Review

2000-2001

THE HIGHER TECHNICAL INSTITUTE

The Higher Technical Institute (HTI) was established in 1968 as a Government of Cyprus project with assistance by the United Nations Special Fund (UNDP) the United Nations-Education-Scientific and Cultural Organisation (UNESCO) and the International Labour Office (ILO). Cyprus Government Executing Agency: The Ministry of Labour and Social Insurance

Review

2000-2001

No. 30 November 2001 Nicosia Cyprus

Students working in the HTI Workshops

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2001 HTI Graduation Ceremony

The Higher Technical Institute held its 31st Graduation Ceremony on Friday, 29 June 2001 at the Cyprus International Conference in Nicosia.

The President of the Republic, Mr Glafcos Clerides, attended the ceremony and awarded the Presidential Prize of £5.000 to Mr Marios Raspopoulos, the graduate with the highest overall performance. Additionally the President awarded a prize of £1000 from his personal budget to Mr Yiannis Zaltis the graduate with the highest overall performance from the Marine Engineering Department.

The Minister of Labour and Social Insurance Mr Andreas Moushouttas who also attended the Ceremony proceeded with the award of the diplomas to the one-hundred and twenty seven graduates while the HTI Acting Director awarded the prizes sponsored by organisations and professional bodies to the graduates who excelled in their academic studies.

The Ceremony was also attended by the Director General of the Ministry of Labour and Social Insurance Mrs Lenia Samouel, members of the Parliament, government officials, representatives of the political parties, trade unions and professional bodies.

The President of the Student Union, Mr Michalis Heraclides addressed the gathering and highlighted the students' efforts and demands for professional recognition and restructuring of the Higher Technical Institute.

The main speaker was the HTI Acting Director Mr C. Loizou who thanked the dignitaries and all those who attended the Ceremony. His speech is as follows:

On behalf of the Ministry of Labour and Social Insurance, the Higher Technical Institute and to-day's Graduating Students, I would like to thank you for honouring us with your presence at the thirty first Graduation Ceremony of the Higher Technical Institute.

We consider your presence at our Ceremony as a proof of your interest in the work carried out at the Higher Technical Institute.

This year 127 students graduate from the three-year full-time courses namely, 35 in Electrical Engineering, 32 in Mechanical Engineering, 14 in Marine Engineering, 44 in Civil Engineering and 32 in Computer Studies.

Apart from the full-time courses, the HTI has also organized, 15 short courses with a total of 208 participants from industry in the framework of Continuous Professional Development.

It is well known that HTI was established in 1968 on the basis of a 5-yearProgram of the Government of Cyprus with the assistance of the United Nations Development Program (UNDP), UNESCO and the International Labour Office (ILO).

We have given a total of 4246 Graduates to the Cyprus Industry and elsewhere from Technical Engineers to University Professors both in Cyprus as well as in numerous Universities abroad.

However, we continue facing problems regarding the professional recognition of our graduates. We hope that the negotiations taking place concerning the employment of graduates in the Government Sector as well as their professional rights in the private sector will lead to a fruitful conclusion.

All the Academic and other Bodies specified in the H.T.I. Law regarding the Establisment, the Organizations and the Operation of the Institute were formed and operated during this Academic Year.

Over and above this, a most important event occurred in February, namely, the decision of the Council of Ministers to establish a Technological University of Applied Science & Arts in which University the Higher Technical Institute together with all the Government Institutions of Tertiary Education will participate.

As far as the HTI infrastructure is concerned, work is in progress to complete the sport grounds and parking around the Sports Hall as well as four lecture rooms and twelve offices. We are now turning our attention to the improvement of our computer and laboratory facilities. Also efforts are made to introduce the Credit Point System in September 2002.

HTI participates actively in the European Union Program Socrates / Erasmus for staff and students exchanges.

In the meantime, the HTI continues to offer excellent training to its students and in addition, it is participating in research programs financed by the European Union as well as by the government.

Furthermore, the HTI continues to offer its services to industry in consultancy work as well as in testing of materials.

Before ending my Graduation speech I would like to thank the various industries, organizations as well as individuals, for their generous donations, scholarships and prizes given to us this year. Their names appear in the Graduation Ceremony booklet.

I would also like to express our thanks to his Excellency the President of the Republic for the Presidential Prize value CY5.000 which is awarded to the best graduation student.

Apart from this prize however, his Excellency the President of the Republic has offered, the same as last year, a personal prize of CY1.000 to the best Marine Engineering graduating student for which we wish to express our special thanks.

Concluding my speech I would like to wish, on behalf of the Ministry of Labour and social Insurance and the Government, to today's graduating students progress in life and a successful career.

EDUCATIONAL ACTIVITIES

Short courses organised by H.T.I.

SHORT COURSES ORGANISED BY HTI

1. **The Electrical Engineering Department** in collaboration with the IEE Cyprus and the Human Resources Development Authority of Cyprus organized four short courses on "Intranets Cabling,Devices & Software" (27.11-1.12.2000, 11-15.12.2000, 29.1-2.2.2001 and 11- 15.6.2001).

All courses were intended for personnel working in Industry and CYTA. The courses were developed and presented by Mr Charalambos Theopemptou, Lecturer, Electrical Engineering Department, HTI.
The duration of each course was 30hrs and included theoretical and practical sessions.
The courses were attended by a total of 116 participants.

2. **The Civil Engineering Department** in collaboration with the Cyprus Group of Civil and Mechanical Professional Engineers organised in the academic year 2000-2001 the following courses:

a. Endorsement Course in Quantity Surveying Principles and Building Contracts Administation
   Part 1: Tendering and Pricing
   Part 2: Law and Building and Civil Engineering Contracts
   Part 3: Principles of Measurement and Description of Specification of Construction Works.
   Part 4: Pre-Contract and Post Contract Administration and Project Cost Control.
b. Earthquake Engineering.

3. **The Engineering Practice Department** in co-operation with the University of Albany and the Planning Bureau organized a 20-hour short course on "Engineering Training Management".The course was held between 26-30 March 2001 at the Amphitheatre of the Higher Technical Institute and was delivered by the Professor Demetris Grivas of

Rensselaer Polytechnic Institute USA. The course was attended by the Chairman of the Central Academic Board, the Heads of Departments, the Workshop Superintendent, Senior Lecturers, Senior Instructors and members of the Central Academic Council.

