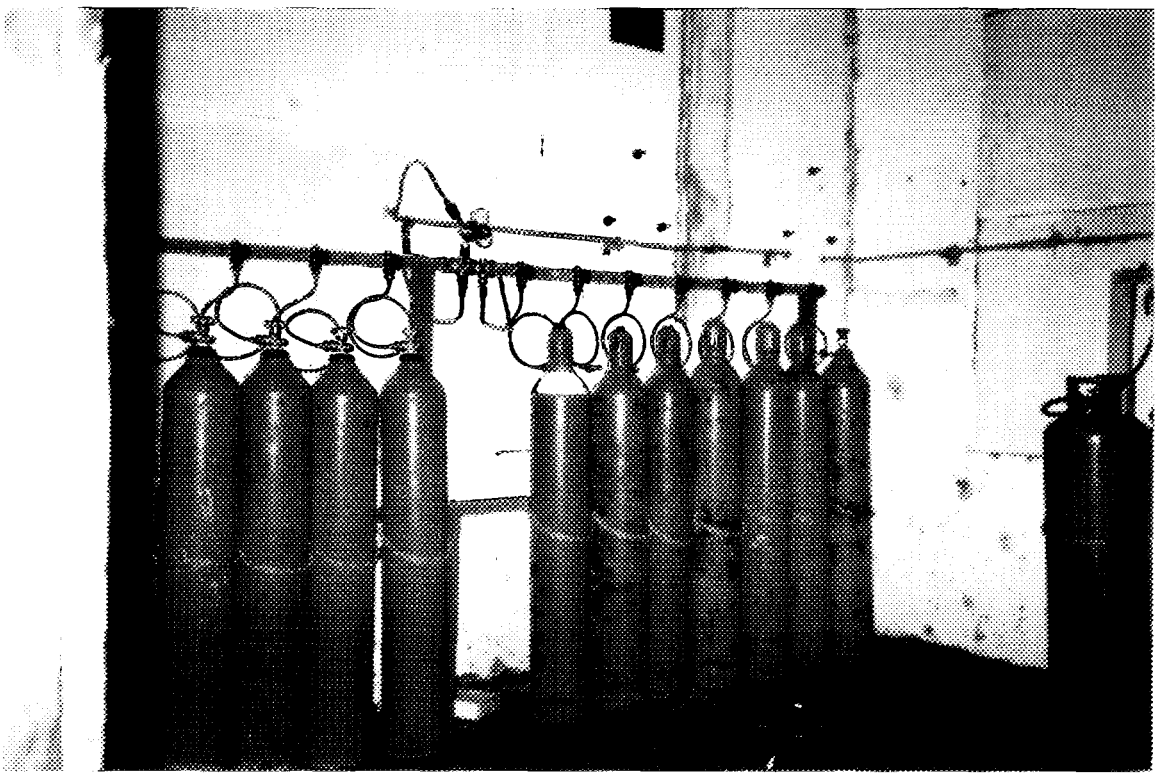
Work station for building-up of wheels



Exhauster



Oxygen and LPG manifolds for pre-heating purposes



4.3. FLOW OF THE PROCESS

The process flow is shown in Appendix 12.

Below, we will discuss the different steps of the building-up process and illustrate them with photographs.

4.3.1. Selection of the wheels suitable for building-up

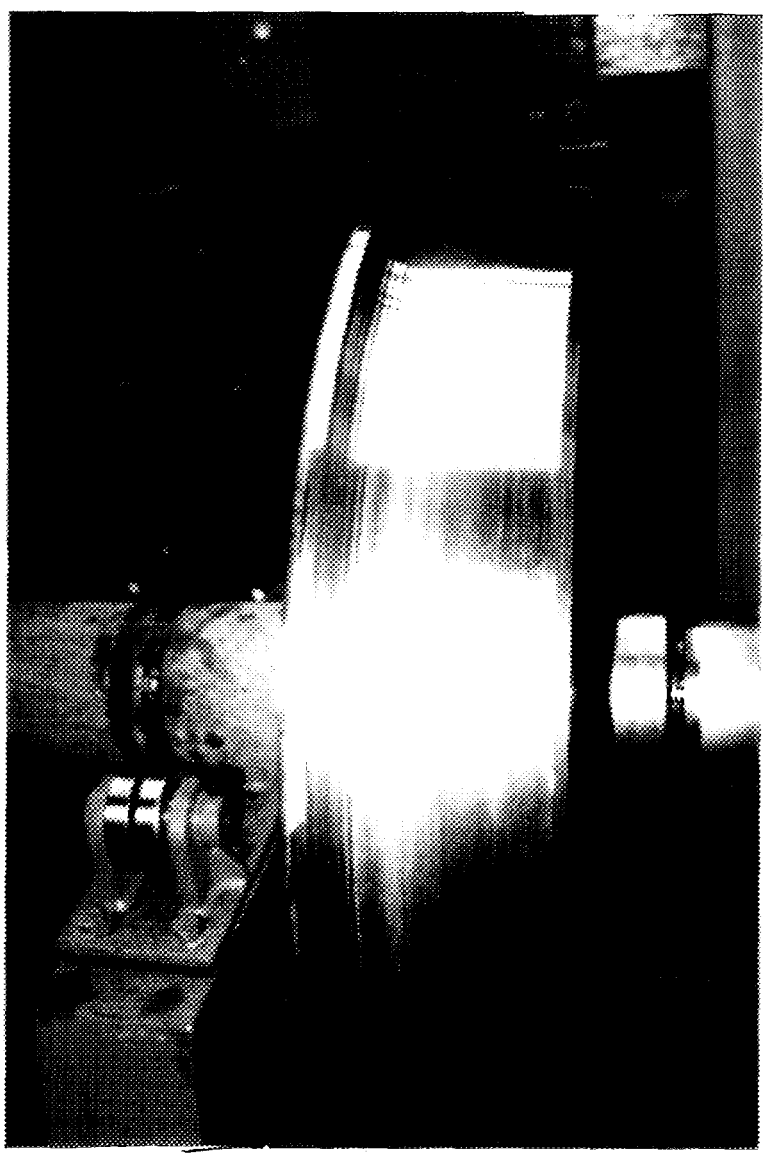
As stated in the inception report, we would only build up solid wheels. At the start of the implementation phase we have built up CC (coaches) and KRL (electric rail cars) solid wheels. During the last mission PERUMKA asked us to build up tyre wheels and solid locomotive wheels as well.

4.3.2. Weld preparation

In order to obtain a good welding quality, the surface of the wheel to be built up should be clean. This is done by reprofiling the wheels on the wheel lathe.

The reprofiling is executed as follows :
- determine the wheel of the wheelset with the smallest diameter;
- reprofile both wheels to this smallest diameter minus 1 mm by machining in automatic mode;
- remove the remaining upper layer of the wheel flange by machining in manual mode.

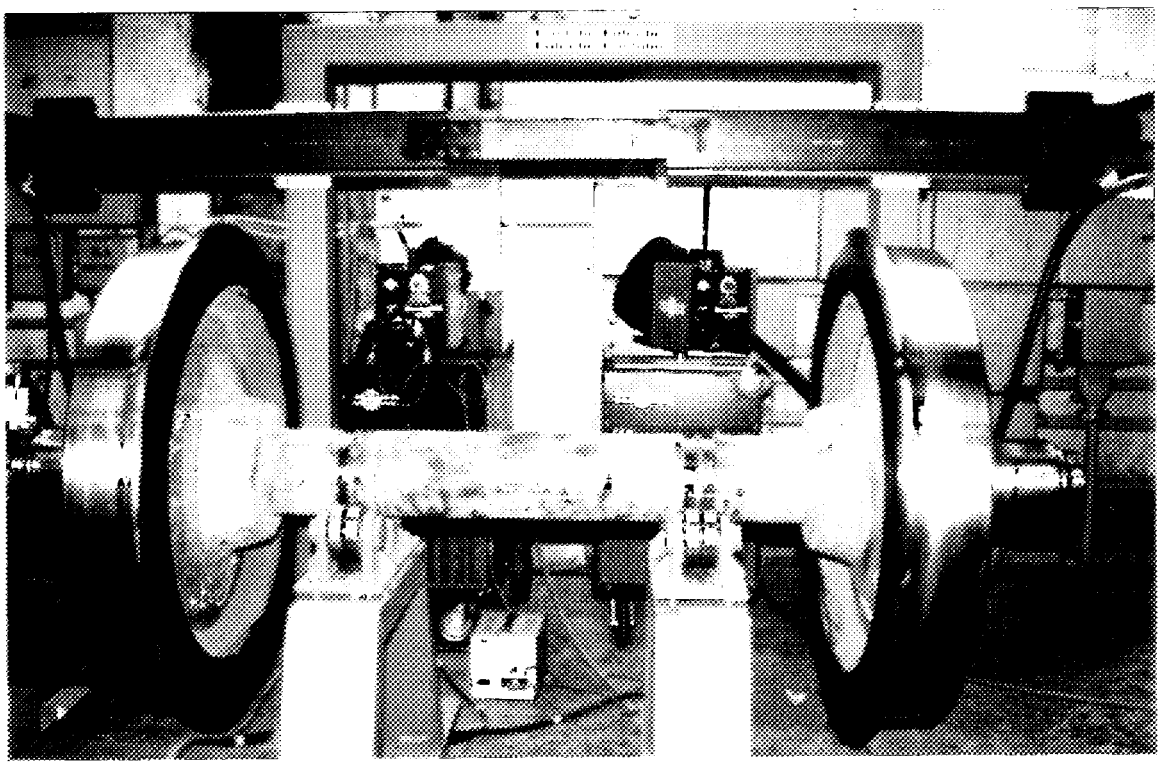
The next photograph shows a wheel already prepared for building-up.

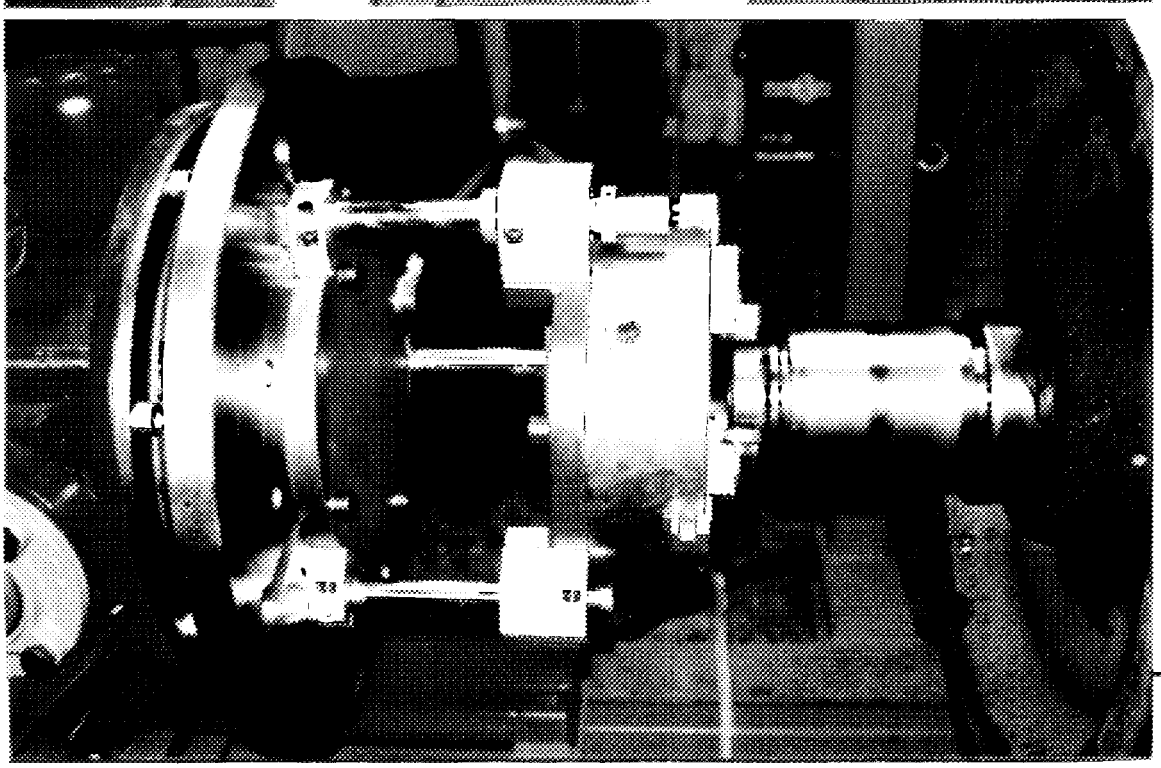


4.3.3. From the wheel lathe the wheelset is transported by overhead crane to the work station for building-up

4.3.4. Mounting of the wheelset on the turning table

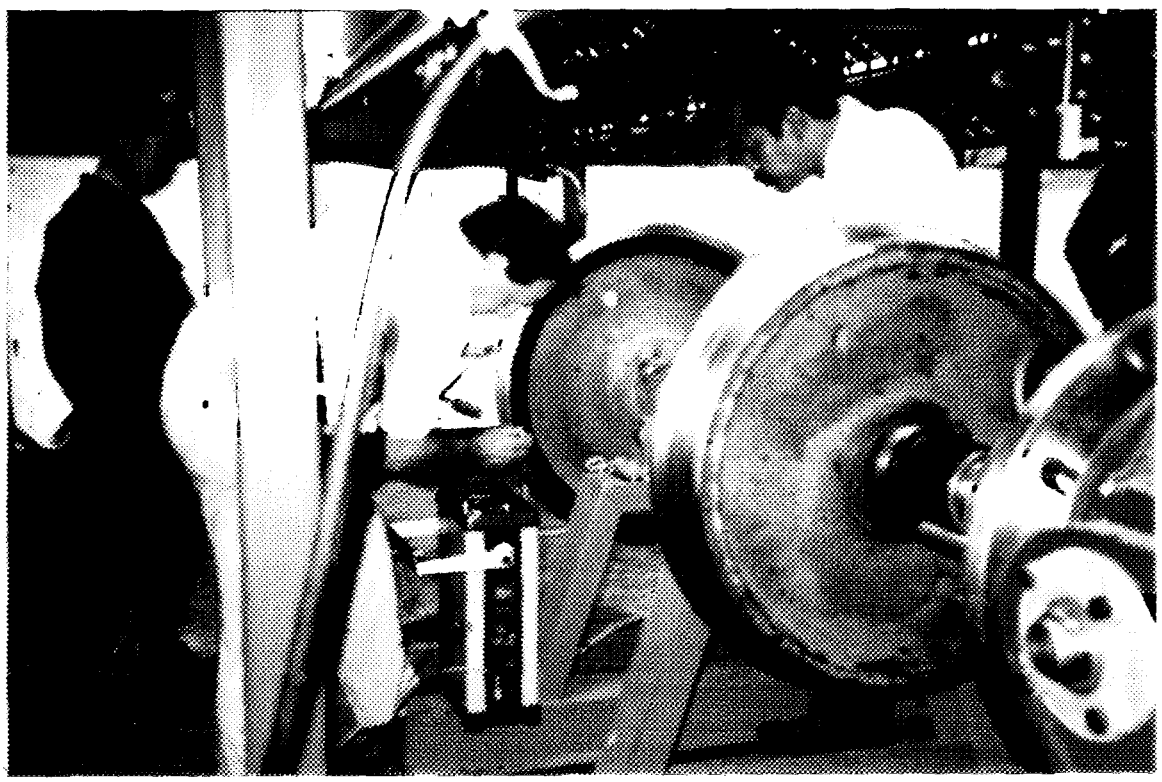
The wheelset has to turn round during preheating and welding. The next two photographs show the wheelset mounted on the supports of the turning table and the claw plate that transfers the revolving movement of the turning table through the axle journal to the wheelset.





4.3.5. Inspection of the wheel before building-up

It is necessary to check the wheels before building-up to be sure that there are no cracks in them. We have to perform three tests : visual inspection, sound test and ultrasonic test.
On the photograph the ultrasonic testing of the wheel tyre is shown.



4.3.6. Preheating

Preheating means heating the base metal to a certain level before welding. The aim of preheating the base metal is to keep the martensite content of the heat-affected zone to a minimum.

Martensite is actually formed during the cooling of the heat-affected zone of the base metal. The slower the weldment cools off, the less martensite forms. Below a characteristic cooling rate for each metal, no martensite forms at all. Instead individual grains of a more ductile microstructure called pearlite will be produced.

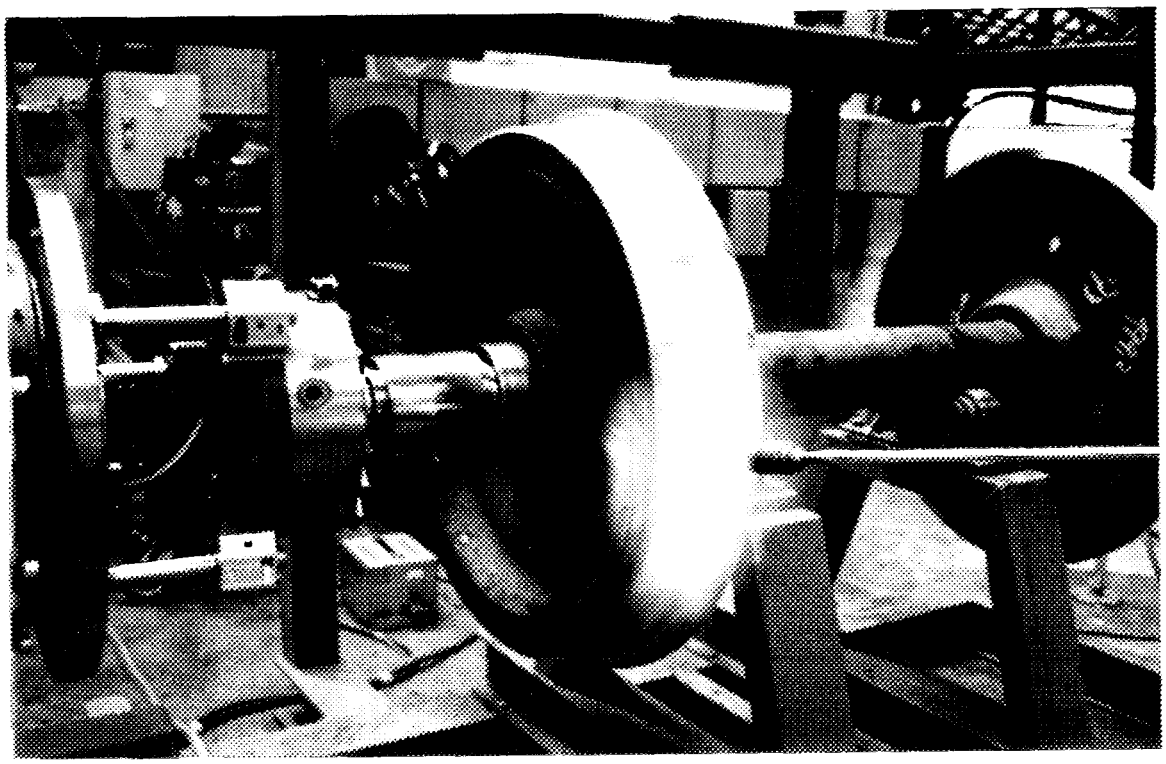
The critical cooling rate can be determined on the I-T diagrams. The I-T diagrams of a 90 % carbon steel is shown in Appendix 13.

