Training and Supervision of the Vehicle Maintenance for the Shanghai Maglev Transrapid Project

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ABSTRACT: This paper is a report on maintenance staff training and maintenance process supervision of the Shanghai Maglev Transrapid Project's vehicle fleet. The Training and supervision provided played a very important role in the execution and successful completion of the Shanghai Maglev Transrapid Project. ThyssenKrupp Transrapid GmbH worked out a well thought-out plan to the maintenance staff training. Our engineers passed their knowledge, skill and experience to their Chinese counterparts conscientiously and effectively. Our Chinese colleagues were highly motivated and worked very hard to obtain the expertise to run and support the system. As a result, through excellent co-operation between the German and Chinese partners all parties shared in a great success.

1 INTRODUCTION

The authors of this paper were in charge of transferring their knowledge of assembly and maintenance of the vehicle to the Chinese side.

According to the Contract, the Shanghai Maglev Transrapid Project German side was to provide training for the personnel of the Chinese side, to maintain the Transrapid system's vehicle. Once operation of the Shanghai Maglev began, the Chinese personnel were to assume management, operation and maintenance responsibilities for the system.

Two types of training, factory and on site, were agreed upon in the Contract. Factory training took place in Germany and ended before the 1st vehicle's on site reassembly. This instruction covered an overview of the vehicle, the handling of the vehicle and the vehicle maintenance.

On site training started with the 1st vehicle's reassembly in Shanghai. This provided intensive practical training to carry out and organize vehicle maintenance. The instruction accompanied reassembly, commissioning and maintenance during the test operations until the system's Overall Acceptance.

The 4 Milestones:

Contract signed	January 23, 2001
Reassembly of 1st Vehicle started	August 10, 2002
Overall Acceptance	April 13, 2004
Supervision by German Side ended	April 12, 2005

2 CONTENT OF TRAINING

The vehicle represents a new mode of transportation that incorporates advanced technologies. The Shanghai Maglev Transrapid Project was the first conventional project of its kind. What was the essential information that had to be taught? What should the customer be able to do with the vehicle maintenance and the operation? They had to be able to;

- operate the vehicle
- carry out daily maintenance
- clarify the diagnostic message
- test vehicle units and components by means of testing devices
- manage the vehicle maintenance with a computer aided management system before Overall Acceptance.

2.1 Handling of the vehicle

Instruments or switches on the front desk, the onboard power system and the diagnostic computers had to be switched before or after operation.

2.2 Maintenance Measures

The maintenance measures are defined in the Vehicle Maintenance Program. This included approximately 490 scheduled or unscheduled maintenance measures.

2.3 Maintenance Testing Devices

The vehicle is an electromagnetic system. As a result, there are a multitude of electrical and electronic units in the vehicle. The functionality of these units are checked on approximately 20 different special testing devices.

2.4 Understanding the Diagnostic Messages

The vehicle has an online diagnostic system that monitors relevant signals of the electrical and electronic units. About 380 diagnostic messages reflect the operating state of the vehicle. Dependent on failure messages generated by this system, unscheduled maintenance measures will be determined.

2.5 Maintenance Process and Maintenance Management System

The maintenance process is managed by a computer aided maintenance management system (MMS). Chinese side built up this maintenance process based on the experience from the Transrapid Test Facility in Emsland (TVE) and mapped it into the MMS.

During the projects initial phase it was found that transportation companies in China were not familiar with a MMS. Consequently, Chinese personnel had never used a MMS before the Transrapid project and had to first learn the structure of the maintenance process.

3 CHINESE VEHICLE TEAM

At the beginning of 2002 a small team was formed to operate and maintain the Transrapid system by Chinese side. This team was composed of engineers with academic training, holding bachelor degrees or higher. They were the first trainees of the Transrapid.

They should have become the team leaders and teachers of the Shanghai Maglev Transrapid Subsystems, Vehicle, Guide Way, Operation Control System, Propulsion and Power Supply System.

Peoples who are skilled in hands on tasks were indispensable to perform maintenance. This team later on, completed by a few proficient technicians. They became the best trainees and the best maintainer and shift leaders of vehicle maintenance to date.