4. **The Engineering Practice Department** organized a short course on "The use of Computers" in co-operation with the Public Administration and Personnel Service. The duration of the course was 30 hours and started on the 7 May 2001, and was completed at the end of June 2001. Ten Instructors attended the course.

5. Dr I Angeli. Laboratory Assistant 1st Grade in the Mechanical Engineering Department delivered a four day short course on Total Quality Management between 13-21 March 2001. The course was organized by HTI and CC.

CONFERENCES/SEMINARS

1. Dr Christis Chrysostomou participated in the educational program entitled "Mitigation of seismic risk-support to recently affected European Countries"(26-30.3.01) organized by the European Commission Directorate General and Joint Research Centre. His participation was funded by the Scholarship and Training program of Government Employees. Dr Chrysostomou lectured for a total of 8 hours at the Southbank University in the U.K.

2. Dr I Angeli, participated in the Quality Forum 2000 organised by ECO-Q in Athens and presented a paper on "Statistical Process Control using Computers" between 16-18 November 2000.

3. Dr I Angeli, participated in the 4th Panhellenic Conference organized by ECO-Q and OEB in Nicosia and presented a paper on "Design of Experiments: a case study in food industry" between 27-29 June 2001.

4. Mr George Iordanou and Mr Theodoros Symeou, the Head and Lecturer of the Mechanical Engineering Department respectively, participated in the Seminar «Train the Trainers» in the framework of the EnroMediterranean Energy Policy Training Network, MED-NET, held in Athens between 1-11 July 2001.

5. Dr D Sergides, Senior Lecturer of Civil Engineering Department, participated in the following Conferences/Seminars:
(a) "EuroSun 2000" ISES – Europe Solar Congress Denmark between 19/6-22/6/2000
(b) Alvar Aalto Architectural International Symposium" – Finland during 10/8-13/8/2000.
(c) "The Future of Renewable Energy" – Denmark during 21/8-27/8/2000
(d) "Sunday 2000" ISES – Cyprus – Larnaca on 18/6/2000.
(e) Participation in Discussions at the Parliamentary Committee of Energy Commerce & Industry on 8/6 and 15/6/2000.

6. The Workshop Superintendent participated in the Annual General Meeting of EurEta which was held in Basel, Switzerland, between 14 and 18 June 2001. The conference dealt extensively with topics regarding the standards of education and training of engineers.

VISITS/EDUCATIONAL EXCHANGE PROGRAMMES

1. Under this year's educational exchange program Dr Soteris Kalogirou visited the University of Glamorgan from 30 October to 3 November 2000. During the visit Dr Kalogirou had the opportunity to visit the laboratories and the new equipment acquired recently by the University. He also gave three lectures to students on matters related to his specialization.

2. Professor Karoly Veszpremi visited the Engineering Practice Department of H.T.I. between 14 February and 20 February 2001. During his visit Professor Veszpremi discussed the possibility of further co-operation in the area of short courses, research and staff exchange. Professor Veszpremi had talks with the other Engineering Departments as well.

3. Mr C. Georghiades Senior Instructor visited Salonica TEI between 23-27 April 2000 under the EU Programme Socrates/Erasmus.

4. The Workshop Superintendent participated in a study visit between 23-27 April 2001 in Spain under the EU

programme Leonardo. The area covered by the study visit was "Initial Training of Young People".

5. The Workshop Superintendent participated in the meeting of the Board and the Registration Committee of EurEta that took place in Lund of Sweden between 9 and 12 November 2000.

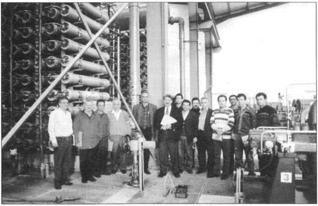
6. Mr A Loizides and Dr I Angeli visited British Organisations and Universities for one week in September 2001. The purpose of their official visit was to acquire knowledge and experience on how Quality Management systems can be implemented in Educational Establishments and guide HTI staff and consultants on how those systems can be implemented at the HTI. They visited the University of Glamorgan, the Quality Assurance Agency, the Warshash Marine Academy in Southampton, the International Marine Organisation Headquarters and Brunell University. Their visit proved to be quite beneficial for the implementation of our Quality System.

IMPLEMENTATION OF 1SO 9000:2000 BY THE H.T.I.

Following a decision by the Board of Directors of HTI, the contract of implementation of Quality Management System (ISO9000:2000), has been allocated to the consultants PriceWaterHouseCoopers in April 2001. The major project is expected to last two years and it will lead to Certification with ISO 9000:2000. For this purpose a steering committee has been appointed by the HTI Management. All HTI personnel received a one day course on "Introduction to ISO 9000:2000 in April. Twenty-five members of the academic staff received a four day training course on "How to write procedures of ISO 9000:2000". Twenty-five members of the academic staff are expected to be trained and act as Internal Auditors in a 3 day course at the end of October. Dr I Angeli, Quality Management Systems Auditor, has been appointed by the HTI Management as the General Coordinator of the whole project.

IAESTE ANNUAL GENERAL MEETING

Mr C. Loizou, Head of the Electrical Engineering Department and Ag Director and Mr Ch. Chrysafiades, Senior Lecturer of the Electrical Engineering Department participated in the annual General Meeting of IAESTE which took place at Durban, South Africa between 19-26/1/2001.



Study visit to Dhekelia Water Desalination Plant

Honorary Award

The Organising Committee of "ECO Q 2001 Honorary Award of Greece" has decided that the award for the person with the best publication in the field of quality be awarded to Dr Ioannis Angeli of the HTI Mechanical Engineering Department (second from the right).

The Quality Award Ceremony took place in the "Le Meridien" Hotel in Limassol on 5 September 2000 and the awards were presented by the President of the House of Representatives Mr Demetris Christophias.

During the ceremony the following were also honoured: The Minister of Commerce & Industry Mr. N. Rolandis, the Director General of CYTA Mr N. Timotheou as Operational Manager, the Electricity Authority in the Field of Services, the Strovolos Municipality in the Field of Public Organisations and the Employers and Industrialists Federation in the Field of Industry and finally Christy's Company in the field of Industry.

CRITICAL DISCUSSION ON THE DIFFERENT PURPOSES OF STUDENT ASSESSMENT

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The word 'assessment' is a global term which incorporates a variety of testing methods in order to measure students' learning.