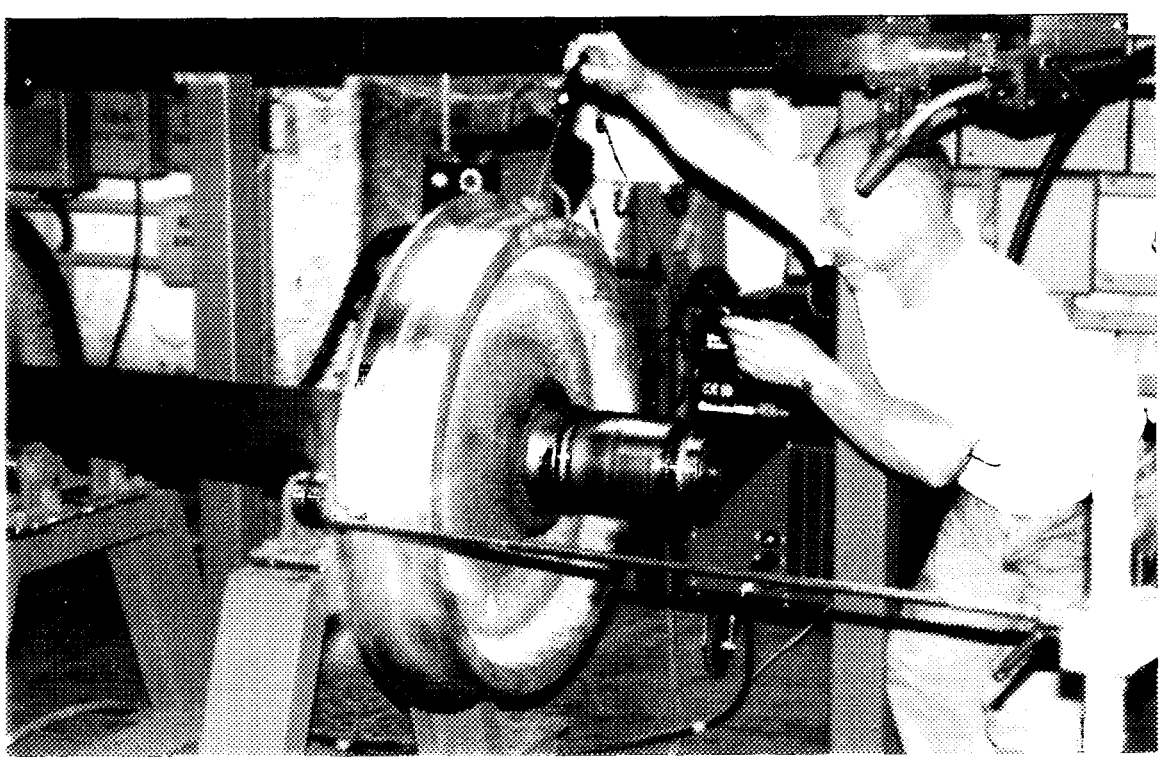
Therefore heating the steel before welding it, keeping it fairly hot between two passes and controlling the cooling rate after welding all slow down the amount of martensite that can form, greatly reducing the chances of base metal cracking.

Preheating is done by heating with a burner pointed to the wheel flanges while the wheel slowly turns round. After about 15 minutes of heating, the base metal turns blue and the required temperature of 300 °C is reached. The value of 300 °C was determined by calculating the equivalent carbon content of the base metal.

When we start welding, the burners can be switched off because we get enough heat input from welding to keep the temperature of the wheel flange sufficiently high. Just before welding the last layer it is necessary to heat again during one tour to keep the temperature of the wheel flange sufficiently high.

The next photographs show the preheating of the wheel and checking of the temperature

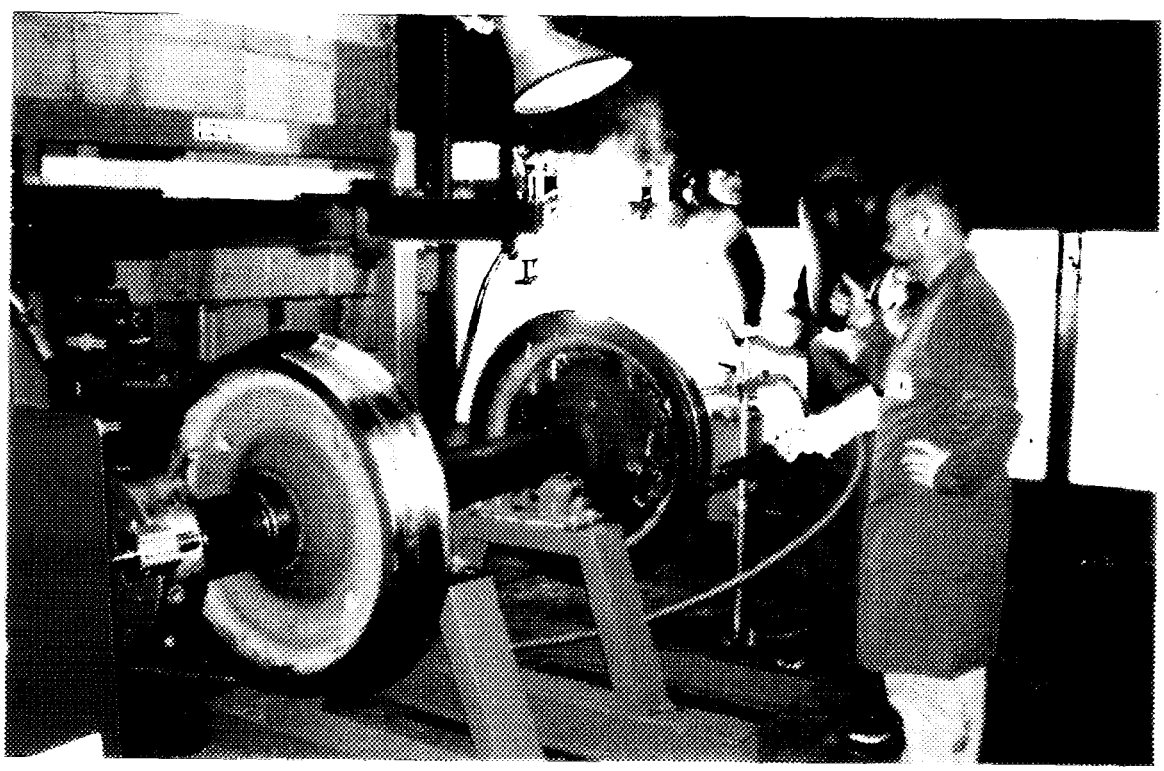




4.3.7. Building-up of the wheels

The positioning of the welding torches is done manually which makes the whole system flexible in use. It permits to build up only the worn-out part of one wheel if necessary instead of both wheels, thus reducing the consumption of welding wire, energy and execution time.

As a matter of fact, the wear on both wheel flanges of the same wheelset is never the same because PERUMKA do not turn the coaches during operation. It happens that only one wheel needs to be built up as you can see on the next photograph.



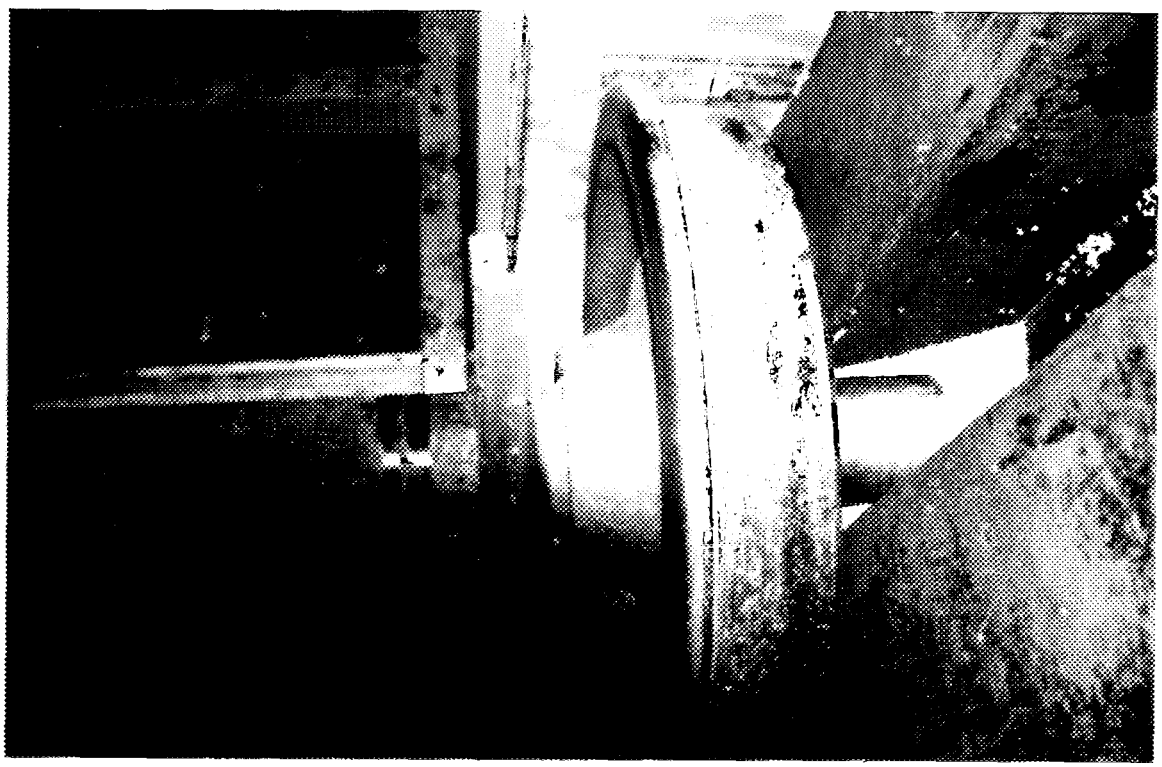
For example it can happen that one wheel needs five layers and the other ten layers for building-up of the existing wear. The welding on the first wheel will be stopped after five layers. While the building-up of the second wheel continues, the burner is heating the first wheel to keep its temperature sufficiently high.

The next photograph shows the wheel after building-up.

4.3.8. Cooling off

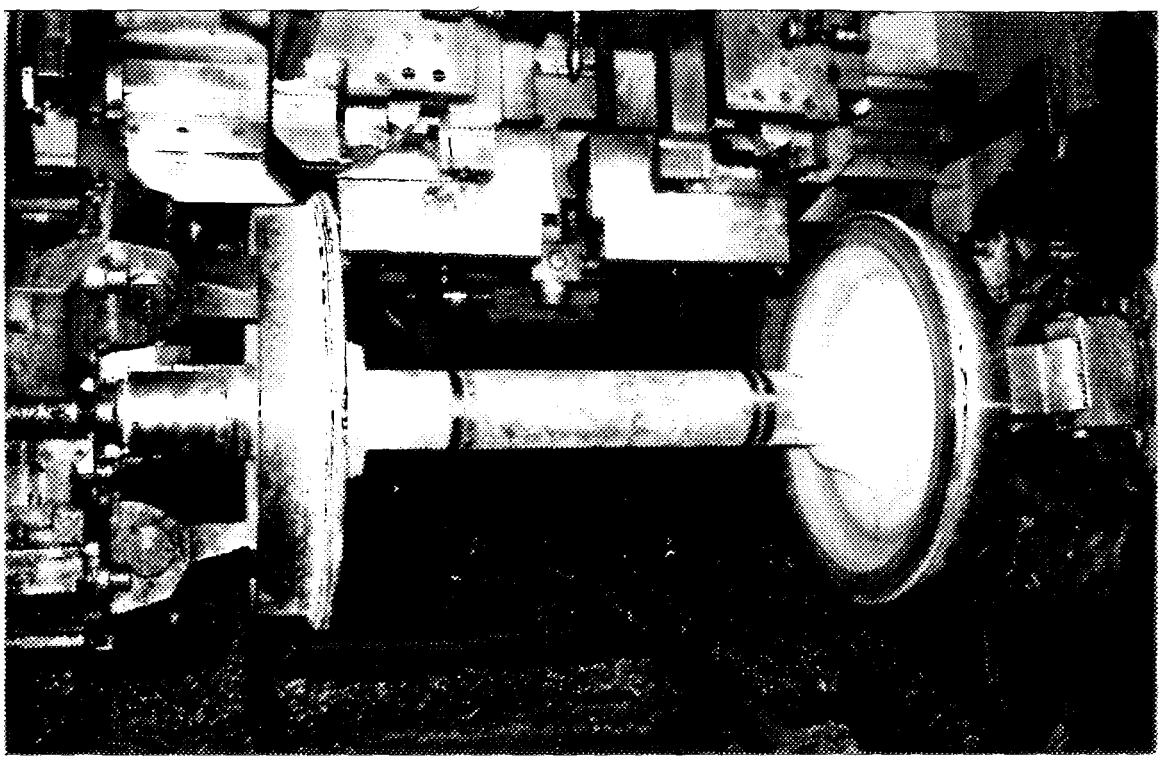
After welding the wheelset is put into a cooling off container with the overhead crane. The wheelset is then completely covered with the insulation material Vermiculite so that it cools off slowly. The cooling rate should never exceed 50°C per hour

The next photograph shows the wheelset in the container and the filling of the container with Vermiculite.



4.3.9. Reprofiling

The next photograph shows the wheelset on the wheel lathe for its final reprofiling.

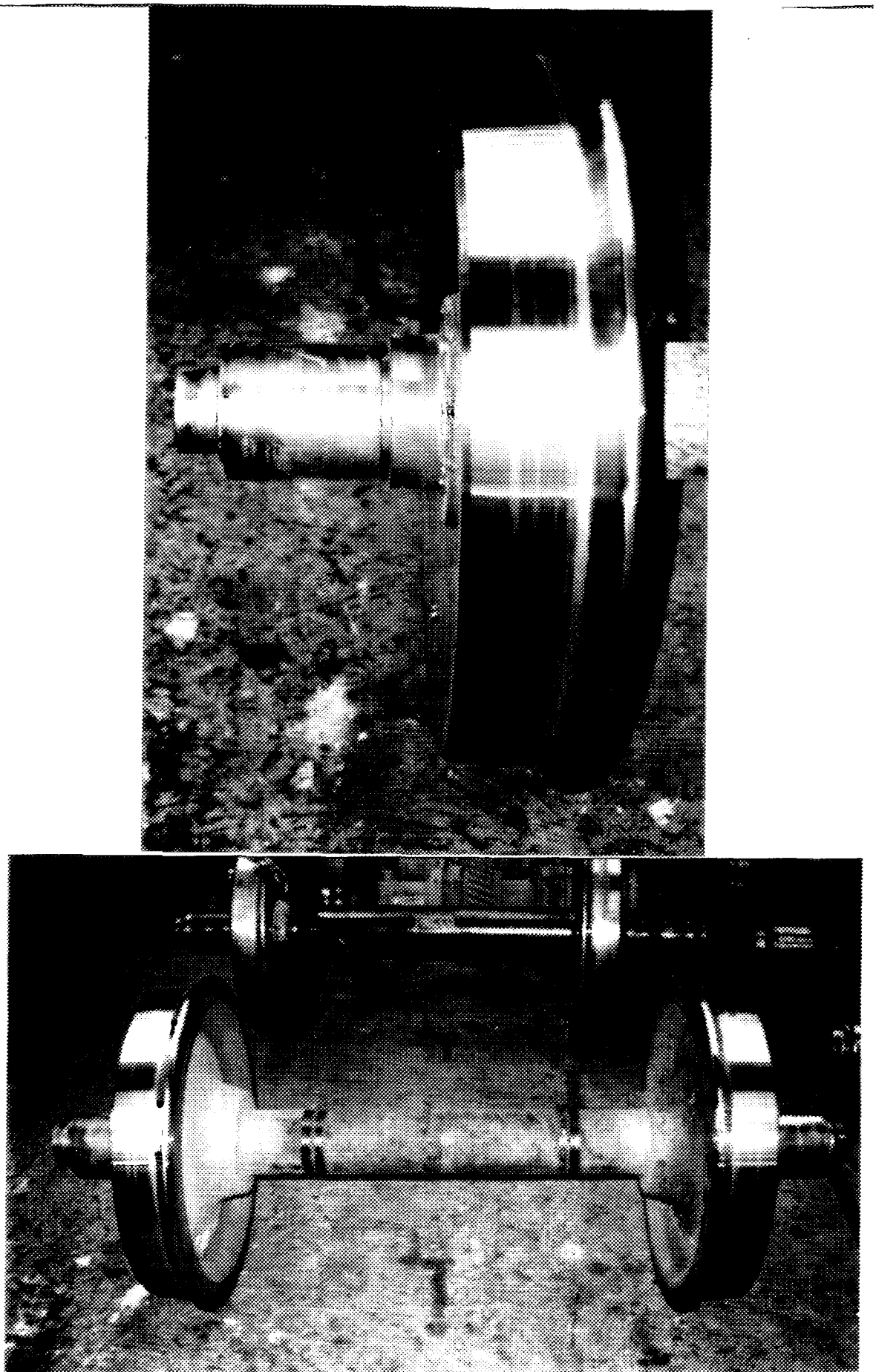


4.3.10. Final inspection.

The final inspection is carried out after reprofiling and consists of a visual inspection and sound test.

The wheelset receives an identification mark on each wheel that corresponds with the job number on the list of the built-up wheels.

On the next photographs, some finished wheels are shown.



4.4. WORKING INSTRUCTION

On request of Mr Kaulfersch, UNIDO HQ, a working instruction has been drafted. This working instruction is an addition to the welding procedure specifications. See Appendix 14.

The working instruction and the welding procedure specifications should be translated in Indonesian and approved by the TKBK of the workshop. These documents should be fixed to the wall of the workstation in Indonesian and English so that they can be easily consulted by the shop floor personnel.

4.5. WELDING PROCEDURE SPECIFICATIONS

The welding procedure specifications WPS-PER-01 until 04 can be found in Appendices 15 till 18. These welding procedures have been drafted by CASTOLIN EUTECTIC and may only be modified by them.

4.6. QUALITY CONTROL REPORT

A quality report is made on each wheelset that has been built up. An example of such a report LOFC on which the responsible signs next to each operation is shown in Appendix.19.
The responsible manager will assure that a LOFC is completed for every wheelset and collected in a map at the project site. He will from time to time check if the welding procedures are met and the LOFC are filled in correctly.

We have noticed that this wasn't done any longer after the welding experts had left.

4.7. PRODUCTION

The production is recorded on a production list. Appendix 20 shows the list of wheelsets that have been built up during the project..

On the list you will notice that in some cases only one wheel of the wheelset is built up. The reason for this is that, as PERUMKA does not turn the coaches on a regular basis, the flange of only one wheel of the wheelset is worn out. By reprofiling the wheelset before building up one wheel obtains its normal wheel profile while the other does not. PERUMKA has decided in this case to build up only the worn-out wheel.

In the column "date of welding", you will notice that, on 30-09-96, we were able to build up four wheelsets per day, which was one of the objectives.

For the other days we could not reach this production because there were not enough wheelsets available to build up. As explained before wheels with cracks are always excluded from the project and the tyre wheels also at the start of the production.

4.8. RESPONSIBILITIES

The welding procedure specifications can be found in Appendices 15 till 18. These welding procedures have been drafted by CASTOLIN EUTECTIC and may only be modified by them.

It is understood that CASTOLIN EUTECTIC who is carrying out a part of the personnel services and who has supplied machinery and welding wire is the sole responsible for the correctness of these welding procedures and the results of their application.

It is obvious that they can only be held responsible for wheels that have been built up under the supervision of their welding expert Mr Maerten, the welding procedures and the quality of the welding wire. See letter of CASTOLIN BENELUX in Appendix 21.

TRANSURB CONSULT guarantees that the wheels built up under supervision of their welding expert Mr Van De Walle have been thoroughly checked and built up according to the welding procedures.

The personnel appointed by PERUMKA have been fully trained by the welding experts and can perform a good quality of work if they accurately follow the welding procedures. Therefore the Manggarai Workshop is the **only responsible** in case of failures or accidents caused by the wheels built up by themselves.

Important notice :

We have detected cracks in 7 out of 8 wheels that have been built up before by PERUMKA with the 'old' building-up method. We have analysed this high-deposition-rate flux-cored wire welding process using CO_2 as shielding gas without any preheating nor slowly cooling off in the inception report. At the time we have warned PERUMKA about this poor practice and the cracks that would occur.

It is obvious that these wheels are excluded of building-up and should be reprofiled until all cracks have been removed.

The list of these rejected wheelsets can be found in Appendix 22.

