

## Industry collaboration in a Master degree

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## INTRODUCTION

The education of future engineers requires of knowledge and abilities to be updated and adapted to the industry where they access with technical responsibilities. This education needs the industry's cooperation in the teaching activities in a direct and continues way, especially in a Master degree, whereby students will achieve specialization.

The Master in Maintenance Engineering [1] of the School of Design Engineering ETSID at Technical University of Valencia UPV has been practicing this industry collaboration in the education of its students since its beginning in 2006,.

Within this master students perform internships at several companies, as is the case of vehicle inspection facilities and buses of the Municipal Transport Company of Valencia. Likewise, for all courses, two seminars are being organized, one dedicated to the Energy and the other to the Maintenance, in which the most relevant industry professionals and Spanish public administration participate. They expose the latest technological advances and the most trending topics, noteworthy is the participation of companies known as Iberdrola, Repsol, RENFE , Red Eléctrica Española, etc.

Additionally, it is made clear the importance of work experience inside companies to students as a manner of putting into practice their knowledge, acquire required skills to elaborate industrial projects and show their abilities to join the labour market. These work experiences extend from 4 to 6 months in a variety of industrial sectors: industry, agricultural cooperative, fleet of transports and etc.

In this paper we show its best practices that made it to be awarded as "Best UPV Master" during 2013/14.

## 1 BRIEF HISTORY OF THE UPV MASTER IN MAINTENANCE ENGINEERING

Maintenance engineering studies were initiated at UPV in 2000, giving a degree of "Specialist professional", aimed at students from engineering, with the aim of completing their training in this area, with a load of 360 hours. This title was already offering good training in basic Industrial maintenance materials, so that students could access to the working world with sufficient knowledge for technical positions in Maintenance Departments of companies.

After the upcoming of the EHEA in Spain, UPV requested this "Specialist professional" degree to become a Master degree by subsequently expanding its contents in 2006-2007. This Master began with a curriculum of two courses duration and 120 ECTS credits, of which 100 ECTS correspond to subjects, 10 ECTS to internships and 10 ECTS to the Master Final Project (MFP).

Bachelor degrees in Spain passed in 2010 from 3 to 4 years of duration, ending the first promotion of these students in the academic year 2013-2014. This new situation meant that two additional courses of Master was a little bit lengthy; which coupled with a great acceptance of the Master by foreign students, especially Latin Americans who demanded a shorter duration, as well as the experience gained during seven years, raised the need for a reshaping of the curriculum, leaving it in 72 ECTS, of which 54 ECTS belonged to 12 subjects of 4.5 ECTS; 6 ECTS of internship with a duration between 2 and 8 months, and 12 ECTS of MFP. Thus, the Master degree may be earned in one year if the student already has got work experience, or two years if company internship is necessary in the case of just graduates.

## 2 MASTER IN MAINTENANCE ENGINEERING AND INDUSTRY NEXUS

### 2.1 The knowledge demanded by industry

Since the main objective of the Master is the training of students for positions of responsibility in the Maintenance Department of companies, the knowledge demanded by industry has been had in mind when designing its curriculum [2, 3].

The training required for a graduate in a traditional engineering degree to complete his studies in order to have professional training in maintenance can be divided into four major areas of knowledge:

- General knowledge: applicable in any type of industry or service, called the fundamentals of the maintenance engineering: definition, objectives, history, types, methods of implementation, organization, regulation, indicators, etc. This knowledge will be the "pillars" upon which to settle maintenance system of the company, being the basis and starting point, always with the mind set for continuous improvement of the system, the well-known Kaizen philosophy, which we must instil into our students so that they transmit it to their workers.

- Modern maintenance strategies: RCM, TPM, 5S, LCC, the new ISO 55000 Application of the analysis of reliability, maintainability, and availability, to be able to determine typical failures and learn to apply the models of life (normal, exponential

and Weibull). A very important aspect that the person responsible for maintenance must know is the management of spare parts and tools in warehouses and inventory control. There are other side skills that tend to be useful to the maintenance technician, which are usually allocated responsibilities in the area of occupational risk prevention and the Elimination of toxic and hazardous waste within the system of environmental management of the company.

- Expertise: maintenance engineer should know about many facets of engineering that will be useful when it comes to optimizing the maintenance, in addition to the own subjects of studies of races, must have a strong grasp of materials as the lubrication together with the modern techniques of monitoring and troubleshooting using non-destructive testing (Non Destructive Testing): such as the analysis of vibration and noise, thermography, etc. In this area we include a very important facet, as it is the domain for the selection and implementation of a Computerized Maintenance Management System (CMMS).