Assessment has always played an important part in education because it helps the evaluation not only of students but of teachers and institutions as well.
The value and necessity of assessment cannot be denied by any educationist but there are however a number of questions and critiques concerning this. If assessment is used properly, then the benefits from it are unquestionable. If however it is misused or over-used, teaching and learning will suffer.

Qualifying examinations were very early introduced throughout the globe initially for doctors and accountants around 1835. With the development of the social structure and industrialism, the need for testing and selecting became imminent, and there was a great need for professional and trained teachers. Patronage and social class were now simply not enough.

The Universities and the Civil Service were next to follow with entry examinations in the 1850's and later on we have the awarding of the school certificate at the end of the Secondary School, after successful examinations. It is therefore obvious that by now written assessment was well on the way for recognition. It was an inevitable development of the changing needs of society.

Assessment in our modern society is part of everyday life and is expressed through written exams, essays, oral interviews, practical testing, coursework and teacher observations. As Gipps (1994) puts it: *"the prime purpose of assessment is professional : that is assessment to support the teaching/learning process"*.
(Gipps is a very experienced educationalist, psychologist, test developer and Lecturer at the University of London, Institute of Education)

Purposes: The purposes of assessment are multi-functional. There has been a number of groupings depending on the various functions of assessment, but I would like to keep to Gipp's divisions in my effort to present this article as coherently and critically as possible.

Screening is the first type of assessment we will examine. This is a process which enables students with special needs to be identified. Through prompt identification, immediate help can be offered, whether this might be medical, psychological or academic. Screening is an absolute necessity in academic institutions because it will pick out students who are perhaps visually impaired, or with hearing problems or even students suffering from dyslexia and having learning problems. The various cases will then be allocated to the right professionals or remedial teachers for rectification. I have recently though, come across a case where a child with dyslexia was not screened out until the age of fourteen. This is an absolute tragedy which embarrasses the educational system.

Diagnosis will then follow and its main purpose is to identify students' strengths and weaknesses. This can be dealt with either by educational psychologists, specialists or advisory teachers. Of course the argument here could be that not all schools carry out this process or even if they do they might either not have the professionals to deal with the individual students' needs or they may simply ignore the results. Certainly in many schools in Cyprus this is a process which is simply inadequate.

Record keeping is the process where test results and records of attainment on various subjects are put into record books by academics, not because they want to use them in any professional way but because they want to make results available to anyone who may inquire about standards and achievement. This method is obviously very bureaucratic and not educational. The administrative role of record keeping is nevertheless quite useful and offers us, teachers, the chance for background information on students.

Feedback on performance is aimed at providing details about students' progress to teachers, parents, Local Educational Authorities, Ministries, but most importantly to students themselves. *"Feedback or knowledge of results is the lifeblood of learning. Effective feedback enables the student to identify his strengths and weaknesses and shows him how to improve where weak or build upon what he does best"* (Derek Rowntree, 1987). I think this declaration by Rowntree sums up the importance of feedback to students. It is a vital process which will contribute immensely to the improvement of students but unfortunately it is a process which is not carried out in all schools satisfactorily either because of lack of time or professional availability. However, in private schools or smaller group classrooms and institutions where tutorials are available, feedback is carried out very successfully and efficiently.

Certification is the actual awarding of a certificate which indicates that a student has successfully completed a course or passed an examination. This is a strictly bureaucratic test which is necessary for purely administrative reasons.

Selection is the final role of assessment we will examine, and as I stressed at the beginning of my article, selection became necessary following certain social changes. We currently use educational selection assessments for entry to different schools, institutions and universities. It is required that in order for students to be allowed to study a certain 'A'-level subject they need to reach a particular grade in GCSE exam. This is a good practice because it provides students with motivation to do well, if they want to continue with their academic work.

Limitations / critiques / different types of assessment:

Formative assessment or diagnostic is the type of assessment that helps the teacher to help the student. It involves using assessment information to feed back into the teaching/learning process. The teacher monitors the problems or strengths, so as to rectify the problems or build on the strengths. However, one critique on this suggests that..*"the teacher may be seen as judge rather than facilitator"* (Gipps, 1994). I believe that this is an exaggerated view and the truth of the matter is that conscientious students value this "feedback" from the teacher and consequently make full use of tutorials. Personally, I find this type of assessment imperative, very educational and absolutely vital.

Summative assessment takes place at the end of a term or year and is terminal. Students either pass or fail. Of course this indicates how much the students have learned and how well a course has worked. Although this kind of assessment cannot improve the educational level of students, it is indicative of their achievement and whether students like it or not, unavoidable. As Dennis Lawton said in one of his lectures *'It's like doing the espionage after the war'*.
(Dennis Lawton, a renowned educationalist, is Professor of Curriculum Studies at the Institute of Education, University of London)

Norm-reference assessment is when students' performances are compared with each other. Grades are awarded according to the distribution of marks.

The Criterion-reference assessment has clearly specified grades and all the boards apply the same standards in awarding grades (Orr and Nuttall, 1983). This kind of assessment aimed to better standards and encouraged low-ability students. Examinations of this kind in Britain were the GCSE (General Certificate of Secondary Education) and the RoA (Record of attainment). Despite the various critiques on this kind of assessment, about *"over-specification" and "complexity"* (Sandler, 1987), I tend to believe that it is a very rewarding kind of assessment, because it makes students set certain goals which they see materialised gradually. Basically criterion-reference assessment means awarding marks or grades according to the absolute standard and criteria. Everybody can pass, everybody can fail.

The ipsative assessment is another type of assessment where students compare their grades with their previous ones. This is a good way of being judgemental about their own achievement and it can only make students try to do better.

Finally we should not forget the **informal assessment,** where we are always assessing students and providing comments on their work. It is an ongoing process and obviously important in learning. And of course the students are always assessing their teachers, instructors, lecturers.

Assessment-driven curriculum:

We have so far examined the purposes of assessment and different types of it. We should certainly not overlook the connection between assessment and curriculum. The two should be working parallel to each other and not independently. What I mean by this is that assessment should be "curriculum-driven" and not the other way round. Teaching to succeed in examinations is a very common practice in the USA, although it is understood in the UK too, with the "refined" term, preparation for exams. This activity conveys many dangers for the students because emphasis is given on the examination itself rather than the acquisition of learning. This is what educationists call *extrinsic motivation* (working for a reward) rather than *intrinsic motivation* (working for something enjoyable and interesting). This practice limits the learning of students immensely because only the subjects that will be examined are taught. Needless to say that this is not very beneficial to students since their learning is limited to what the various syllabi for exams specify. It is of course an excellent way of controlling what the teachers teach.