We have refused to build up these wheels but nevertheless the Manggarai Workshop has rebuilt them on the "old" workstation instead of scrapping them. We are afraid that during our absence such wheels will also be built up on our workstation.

4.9. TECHNICAL RESULTS

4.9.1. Condition of the built-up wheels

At the end of the project, we have only data about wheels running for about six months or 100,000 km in trains used for servicing the return trip Jakarta - Bandung.

During the trip from Bandung, that lays on 800 metres above sea level, to Jakarta the train has to brake frequently to keep the speed within limits. Because of this, the wear on the wheel's diameter or the increase in the the height of the wheel flange will be more important here than for other trips such as Jakarta - Surabaya.

4.9.2. Comparison wear between built-up wheel and non built-up wheel

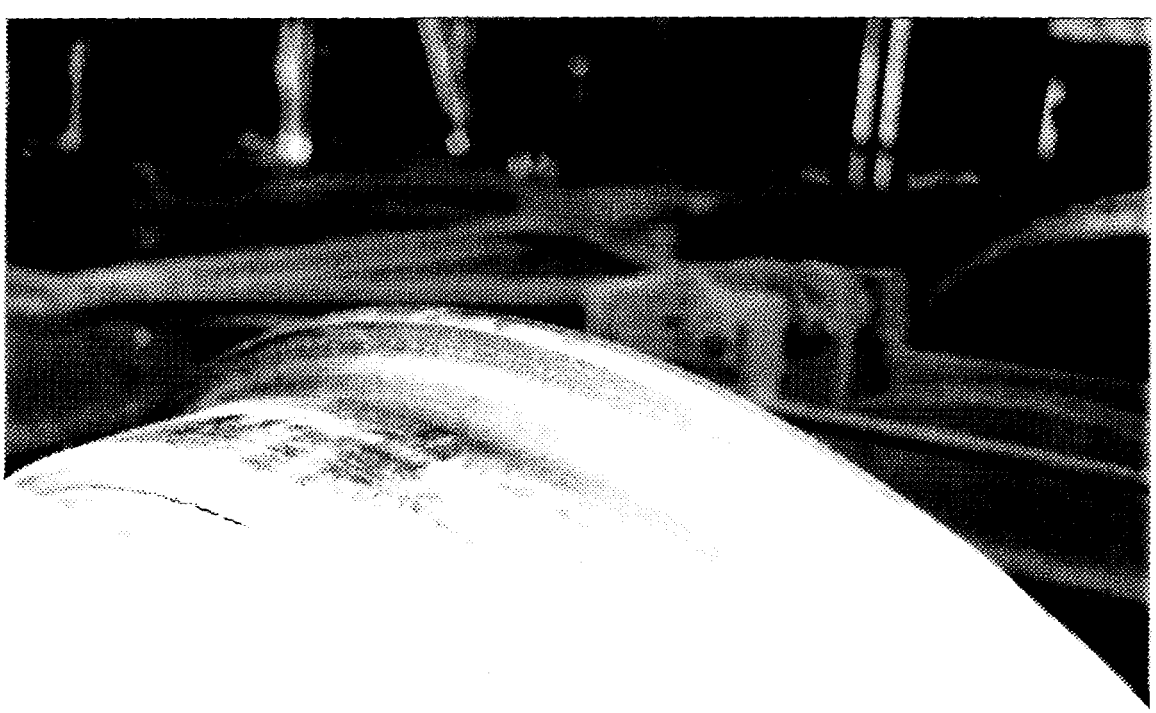
In Appendix 23 you can find the measurement results in millimetres of 16 wheelsets. In the table below we give the summary.

	Number		Nominal			Mean value			Avg. wear after 100,000 km		
	Left	Right	Qr	H	T	Qr	H	T	Qr	H	T
Built-up	11	5	10	27	30	8.19	29	28.0	1.73	2	1.9
Non built-up	5	11	10	27	30	8.25	29	27.5	1.67	2	2.4

We can conclude from this that, after 100,000 km, there is no significant difference in wear between a non built-up wheel (base metal) and a built-up wheel.

4.9.3. Condition of the built-up wheel

The photographs below show built-up wheels after 100,000 km of operation.



From this we can conclude that :

- the wheel flanges are worn equally according to the shape of the rail head. This is similar to new wheels;
- reprofiling of the built-up wheel after work hardening does not cause any problems. It can be easily done with the existing cutting tools at normal cutting speed on the wheel lathe;
- no cracks or other defects have been detected.

4.9.4. Hardness of the built-up wheel

We have collected data about the hardness of both built-up and non built-up wheels. The results can be found in Appendix 24.

From this we can conclude that the hardness of the built-up deposit is work hardening. Through this increase in hardness the wear will stabilise.

4.9.5. Conclusions

First we can conclude that the building-up technology implemented by this project has the following advantages over the previous building-up method (See inception report):

At the time of building-up :
- high welding quality, no porosities, no cracks;
- none had to be scrapped because it cracked after cooling down;
- easy machinable.

After 100,000 km of operation :
- all wheels that were built up under the project are still in operation;
- remains machinable with existing means;
- no cracks or other defects;
- same wear as a new wheel.

It is obvious that this welding technology has improved the safety of operation in a significant way.

The present situation proves that :
- this technology is adapted for use in a country with difficult conditions;
- it can easily be mastered by the local staff through training;
- if the welding specifications are applied, a good welding quality is achieved without any failures;
- all typesof wheels can be built up;
- the equipment is robust, easy to use and to maintain.

Secondly, on the possible increase in running kilometres compared to new wheels, it's still too early to draw final conclusions. Therefore, a follow-up is needed after six months or another 100,000 km to check the following :

1. The progress in wear of the thickness of the flange of the wheels that have been measured.
2. The increase in the hardness of the base metal and the built-up deposit in terms of running kilometres for wheels put into operation. A measuring programme should be set up.
3. Collect information about wheels running on flat track. For example Jakarta - Surabaya.

The purpose is to get information about how the hardness because of work hardening increases and how the wear develops accordingly.

5. ECONOMIC EFFECTIVENESS OF BUILDING-UP OF RAILWAY WHEELS

5.1. INTRODUCTION

The economic effectiveness of building-up of railway wheels is assessed by means of a comparative analysis of the possible technical solution variants based on reconditioning, reprofiling and procurement costs.

We consider three technical solution variants :

1. Variant 1 : Building-up of one wheel per wheelset.
2. Variant 2 : Building-up of two wheels per wheelset.
3. Variant 3 : Reprofiling of the two wheels per wheelset without building-up.

The cost of each variant consists of :

- variable costs or operating costs
- fixed costs taking into account capital investment, depreciation etc.

These costs are calculated in the next chapters. As a basis, we take the actual Rupiah rate of 2300 Rp per 1US$ into account.

5.2. OPERATING COSTS or VARIABLE COSTS

5.2.1. OPERATING COST OF THE BUILDING-UP PROCESS (VARIANT 1 AND 2)

The operating cost consists of :

- labour costs based on a time analysis
- material costs based on an average consumption after building-up 100 wheels

5.2.1.1. LABOUR COSTS

a) Time analysis of the building-up process

The flow chart of the building-up process can be found in Appendix 12.

Oper.	Description	Operator	Exec. time in minutes	Alloc. time in minutes
			one wheel	two wheels
1	Weld preparation by reprofiling (incl. mounting on and dismounting from wheel lathe)	Wheel lathe	25	25
2	Transport to temporary storage track / workstation before building-up.	Wheel lathe	5	5
3	Mounting of the wheelset on the turning table (incl. cleaning, positioning and fastening)	Welder	5	10
4	Inspection (visual, sound test, ultrasonic inspection)	Inspector	10	15
5	Preheating	Welder	15	30
6	Building-up of the wheel (average 10 welds)	Welder	50	100
7	Putting into cooling container (incl. dismounting from turning table, transport, covering with vermiculite)	Welder	8	16
8	Lifting of wheelset out of container	Welder	5	10
9	Transport to wheel lathe	Welder	3	6
10	Reprofiling (incl. mounting on and dismounting from wheel lathe	Wheel lathe	25	25
11	Final inspection and recording of data	Inspector	10	15

Remark :
In the case of building-up one wheel of the wheelset, only one welder is needed and the execution time is equal to the allocated time.
On the other hand, when the two wheels are built up at the same time the executing time will remain unchanged while the allocated time for the welder will double because the job has to be done by two welders.

Summary

Operator	Total time in minutes one wheel	Total time in minutes two wheels
Wheel lathe	55	55
Welder	86	172
Inspector	20	30
Total operating time	**161**	**257**
Unforeseen events (10% execution time)	16	26
Total allocated time	**177 or 3 hours**	**283 or 5 hours**

As we can notice in the table, the longest execution time is this of the welder with about 1.5 hour of working time. This means that it is possible to produce four wheelsets during one eight hour shift.

b) Calculation of the labour costs

The basic wages of workers directly involved in the reconditioning process are the main element for the calculation of labour costs. In the case of the Manggarai Workshop this is 1,500 Rp per hour.

We have to add to the direct labour cost a certain amount for indirect costs such as :

- shop expenses;
- management expenses;
- planning expenses, etc.

These indirect cost standards are normally calculated on the basis of statistical indicators proper to the workshop. These indicators are unknown for the Manggarai Workshop. Therefore, after discussion with the local project manager, the indirect labour costs were determined at 1,500 Rp per man-hour.

The labour costs

Operation	Man-hours	Labour cost/hour	Total labour cost
		Rupiah	Rupiah
One wheel	3	3,000	9,000
Two wheels	5	3,000	15,000

5.2.1.2. MATERIAL COSTS

Material	Unit	Unit price (Rupiah)	Average consumption per wheel	Cost (Rupiah)
Welding wire	kg	36,800	2.5	92,000
LPG gas	cylinder 50 kg	78,300	0.089	6,968
Oxygen	cylinder 7 m^3	22,800	0.346	7,889
Electricity	kWh	130	4.5	585
Total for one wheel				**107,442**
Total for two wheels				**214,884**

The unit price includes all costs for purchasing and stock keeping.

5.2.1.3. OTHER COSTS DUE TO REPROFILING (TOOLS AND ENERGY)

For reprofiling and handling of the wheels only marginal costs are taken into account because there is a wheel lathe and a crane bridge.

These costs are estimated at 7,000 Rp in case of one wheel and 14,000 Rp in case of two wheels.

5.2.1.4. SUMMARY

Operation	Total cost
	Rupiah
Building-up of one wheel per wheelset	
1. Labour costs	9,000
2. Material costs	107,442
3. Other costs due to reprofiling	7,000
Total	**123,442**
Building-up of two wheels per wheelset	
1. Labour costs	15,000
2. Material costs	214,884
3. Other costs due to reprofiling	14,000
Total	**243,884**

5.2.2. Cost of reprofiling without building-up (variant 3)

For reprofiling and handling of the wheels, only marginal costs are taken into account because there is a wheel lathe and a crane bridge.

5.2.2.1. LABOUR COST

As you can see in table under 5.2.1.1. Time analysis, the execution time is 30 minutes.

The labour cost is thus 1500 Rp for one wheelset or two wheels.

5.2.2.2. OTHER COSTS DUE TO REPROFILING (TOOLS AND ENERGY)

These costs are estimated at 14,000 Rp.

5.2.2.3. SUMMARY

Operation	**Total cost**
	Rupiah
Reprofiling without building-up	
1. Labour costs	1,500
2. Other costs due to reprofiling	14,000
Total	**15,500**

5.3. COMPARATIVE ANALYSIS OF THE THREE VARIANTS

We refer to 4.9. Technical results presented at the TPR meeting. This analysis is valid for wheels running in trains between Jakarta and Bandung. For other destinations data should be collected in the same way.
For Jakarta - Bandung the average value of wear on the wheel diameter = 4 mm per 100,000 km.

- the maintenance programme for coaches defines that the periodicity between two overhauls for wheelsets is fixed at 250,000 running kilometres
- for reprofiling, we remove, on average, 4 mm material on the wheel diameter when building up and 15 mm material without building up
- cost price of a new solid wheel = 1,160,030 Rp.
- diameter new wheel = 774 mm, minimum diameter = 698 mm (at the time of overhaul in workshop)

Variant 1. Building-up one wheel per wheelset

Values

n	**diameter wheel**		
	wear	reprofiling	total
250,000	10	4	14

Operating	Running	Scenario	Diameter	Reprofiling	Building-up	Building-up	Cost
period (*)	kilometres		mm		wheel 1	wheel 2	Rp
	0	New wheel	774	No	No	No	2,320,060
1n	250,000	Building-up	760	Yes	Yes	No	123,442
2n	500,000	Building-up	746	Yes	No	Yes	123,442
3n	750,000	Building-up	732	Yes	Yes	No	123,442
4n	1,000,000	Building-up	718	Yes	No	Yes	123,442
5n	1,250,000	Building-up	704	Yes	Yes	No	123,442
6n	1,500,000	Replacement	694	No	No	No	0
Total cost for 6n kilometres for one wheelset (two wheels)							**2,937,270**
Average cost per n kilometres for one wheelset (two wheels)							**489,545**

(*) n = operating km before the wear limits are reached for a new wheel

Variant 2. Building-up of the two wheels of the wheelset

Values

n	diameter wheel		
	wear	reprofiling	total
250,000	10	4	14

Operating	Running	Scenario	Diameter	Reprofiling	Building-up	Building-up	Cost
period (*)	kilometres		mm		wheel 1	wheel 2	Rp
	0	New wheels	774	No	No	No	2,320,060
1n	250,000	Building-up	760	Yes	Yes	Yes	243,884
2n	500,000	Building-up	746	Yes	Yes	Yes	243,884
3n	750,000	Building-up	732	Yes	Yes	Yes	243,884
4n	1,000,000	Building-up	718	Yes	Yes	Yes	243,884
5n	1,250,000	Building-up	704	Yes	Yes	Yes	243,884
6n	1,500,000	Replacement	694	No	No	No	0
Total cost for 6n kilometres for one wheelset (two wheels)							**3,539,480**
Average cost per n kilometres for one wheelset (two wheels)							**589,913**

(*) n = operating km before the wear limits are reached for a new wheel

Variant 3. Reprofiling without building-up

Values

n	diameter wheel		
	wear	reprofiling	total
250,000	10	15	28

Operating	Running	Scenario	Diameter	Reprofiling	Building-up	Building-up	Cost
period	kilometres		mm		wheel 1	wheel 2	Rp
	0	New wheel	774	No	No	No	2,320,060
1n	250,000	Reprofiling	746	Yes	No	No	15,500
2n	500,000	Reprofiling	718	Yes	No	No	15,500
3n	750,000	Replacement	690	No	No	No	
Total cost for 3n kilometres for one wheelset (two wheels)							**2,351,060**
Average cost per n kilometres for one wheelset (two wheels)							**783,687**

Comparative analysis of the three technical solution variants.

In variant 1 and 2 "Building-up of wheels", the wheels have to be replaced after 6n kilometres. In order to compare the two building-up variants with variant 3 "Reprofiling without building-up" we will calculate the maintenance and renewal cost for each scenario to cover 6n kilometres.

Kilometres	Variant 1	Variant 2	Variant 3
	Rp	Rp	Rp
Maintenance and renewal cost			
0	2,320,060	2,320,060	2,320,060
1n	123,442	243,884	15,500
2n	123,442	243,884	15,500
3n	123,442	243,884	2,320,060
4n	123,442	243,884	15,500
5n	123,442	243,884	15,500
6n	0	0	0
Total	**2,937,270**	**3,539,480**	**4,702,120**
Percentage	**62%**	**75%**	**100%**
Currency			
Foreign	2,780,060	3,240,060	4,640,120
Percentage	**60%**	**70%**	**100%**
Local	157,210	299,420	62,000
Lifetime			
Kilometres	6n	6n	3n
Percentage	**200%**	**200%**	**100%**

The foreign currency component consists of :
- welding wire = 92,000 Rp/wheel
- solid wheel = 1,160,030 Rp/wheel

5.4. FIXED COSTS

The fixed costs are the costs resulting from the investment made to procure the machines with an actual value of 52,421 US$ or 120,568,300 Rp. For this kind of equipment, the writing off period is fixed at 10 years.

This is of course only valid for future investments because the machines supplied under the UNIDO project are on grant basis.

The yearly fixed costs in actual Rupiah is 30,142,075 Rp as you can see in the next table.

Year	Investment		Writing off 10%	Rest value	Interest rate 15%	Total fixed cost
	US$	Rp	Rp	Rp	Rp	Rp
0	52,421	120,568,300				
1			12,056,830	108,511,470	18,085,245	**30,142,075**
2			12,056,830	96,454,640	18,085,245	**30,142,075**
3			12,056,830	84,397,810	18,085,245	**30,142,075**
4			12,056,830	72,340,980	18,085,245	**30,142,075**
5			12,056,830	60,284,150	18,085,245	**30,142,075**
6			12,056,830	48,227,320	18,085,245	**30,142,075**
7			12,056,830	36,170,490	18,085,245	**30,142,075**
8			12,056,830	24,113,660	18,085,245	**30,142,075**
9			12,056,830	12,056,830	18,085,245	**30,142,075**
10			12,056,830	-	18,085,245	**30,142,075**

This amount of 30,142,075 Rp is divided over the total yearly production. The next table shows the relation between the production and the reconditioning costs of building-up.

Fixed cost	Capacity	Wheelsets			Wheels		
Rp	use	Qty/day	Qty/year	Rp	Qty/day	Qty/year	Rp
30,142,075	25%	1	250	120,568	2	500	60,284
30,142,075	50%	2	500	60,284	4	1,000	30,142
30,142,075	75%	3	750	40,189	6	1,500	20,095
30,142,075	100%	4	1,000	30,142	8	2,000	15,071

In the next table, we compare the total costs of variant 1 "Building-up of one wheel per wheelset" with those of variant 3 "Reprofiling without building-up" for a capacity use of 25% and 100%.

Variant 1

Kilometres	Capacity use 25%			Capacity use 100%			Variant 3
	Variable	Fixed	Total	Variable	Fixed	Total	
	Rp	Rp	Rp	Rp	Rp	Rp	Rp
Maintenance and renewal cost							
0	2,320,060		2,320,060	2,320,060		2,320,060	2,320,060
1n	123,442	120,568	244,010	123,442	30,142	153,584	15,500
2n	123,442	120,568	244,010	123,442	30,142	153,584	15,500
3n	123,442	120,568	244,010	123,442	30,142	153,584	2,320,060
4n	123,442	120,568	244,010	123,442	30,142	153,584	15,500
5n	123,442	120,568	244,010	123,442	30,142	153,584	15,500
6n	0	0	0	0	0	0	0
Total	**2,937,270**	**602,840**	**3,540,110**	**2,937,270**	**150,710**	**3,087,980**	**4,702,120**
Percentage			**75%**			**66%**	**100%**

From this, we can conclude that following savings can be obtained over the wheels' lifetime:
- savings of 25% even with a low capacity use of only 25%;
- savings of 34% if the workstation is used at its maximum capacity.

In the next table, we compare the total costs of variant 2 "Building-up of two wheels per wheelset" with those of variant 3 "Reprofiling without building-up" for a capacity use of 25% and 100%.

Variant 2

Kilometres	Capacity use 25%			Capacity use 100%			Variant 3
	Variable	Fixed	Total	Variable	Fixed	Total	
	Rp	Rp	Rp	Rp	Rp	Rp	Rp
Maintenance and renewal cost							
0	2,320,060		2,320,060	2,320,060		2,320,060	2,320,060
1n	243,884	120,568	364,452	243,884	30,142	274,026	15,500
2n	243,884	120,568	364,452	243,884	30,142	274,026	15,500
3n	243,884	120,568	364,452	243,884	30,142	274,026	2,320,060
4n	243,884	120,568	364,452	243,884	30,142	274,026	15,500
5n	243,884	120,568	364,452	243,884	30,142	274,026	15,500
6n	0	0	0	0	0	0	0
Total	**3,539,480**	**602,840**	**4,142,320**	**3,539,480**	**150,710**	**3,690,190**	**4,702,120**
Percentage			**88%**			**78%**	**100%**

From this, we can conclude that following savings can be obtained over the wheels' lifetime:
- savings of 12% even with a low capacity use of only 25%;
- savings of 22% if the workstation is used at its maximum capacity.