- Specific knowledge of maintenance of machines and facilities: University races are has an impact on the knowledge of the operation of the installations, machines and engines: electrical, thermal, hydraulic, building, etc., but very little on how to maintain it. Therefore a good training for maintenance must contain specific subjects for maintenance of these machines and infrastructures, taught by specialists from each of these materials.

With this knowledge, the possible lines of action of the maintenance engineer are covered in various sectors: energy, industrial, transport, buildings, services, etc.

## 2.2 Collaboration of industry in the acquisition of skills

University departments have laboratories for practical classes with equipment and instrumentation that is found in the companies. But these practices do not give the complete picture of a real maintenance system and how running these techniques enables monitoring facilities, machinery, or vehicles in enterprises. Thus they are complemented by visits to facilities of some companies as RENFE, where they keep the locomotives and wagons of the Spanish railway; the Municipal transport company in Valencia, running urban buses; the production plant of lubricating oils of TEXACO, where the "blending" for the preparation of oil lubricants is done, as well as important industries such as HEINEKEN or FORD, both near Valencia, and even military installations where the maintenance of helicopters is made. In all these companies emphasis is put to observe maintenance rather than facilities or production line.

In order to complete the training of the students, giving them insight into the professional world, two seminars are organized each course, the first one focused on maintenance in spring and the second one in the field of energy in autumn. In these seminars, technical managers of the leading national companies in these two aspects do participate, always with the collaboration of the main Spanish energy company, IBERDROLA, as well as others that kindly participate, as REPSOL, CEPSA, Red Eléctrica Española, ENAGAS and GENERAL ELECTRIC from the energy sector; IVECO and MAN from the road transport sector; Air Nostrum and INAER from the aeronautical sector; VOSSLOH, RENFE and ADIF from the railway sector; BUREAU VERITAS, SCHAEFFUER, FERROSER, SISTEPLANT, FAG, ATISAE from the service sector; or large plants such as HEINEKEN, UBE CORPORATION or FORD Spain among the best known.

Every seminar runs Monday through Thursday, with two lectures each afternoon in which the lecturer exposes in detail the case during the first hour and is followed by a half-hour discussion so that students can discuss any questions they might have. It is noteworthy that maintenance seminars are always inaugurated by the Chairman or a

representative of the Spanish Association of Maintenance presents a topical subject in this sector. With all this, students acquire an insight into the professional world that facilitates a quick employment.

### **2.3 Practical training of engineer of maintenance in the industry**

Previous sections deal with knowledge and skills that the engineer of maintenance must have. However professional maintenance meet special features to deal with such as precarious or risk conditions, the need to work on holidays or erratic hours and night shifts, sometimes in the open air and with adverse atmospheric conditions, which requires a clear vocation and usually *hook* the good professional. This capacity of adaptation to changing conditions and service requires certain attitudes based on some skills and a great sense of responsibility. These competence requirements may hardly be transmitted in classes, not to mention something as intangible as it is the leadership of working groups. All these have a training methodology but practice and experience are a must to ensure the maintenance success by the responsible technician of a company.

Some of the students who follow the Master come from the industry and look for a more professional training, often already having positions of responsibility in maintenance, so they have some professional experience to manage the responsible working groups and crisis situations that appear within maintenance. However, most students that begin this master, make it as an immediate continuation of their recently finished college careers. For them, it has been included within the training program a curricular work experience in enterprise, i.e. mandatory. Fortunately the relationship Industry/Companies - University has improved in recent times, promoting the acceptance of students for these stays.

Our experience in the capacity of training of students in these internships is very positive, most of the students made them quite easily during the years of economic boom 2006-2008 and with more difficulty nowadays. Many of these students address problems not well resolved in enterprises such as structuring preventive maintenance plans, incorporation of new techniques of predictive maintenance and as a generalized challenge the introduction of a new computerized management system (CMMS). The success in this work makes that in a high percentage they become valuable people, advising his hiring at the company. The size of the companies and areas of work where they do the practices is very varied, showing the versatility of the training acquired by these students.

In relation to the collaboration of companies in the reception of students of the Master in Maintenance Engineering we can provide some interesting data.