Ideally assessment should be a continuing and ever persistent process that takes into consideration the student as a whole, and not limiting his evaluation on a specific, number of exam papers. The proposed credit-point system, together with gradual, segmental marking that the H.T.I is considering to implement, will be a very positive step towards more objective assessment. The introduction of project work also as well as student presentations will contribute immensely to deeper, more lasting, fundamental and meaningful learning.

Concluding I would say that despite the certain limitations of the various methods of assessment that exist, it is still a practice absolutely vital to education. Students need a high level of motivation and the competition-element that assessment conveys, provides this motivation. We could of course argue that the fact that students compete with each other discourages them from helping one another with their academic work. It also tends to segregate students into different ability groups.

Nevertheless, assessment is part of our life and an unavoidable social phenomenon. Our efforts, our lives, even our dreams are constantly examined and criticised by the rest of society. And as W.B.Yeats eloquently and poetically puts it :

> *"I have spread my dreams under your feet;*
> *Tread softly, because you tread on my dreams".*

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NANO COATINGS FOR PROLONGING TOOL LIFE

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Abstract

With a view to further promoting technology transfer, the recently established Nanomaterials Research Center (NRC) has initiated a major proposal within the 5th EU Framework. The proposal was prepared in collaboration with nine Small and Medium European Enterprises, three European Universities and three European Research Institutes. NRC will be put to use for the thermochemical processing of bulk test quantities of amorphous and nanophase powders. The powders will be utilized by a consortium of end-user companies, which will pursue prototype coating development, performance testing and market research.

NRC has been established to serve as a bridge for technology development between the Institute and the technology users (industry at large). Under this center, an array of operating divisions has been established, each with its own application goal(s) and commercialization strategy. Now being in its third year of operation, NRC has already established two operating divisions: (1) nanopowder synthesis, which is commercializing high rate production of non-agglomerated nanoparticles and (2) large area deposition of coatings. Both divisions focus on the commercialization of advanced materials processes for enhanced mechanical and thermal properties.

The primary objective of the proposed program is to fabricate nano(structured) coatings from amorphous powders by a thermal spray process or otherwise to be used towards prolonging tool life and in a wide range of other products. Nano coatings will enable increased wear, heat transfer and corrosion resistance, fatigue strength and fracture toughness compared with conventionally manufactured coatings. High performance nanostructured coatings are projected to have a large economic impact in the energy, transportation and aerospace industries in the 21st century.

In what follows we present *selective excerpts* from the proposal.

Introduction

Advances in high performance materials for structural applications will increasingly depend on our ability to control the size, distribution and morphology of their constituent phases at the sub-micrometer or nanometer level. Since capabilities for synthesizing such nanostructured materials in bulk are becoming available, it is now possible to produce quantities of materials needed for prototype development and testing.

What are nanostructures?

Nanostructured materials are a new class of synthetic materials with ultrafine microstructures, somewhat arbitrarily defined as structures smaller than 100 nanometers. These materials may be composed of metals, ceramics, polymers and their composites. The materials can be in the form of powders, thin films, porous media or dense structures.

How are nanostructures made?

Many different chemical, physical, and mechanical methods have been devised for synthesizing nanostructured materials. Nanostructured thin films are routinely produced by sputtering, laser ablation, electrolytic deposition, chemical vapor deposition and molecular bean epitaxy. Nanostructured powders are synthesized by gas phase condensation, gas jet deposition, laser pyrolysis, cryomilling and solution/precipitation methods. The as-synthesized powders can be fabricated into controlled porosity structures or theoretically dense structures by a number of different techniques including thermal spraying, hot isostatic pressing, hot pressing, cold compaction/sintering and powder injection molding. This rather confined account merely serves to illustrate the broad range of technologies being applied to the synthesis and processing of nanostructured materials and does not take into account the particular challenges encountered in the synthesis and processing of polymeric nanostructured materials.

What are nanostructured materials good for?

Nanostructured materials can exhibit improved and even novel properties, which can be exploited in (1) superplastically formable ceramics for advanced heat engines and propulsion systems, (2) faster computers using Josephson junctions and quantum well devices, (3) solid state refrigeration using magnetocaloric materials and (4) harder/tougher cutting tools for high speed machining and drilling.

Innovation, Novel Aspects and Commercial Objective of the Work

Thin ceramic coatings produced by established PVD and CVD variants are now widely used in cutting/abrasive applications such as application to milling cutter, drill bit or press tool. The most common examples of these are Titanium Nitride and Chromium Nitride. The attractive features of these coatings are of high hardness (2000–2500 HVN) and low surface energy. These coatings have been seen to increase tool life by 5 times in many cases. The disadvantages of these coating types are high cost, high application temperature and the inability to coat large complex structures. Also the tribological properties and adhesion levels of these coatings can be seen to vary depending on factors such as substrate type and nature of abrasive loading.

Many studies have found that hardness alone is not the primary material property which defines wear resistance. There is evidence to suggest that elastic modulus has a crucial influence on wear behavior[1]. The ratio of hardness to elastic modulus (H/E) has been found to be a more reliable parameter for predicting wear resistance than hardness alone. Studies suggest that the allowable elastic strain to failure (related to H/E) is an important factor in determining tribological property.

Whilst possibly not exhibiting such high hardness values as their crystalline counterparts, amorphous films may exhibit superior tribological properties as a result of lower elastic modulus and increased toughness[2]. These features may be accompanied by increased fracture toughness and a subsequent resistance to crack formation. It is precisely this combination of high hardness, increased toughness and resistance to fracture which makes these coatings potentially superior to others presently in use.

The ability to apply these coatings cheaply and quickly in bulk to a variety of complex structures makes them very desirable. Applications can be envisaged on cutting tools, large structures (aircraft) and many forming and pressing tools where the existing coating methods are not practical. The adaptability of the process to produce alloyed and multi-component coatings is another very desirable feature[3].

In this respect, a novel thermochemical processing method for preparing amorphous powders starting from homogeneous precursor compounds has been developed by Nicos Angastiniotis et al. (European Patent # EP 0800883). The invention relates to the formation of amorphous metal powders from amorphous metal oxide powders and, in addition, relates to a method of producing amorphous tungsten, molybdenum and molybdenum alloys and their alloys with chromium, iron, cobalt and nickel and, further, to the use of these powders to form refractory metal compounds of amorphous/nanocrystalline grain size. In addition to being useful for formation of silicides, carbides and nitrides and other refractory composition, the present invention is also useful in the elemental form to provide amorphous/nanostructured powder coatings and the like. They can also be blended with compositions for alloying and used in any application in which elemental metal is employed. The amorphous metal oxide can also be used in any reaction calling for such an oxide. The decreased particle size should facilitate mixing and improve reactivity. The particle size of the oxides makes these oxides useful as pigments and coatings and in ceramics.