5.5. CONCLUSION

The following conclusions can be drawn :

- The building-up technique allows important savings in terms of the average maintenance renewal costs up to 38 % and foreign currency up to 40 %. The lifetime of the wheel is doubled.
- The choice which building-up variant has to be used depends on the wheel flange dimensions after reprofiling before building-up. There is for the moment no significant argument to build-up both wheels systematically.
- It is clear that PERUMKA should try to use the workstation at its full capacity of four wheelsets per day to generate more savings. This is possible because all types of wheels without cracks can be built up with the implemented technology.
- Even in the case of procurement of the equipment for extension towards other workshops, the investment will generate important savings up to 34 %.

6. POSSIBILITIES FOR PRIVATE AND PUBLIC INVESTMENTS

6.1. In Indonesia

We had a meeting with PADI, local distributor of Eutectic+Castolin, who has shown interest to take over the workstation from PERUMKA and to build up the railway wheels at a fixed cost. They have submitted a proposal to Mr Iim Abdul Hakim, national project manager. There is not yet an agreement on this matter.

Mr Decostere met Mr Koensabdono, Kasubdit Balai Yasa and Mr Bambang, Kepala Bidang Traksi on 29 April in Bandung to discuss the results of this project and to search for further possibilities for extension towards other PERUMKA's workshops : Yogyakarta (locomotives), Surabaya and Tegal (wagons) and Lahat (wagons). From this meeting we could conclude that PERUMKA will evaluate the technical results and the economic effectiveness of the project. If they decide to extend it to the other workshops, they will send an official request with a draft project document to UNIDO for further technical assistance.

6.2. South-East Asia

Other countries that have shown interest are Vietnam, India and Myanmar.

A similar equipment has already been supplied to the Vinh Locomotive Workshop in Vietnam. Other possible workshops are Gia Lam at Hanoi and Saigon.

The Indian Railway Company is also interested according to Mr Tinjani of Eutectic+Castolin whose company Larsen&Toubro Limited is located in Bombay, India.

Mr Decostere participated in the World Bank Technical Assistance Project for Myanma Railways in 1993 - 1994. At that time there was demand to seek finance for a workstation at the
Insein Workshop near Yangon and Myitnge Workshop near Mandalay.

6.3. Africa, Latin America and Eastern Europe

Other developing countries in the world facing the same difficulties as Indonesia, see under 2.1. Background, could also be interested.

We believe that a promotion video of this technology could be very useful in convincing Railways authorities of the quality and the economic effectiveness.

7. EVALUATION OF THE PROJECT

On 24 April 1997, the Tripartite Review Meeting took place with all concerned parties. At this meeting, the results of the project were evaluated. Hereafter, we give the text of Mr Iim Abdul Hakim, National Project Director, on the achievements of the project outputs, technical problems and the lessons learned.

7.1. ACHIEVEMENT OF THE PROJECT OUTPUTS

7.1.1. Purpose (Immediate Objective) of the project

- 500 built-up wheelsets, quality control of the upwelding included;
- a fully equipped workstation for building-up of railway wheels with a capacity of 100 wheelsets per month;
- a team of four skilled workers trained in building-up of wheels.

7.1.2. Project outputs

1. An inception report describing in detail the implementation modalities/workplan, the expertise of the local wheel conditions (wear-out dimensions, chemical components steel, etc.), the welding procedure, the required logistics (workshop, work space, power supply, handling and welding equipment, manpower, etc.), technical specifications of equipment.
2. A fully equipped workstation for building-up of railway wheels and quality control with a capacity of 100 wheelsets per month, start of series production, 500 built-up wheelsets during project implementation.
3. Through on-the-job-training, four local technical staff memberstrained in operating the workstation and applying the new building-up technology.
4. Appropriate welding technology data collected, analysed, evaluated and quality control tests manual compiled; manuals and maintenance specifications of supplied equipment available, general recommendations on the workshop/workstation management prepared by the international experts for the use of the Government to facilitate their decision-making to introduce the railway wheels building-up technique within other railway workshops in Indonesia.
5. An assessment of the possibilities for private or public investment in this technology in Indonesia as well as in similar countries of South-East Asia

7.1.3. Achievements of the project outputs

7.1.3.1. WORKSTATION, EQUIPMENT AND CONSUMABLES

The **workstation**'s design and layout have been done in a way that they could be integrated as a whole in the existing wheelshop at a limited cost for :

- civil works : concrete floor and storage tracks;
- electric power supply : use of existing electric board and installation of some additional switch boxes;
- compressed air supply : the compressed air is supplied by a newly installed compressor;
- lifting equipment : use of existing crane bridge that has been electrified;
- gas and oxygen supply : manifolds for LPG and oxygen have been installed equipped with gas flow regulators and sparkarresters for safe operation;
- work safety : wooden fences to protect the other employees against Ultra Violet and Infra Red rays.

The **equipment** was supplied according to the terms of reference in the inception report:

- two welding posts;
- one turning table equipped with a special claw plate mounted together with the two supports on a solid frame to facilitate handling and alignment during the installation;
- one exhauster with two hoods to evacuate the fumes from welding;
- two pneumatic weld scalers to remove the slag;
- four heavy duty burners and flow-regulators for LPG and oxygen for preheating;
- a set of spare parts;
- the instruction manuals and spare parts list.

These are mainly standard and multi-purpose machines, which is an advantage for maintenance and spare parts supply.
The equipment is easy to operate by the trained welders and until now we haven't had any breakdowns. A weak part in the torch head that was detected after 4 months of use has been replaced by an adapted and improved design by the Contractor.

As consumables we have received 5000 kg of the welding wire Teromatec AN 3205 ∅ 1.6 mm and sufficient vermiculite as insulation material.

7.1.3.2. TRAINING

Following staff have been trained by the welding experts in using the welding technology, in doing quality control and preventive maintenance: one supervisor, one mechanic and two welders.

7.1.3.3. STUDY TOUR

A **study tour** has been organised by the Contractor for the National Project Director Mr Iim Abdul Hakim in Belgium on the reconditioning of spare parts by welding and spray techniques. This study tour consisted of a number of seminar days on the subject and field visits to workshops of the Belgian Railway Company (Gentbrugge, Mechelen and Salzinnes) and Castolin-Eutectic (Brussels and Eindhoven).

7.1.3.4. TECHNICAL ASSISTANCE

The technical assistance has been provided as follows :

a. Identification phase - See inception report

- a detailed expertise of the local wheel conditions (wear-out dimensions, metallurgic composition steel, etc.);
- a survey on the previously used method of building-up of wheels and comments on the quality;
- a survey of the workshop facilities and equipment in terms of availability of LPG gas, oxygen, electric power, compressed air, handling equipment, wheel lathe, ultrasonic testing device;
- design of the workstation to define the necessary infrastructure works;
- define the list of the necessary equipment and tools and their technical characteristics;
- define the welding specifications according to the composition of the base metal.

b. Preparation phase - See progress report

- testing of the equipment at the supplier's prior to its shipment to Indonesia;
- installation of the equipment in the Manggarai Workshop;
- trial before start of the production.

c. Implementation phase

Implementation phase - 1st part - See quality control report

- trial to build up solid CC and KRL wheels to update the draft welding specifications and building-up process flow chart after quality check;
- draft the welding specifications for building-up of the CC and KRL wheels;
- training of the workshop's staff in building-up and quality control.

Implementation phase - 2nd part - See draft final report

- inspection of the quality of the building-up and the application of the welding specifications;
- further training of the welders in maintaining of the equipment;
- conducting a seminar on the reconditioning of spare parts by welding and their application in different sectors of Industry and the building-up of railway wheels in particular;
- draft a first appraisal report on the economic effectiveness of building-up of railway wheels.

Implementation phase - 3rd part - See final report

- building-up of tyre and locomotive wheels. This means that all kinds of wheels in use at PERUMKA can be built up with the building-up technique implemented by this project. Technically spoken, an extension towards the building-up of locomotive wheels at the Yogyakarta Workshop and wagon wheels at the Workshops of Surabaya, Tegal and Lehat is possible using similar equipment and adapted welding procedure specifications;
- final report on the economic effectiveness of building-up of railway wheels;
- Tripartite Review Meeting.

7.1.3.5. PRODUCTION : 500 BUILT-UP WHEELSETS (1000 WHEELS)

The total number of 500 built-up wheelsets or 1000 wheels could not be reached at the end of the project because of :

- PERUMKA could not put 80 wheelsets a month at the disposal of the project as requested under "Government Contributions" in the inception report. This was caused by a lack of coaches entering for overhaul, tyred and cracked wheels which are excluded from the project;
- as a general rule only one wheel of the wheelset needs to be built up. The reason for this is that, as PERUMKA does not turn the coaches on a regular basis, the flange of only one wheel of the wheelset is worn out. By reprofiling the wheelset before building up one wheel obtains its normal wheel profile while the other does not. This means that 1000 wheelsets instead of 500 wheelsets will be necessary to reach 1000 wheels;
- The actual production is 152 built-up wheelsets.

7.1.3.6. ASSESSMENT OF THE POSSIBILITIES FOR PRIVATE INVESTMENT

A proposal from PADI, local distributor of Eutectic+Castolin, who has shown interest in taking the workstation at the Manggarai Workshop over from PERUMKA, to build up the railway wheels at a fixed cost is under discussion with PERUMKA.

7.2. Technical problems encountered

Below we give an overview of the technical problems encountered and how they have been solved.

7.2.1 Set-up of workstation. Infrastructure works by PERUMKA.

Problem	Solution
A. Energy supply	
1. Electric switch boxes not available at location	Installing electric switch boxes (welding posts, turning table and exhauster)
2. Compressed air not available at location	Installing of new compressor and pipe line towards the workstation
3. LPG and oxygen not available at location	Installing of manifolds for LPG and oxygen, flow regulators and pipeline towards the workstation
B. Handling equipment	
1. Overhead travelling crane. Lifting manually.	Motorisation of the lifting movement.
C. Ultrasonic crack detector	
1. Measuring cable and normal probe missing.	Procurement of these parts
D. Workstation	
1. Concrete floor in poor condition	Renewal of the concrete floor Installing of two short tracks for wheelsets awaiting building-up
2. Location of the workstation in the centre of the wheelshop and the presence of workers who are not protected against UV and IR rays.	Construction of a separation wall around the workstation with entrance
E. Cooling down containers	
1. Have to be designed and manufactured to hold the wheelsets after building-up	Manufacturing of : ■ four containers for CC/GG wheels ∅ 774 mm ■ one container for KRL wheels ∅ 860 mm

Completion as scheduled on January 1996

7.2.2. Equipment. By supplier Castolin+Eutectic Benelux.

Problem	Solution
1) Alignment of the turning table and the supports wheels. Difficulty for installation in the project area.	1) Mounting of the turning table and supports on a solid frame to make handling and installation easier, to guarantee perfect alignment.
2) Difference in axle diameters. Therefore the height of the supports should be easily changed.	2) Modification of the supporting wheels and manufacturing of thickness plates to adjust the height of the supporting wheels.
3) The thread of the torch holder gets easily damaged	3) The design has been changed and two extra torch holders have been supplied

7.2.3. Installation of the equipment. By contractor Transurb Consult and Castolin+Eutectic.

Time schedule	
1) Order equipment by UNIDO	20 February 1996
2) Testing equipment at supplier	17 April 1996
3) Shipment equipment to Jakarta	30 April 1996
4) Arrival at Manggarai WS	30 July 1996
5) Start installation	26 August 1996
6) Start production	2 September 1996
Problem	**Solution**
1) sparkarresters for LPG and oxygen were forgotten on the equipment list and are missing.	1) Sparkarresters were purchased from the local supplier Aneka Gas Industries by PERUMKA

7.2.4. Start of production

Problem	Solution
1) Demand of PERUMKA to build up all types of wheelsets sent for overhaul to the wheelshop. At the beginning only solid wheels would be built up and not tyred wheels. A trial to build up tyred wheels at the start of the implementation failed.	1) 1st step : Solid wheels CC and KRL wheels. From the start of implementation. September '96 until due 2) 2nd step: Tyred wheels for coaches. Modification of the welding procedure specification. Trial successful. April 1997 3) 3rd step : Locomotive wheels from Sumatra. Building-up of the whole running surface of the wheel in order to reuse wheels that have reached their minimum diameter. April 1997. 4) 4th step : KRL wheelsets with gearbox. April 1997.
2) Overestimation of the number of wheels that could be built up per month. In the inception report 80 wheelsets per month were mentioned. Because of : - less coaches entering for overhaul, so less wheelsets available for overhaul; - cracked wheels excluded from building-up; - only solid wheels CC and KRL.	As already stated above, the Contractor has done tests and drafted new welding procedure specifications to extend the project scope to tyred wheels for coaches and locomotive wheels. As a result more wheels can be built up with the new building-up technique and the production will increase.
3) The capacity of the workstation is limited to 4 wheelsets per 8 hours shift. This was one of the objectives.	The total capacity of the workstation is not used. But should there be an increase in production, PERUMKA could consider to modify the old workstation towards the new building-up technology.
4) Wheels that have been built up with the previous building-up technique have cracks which exclude them from the project.	PERUMKA should : - reprofile without building up these wheels until there are no longer cracks visible. After being put into operation and no new cracks visible, building-up with the new technique can be done. - stop using the old workstation.

7.3. LESSONS LEARNED

To make a proper evaluation and analysis of the results using this building-up technology, it is necessary to collect reliable data about the wearing process.

This could not be done properly because of :

- The identification of the wheels is difficult once they are in operation. Although each axle and wheel have their own serial number painted in yellow the number becomes unreadable and cleaning is necessary. Measurements are also difficult to do while the coach is in the train because of the limited space.
- An accurate measurement device for measuring the dimensions of the wheel flange was not available from the start. It was brought from Europe for temporary use. PERUMKA plans to order one.
- We have noticed that some wheels had important differences after reprofiling due to misadjustment of the wheel lathe. This was not noticed at the start of the production and the initial values of height and thickness are not available.
- According to the technical characteristics of the welding wire, a hardness of 420 HB should be obtained after work hardening. This was not measured at the start because a mobile hardness tester was not available.
- The wear we notice on the built-up wheel will stabilise after it reaches its maximum hardness. After how many running kilometres this happens and to what extent are parameters we don't know yet.
- We could only collect data about wheels running in trains between Jakarta and Bandung.

Recommendations :

We recommend to:

a) plan **a follow-up** of the results within six months by the Consultant. The collecting should be organised as follows :

- take a sample of 40 wheelsets for follow-up, 20 wheelsets should be put under coaches running between Jakarta - Bandung (mountain) and 20 wheelsets in trains between Jakarta - Surabaya (flat);
- record carefully the dimensions (height and thickness) and hardness of built-up deposit and base metal before putting the wheelsets into operation;
- put a special mark on the bogies/coaches under which they are put and which is clearly visible by the inspector;
- record carefully the number of running kilometres of the coach and notify the workshop about any replacement of wheels or bogies so that the recording of the kilometres continues to be reliable;
- check the hardness after each round trip until it doesn't change any longer to collect information about the work hardening process;
- three-monthly record the progress of wear and the number of running kilometres.

b) supply measuring equipment to measure the dimensions of the wheel flange and to test the hardness.

8. FOLLOW-UP PROPOSALS

8.1. Follow-up mission

As already discussed under "7.3. Lessons learned" it is necessary to plan a follow-up mission after six months :

- to analyse the collected data about the wearing progress;
- to check the condition of a number of built-up wheels under coaches returning for their overhaul to the Manggarai Workshop;
- to check if the Manggarai Workshop still follows the welding procedure specifications;
- to check the quality of the building-up process;
- to check if the workstation has been well maintained and is still functioning;
- to remedy all problems encountered to guarantee a smooth continuation of building-up of wheels.

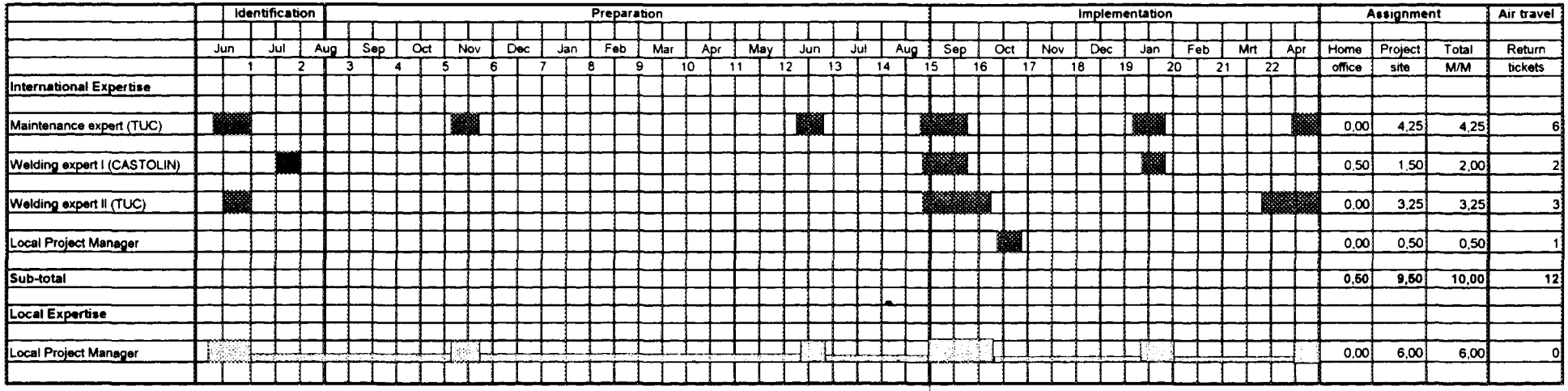
8.2. Promoting of the building-up technology

In order to promote the building-up technology to other Railway Companies of developing countries we recommend to produce a video. This video should show the workstation, the building-up process, the training, the technical results and wear after operation and highlight the economic benefits.

8.3. Extension of the building-up technology towards the other PERUMKA workshops.

We propose to assist PERUMKA in making a market assessment to define which workshops should be equipped for implementing this technology. This could be corporated in a overall assessment of the existing practices of overhaul and repair of wheelsets.

APPENDICES



LEGEND

		realised
On specific assignment on project site (foreign staff)		■
On specific assignment at home office (foreign staff)		■
On specific assignment on project site (local staff)	100%	□
	partly	—
Facility ready for operation		milestone

Order equipment by UNIDO : 20 February 1996
Testing equipment : 17 April 1996
Shipment equipment to Jakarta : 30 April 1996
Arrival in Jakarta : 25 May 1996
Arrival in Manggarai WS : 30 July 1996
Start implementation : 26 August 1996
End project : 2 May 1997

Modification approved by UNIDO

- Replacement of Mr De Greef, Industrial Economist, by Mr Decostere, Team Leader
- Study tour to Europe of the Local Project Manager

Appendix 1

WORK SCHEDULE 3/06/97

Building up of Railway Wheels. Project US/INS/93/196

Appendix 2

Professional Services. **Final status on 2 May 1997**

1. W. Decostere - Team Leader + Industrial Economist

	Start	End	Days	Weeks	Months	Remarks
1st mission	**12/06/95**	**30/06/95**	15	3		realised
2nd mission	**6/11/95**	**21/11/95**	12	2,4		realised
3rd mission	**10/06/96**	**21/06/96**	10	2		realised
4th mission	**26/08/96**	**20/09/96**	20	4		realised
5th mission	**6/01/97**	**24/01/97**	15	3		realised
6th mission	**14/04/97**	**30/04/97**	13	2,6		realised
Total			85	17	4,25	

Remark : Mr Decostere takes 1 week of Mr Vandewalle. Sixth mission becomes 13 days instead of 8 days.