4 TRAINING

Since so many different activities related to training were mentioned in Chapter 2, we had focused on the main points at first.

4.1 Factory Training

The highlights of the factory training were the overview about;

- functions of the vehicle
- components of the vehicle
- maintenance activities
- handling of the vehicle
- and the reassembly of the magnet modules that would be the first job of the Chinese personnel after delivery of the 1st vehicle in Shanghai.

Factory training was separated into three courses spanning a total of two months. It consisted of 5 packets that addressed the following subjects;

- overview of vehicle and vehicle maintenance,
- vehicle handling
- maintenance activities of electrical units
- maintenance activities of mechanical components
- and the assembly of magnet modules

The trainees were introduced to the vehicle and provided with as much information as possible about the vehicle's maintenance during the factory training period. This instruction occurred at the TVE and at the assembly line in Kassel, Germany.

All of the training at the assembly plant had to conform to the assembly plan, such as the magnet modules assembly instruction. This was exercised step by step incorporated with the real assembly process.

During the courses the training manager had to pay close attention to any problems and consider the feedbacks from trainers and trainees at all times.

For example, we found out that the Chinese team had never used a torque wrench because the mechanical measurement tool in China was not commonly used. It was apparent that torque wrench handling and torque measurement had to be added to the training program.

Communication in English during the training courses was sometimes problematic especially in practical training where the instructor and the trainees had lack of English language. An interpreter was effectively used in such cases to clarify any misunderstandings.

4.2 On Site Training, Assembly

After delivery of the 1st vehicle, on site magnet module assembling and the training was started at the Maintenance Center (MC) in Shanghai.

The first practical test of our training exposed some problems. We discovered that the assembly team could not assemble the magnet module. The reason was that the task had been outsourced to another company. The on site assembly staff were migratory peasants who had minimal vocational education. There were no factory trained Chinese personnel in the reassembly team. The magnet module assembly instruction had to be repeated to the current peasant workers in Shanghai.

Teaching people with limited vocational education is laborious, but it is no more problematic than training staff that later on don't perform that particular skill. This practical experience gained at the beginning of the on site project helped avoid the same mistakes.

4.3 On Site Training, Skills

After assembly of the 1st vehicle, commissioning and test runs started immediately. Training had to be incorporated with the vehicle's maintenance activities. We worked out a program of training so that daily, weekly, monthly and yearly maintenance measures could be introduced sequentially so that the Chinese staff could practice maintenance in a real time situation with our instruction team.

There are two groups of maintenance measures. The first group of activities is done directly in or at the vehicle, while the second group takes place outside the vehicle in workshops.

The first group of measures included replacement of components, visual inspections and function checks in the vehicle. The training of these maintenance measures was only possible, when the vehicle stayed in the maintenance hall. That means, this training had to take place after vehicle operation in the evening.

Maintenance measures in the workshops, such as function tests utilizing testing devices or the repair of a defective component could be done independently of vehicle operation. Thus the training was better arranged during the day.

Practically, the maintenance team was divided into two main groups, the shift group maintained the vehicle and the daily group tested and repaired components in the workshops.

From August 2002 to April 2004 we gave 45 training courses to 15 Chinese employees by classroom instruction and practical lectures. More than 30 experts from our company or from our suppliers passed on their knowledge, skills and experience to their Chinese colleagues in a helpful and informative way.

All of us, the German and Chinese staff, had to master daily maintenance assignments and training because of the test runs. Our 15 Chinese colleagues had to study very hard. Sometimes they worked on the night shift and then took part in morning training courses without a break. They became the core vehicle maintenance team for the Shanghai Maglev Transrapid.

4.4 On Site Training, Maintenance Process

Learning maintenance does not only include becoming proficient in the skills to do the work. An important part of maintenance is maintenance management, which takes in building up processes, defining regulations, documenting process flows, analyzing events and improving the process.

Many processes with regulations and protocols had to be defined, these included;

- handing over the vehicle before and after operation between the maintenance staff and the operation staff,
- generating fault report,
- creating work order,
- recording maintenance history of components

These processes were mapped and are now used in the MMS of the vehicle maintenance of the Shanghai Maglev Transrapid.