The breadth of this research initiative places it in a position to achieve a strong proprietary position in both the manufacture and application of nanostructured powders.

Apart from the nano coating perspective, potential opportunity areas include the thermochemical process for making various other nanostructured powders, the powder products of that process, processes for creating net-shaped parts from nanostructured powders, such as PIM and nanostructured net-shape parts. The research vision is to focus on maximising the commercial prospect of this technology. The initial commercial goal is to capture a share of the European market by introducing nanostructured powders, coatings and parts for high performance applications.

Finally, we note that there are commercial opportunities for W-based nanocomposite materials. Such materials have found applications in both military markets (kinetic energy penetrators, explosively formed projectiles, shaped charge liners and civilian markets (sporting equipment, radiation shielding, counterbalances and high voltage contacts). Copper, strengthened with a nanodispersion of either tungsten or tungsten carbide, has the potential of being a good material for welding electrodes, Currently, copper that is dispersion strengthened with alumina is used for this purpose, but its performance leaves much room for improvement. Welding electrode performance is particularly critical when the welding process is highly automated and performed by robots, as in automobile manufacturing.

Potential broad impact of nanostructured coatings

The present proposal deals primarily with the deposition and development of novel nanostructured coatings on selective substrates. Coatings fabricated out of the aforementioned amorphous elements and their alloys, composites and compounds thereof, if pore free are anticipated to exhibit extraordinary thermal stability, hardness, toughness, ductility, wear resistance and adherence. We envision a wide use of these coatings on cutting tools, vehicles, various naval, aerospace and industrial components to reduce the need for expensive maintenance.

Items fabricated from nanophase materials have superior characteristics. For example, nanophase copper has hardness and yield strength 500 percent greater than conventionally produced metal and a nanophase ceramic material can be manufactured with much greater ductility than the conventionally manufactured counterpart. These same bulk-nanophase characteristics result in similar improvements in the characteristics of nanophase coatings, particularly in applications requiring enhanced wear resistant surfaces and increased thermal protection.

It is difficult to estimate the total impact of nanostructured materials in the 21^{st} century, but it will be significant. For example, in gas turbine engines, even as little as five degrees increase in metal operating temperature in the high turbine section of the engine can realise several hundred million Euro's in fuel savings per year for commercial European airlines. The much larger increase in operating temperature projected for ceramic composite components will have a profound impact on engine operating efficiency and consequent economic effect. Application of ceramic components to adiabatic heat engines will realise similar large economic consequences in the trucking industry. Since nanostructured materials are expected quite generally to possess greatly improved properties and superior performance, investments in technologies to produce such materials are highly leveraged.

It is the primary research objective of this proposal to establish a network which is to be a leader in the rapidly emerging field of nanostructured materials and to achieve rapid growth and attractive earnings from its initial proprietary position.

Hard Coatings

The interest in nano coatings for wear and abrasion resistance is justified due to the enhancement of both hardness and ductility found within materials with reduced grain size. Even though it has not been decided as of yet which will be the specific composition of the powder to be used, it is safe to say that the as deposited properties will be characterized by higher hardness and wear resistance than the conventional counterpart of the same composition. The possibility exists that the nano coatings will be characterized by a trade off between hardness and toughness at higher levels with a remarkable enhancement of both hardness and ductility. The potential benefits will be realized due to the reduced defect size and enhanced grain boundary relaxation. Diffusivity will be greatly enhanced due to the larger volume of grain boundaries. The critical control parameters during deposition will focus on the optimization of hardness and good adhesion.

The following comprises an outline on existing technology as it relates to the very popular WC-Co cermet material. Most of the research on WC-Co powders has been directed towards the formation of low porosity coatings.

Thermal spray methods for preparing coatings from conventional WC-Co powders include low velocity combustion (LVC), high velocity oxygent fuel (HVOF), conventional plasma (CP), and high energy plasma (HEP). The effectiveness of these coating methods can be rated on the basis of the WC in the coating, which correlates with wear performance. The highest amount of retained WC and therefore the lowest wear rate, occurs for the HVOF process. This is because the lower flame temperature and higher particle velocity, compared with the other processes, minimizes the decomposition rate of WC in the oxidizing environment of the flame or the plasma. The oxidative decomposition involves decarburization of the WC phase to form W.

Similar oxidative decomposition reactions should occur in thermal spraying of nanostructured WC-Co powders, except that the problem will be exacerbated by the high surface area of the as synthesized powders. The severity of the problem can be diminished to some degree by densification of the powder particles prior to thermal spraying. Even so, particle degradation in the flame or plasma should persist, so that much of the benefit of having an ultrafine structure in the coating will not be realized.

Thus, both conventional and nanostructured WC-Co powders are susceptible to decarburization during thermal spray deposition in an ambient air environment. To date, the only practical solution to this generic problem has been to conduct the thermal spraying operation in vacuum, as in vacuum plasma spray (VPS) and low pressure plasma (LPPS). This technique has been used successfully for depositing WC-Co coatings on various substrates using conventional powders as feedstocks.

An important distinction between thermal sprayed conventional and nanostructured powders is their different melting and solidification characteristics. Conventional powder particles experience surface melting only, accompanied by slow and limited dissolution of the WC particles in the liquid Co, as the temperature is increased above the pseudo-binary eutectic (~1350°C). The resulting spray deposited coating layer, therefore, tends to be somewhat porous, since the presence of the relatively large WC grains in the partially melted particles impedes fluid flow on the substrate surface.

Nanostructured powder particles, due to the high surface area of contact between the Co and WC phases should undergo homogeneous or "bulk" melting, accompanied by rapid and extensive dissolution of the WC nanograins with increasing superheat above the eutectic. In this case, the resulting coating will be much denser, owing to the facility with which the nano-dispersed semisolid or "mushy" particles can spread out over the substrate surface.

Although a direct comparison of the porosity of coatings prepared from the two types of powders of the same composition has not yet been made, there have been indications that the enhanced fluidity of the mushy particles does promote the formation of dense particles.