2. A. Maerten - Welding Expert

	Start	End	Days	Weeks	Months	
Home office	**10/07/95**	**21/07/95**	10	2		realised
1st mission	**26/08/96**	**20/09/96**	20	4		realised
2nd mission	**13/01/97**	**24/01/97**	10	2		realised
Total			40	8	2	

3. L. Van De Walle - Welding Expert

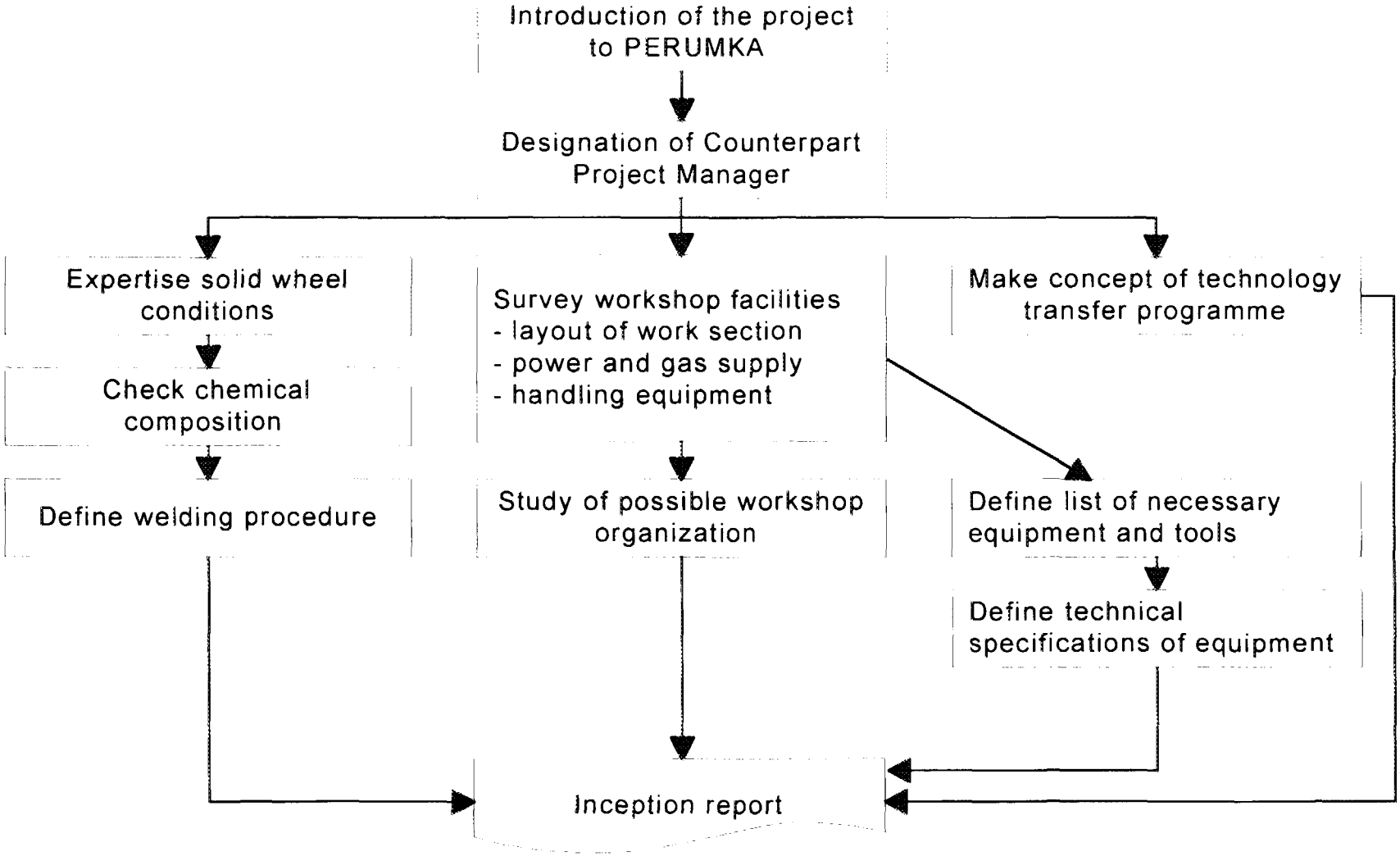
	Start	End	Days	Weeks	Months	Remarks
1st mission	**19/06/95**	**30/06/95**	10	2		realised
2nd mission	**26/08/96**	**4/10/96**	30	6		realised
3rd mission	**31/03/97**	**2/05/97**	25	5		realised
Total			65	13	3,25	

Remark : 1 week of Mr Van De Walle goes to Mr Decostere. Third mission becomes 25 working days or 5 weeks.

4. Iim Abdul Hakim - Local project manager

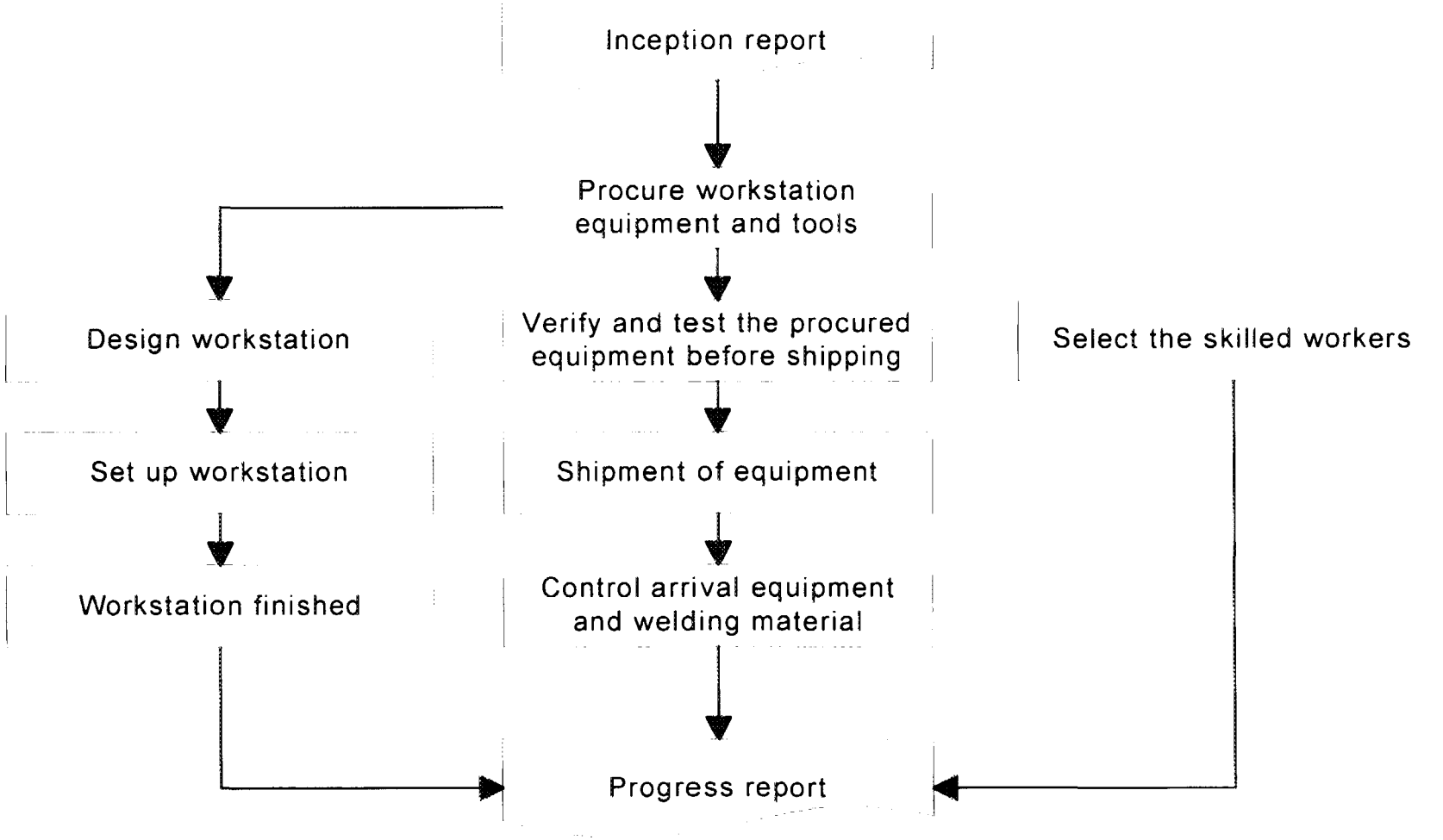
	Start	End	Days	Weeks	Months	Remarks
Study tour	**14/10/96**	**25/10/96**	10	2		realised
Total			10	2	0,5	

1. Identification phase



Appendix 3

2. Preparation phase

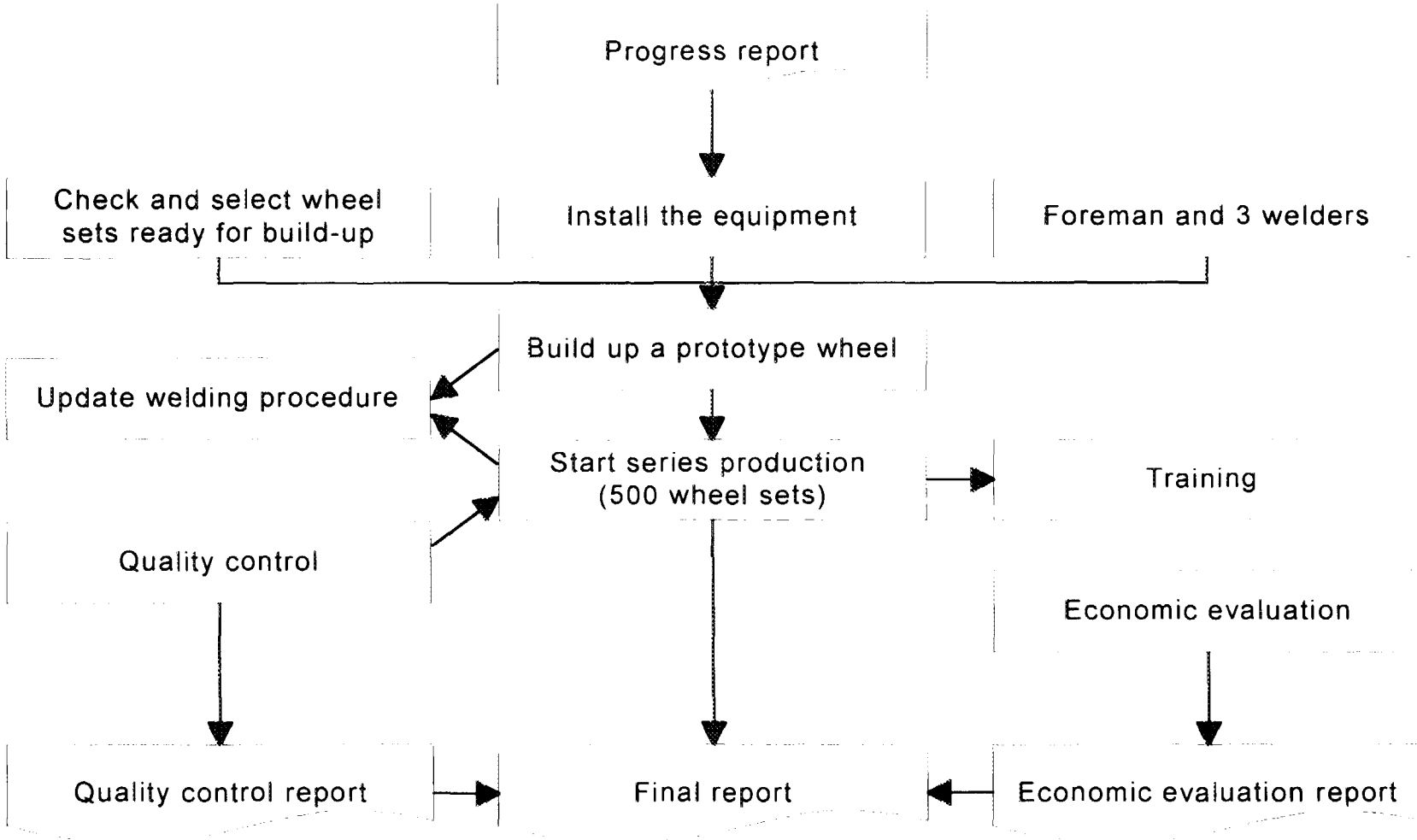


Appendix 5

PREPARATIVE WORKS FOR THE WORKSTATION BY PERUMKA

Tasks	Status on 31/01/96
1. Energy supply	
1.1. Provide electric power - electric cable and switch boxes	OK
1.2. Provide compressed air - new compressor	OK
1.3. Provide oxygen - room - manifolds, pipeline and outlets - heavy duty gas regulators	 OK OK OK
1.4. Provide LPG gas - room - manifolds, pipe line and outlets - heavy duty gas regulators	 OK OK OK
2. Handling equipment	
2.1. Rehabilitation of the two overhead travelling cranes. Electrical movement.	OK
3. Ultrasonic crack detector	
3.1. Create lifting point to turn the wheels while checking for cracks	Not necessary. Can be done on turning table.
3.2. Purchase measuring cable and normal probe	OK
3.3. Manufacture a fixed rack to hold the ultra son crack detector.	Not necessary. Can be done on the turning table
4. Workstation	
4.1. Renewal of the concrete floor	OK
4.2. Make an additional track for wheel sets awaiting building-up	OK
4.3. Make a separation wall with entrance around turning table	OK
5. Cooling down containers	
5.1. Manufacture four containers for CC wheels. ∅ 774 mm	OK
5.2. Manufacture one container for HH wheels. ∅ 860 mm	OK
5.3. Make an inquiry about the supply of vermiculite	Supplied by Castolin Benelux

3. Implementation phase



Appendix 7

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UN Building
Jl. M.H. Thamrin No. 14, Jakarta Pusat
P.O. Box 2338, Jakarta 10001. Indonesia
Telephone : 3141308. Cable Address : UNDEVPRO Jakarta. Telex : 69108 UNDP IA FAX : (6221) 3907126/3145251

US/INS/93/169 19 September 1996

Dear Mr. Kaulfersch,

Subject: US/INS/93/169 - Assistance in Building up Railway Wheels

We are writing to you concerning the above on-going project. We wish to inform you that on 10 September 1996 we attended a demonstration of this building up technology.

We hereby certify that the work station is ready for operation and that the production of reconditioned wheels has started. At the demonstration attended above, we also witnessed the fact that the training had started for counterpart personnel from the railway workshop which is the direct beneficiary of this project.

Thank you very much for your support and cooperation and with best regards,

Yours sincerely,

S.A. Hasnain
Country Director

Mr. Rainer Kaulfersch
Industrial Development Officer
Engineering and Metallurgical Industries Branch,
UNIDO, Vienna
AUSTRIA

PERUSAHAAN UMUM KERETA API

BALAI YASA TRAKSI MANGGARAI

Jakarta, 2 September 1996

SUBJECT : US/INS/93/169 - BUILDING UP OF RAILWAY WHEELS IN INDONESIA

Undersigned Mr Iim Abdul Hakim, Local Project Manager, and Mr W. Decostere, Team Leader, declare :

- that the equipment and welding wire have been supplied to the end user Manggarai Workshop in good condition and according to the purchase order nr 15-6-4032M of 15 February 1996;
- that all equipment has been installed by the expert team and that all machines are functioning;
- that the implementation say production has started;
- that the supervisor, the welders and maintenance staff have received sufficient training in building up of railway wheels and maintenance of the equipment.

Local Project Manager

Mr Iim Abdul Hakim
UK I Manggarai WS
PERUMKA

Team Leader

Mr W. Decostere

Appendix 9

TIME SCHEDULE AND CONTENTS OF THE STUDY TOUR

Date	Day	Activity	Location
11 Oct	Fri	Departure from Jakarta	
12 Oct	Sat	Arrival in Brussels, Belgium Transfer to Hotel by Mr Decostere.	Brussels
13 Oct	Sun	Free day at Bruges organised by Mr Decostere.	Bruges
14 Oct	Mon	Opening meeting with Transurb Consult and Castolin at SNCB HQ's on : ■ the results after starting the project's implementation; ■ difficulties encountered and solutions; ■ adjustments to be made to the project's work plan; ■ the proposed programme of the study tour and its schedule. Meeting with the staff of the SNCB's study office for welding to discuss in general the way in which reconditioning of spare parts is organised at the Belgian Railway Company.	Brussels
15 Oct	Tue	Lecture on spare parts reconditioning by welding by Castolin. Applications in industries, applied materials and machines.	Brussels
16 Oct	Wed	Lecture on spare parts reconditioning by hardsurfacing by Castolin. Applications in industries, applied materials and machines.	Brussels
17 Oct	Thu	Lecture on spare parts reconditioning by thermal spraying by Castolin. Applications in industries, applied materials and machines	Brussels
18 Oct	Fri	Lecture on economic selection of the reconditioning method by Castolin	Brussels
19 Oct	Sat	Free.	
20 Oct	Sun	Free.	
21 Oct	Mon	Visit to the CW Salzinnes for diesel locomotives. Reconditioning of locomotive parts.	Namur
22 Oct	Tue	Visit to the SNCB Laboratory. Control methods (non-destructive tests, tests on steel and metallographic analysis)	Brussels
23 Oct	Wed	Visit to the CW Mechelen for passenger coaches and electric railcars. Reconditioning of coach parts	Mechelen
24 Oct	Thu	Visit to the CW Gentbrugge for freight wagons. Reconditioning of wagon parts.	Gentbrugge
25 Oct	Fri	Final discussion at SNCB HQ's.	Brussels
26 Oct	Sat	Departure to Jakarta.	

TECHNICAL SPECIFICATIONS OF THE EQUIPMENT

1. Welding wire : Teromatec 3205 AN16

- Anti-wear alloy.
- Continuous flux-cored electrode, highly alloyed Cr. 12.5 % and Mn 14,5 %.
- Tensile strength: 750 - 800 N/mm²
- Elongation (l = 5d): approx. 25 %
- Impact resistance ISO V: approx. 80 J at 20 °C
- Hardness as welded: approx. 250 HV
- Hardness after hammering, work hardening: approx. 450 HV
- Electrode diameter: 1.6 mm
- Weight per roll: 12.5 kg

Quantity : 5,000 kg.

2. Turning table

Function

The turning table will be used to rotate the wheel set at an appropriate rotation speed while building up both wheel flanges at the same time.

Description

The workstation consists of two parts : the turning table and a pair of supports to carry the wheel set on its axle.

a) Turning table

Universal turning table with inclinable plate and continuously adjustable rotation speed.
The control unit must comprise at least the following features :

- on/off switch;
- left/right selector switch;
- continuously adjustable rotation speed.

The turning table is equipped with a three-jaw chuck to clamp one of the axle journals and through which the welding current will flow to the mass. The jaws may not damage the surface of the axle journal to avoid any problems in remounting of the roller bearings.

A special device is mounted between the turning table and the three-jaw chuck that permits :
- a certain shift while the wheel set is turning around;
- to shift the wheel set into the open jaws of the clamping chuck;
- to facilitate the rotating of the wheel set.

Technical specifications

Max. load	± 750 daN
Axle height of support above the floor	min. 625 mm
Inclination angle	130 °
Diameter of plate	± 1000 mm
Clamping range of three-jaw chuck	80 - 120 mm (See dimensions of axle journals)
Rotation speed	0,1 - 1,0 Rpm
Turning moment	1400 Nm
Max. welding current	750 A DC
Power supply	220V/monophase/50 Hz
Max. input power	0,5 kVA

Quantity : 1 unit

b) Supports

A pair of supports will carry the wheel set on its axle between the two wheels. They will be fixed on a solid steel frame with bolts together with the turning table. The supports consist of two sets of four steel wheels.

Because of the difference in diameter of the wheel axles : 140, 155 and 175 mm the height of the supports is adjusted against the fixed centre height of the clamping chuck by adding thickness plates.