- The Master has limited to 30 the number of admitted students, from which around 20 students perform practices in enterprise and the rest do not need to make them as they have them recognized for being working or having worked (foreign students are usually subsidized by their companies or some national entity).

- The variety of companies that receive Master students indicates that maintenance engineering is present in all types of industries, transportation, buildings, etc. We can count up to 63 different companies, highlighting their importance: BAYER, BOSCH, CLECE, EULEN, FERROVIAL, FORD, NISA hospitals, KAMAX, SIEMENS, SP-BERNER, TELEFÓNICA, UBE CORPORATION, VOSSLOH, etc.

- Over the 7 years of existence of the Master, 153 internships, counting both the mandatory and the optional, have been signed.

Students culminate their training by doing their Master Final Project on some of the actions for the improvement of the maintenance system which in some cases is in

fact implemented in a given company. Many of the students are employed to continue with these improvements after an internship period.

## 2.4 Employability

There is no doubt that the success of a university degree is measured by the high employability of its graduates. The Master in Maintenance Engineering of maintenance is proving to be a good platform for graduates to find a first job or improve the one they already have, noteworthy being that most of them work as maintenance technicians with greater or lesser level of responsibility.

Quite recently the Master has gone under a reaccreditation process by the Evaluation National Agency of the Spanish university studies, and a survey was performed among graduates to know about their jobs and the impact of the Master.

As overview of this survey we should start by pointing out the high number of alumni who answered and expressed very satisfactorily the knowledge and acquired skills that has been implemented later in their companies.

Latin American graduates work at universities, in large hotels, mining facilities, petroleum refineries, sugar cane, in industrial processing, maintenance of ships of the Navy or military vehicles, etc.

In Spain graduates are working in the agro-food sector, railway construction, hospitals, services, maintenance, design and maintenance of air conditioning, electrical, hydraulic, thermal and nuclear facilities, automobile components, manufacturing plants and car factories, road maintenance, steel, etc.

All this shows the variety of companies in which maintenance engineers can develop their work.

## 3 THE CERTIFICATION OF MAINTENANCE

The Spanish Association of Maintenance (AEM), following the guidelines of the European Federation of National Maintenance Sociétés (EFNMS), raised interest in the certification of personnel serving in maintenance as well as enterprises or organizations that hire them [4].

Certification of individuals is based on the demonstration of a combination of formal knowledge and practical experience that guarantees the qualification and capacity of the person responsible for, or that is making, a particular activity

Since 1993 the EFNMS took up the certification process for people in their field, the AEM doing several attempts to start up its certification system since 1998 in which the formation of the applicant should be subject to examination. This was settled in 2010 and practical experience has to be demonstrated in order to be certified.

The certification process is set up in three aspects:

1. Knowledge.
2. Work experience.
3. Professional competence.

And there are three levels of certification for people:

- Maintenance Manager.
- Maintenance Supervisor.
- Maintenance Operator.

In the case of the Maintenance Manager, which is the highest level, it is required for the candidate to enjoy some university engineering, architecture or equivalent qualification and to have completed a master degree or specialization course recognized by the AEM. UPV Master in Maintenance Engineering is highly valued by AEM. In addition at least two years of work experience in positions of maintenance must be accredited. Candidates must reflect some personal action work in the field of maintenance to be presented and defended in front of a 3 member board appointed by the AEM with relevant professional experience.

It should be noted the academic Director and a professor of the Master are active members of the Board of Directors of the AEM and are the delegates of the Board for the certification of in-house development of the EFNMS, as well as in the Spanish Committee of Standardization (AENOR) in the field of maintenance.

In the successive editions of the Maintenance Manager accreditation several students of the Master, with sufficient work experience, have been certified, using as personal action work the Master Final Project. This gives added value to the Master and its graduates by their almost direct recognition of professional skills.

#### **4 SUMMARY**

The education of a professional engineer that will be incorporated into responsibility positions of a company, as it is the case of the maintenance engineer, requires linking it closely to the demands that will be found in their professional development.

Thus care must be paid to its curriculum design which is to be in line with the demand of knowledge required by the industry, training in practical skills with equipment and instrumentation that will be found in the companies and knowing how these tasks are executed in their facilities, making visits and contacting engineers and workers who run them and are responsible for the maintenance departments of large national companies.

Finally a good training of future engineers of maintenance is also based on professional experience. This enables applying their knowledge and skills, work in a team in intermediate positions and begin to exercise the leadership of people and the entailed responsibility.

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