Thermal Barrier Coatings

Thermal barrier coatings are critical in engine technology, allowing operation at higher temperatures. They are fabricated by thermal spray techniques to combustion chambers, turbine air foils and afterburners and play a critical role in increasing gas turbine engine efficiency and performance. The development of superior thermal barrier coatings is required to enhance thermal impedance, thermal shock resistance and cyclic fatigue properties by hindering the spalling in the ceramic splat boundaries near the ceramic to metal interface. It should be possible not only to strengthen the boundaries by refining the structure to the nanoscale but also to maintain the nanocrystallinity at elevated temperatures.

An ideal candidate for high temperature structural applications is the $MoSi_2$-based nanocomposite. We intend to develop $MoSi_2$-based nanocomposites in a manner that is completely analogous to the approach that we have used for WC-based materials. We must note that the much lower density $MoSi_2$-based composites have been targeted for development by the U.S. Air Force. We recognise this need, but we will choose to study the Mo^3Si-based system because of its compatibility with the ductile Mo(Si) solid solution phase. It is not yet clear how to design an $MoSi^2$-based composite that possesses some ductility at low temperatures, which is a prerequisite for most high temperature structural applications. Nevertheless, these alloys are attractive materials for coatings because of their superior oxidation resistance. Such alloys may be the preferred coatings for the Mo(Si)-Mo_3Si alloys. A network of companies will be established to pursue the development of nanostructured $MoSi_2$-based ceramic composites.

Fiber Coatings

The polymeric matrix composites but also metal matrix composites and ceramic matrix composites comprise unique candidates for nano coatings.

The primary objective is to develop a suitable nano coating on carbon fibers in order to control the fiber-matrix interactions during fabrication and in service. The powders can be synthesized by the thermochemical process from the previously mentioned homogeneous precursor compounds. Deposition of such type of nano coating on carbon fibers has never been implemented before.

The application of a coating to the fiber surface is one of the most versatile methods for reinforcing the fiber interaction with the matrix. The type of bonding required at the fiber-matrix interface will often dictate the characteristics that must be designed into the fiber surface. In addition, surface coating layers may be required to enhance the fiber strength, to act as a diffusion barrier preventing chemical attack by the matrix, or to accommodate any thermal expansion coefficient mismatch between fiber and matrix. Coatings offer the possibility of tailoring the fiber-matrix interfacial properties so that optimum composite properties can be achieved. Fiber coatings can have a profound effect on the composite material at all stages of its existence from fabrication to in-service use. Fiber coatings perform the following general functions:

Control fiber-matrix bond strength.
Improve strength by reduction of surface stress concentrations.
Alter the wettability of fibers by the matrix.
Improve the chemical compatibility with the matrix.
Provide diffusion barriers.
Protect the fiber and fiber-matrix interface from environmental degradation during service.

There are many different methods for applying coatings to fibers even though efforts on fiber coating processes and fundamental studies on interfacial effects between fibers and matrices are needed. The most frequently used techniques include electrodeposition, chemical vapor deposition, metallorganic deposition and vacuum deposition i.e. sputtering, physical vapor deposition, e-beam evaporation, plasma assisted chemical vapor deposition, ion-plating techniques.

Nanocoatings of W, Ni, Ni-Cr are quite attractive since the powder synthesis is already being accomplished and pertinent collaboration is already been established with Companies and Research Institutes which have the appropriate background and means to exploit the coating capabilities of these amorphous powders. We expect such coatings to exhibit remarkable properties.

Furthermore, coatings can even be applied on the external macroscopic surface of a polymeric matrix composite and it is our belief that *this scenario is still very attractive and makes the deposition of nanocoatings even more enticing.* The nanopowders we have developed are of high surface area (>400g/m^2), in a metastable state and are reactive even at room temperature. We do appreciate the intrinsic thermal limitation of the polymer as it does not withstand temperatures above 130°C but the deposition method should be judged not upon the operational temperature but on the temperature of the powder as it arrives on the surface to be coated. The nanostructured nature of the powders is such that by the time the particles reach the surface to be coated they will be at a considerably reduced temperature. The innovation here is that even at low temperatures the adherence of the coating will be greatly enhanced due to the metastability and high surface area of the nanostructured powder. In this context, the research initiative which stands a great chance of success will focus on the minimum deposition temperature versus adherence and wear characteristics.

Timeliness of proposal

Even though we intend to be a front runner in the commercial scale processing of nanostructured composite materials and their respective coatings, it has become clear that there is growing competition world-wide. Japanese companies are taking very seriously the scale-up of nanostructured materials processing by the gas phase condensation method. German companies have assumed a leadership position in arc processing of C_{60} clusters (so called Bucky Balls). The Soviets have developed nanoporous metals for filtration purposes and fuel cell electrodes. This proposal is therefore considered to be timely in that it will enable the European Community to maintain leadership in powder technology and to broaden the range of its applicability to additional economically important materials.

Coatings are in the forefront of today's powder technology and is beginning to enjoy considerable success. It is timely and appropriate, therefore, to take advantage of the ability to produce bulk amorphous powders for forming coatings with exotic properties. In this proposal we are coupling powder processing with thermochemical conversion, two cutting edge technologies, in the coatings field. Our ultimate goal is to achieve flaw-free production of nanostructured high performance parts for diverse applications.

Technology transfer benefits

A major concern in today's competitive industrial environment is the long lead time from discovery to commercialization. This is a consequence of the sequential development pathway that has been used in the past, where lead times are typically 10-15 years. We propose to exploit concurrent development as a means to expedite technology implementation. Using this methodology, lead times can be reduced to 3-5 years. A distinguishing feature of concurrent development is that it recognises that the critical inventions can occur at any place in the innovation chain.

Industrial Partners

The partners in this research initiative are companies which face problems during fabrication of components due to high wear rate or thermal instability. The intent is to resolve the aforementioned problems by developing the most suitable amorphous or nanophase powders of predetermined composition and subsequently apply them by a thermal spray technique or otherwise. Improving the wear and/or temperature resistance will be of utmost importance in increasing the life of the component. At the Higher Technical Institute we are willing to develop the most suitable powders and also participate in the resolution of the pertinent experimental parameters as they relate to the fabrication of nano coatings.