Max. load	1000 daN

Quantity : 2 units

3. Welding power source

Function

The welding power source will supply electric power for welding and feed the welding wire.

Description

The electrical characteristics of the welding power source must be adapted to weld MIG/MAG solid wire and in particular cored wire electrodes with a diameter of 0,8 up to 2,4 mm.

The power source must be powerful and robust, able to weld in automatic process at least 1,6 mm cored wire under severe tropical conditions of temperature and humidity.

The power source must fulfil all requirements of the Standard EN 60974-1 and in particular these concerning safety for use in an environment with an increased risk of electric shock
The power source must be based on a stepping transfo-rectifier and comprise the following features:

- 4-roller drive for wire diameter 0,8 - 2,4 mm
- 2-step/4-step, as well as point and stick welding
- continuously adjustable point welding time
- continuously adjustable burn-back time
- currentless and gas-free wire feed for economical and safe loading of the welding torch
- automatic creep speed of the wire feed during ignition

Technical specifications

Current range:		30 - 430 A
Welding current:	at 45% ED *)	430 A
	at 60% ED *)	400 A
	at 100% ED *)	310 A
Max. open-circuit voltage:		44,5 V
Welding voltage:		15,2 - 34 V
Number of voltage phases:		6 x 6
Adjustable wire feed speed:		1 - 20 m/min
Conveyable wire diameters:		0,8 - 2,4 mm
Main voltage:		380 V, 3 phase, 50 Hz
Max. input power:		18,5 kVA
Max. input current:		27 A
Power factor cos φ :		0,95 at 400 A
Fuse rating:		32 A lag
Feed line:		4 x 4 mm^2
Enclosure protection class:		IP 21
Cooling system:		AF
Insulation class:		F

*) according to EN 60974-1

Quantity : 2 units

4. Welding torch

Function

The welding torch guides the wire into the weld zone and the welding current.

Technical specifications

Type:	BERNARD
Rating:	600 A/ 60 %
Cooling:	air-cooled
Length:	3 meter

Quantity : 2 units

5. Welding torch support and adjustment

Function

A support will hold the two welding torches in order to adjust them against the railway wheels in the right welding position.

Description

This self-supporting construction consists of a horizontal beam supported by two vertical beams fixed on the steel frame together with the turning table and supports. A sliding rail is mounted on the horizontal support beam provided with two carriages. Each carriage support holds a swivelling arm on which the welding torch is fixed by means of a torch support. The swivelling arm must be adjustable in horizontal and vertical direction.

The width and height of the support construction must allow exact dimensional positioning against the railway flanges.

Quantity : 1 unit

6. Fume extractor

Function

The fume extractor will remove the hazardous welding fumes.

Description

The fume extractor must be a fixed installation, comprising the following units:

- one central extractor with wall bracket
- two articulated fume captor arms consisting of:
    - aluminium tubes with diameter 150 mm;
    - external self-supporting hinge joints that makes movements of the arms possible in all directions;
    - total arm length of at least 3,3 meter;
    - the flexible connections at the hinge joints should be non flammable;
    - fume captor hood with throttle and grid;
- connection tubes and all necessary accessories between extractor and fume captor arms
- exhausting tube diameter 160 mm, length 5 meter and cap

Technical specifications

- extractor house and impeller:	silumin alloy or similar
- rated air flow:	min. 2200 m^3/hour
- voltage:	380 V, 3 phase, 50 Hz
- motor protection relay	
- max. sound level at 1 meter	75 dB(A)

Quantity : 1 unit

7. Burners

Function

The burners are needed to preheat the wheels and to maintain the right temperature in order to avoid the formation of martensite or cracks during welding.

Description

The burner must be a professional type to work with LPG professional heating gas and oxygen, consisting of a brass light weight handle, a universal pressure mixer, a long curved tip tube and a heavy duty heating tip.
They must be equipped with appropriate spark arresters for oxygen and LPG.

Technical specifications

Handle:	HARRIS 63-2 *)
Mixer:	F medium pressure
Tip tube:	2393-IF
Heating tip:	2290-4H (14000 - 28400 Lt/hr oxy) (3600 - 7000 Lt/hr LPG)

*) Available at Jakarta, Indonesia. Local supplier of the Manggarai WS.

Quantity : 4 burners and 8 heating tips

8. Heavy duty regulator and spark arresters

Function

The heavy duty regulators for oxygen and LPG (propane) are needed to regulate the supply of both gases from the manifolds.
The duplex manifold for oxygen consists of two banks of eight 6 m^3 O_2 cylinders that supplies 55 m^3 oxygen per hour on 5 bar.
The duplex manifold for LPG consists of two banks of three 50 kg LPG cylinders that supplies 17 m^3 LPG per hour on 1.5 bar.

Description

The types of heavy duty regulators have been selected by PT ANEKA GAS INDUSTRI, JAKARTA that will install the manifolds for PERUMKA. This company is the local distributor of HARRIS in Jakarta.

Technical specifications

a) Oxygen

Heavy duty regulator

Type:	Single stage regulator with two gauges
Model:	HARRIS 25-7M Oxygen
Flow:	55 m^3/hour
Max. delivery pressure:	7 bar
Gauge scale:	
- working pressure	0 - 16 bar
- cylinder pressure	0 - 315 bar

Spark arrester

Flow:	55 m^3/hour

Quantity : 1 unit

b) LPG gas (propane)

Heavy duty regulator

Type:	Single stage regulator with two gauges
Model:	HARRIS 25-3.5M Propane
Flow:	17 m³/hour
Max. delivery pressure:	3.5 bar
Gauge scale:	
- working pressure	0 - 5 bar
- cylinder pressure	0 - 40 bar

Quantity : 1 unit

Spark arrester

Type	LPG
Flow	17 m³/hour

Quantity : 1 unit

9. Digital thermometer

Function

The digital thermometer is needed to measure and to control the temperature of the wheel flange to weld according to the welding procedure.

Description

The digital thermometer consists of a thermometer unit in ABS housing and a separate temperature sensor which is easily exchangeable. The display is a large LCD screen with a hold function of the measured value.

Technical specifications

Temperature range:	- 60 °C till 1000 °C
Precision:	± 1 °C
Resolution:	1 °C
Life time battery:	> 100 hours
Automatic cut off it not in use.	
Ambient temperature:	0 °C - 40 °C
Sensor range:	- 60 °C till 300 °C (500 °C for a short period)
Response time:	1 sec

Quantity : 2 units

10. Pneumatic weld flux scalers

Function

The pneumatic weld flux scalers are necessary to remove the slag off each weld.

Description

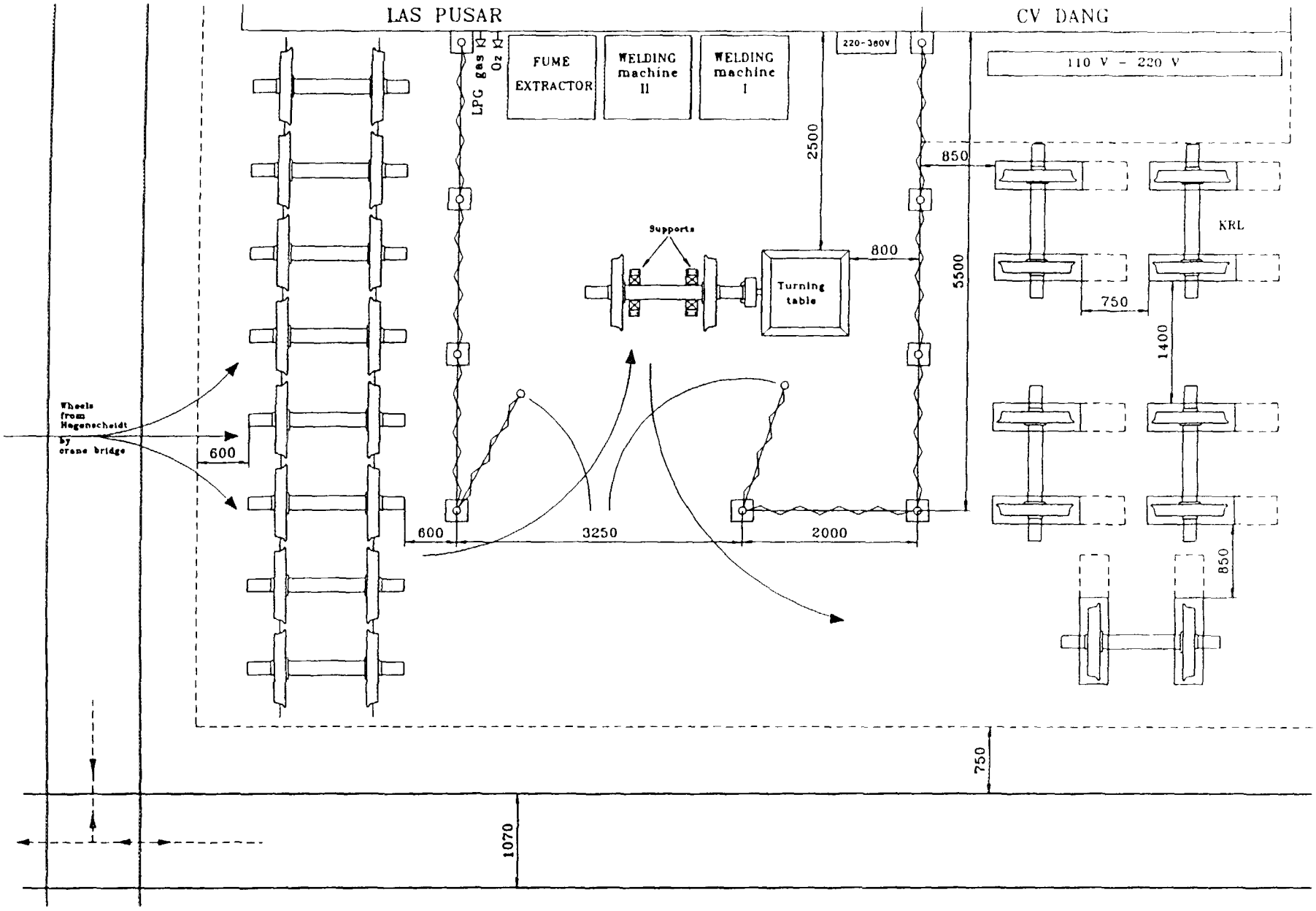
The air-operated weld flux scalers are mechanical hammers that consist of several needles.

Technical specifications

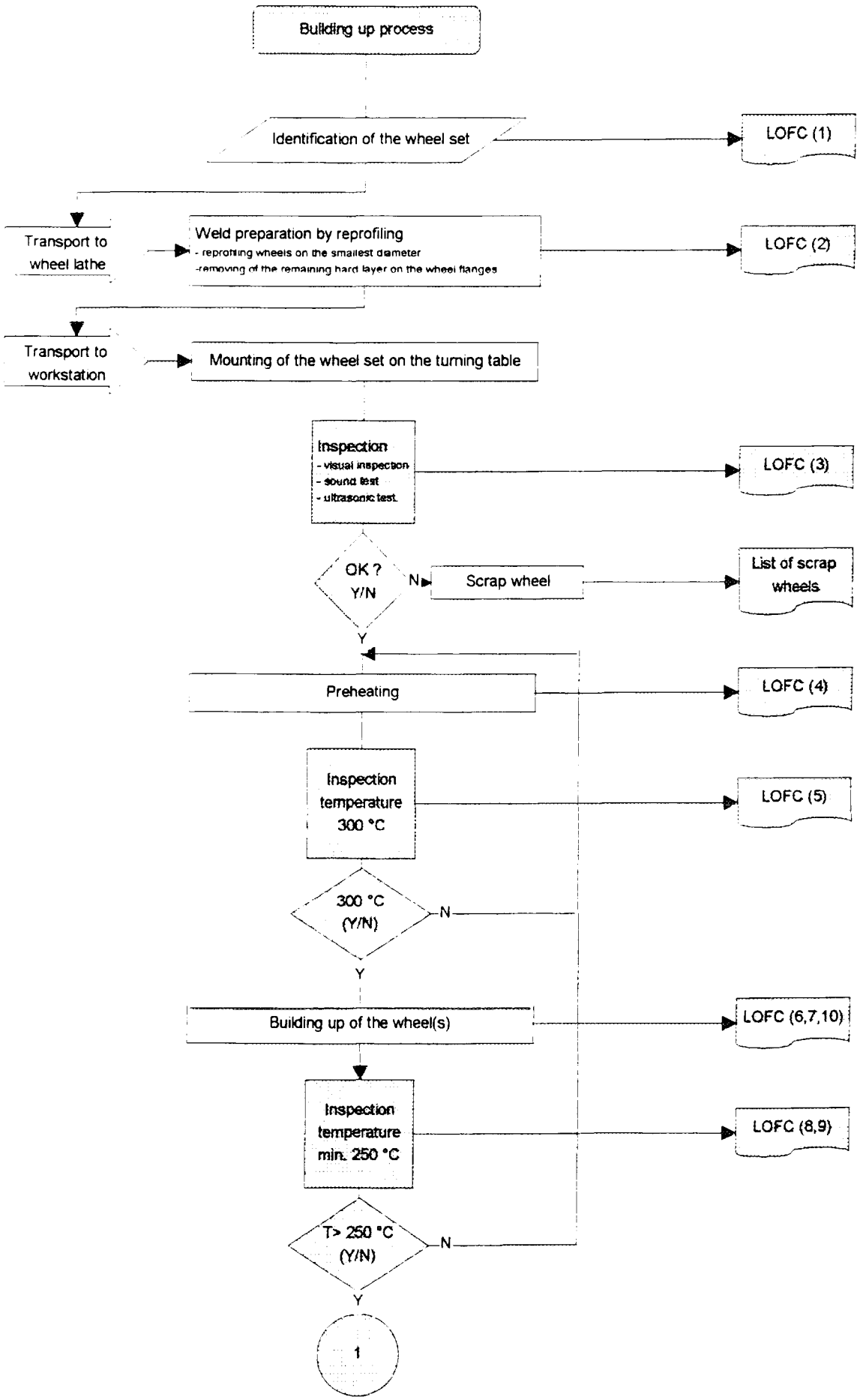
Air consumption:	100 l/min
Air pressure:	6 - 7 bar
Number of strokes:	± 3800/min
Weight:	< 3 kg
Diameter of the needles	2/3/4 mm

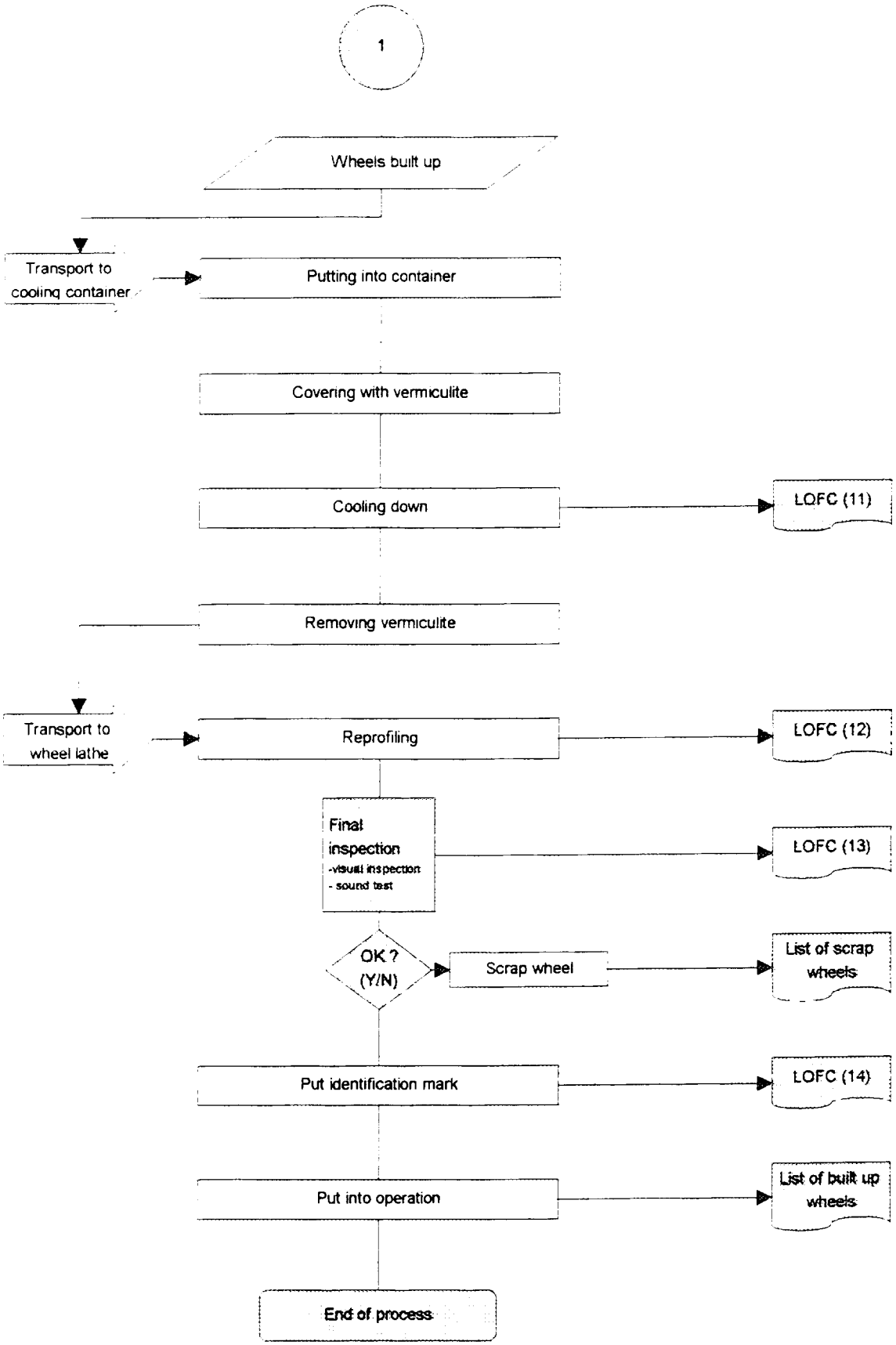
Quantity : 2 units

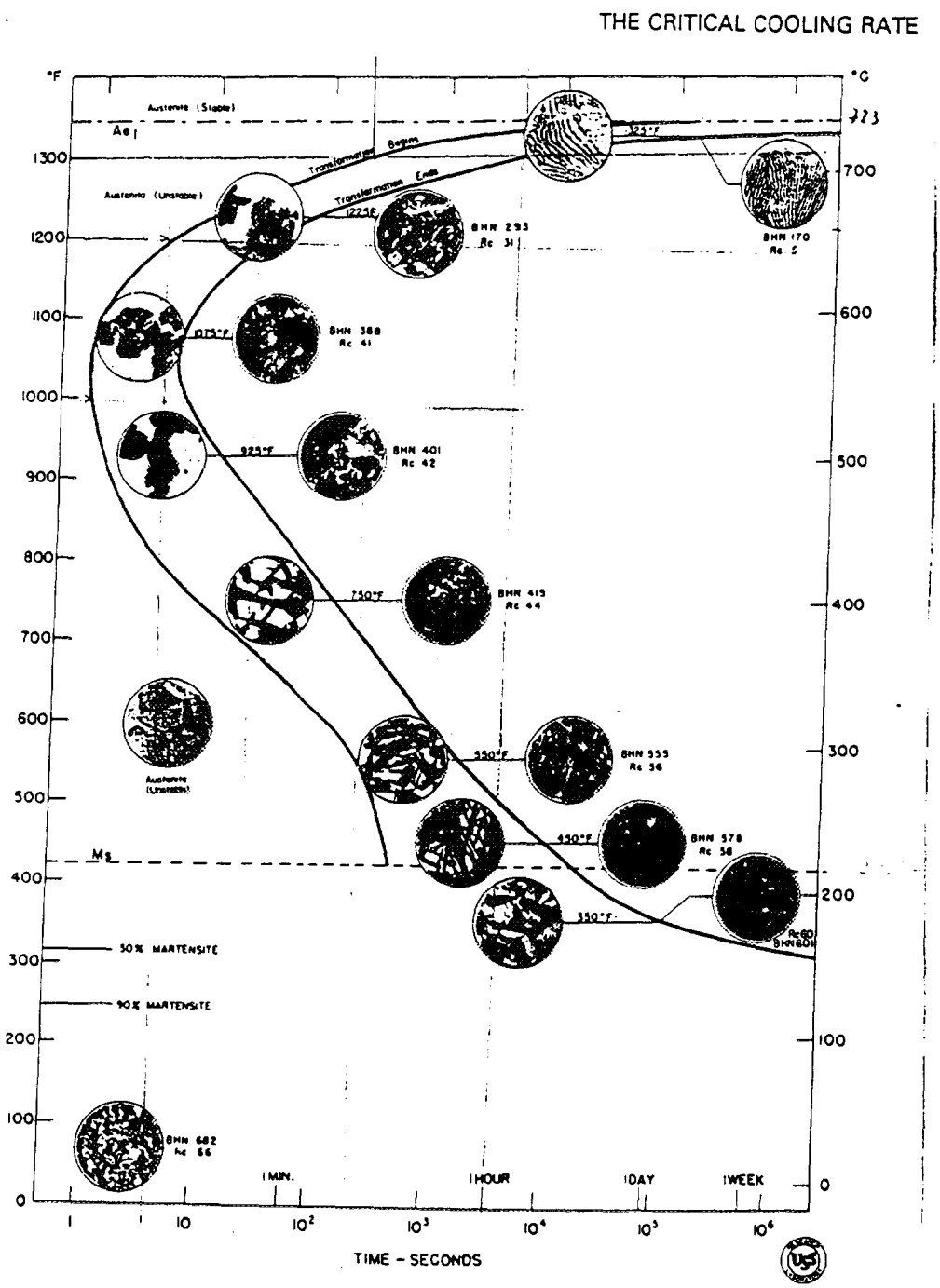
WORKSTATION FOR BUILDING UP RAILWAY WHEELS
WORKSHOP MANGGARAI, PERUMKA



Appendix 11


Building up process
Identification of the wheel set
LOFC (1)
Transport to wheel lathe
Weld preparation by reprofiling
- reprofiling wheels on the smallest diameter
-removing of the remaining hard layer on the wheel flanges
LOFC (2)
Transport to workstation
Mounting of the wheel set on the turning table
Inspection
- visual inspection
- sound test
- ultrasonic test
LOFC (3)
OK ? Y/N
N
Scrap wheel
List of scrap wheels
Y
Preheating
LOFC (4)
Inspection temperature 300 °C
LOFC (5)
300 °C (Y/N)
N
Y
Building up of the wheel(s)
LOFC (6,7,10)
Inspection temperature min. 250 °C
LOFC (8,9)
T> 250 °C (Y/N)
N
Y
1