5 FACTORS TO SUCCESS

After Overall Acceptance of the Shanghai Maglev Transrapid Project on April 13, 2004, the Chinese staff took over the responsibility of operation and maintenance. One year later, after the warranty period, the entire vehicle maintenance and supervision team came back to Germany.

Since April 2005 the Chinese vehicle maintenance team executed vehicle maintenance in accordance to the Maintenance Program and Maintenance Handbook, independently. The Shanghai vehicle maintenance team has now grown to about 40 people. The original 15 trained Chinese peoples are now qualified team members or team leaders of the vehicle maintenance staff. The other 25 members are workers with simple vocational skills.

Since Overall Acceptance, the actual availability of vehicles for scheduled passenger trips reached 99.98%.

We believe this high rate of efficiency proves that the vehicle training provided was extremely infor-

mative and successful. The maintenance of the Transrapid vehicle utilizing advanced technologies can be shouldered by the trained indigenous maintenance personnel.

To reach this level of success there were several important factors that I would like to mention.

5.1 Personnel

5.1.1 Trainers and Supervisors team

The instruction of vehicle maintenance required not only different experts with systematic knowledge and experience of vehicle maintenance, but also experienced maintainers, skilled mechanicians and electricians for practical training. The core team of trainers should be also the core team of supervisors, too.

5.1.2 Trainees Team

The Shanghai Project's vehicle training covered all procedures of vehicle maintenance, from execution to management. The trainee's team was composed of approximately 50% engineers and 50% technicians. The engineers focused on the vehicle's function and management, while the technicians learned the skills to execute maintenance work. Today the technicians work as shift leaders who plan and supervise maintenance execution. In retrospect, the trainee's team with more technicians would be helpful for the operation.

5.1.3 Training Management

The tasks of training management were;

- planning the training at the right time and in the correct sequence
- calling and checking training manuscripts
- coordinating and
- and documenting the training.

An important job of management training is to pay close attention to the communication between the instructors and the trainees. Since each group came from different cultures and had different ways of looking at things, the manager had to find out if the trainees understood the instructors and visa versa.

For the comprehension of instructions German side had Chinese native speaker in its trainer's team.

5.2 Maintainability of Vehicle

The vehicle is designed for easy maintenance which includes the following features;

- standardized modular structure
- functional redundancy
- and an online diagnosis system.

The diagnostic system monitors the functionality of the vehicle during operation. The vehicle's diagnostic messages indicate failures and provide detailed information about the component and its installation position. The replacement of a component after a diagnostic failure message normally takes place during night time at operation's break. Most of the components can be replaced within 15 minutes.

5.3 Structured Maintenance Instructions

Maintenance measures are described in the maintenance instructions of the digital Vehicle Maintenance Manual. These instructions clarify maintenance measures step by step within a uniform structure. The materials, tools and resources needed are listed in the maintenance instructions too. With formulated protocols, the performance of maintenance procedures will be recorded.

5.4 Supervision

After training the Chinese personnel had to be familiar with the maintenance routine. They had to learn to work and manage things independently. The supervision period provided them a good chance. The training team accompanied and supervised during this period. The Chinese group defined daily maintenance measures and informed their supervisors. The specific maintenance measures would then be discussed and sometimes modified if necessary. The supervisor answered questions, watched the process of maintenance and checked the protocols.

6 CONCLUSIONS

Since April 2005 the Chinese vehicle team has taken full responsibility of maintaining the Transrapid vehicle. Personnel support from German side has not been required. During this period, daily operation time was extended from 9 hours to 14 hours.

The principle, "train the trainer" has been successfully exercised. It has been proven that Transrapid technology can be operated and maintained by local staff without the support of foreign experts.

The time, from the first training course in Germany on February 2002, to the last day of supervision on April 12th 2005 in Shanghai, was not only very busy and strenuous but also successful and unforgettable. The authors would like to take this opportunity to express our thanks to all the people who took part in the training and supervision for the good co-operation.

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