1. *Monitor Coatings Ltd, Wallsend, UK*

Monitor coatings are an active and expanding coatings company presently using a variety of spraying techniques (Thermal, Plasma, High Velocity Oxy Fuel, and LPPS (low pressure plasma) to apply coatings for application as thermal and corrosion barrier to turbine blades. Examples of coating types deposited at present include Al_2O_3 and WC. They are a very progressive company who would like the opportunity to diversify.

2. *Ernest Bennet & Co., Darlington, UK*

Ernest Bennet & Co are a producer of saw blades for cutting many materials. In the past they have experimented with PVD coatings (TiN) for increased wear resistance. They are very keen to experiment with new coating types to increase tool lifetime and reduce cost.

Research Institutes

AMRI (Advanced Materials Research Institute)

AMRI would be able to provide a full characterisation of coatings (using SEM/EDX, XRD, STM, AFM) in addition to testing the properties of such coatings under a variety of conditions.
Testing would include: hardness, wear resistance (pin on disc or sliding block), high temperature wear resistance, adhesion scratch testing.

In addition to internal testing, AMRI has extensive contacts with industry and could arrange for application of coatings into a variety of different application to measure performance. AMRI also possesses its own purpose built PVD facility for depositing coatings such as TiN, CrN, TiC etc. This would provide an excellent opportunity for comparative testing.

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INFORMATION TECHNOLOGY AND THE CYPRUS RALLY – AN FIA WRC EVENT

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After a successful bid in 2000, the Cyprus Rally was promoted to a World Rally Championship (WRC) status by FIA, the world governing body in motorsport.

This is not only the biggest annual sporting event in Cyprus, but in the whole of the Middle East and we are of course very proud to be running a World Rally Championship event.

Just to give a brief outline of the interest world wide for this event, it should suffice to say that in September 2000, 314 journalists and photographers covered the event, coming from as far as Australia, Japan and Argentina, as well as Europe and the Middle East.

Cyprus also entered the homes of billions of television viewers in 186 countries and it gained literally thousands of column inches in the written press. It is very difficult to obtain statistics as to how many people came to the island to follow the event, but that weekend in September it was very hard to find a hotel room in Limassol with a great number of visitors staying over in Paphos and in Larnaca. The Royal Automobile Club in UK estimates that the overall income to a country from a WRC event is approximately 15million pounds.

An added benefit is the inclusion of the Cyprus Rally in the related PC games. A European firm has already filmed in detail the entire Cyprus Rally 2001 route for inclusion in a 3 dimensional presentation of the event over the Internet.

The running of a world event of this type, with manufacturers spending millions of pounds in preparing their teams, comes with a great number of regulations, procedures and directives that need to be followed closely. Otherwise, the event will be taken up by another country, and there are many with their eyes set on securing this event. So, what does it take to run event of this type?

The FIA "spy" module

In order to prevent teams from running unauthorized service stops and in addition making sure that a car stays in its prescribed route, FIA fits into each of the main competing cars, a GPS recording module. This is a small device, the size of a book, running on batteries, which is attached inside the competition car. On arrival, the FIA engineer collects all the modules, which when hooked on his laptop give out statistics on the route followed, the duration and time of any stops and other details.

This is not the only method used to monitor the competition cars, as there is an FIA airplane and a helicopter flying above the routes.

The "accuracy" and "I want it now' problem

FIA rules specify an accuracy better than a tenth of a second. It is obvious that manually activated timings cannot be used. There are three systems worldwide, which are developed for WRC event timing and are worth considering. These are a system used in Australia, a system developed by a European firm and the system developed by Rally Argentina. The Rally Argentina system is also used by other Rally organisers and because of its low price and excellent support was selected for use in our event.

The Argentineans fit every competing car with a module that provides to the sensors the identity (number) of the car. Sensors are placed at the beginning and end, of every timed special stage, so as soon as the competing car crosses, at the sign of the marshal, the start line the street sensors detect this. The driver runs through the special stage as fast as he can. As soon as he crosses the finish line, the outside street sensors will also detect the car number and make a note of the time. So, this way we know the start and finish times and we can therefore compute the time it took the driver to do the special stage. Therefore, that solves the problem of accuracy.

This of course is not enough. A way must be devised to send the results to the main computers that do all the calculations. The solution to this is to use radio sets attached to each street sensor to transmit the time and car numbers to the main computer for processing.

Problem is that the rally takes place in rural areas, in deep valleys and gorges and it is not easy to maintain a radio link with headquarters.

The solution we arrived at in order to maintain a constantly running link with the sensors, was to fit two small airplanes with a number of radio repeaters and have them in turn fly high, over the rally route. An aerial fitted on the roof of the hotel used for the headquarters (HQ) in Limassol, picks up the retransmitted signals from the plane.

As a result, the computer at HQ is updated within seconds and it provides instant and accurate results.

The Headquarters (HQ)

The rally HQ is the place where many functions take place before and during the rally and is also the place where the computing center is housed.

Network Infrastructure

With hundreds of reporters, FIA representatives and manufacturers using an overall number of 80 computers meant that care should be taken in assuring the high performance levels expected.

In addition to the rally HQ, a nearby hotel was used to house the press and the manufacturers.

So in order to provide the highest performance a switch based network design is used.

Four 24-port Intel switches are used, two in each hotel and the two hotels are linked together via a 100BASE-FX Fiber optic link. All network cabling is Cat-5, ensuring 100Mbits over 100BASE-TX.

The results servers.

In order to maintain high speed processing of the results, two high-speed Windows NT servers are used for running the Argentinean results software, whose front end, is based on Visual FoxPro. The servers are arranged in order to provide backup in the case of a hardware failure and are of course powered through a large UPS (Uninterruptible Power System).

In order to handle the large throughput to the network, each server is fitted with four Ethernet cards configured for load sharing.

In 2000, three days before the event, a test was run on 65 computers connected to these servers that simulated results enquiries just to make sure that the performance was as expected. The CPU activity of the servers did not exceed the ten percent mark. It is generally accepted that over 50% loading is a problem and that 70% is not acceptable.

The high performance of the system during the event was noticed and commented upon by everybody.

Other servers

The protocol used throughout the network is TCP/IP.

A main (Primary Domain Controller) Windows NT server together with an additional back up (Backup Domain Controller) are used for handling the logins, the word processing and other rally documents for internal use. These servers also auto-configure all the client PCs in the network through the DHCP services of NT.

For internal and external communication, an Email server is configured with accounts generated for all the users. The Internet server of the Cyprus Automobile Association (CAA), which is located in USA under the domain CyprusAA.org, has a "corporate Email POP" account, that collects all the email addressed to CyprusAA.org. The mail server at HQ collects all these emails and distributes them internally to its users, thus giving the ability to all, to send and receive internal and external email.