1
Wheels built up
Transport to cooling container
Putting into container
Covering with vermiculite
Cooling down
LOFC (11)
Removing vermiculite
Transport to wheel lathe
Reprofiling
LOFC (12)
Final inspection
-visuall inspection
- sound test
LOFC (13)
OK ? (Y/N)
Scrap wheel
List of scrap wheels
Put identification mark
LOFC (14)
Put into operation
List of built up wheels
End of process



IGURE 4. I-T diagram of
89 percent carbon steel.
:opyright 1951 by United
:ates Steel Corporation)

WORK DESCRIPTION

1. Reprofile the wheel to prepare it for building up as follows :
   - measure the wheel diameter of both wheels and select the wheel with the smallest diameter;
   - adjust the wheel lathe to reprofiling at this smallest diameter;
   - reprofile both wheels in automatic mode;
   - remove the remaining hard layer on the wheel flanges in manual mode until we get a shining surface.

   Remark : WPS-PER-04 Prior to reprofiling of tyred wheels (WPS-PER-04) it is necessary to check if the tyre is not loose : sound test and check of marks. If the tyre is loose it must be replaced.

2. Mount the wheelset on the supports of the turning table by crane bridge. Change eventually the bearing plates of the supports according to the wheel axle diameter.

3. Clean the axle journal with a rag.

4. Tighten the axle journal in the clamping chuck.

5. Put the variator of the turning table on position 10 to let the wheel turn.

6. Clean the surface to be built up. Remove all oil and grease.

7. Check the wheel on cracks. Visual inspection, sound test and ultrasonic test. Wheels that have cracks are excluded from building up. The supervisor will decide if the wheels have to be scrapped or reprofiled until all cracks have been removed.

8. Start preheating.

WPS	**WPS-PER-01**	**WPS-PER-02**	**WPS-PER-03**	**WPS-PER-04**
Wheel	Solid wheels	Solid wheels	Solid wheels	Tyred wheels
Type	Type CC	Type HH - KRL	Type HH - Loco	Type HH - KRL
Temperature	300°C	300°C	300°C	300°C
Preheating time	15 minutes	25 minutes	30 minutes	25 minutes

9. Tune the welding posts Castomig 448 as follows:

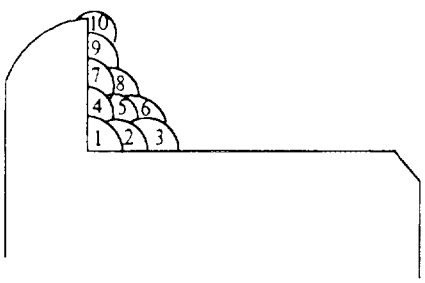
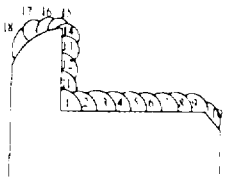
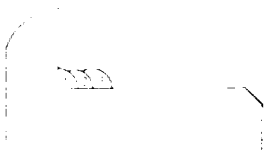
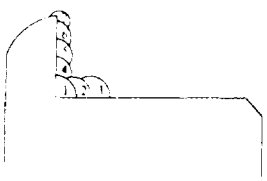
   - position buttons: C 8 - 200 Ampere
   - position earth cable: C
   - wire speed: 5 m/min

10. Put the welding torch in the right position: 1 G Rotated.

11. Put the captor arms of fume extractor in the right position.

12. Put the variator of the turning table on position 2 to let the wheel turn.

13. Start building up according to the wear. Use for this purpose the gauge.
    Weld accordingly to the sequence in the drawings below.
    The number of layers can change whether the wear is more or less important.

WPS-PER-01	WPS-PER-02	WPS-PER-03	WPS-PER-04
Solid wheels	Solid wheels	Solid wheels	Tyred wheels
Type CC	Type HH - KRL	Type HH - Loco	Type HH - KRL
			Step 1  Step 2 

Remove the slag between every layer with a pneumatic weld flux scaler.

Check regularly temperature of the running surface of the wheel by digital thermometer. Start heating until 300 °C if the temperature drops below 250 °C.

14. Start heating again while welding the last layer but one until 300 °C.

15. Weld the last layer and don't remove slag.

16. Loose the clamping chuck.

17. Move the torch holders to their utmost position.

18. Move the captor arms of the fume extractor away from the turning table.

19. Shut down the fans.

20. Start cooling off :

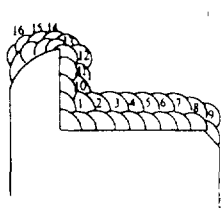
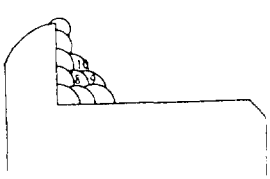
WPS	WPS-PER-01	WPS-PER-02	WPS-PER-03	WPS-PER-04
Wheel	Solid wheels	Solid wheels	Solid wheels	Tyred wheels
Type	Type CC	Type HH - KRL	Type HH - Loco	Type HH - KRL
Medium	In cooling down container covered with insulation material Vermiculite			Cover tyre with glass wool blanket
Cooling off rate	max. 50 °C per hour			
Cooling off time	6 hours			4 hours

Remark : WPS-PER-04. Use glass wool blanket to obtain a cooling rate of 50°C/hour to get enough shrinkage to avoid loose tyre.

21. After cooling off min. 150°C :

WPS	WPS-PER-01	WPS-PER-02	WPS-PER-03	WPS-PER-04
Wheel	Solid wheels	Solid wheels	Solid wheels	Tyred wheels
Type	Type CC	Type HH - KRL	Type HH - Loco	Type HH - KRL
Transport	To wheellathe for reprofiling.		To turning table for further building-up	
Next work	Go to work number 23.		Go to work number 22	

22.

WPS	WPS-PER-03	WPS-PER-04
Wheel	Solid wheels	Tyred wheels
Type	Locomotive - KRL	Type KRL
Works	Repeat works number 3, 4, 6, 9, 10, 11, 12 Remark : No need to preheat because we are welding on top of the built-up deposit.	
	Build up until the desired wheel diameter. Use for this purpose the gauge.	Start building up according to the wear. Use for this purpose the gauge.
	Weld accordingly to the sequence in the drawing below. The number of layers can change whether the wear is more or less important. Remove the slag between every layer with a pneumatic weld flux scaler.	
Drawing		
Works	Repeat works number 16, 17 and 18.	

23. Reprofile on the wheel lathe.

24. Check the wheel on cracks. Visual inspection and sound test. Wheels that have cracks should be scrapped. The supervisor will report this to the workshop manager who should investigate what went wrong.

25. Complete Quality Control Report - LOFC.

26. Complete the production list.

27. Put identification mark on the wheel.

Created by
Mr Decostere
Team Leader

Approved

Mr Subagio TKBK Manggarai	Mr Iim Abdul Hakim Local Project Manager	Mr J. Belche Technical Manager Castolin Eutectic

Castolin Eutectic
Eutectic Castolin

Appendix 15

	WPS - PER - 01 - REV A
	WELDING PROCEDURE SPECIFICATION

Customer : **PERUMKA INDONESIA**

Wheel Preperation : Reprofiling at smallest diameter in automatic operation followed by removing upper layer of the wheel flange in manual operation.

Base Metal : Solid wheel type CC.
C% : 0.60 - 0.75 / Si% : 0.15 - 0.35 / Mn% : 0.50 - 0.90 / P% : Max 0.05 /
S% : Max 0.05 / Cu% : Max 0.35

Welding Position : 1 G Rotated - Speed : position 2 on variator

Preheat Treatment :
- Turning speed : position 10 on variator.
- Preheat temperature : 300 C or 15 minutes.
- Heat again one tour just before welding the last layer.
- Minimum temperature during welding : 250 C.
- Maximum temperature during welding : 380 C.

Postweld Heat Treatment :
- Cooling rate : max. 50 °C / hour.
- In cooling down container covered with insulation material Vermiculite.

Process :
CASTOMIG 448 + TEROMATEC OPEN ARC WIRE

Filler Metal :

- Spec. no. (S.F.A.)	:
- A.W.S. no.	:
- Ø	: 1,6 mm
- Supplier	: **s.a. Castolin benelux n.v.**
- Trade name	: TEROMATEC 3205

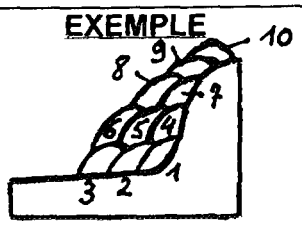
Electrical Characteristics :
- Position buttons C 8 - 200A
- Position earth cable : C

Gas : no gas with this wire
Type :
Debit : l/min.
Composition :

Technique :

- WELDS : 1 until 10 / wire speed 5 m / min.
- Between layers remove slag with a pneumatic hammer.

EXEMPLE



Date : 01 October 1996

A.MAERTEN,
Institute Responsible

Approved by
J. BELCHE,
Technical Manager.

Castolin Eutectic
Eutectic Castolin

Appendix 16

	WPS - PER - 02 - REV A
	WELDING PROCEDURE SPECIFICATION

Customer : **PERUMKA INDONESIA**

Wheel Preperation : Reprofiling at smallest diameter in automatic operation followed by removing upper layer of the wheel flange in manual operation.

Base Metal : Solid wheel type KRL.
C% : 0.60 - 0.75 / Si% : 0.15 - 0.35 / Mn% : 0.50 - 0.90 / P% : Max 0.05 /
S% : Max 0.05 / Cu% : Max 0.35

Welding Position : 1 G Rotated - Speed : position 2 on variator

Preheat Treatment :
- Turning speed : position 10 on variator.
- Preheat temperature : 300 C or 25 minutes.
- Heat again one tour just before welding the last layer.
- Minimum temperature during welding : 250 C.
- Maximum temperature during welding : 380 C.

Postweld Heat Treatment :
- Cooling rate : max. 50 °C / hour.
- In cooling down container covered with insulation material Vermiculite.

Process :
CASTOMIG 448 + TEROMATEC OPEN ARC WIRE

Filler Metal :

- Spec. no. (S.F.A.)	:
- A.W.S. no.	:
- Ø	: 1,6 mm
- Supplier	: **s.a. Castolin benelux n.v.**
- Trade name	: TEROMATEC 3205

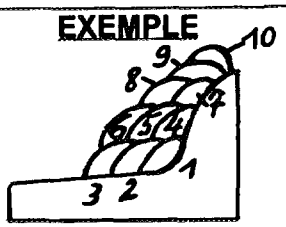
Electrical Characteristics :
- Position buttons C 8 - 200A
- Position earth cable : C

Gas : no gas with this wire
Type :
Debit : l/min.
Composition :

Technique :

- WELDS : 1 until 10 / wire speed 5 m / min.
- Between layers remove slag with a pneumatic hammer.

EXEMPLE



Date : 01 October 1996

A.MAERTEN,
Institute Responsible

Approved by
J. BELCHE,
Technical Manager.

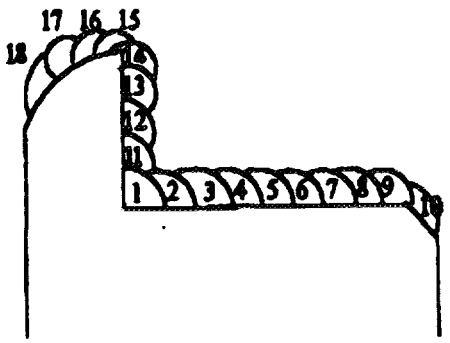
This procedure may not be changed without prior approval of CASTOLIN or HIS REPRESENTATIVE MR. A. MAERTEN.

	WPS - PER - 03 - REV A
	Welding Procedure Specification
Customer : PERUMKA - INDONESIA	
Building-up of wheels that have reached their minimum diameter. In order to avoid scrapping of the wheel the entire running surface will be build up until the desired wheel diameter is obtained. This is only suitable for expensive wheels or wheels which are not available at PERUMKA.	
Wheel Preparation : Reprofiling at smallest diameter in automatic operation followed by removing upper layer of the wheel flange in manual operation.	
Base metal : Solid Locomotive Wheel type HH. C% : 0.60 - 0.75 / Si% : 0.15 -0.35 / Mn% : 0.50 - 0.90 / P% : Max 0.05/ S% : Max 0.05 / Cu% : Max 0.35	
Welding Position : 1 G Rotated - Speed : position 2 on variator	
Preheat Treatment : - Turning speed : position 10 on variator - Preheat temperature : 300 °C or 25 minutes - Heat again during the welding of the layer 14 until ± 300 °C. - Minimum temperature during welding : 250 °C - Maximum temperature during welding : 380 °C - Once the entire running surface of the wheel is built up and it has cooled off in the container no more preheating is necessary for the next layers.	
Postweld Heat Treatment : - Cooling rate : max 50 °C/ hour - In cooling down container covered with insulation material Vermiculite.	
Process : Castomig 448 + Teromatec open arc wire	
Filler metal : ∅ : 1.6 mm Supplier : **s.a. Castolin benelux n.v.** Trade name :Teromatec 3205	
Electrical Characteristics : - Position buttons C 8 - 200 A - Position earth cable : C	
Gas : no gas with this wire ***Type :*** ***Debit :*** l/min ***Composition :***	

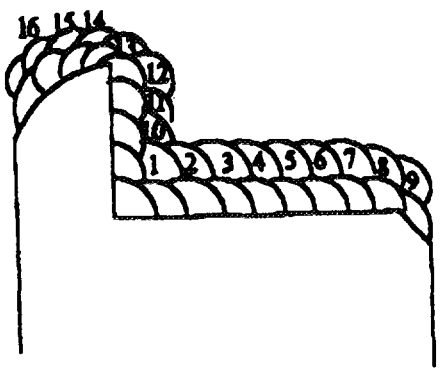
	WPS - PER - 03 - REV A
	Welding Procedure Specification

Technique :

1st step :
- Welds : 1 until 18 - wire speed 5m/min
- Between layers remove slag with a pneumatic hammer
- Don't remove slag of the last layer
- Cooling off in container covered with insulation material vermiculite.
- Remove the slag of the last layer on top of the flange after cooling off in the container.



2nd step :
- Build up until the desired wheel diameter is obtained without further preheating.
- Welds : wire speed 5m/min
- Between layers remove slag with a pneumatic hammer



Date : 05.06.97

J. Belche
Technical Manager

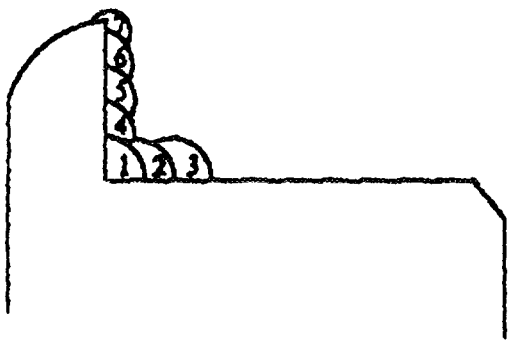
	WPS - PER - 04 - REV A
	Welding Procedure Specification
Customer : PERUMKA - INDONESIA	
Wheel Preparation : Reprofiling at smallest diameter in automatic operation followed by removing upper layer of the wheel flange in manual operation.	
Base metal : Tyred wheel type HH for KRL. C% : 0.60 - 0.75 / Si% : 0.15 -0.35 / Mn% : 0.50 - 0.90 / P% : Max 0.05/ S% : Max 0.05 / Cu% : Max 0.35	
Welding Position : 1 G Rotated - Speed : position 2 on variator	
Preheat Treatment : -Turning speed : position 10 on variator - Preheat temperature : 300 °C or 25 minutes - Heat again during welding of the last layer but one until ± 300 °C. - Minimum temperature during welding : 230 °C - Maximum temperature during welding : 300 °C	
Postweld Heat Treatment : - Cooling rate : max 50 °C/ hour - Cover the wheel tyre immediately with a glass wool blanket during cooling off	
Process : Castomig 448 + Teromatec open arc wire	
Filler metal :	
∅	: 1.6 mm
Supplier	: **s.a. Castolin benelux n.v.**
Trade name	:Teromatec 3205
Electrical Characteristics : - Position buttons C 8 - 200 A - Position earth cable : C	
Gas : no gas with this wire ***Type :*** ***Debit :*** l/min ***Composition :***	

	WPS - PER - 04 - REV A
	Welding Procedure Specification

Technique :

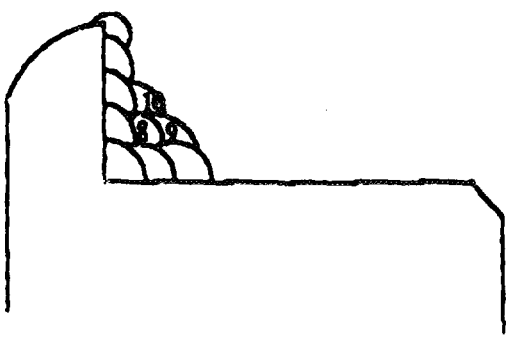
1st step :

- Welds : 1 until 7 - wire speed 5m/min
- Between layers remove slag with a pneumatic hammer
- Don't remove slag of the last layer
- Remove the slag of the last layer on top of the flange after cooling off.



2nd step :

- No preheating because we are welding on top of the built up deposit.
- Welds : 8 until 10 - wire speed 5m/min
- Between layers remove slag with a pneumatic hammer



Date : 05.06.97

Approved by

J. Belche
Technical Manager

L O F C List of Operations, Fabrication and Control			N° JOB : Wheel type : Wheel axle n° : Wheel 1 n° : Wheel 2 n° :			
Op.	**Nr**	**Description**	**Proc.**	**Oper.**	**Date**	**Visa**
1	**2**	**3**	**4**	**5**	**6**	**7**
1		Identification of the wheel set				
2		Weld preparation by reprofiling	PER - 01			
3		Inspection before building up				
	3.1	Visual inspection				
	3.2	Sound test				
	3.3	Ultrasonic inspection				
4		Preheating	PER - 01			
5		Preheat inspection - temperature				
6		Welding - building up of wheel flange	PER - 01			
7		Intermediate inspection				
8		Preheating inspection				
9		Preheat one tour before welding the last layer				
10		Welding - building up of wheel flange	PER - 01			
11		Cooling	PER - 01			
12		Reprofiling on wheel lathe				
13		Final inspection				
	13.1	Visual inspection				
	13.2	Sound test				
14		Put the identification mark				

Project US/INS/93/169. Building up of CC wheels. List of built-up wheel sets

Appendix 20/1

Wheel set Job nr	Date Welding	Type Wheel	Axle Nr	Wheel 1 Nr	Built-up	Wheel 2 Nr	Built-up	Inspector	Date operation
1	03-09-96	CC	3901	7801	Y	7802	Y	SCRAP	SCRAP
2	04-09-96	CC	2180	4359	Y	4360	Y	OK	13-09-96
3	04-09-96	CC	2066	4131	N	4132	Y	OK	13-09-96
4	05-09-96	CC	2041	4081	Y	4082	Y	SCRAP	SCRAP
5	05-09-96	CC	4230	8459	Y	8460	Y	OK	13-09-96
6	06-09-96	CC	157	301	N	302	Y	SCRAP	SCRAP
7	09-09-96	CC	5006	10011	Y	10012	Y	OK	13-09-96
8	10-09-96	CC	5268	10535	Y	10536	Y	OK	13-09-96
9	11-09-96	CC	5640	11279	Y	11280	Y	OK	13-09-96
10	12-09-96	CC	2396	4791	Y	4792	N	OK	18-09-96
11	12-09-96	CC	2060	4119	N	4120	Y	OK	18-09-96
12	12-09-96	CC	5477	10953	Y	10954	N	OK	13-09-96
13	13-09-96	CC	5603	11205	Y	11206	N	OK	18-09-96
14	13-09-96	CC	5589	11175	Y	11176	N	OK	18-09-96
15	18-09-96	CC	5811	11621	Y	11622	N	OK	24-09-96
16	18-09-96	CC	5646	11291	Y	11292	N	OK	24-09-96
17	20-08-96	KRL/HH	13409	26817	N	26818	Y	OK	24-09-96
18	20-08-96	CC	4557	9113	Y	9114	N	OK	24-09-96
19	23-09-96	CC	4257	8513	Y	8514	N	OK	24-09-96
20	23-09-96	CC	5484	10967	Y	10968	N	OK	24-09-96
21	23-09-96	HH	13399	26797	Y	26796	N	OK	24-09-96
22	24-09-96	HH	13408	26815	Y	26816	N	OK	25-09-96
23	25-09-96	CC	143	285	N	286	Y	OK	26-09-96
24	25-09-96	CC	5864	11727	N	11728	Y	OK	27-09-96
25	25-09-96	CC	113	225	N	226	Y	OK	27-09-96
26	26-09-96	CC	6037	12037	Y	12038	N	OK	27-09-96
27	26-09-96	CC	4363	8725	Y	8726	N	OK	30-09-96
28	30-09-96	CC	5105	10209	N	10210	Y	OK	01-10-96
29	30-09-96	CC	5316	10631	Y	10632	N	OK	01-10-96
30	30-09-96	CC	5167	10333	Y	10334	N	OK	01-10-96
31	30-09-96	CC	5648	11295	N	11296	Y	OK	01-10-96
32	01-10-96	CC	3442	6883	Y	6884	Y	OK	02-10-96
33	02-10-96	CC	812	1623	N	1624	Y	OK	09-10-96
34	02-10-96	CC	3744	7487	Y	7488	N	OK	09-10-96
35	04-10-96	CC	5017	10034	N	10033	Y	OK	08-10-96
36	07-10-96	CC	4939	9878	N	9877	Y	OK	09-10-96
37	08-10-96	CC	4386	8772	Y	8771	N	OK	09-10-96
38	09-10-96	CC	1	1	Y	2	N	OK	14-10-96
39	09-10-96	CC	5456	10911	N	10912	Y	OK	10-10-96
40	09-10-96	CC	5381	10761	Y	10762	N	OK	10-10-96
41	10-10-96	CC	4965	9929	Y	9930	Y	OK	12-10-96
42	10-10-96	CC	5359	10718	Y	10717	N	OK	12-10-96
43	11-10-96	CC	4560	9119	N	9120	Y	OK	12-10-96
44	11-10-96	CC	5645	11289	N	11290	Y	OK	14-10-96
45	14-10-96	CC	4561	9121	N	9122	Y	OK	16-10-96
46	14-10-96	CC	4372	8743	N	8744	Y	OK	16-10-96

Wheel set Job nr	Date Welding	Type Wheel	Axle Nr	Wheel 1 Nr	Built-up	Wheel 2 Nr	Built-up	Inspector	Date operation
47	14-10-96	CC	5151	10301	N	10302	Y	OK	19-10-96
48	15-10-96	CC	153	305	Y	306	Y	OK	16-10-96
49	16-10-96	CC	3946	7892	Y	7891	N	OK	19-10-96
50	16-10-96	CC	2486	4922	Y	4921	N	OK	18-10-96
51	21-10-96	CC	5552	11104	Y	11103	N	OK	28-10-96
52	22-10-96	CC	5625	11249	N	11250	Y	OK	28-10-96
53	22-10-96	CC	5732	11474	Y	11473	N	OK	28-10-96
54	23-10-96	CC	5116	10231	Y	10232	Y	OK	28-10-96
55	24-10-96	CC	4201	8402	Y	8401	N	OK	28-10-96
56	25-10-96	CC	5578	11155	Y	11156	Y	OK	28-10-96
57	28-10-96	CC	23	45	Y	46	N	OK	29-10-96
58	28-10-96	CC	5356	10712	Y	10711	N	OK	29-10-96
59	30-10-96	CC	5498	10996	Y	10995	N	OK	08-11-96
60	01-11-96	CC	2594	5687	N	5688	Y	OK	08-11-96
61	09-11-96	CC	4604	9207	Y	9208	N	OK	12-11-96
62	11-11-96	CC	5175	10349	N	10350	Y	OK	12-11-96
63	11-11-96	CC	324	647	N	648	Y	OK	17-11-96
64	11-11-96	CC	5822	11643	Y	11644	N	OK	17-11-96
65	13-11-96	CC	5641	11283	Y	11284	N	OK	16-11-96
66	13-11-96	CC	4480	8959	Y	8958	N	OK	14-11-96
67	13-11-96	CC	509	1017	Y	1018	N	OK	18-11-96
68	15-11-96	CC	5668	11325	N	11326	Y	OK	18-11-96
69	20-11-96	CC	4577	9153	Y	9154	N	OK	22-11-96
70	20-11-96	CC	5109	10217	Y	10218	N	OK	22-11-96
71	22-11-96	CC	5317	10633	N	10634	Y	OK	23-11-96
72	28-11-96	CC	2389	4777	Y	4778	N	OK	30-11-96
73	28-11-96	CC	4811	9621	N	9622	Y	OK	30-11-96
74	04-12-96	CC	4710	9419	N	9420	Y	OK	05-12-96
75	04-12-96	CC	5210	10419	Y	10420	N	OK	05-12-96
76	04-12-96	CC	5123	10365	Y	10366	N	OK	05-12-96
77	05-12-96	CC	174	347	Y	348	N	OK	06-12-96
78	05-12-96	CC	966	1931	Y	1932	N	OK	06-12-96
79	05-12-96	CC	711	1421	Y	1422	N	OK	09-12-96
80	10-12-96	CC	2589	5177	Y	5178	N	OK	17-12-96
81	12-12-96	CC	5650	11299	Y	11300	N	OK	20-12-96
82	12-12-96	CC	5853	11705	Y	11706	N	OK	20-12-96
83	17-12-96	CC	276	551	Y	552	N	OK	20-12-96
84	17-12-96	CC	2178	4356	Y	4355	N	OK	20-12-96
85	21-12-96	CC	314	627	Y	628	N	OK	26-12-96
86	21-12-96	CC	753	1505	N	1506	N	OK	26-12-96
87	21-12-96	CC	3899	7797	Y	7798	N	OK	30-12-96
88	30-12-96	CC	288	175	N	176	N	OK	02-01-97
89	30-12-96	CC	4862	9725	Y	9726	N	OK	02-01-97
90	04-01-97	CC	399	798	Y	797	N	OK	14-01-97
91	04-01-97	CC	5632	11263	N	11264	Y	OK	14-01-97
92	05-01-97	CC	4525	9049	N	9050	Y	OK	14-01-97

Wheel set Job nr	Date Welding	Type Wheel	Axle Nr	Wheel 1 Nr	Built-up	Wheel 2 Nr	Built-up	Inspector	Date operation
93	05-01-97	CC	2423	4845	N	4846	Y	OK	14-01-97
94	09-01-97	CC	247	493	Y	494	N	OK	14-01-97
95	09-01-97	CC	5572	11143	N	11144	Y	OK	12-01-97
96	13-01-97	CC	4369	8737	Y	8738	N	OK	16-01-97
97	13-01-97	CC	2049	4097	Y	4098	N	OK	15-01-97
98	13-01-97	CC	2540	5079	Y	5080	N	OK	16-01-97
99	14-01-97	CC	5613	11225	N	11226	Y	OK	16-01-97
100	14-01-97	CC	5271	10541	N	10542	N	OK	16-01-97
101	15-01-97	CC	4866	9732	Y	9733	N	OK	16-01-97
102	15-01-97	CC	2390	4779	Y	4780	N	OK	16-01-97
103	16-01-97	CC	5563	11125	N	11126	Y	OK	22-01-97
104	16-01-97	CC	36	71	Y	72	Y	OK	21-01-97
105	20-01-97	CC	5358	10715	Y	10716	N	OK	29-01-97
106	20-01-97	CC	365	729	Y	730	N	OK	23-01-97
107	20-01-97	CC	4468	8945	N	8946	N	OK	25-01-97
108	21-01-97	CC	5302	10603	N	10604	Y	OK	23-01-97
109	21-01-97	CC	5365	10725	Y	10736	N	OK	23-01-97
110	21-01-97	CC	5012	10023	Y	10024	N	OK	23-01-97
111	22-01-97	CC	5050	10100	N	1099	Y	OK	23-01-97
112	22-01-97	CC	5501	11001	Y	11009	Y	OK	24-01-97
113	24-01-97	CC	4979	9957	N	9958	Y	OK	21-01-97
114	27-01-97	CC	2521	5042	N	5041	Y	OK	28-01-97
115	28-01-97	CC	5205	10410	Y	10409	N	OK	29-01-97
116	28-01-97	CC	1023	2045	Y	2046	N	OK	29-01-97
117	29-01-97	CC/K5	5863	11725	N	11726	Y	OK	29-01-97
118	29-01-97	CC/K5	2530	5060	Y	5059	N	OK	29-01-97
119	29-01-97	CC/K5	3908	11815	Y	11816	N	OK	29-01-97
120	03-03-97	HH/KRL	13201	26402	Y	26401	N	OK	04-03-97
121	04-03-97	HH/KRL	13117	26234	Y	26233	N	OK	05-03-97
122	05-03-97	HH/KRL	13086	26172	Y	26171	N	OK	06-03-97
123	05-03-97	HH/KRL	13112	26223	Y	26224	N	OK	06-03-97
124	06-03-97	HH/KRL	13284	26568	Y	26567	N	OK	07-03-97
125	12-03-97	CC/K5	5272	10543	Y	10544	N	OK	08-04-97
126	12-03-97	CC/K5	4622	9243	Y	9244	N	OK	08-04-97
127	17-03-97	HH/KRL	13597	261193	Y	261192	N	OK	19-03-97
128	17-03-97	HH/KRL	13605	261209	Y	261210	N	OK	19-03-97
129	18-03-97	HH/KRL	13598	261195	Y	261196	N	OK	19-03-97
130	18-03-97	HH/KRL	13579	261157	Y	261158	N	OK	19-03-97
131	19-03-97	HH/KRL	13008	261216	Y	261215	N		
132	19-03-97	CC/K5	4900	9799	Y	9800	N	OK	08-04-97
133	23-03-97	CC/K5	3553	7106	Y	7105	Y	OK	08-04-97
134	25-03-97	HH/KRL	3982	7903	Y	7964	Y		
135	01-04-97	HH/KRL	3980	7960	Y	7959	Y		
136	02-04-97	CC	4305	8615	Y	8616	N	OK	08-04-97
137	02-04-97	CC	5716	11432	Y	11433	N	OK	08-04-97
138	03-04-97	CC	2842	5683	Y	5684	N	OK	08-04-97

Appendix 20/4

Wheel set Job nr	Date Welding	Type Wheel	Axle Nr	Wheel 1 Nr	Built-up	Wheel 2 Nr	Built-up	Inspector	Date operation
139	03-04-97	CC	2505	5004	Y	5003	N	OK	08-04-97
140	03-04-97	CC	4664	9327	Y	9328	N	OK	12-04-97
141	04-04-97	CC/K7	3708	7415	Y	7416	N		
142	07-04-97	CC/K7	3619	7238	N	7237	Y	OK	22-04-97
143	08-04-97	HH/LOK	3834	7667	Y	7668	N		
144	11-04-97	HH/KRL	13221	26441	Y	26442	N	OK	11-04-97
145	11-04-97	HH/LOK	3850	7699	Y	7700	N		
146	12-04-97	CC/K7	3618	7236	Y	7235	N	OK	22-04-97
147	13-04-97	HH/KRL	13104	26208	Y	26207	N	OK	15-04-97
148	14-04-97	HH/KRL	13253	26506	Y	26505	N	OK	15-04-97
149	14-04-97	HH/KRL	13111	26222	Y	26221	N	OK	15-04-97
150	15-04-97	HH/KRL	13215	26429	Y	26430	N	OK	15-04-97
151	16-04-97	HH/KRL	13158	26215	Y	26216	N	OK	16-04-97
152	16-04-97	HH/KRL	13249	26497	Y	26498	N	OK	16-04-97

s.a. Castolin benelux n.v.

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Appendix 21

NMBS Gent
CW Gentbrugge
To the att of Mr. Decostere
Brusselsesteenweg 602
9050 GENTBRUGGE

cc : AM - JB

LC/fdc.- October 8th, 1996

Dear Mister Decostere,

Reference : rebuilding of Railway Wheels - Indonesia

Following the return of our Mr. A. Maerten from his stay at Perumka, we herewith send you the application procedures for both wheeltypes KRL and CC.

We take this occasion to repeat that the wheels have to be thoroughly inspected for rebuilding and that for security reasons, no cracks can be allowed.

Please inform the operational responsible accordingly and make sure that welding procedures are followed accurately.

Also it is obvious that we can not take responsibility for the rebuilding of wheels others than those realised on site by our specialist Mr. A. Maerten. We understood that these wheels have been separately marked to allow a suitable follow-up.

Trusting that this information will be useful to you, we remain,

yours faithfully,

s.a. Castolin benelux n.v.

L. CEYMEULEN,
General Manager.

Enclosures : 2

LIST OF REJECTED WHEELS BECAUSE OF CRACKS.
Period 20-09-96 until 03-10-96

Type wheel	Axle N°	Wheel N°	Date
CC	4801	9601	23-09-96
KRL	13421	26841	23-09-96
CC	4293	8585	23-09-96
KRL	13407	26813	24-09-96
CC	575	1150	26-09-96
CC	4380	8759	30-09-96
CC	4065	8129	01-10-96

COMPARISON BETWEEN BUILT-UP WHEELS AND NON BUILT-UP WHEELS

Nr	Coach Nr	Trip	Running kilometres	Axle Nr	Wheel 1 - Left side					Wheel 2 - Right side				
					Nr	Built-up	Qr	Height	Thickn	Nr	Built-up	Qr	Height	Thickn
1	K2-82557	Jak-Bd	103229	5006	10011	Y	10,0	27,0	29,0	10012	Y	9,5	30,5	30,0
2		Jak-Bd	103229	5268	10535	Y	9,0	30,0	29,0	10536	Y	10,0	29,0	30,0
3		Jak-Bd	103229	-	-	N	8,5	30,0	29,0	-	N	8	30,5	27,0
4		Jak-Bd	103229	-	-	N	8,5	29,5	29,5	-	N	8,5	31,0	29,0
5	K2-82553	Jak-Bd	110267	143	285	N	7,5	29,5	29,0	286	Y	7,0	31,5	28,0
6		Jak-Bd	110267	5864	11728	Y	8,5	29,0	27,0	11727	N	7,5	29,0	28,0
7		Jak-Bd	110267	-	-	N	9,0	28,0	29,0	-	N	8,0	29,0	27,0
8		Jak-Bd	110267	113	226	Y	7,5	30,5	26,0	225	N	7,5	27,0	26,0
9	K2-82551	Jak-Bd	108436	5359	10718	Y	7,5	29,0	26,5	10717	N	6,5	26,5	24,5
10		Jak-Bd	108436	5456	10912	Y	6,5	29,0	25,0	10911	N	7,0	27,0	25,5
11		Jak-Bd	108436	5381	10762	N	7,0	31,0	26,0	10761	Y	7,0	26,0	25,5
12		Jak-Bd	108436	4965	9929	Y	6,0	29,0	25,0	9930	Y	7,5	26,5	26,5
13	K2-82548	Jak-Bd	95908	5646	11291	Y	9,0	29,0	28,5	11292	N	9,0	29,0	29,5
14		Jak-Bd	95908	4257	8513	Y	9,0	28,5	29,0	8514	N	9,5	29,5	30,0
15		Jak-Bd	95908	5484	10967	Y	8,0	31,0	26,5	10968	N	10,0	30,0	30,0
16		Jak-Bd	95908	5811	11621	Y	9,0	30,0	28,0	11622	N	10,0	30,0	30,0

Summary

	Wheel 1 - Left side				Wheel 2 - Right side			
	Number	Qr	Height	Thickn	Number	Qr	Height	Thickn
1. Number built-up wheels	11				5			
2. Number non built-up wheels	5				11			
3. Mean value built-up wheels		8,2	29,3	27,2		8,2	28,7	28,0
4. Mean value non built-up wheels		8,1	29,6	28,5		8,3	29,0	27,9

Appendix 23

HARDNESS MEASUREMENTS

Measuring device : Equotip, Proceq SA, Switserland

1. Wheels after 100,000 km of operation

		Hardness Hrc			
Wheel nr	Built-up	Flange	Running surface	Increase	Remark
11291	Y	37,5	33,2	113%	After reprofiling
11292	N	29,2	28,2	104%	After reprofiling
10967	Y	47,5	39,3	121%	Without reprofiling
10968	N	41	39,9	103%	Without reprofiling
11621	Y	51,4	40,5	127%	Without reprofiling
11622	N	37,6	40,2	94%	Without reprofiling

2. Built-up wheels after reprofiling, 0 kilometres

		Hardness Hrc			
Wheel nr	Built-up	Flange	Running surface	Increase	Remark
Loco	Y		39,3		Built-up
7236	Y	42,2	32,1		
7235	Y	39,4	34,0		

3. New wheel maufactured in Roumania

		Hardness Hrc			
Wheel nr	Built-up	Flange	Running surface	Increase	Remark
New	N	34	34		