For permanent Internet connectivity, a 1Mbit HDSL lease line is installed by CYTA and all the Internet traffic is handled by a fast CISCO router based on the NAT protocol, since all internal IP numbers used, are "private" 10.0.0.0 numbers.

A sixth server is used for handling the process of updating the Internet website. Details of this appear further below.

Telecommunications facilities

Manufacturers and especially press require the provision of ISDN lines.

15 ISDN lines will be installed in 2001 in Rally HQ and these will be used for live links and radio interviews, but mostly for linking directly to papers and magazines for uploading pictures and reports.

Telephone facilities are provided through an Ericsson system which handles most of the 110 telephone lines and the 80 extensions that are installed over, again, Cat-5 wiring.

But what if I am abroad?

The website

An event like this draws attention from allover the world, as it is the only way that fans can follow the action from their homes.

In order to handle the heavy load, a server is hired in the United States running Red Hat Linux.

The results pages are designed using include directives with initially blank text files. The Argentinean software automatically produces an HTML coded page every time a car crosses the finish line of the special stage. The files are automatically stored in a server and they are then, uploaded to the Internet using FTP software. This way, users can see the results on the Internet; within approximately one minute from the time, the car crossed the finish.

The web server was accessed over 1.5 million times during the rally in 2000. In the days leading to the 2001 event, the server is accessed about 20000 times per day.

SMS and WAP

GSM mobile phones have the ability to not only accept short length text messages, but can also browse specially designed WAP pages.

To provide these services, a special script was developed internally by CYTA and was made accessible over the Internet in secure format. At the end of each special stage, a form is completed on the Internet and the results are sent to all the mobiles that are kept on list. The same script automatically generates a WAP page on the Internet. These services proved to be very popular with everybody in 2000.

Where are the cars?

When you are in charge of running the rally, at rally control, this is the hottest question that you face. This is mainly because one needs to first know as soon as possible, if there is an accident and secondly if the road is blocked. Of the many helicopters that follow the rally, one is equipped to handle emergencies but ambulances are also placed in each special stage to handle these situations.

Nevertheless, the length and spread of the rally, is still a problem at rally control. Therefore, in order to provide at least a partial solution to this problem, the Argentinean system, uses sets of sensors spread throughout the special stages.

This way, rally control at HQ, knows which car passed from each point. This is provided graphically on monitors with the software estimating the time taken to reach each sensor and providing an alarm if a car is late.

Conclusion

The design of the website, the network and the telecommunication facilities above, provides one with unparalleled experience together of course with the satisfaction and feeling of accomplishment, that the 300 volunteers also feel.

ANALYSIS OF THE TYPICAL METEOROLOGICAL YEAR OF CYPRUS AND MEASURES USED TO LOWER BUILDING ENERGY CONSUMPTION

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Abstract - This study uses the TRNSYS computer program for the modelling and simulation of the energy flows of the modern houses of Cyprus examining measures to reduce the thermal load. For the calculations, a Typical Meteorological Year (TMY) for the Nicosia area and a typical model house are used. Initially an analysis of the TMY is presented which shows that the east wall receives the highest total radiation compared to the other orientations. The measures examined are overhangs, orientation and shape of buildings. Overhangs can lower the annual cooling load by 2000 kWh to 3000 kWh depending on the construction of the model house. The overhang length may be 1.5 m over windows and 3 m over doors. Concerning building orientation, the best position for a symmetrical house is to face the four cardinal points and for an elongated house to have its long side facing south. A smaller building wall area to volume ratio exhibits a reduction in heating load of about 1000 kWh.

1. INTRODUCTION

An important measure for economy is to lower building energy requirements to a minimum. The main concern of engineers however is to evaluate the effectiveness of the various measures, which may be applied.

For the estimations carried out in this project a model house was considered. This is illustrated in Fig. 1. It has a floor area of 196 m^2 and consists of four identical external walls, 14 m in length and 3 m in height, with a total window opening of 5.2 m^2 on each wall.

The window area is approximately equal to the area that a typical house would have, but instead of considering a number of windows on each wall, only one window is considered. Since the same model will be used in evaluating the load for various constructions this simplification is not important but will assist in drawing conclusions since similar features are present on every wall. The model house is further divided into four identical zones and the partition walls are considered as walls separating the four zones.

A flat roof is considered in this study. Referring to Table1, the building types considered are:

1. Single wall, no roof insulation, which refers to a house constructed from single walls type D, and a flat non-insulated roof type H.
2. 50 mm roof insulation, which refers to a house, constructed from single walls type D, and a flat insulated roof type J.
3. 50 m roof and wall insulation, which refers to a house, constructed from double walls type F, and a flat insulated roof type J.

The objective of this paper is to present an analysis of the typical meteorological year from which the behaviour of the model house is explained. The effect that measures, such as overhangs, building orientation and shape of buildings, present on the building thermal loads are also examined.

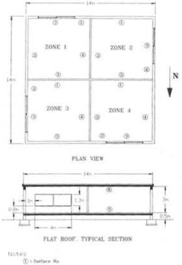

Fig. 1. Model house.

Table 1. Overall heat transfer coefficients of structural elements

Type	Structural element	U-value (W/m^{2}K)
D	Single wall, hollow brick 0.2 m and 0.02m plaster on each side	0.886
F	Double-wall, 0.1m hollow brick and 0.02m plaster on each side and a layer of 0.05m polystyrene insulation in between	0.389
H	Flat non-insulated roof, constructed from fair-face 0.15m heavy-weight concrete	1.91
J	Flat insulated roof, fair-face 0.15m heavy weight concrete, 0.05m polystyrene insulation, 0.07m screed and 0.004m asphalt covered with aluminum paint of 0.55 solar absorptivity	0.481

TRNSYS Type 19 model has been used to model the houses. TRNSYS runs through hourly values of various weather parameters included in a typical meteorological year (TMY) file. The TMY for Nicosia-Cyprus, developed by Petrakis *et al.* [1], is used. This has been generated from hourly measurements, of solar irradiance (global and diffuse on horizontal surface, ambient temperature, humidity, wind speed and direction), for a seven-year period, from 1986 to 1992. Important parameters used in the calculations with TRNSYS Type 19 are shown in Florides *et al.* [2].

2. THE TYPICAL METEOROLOGICAL YEAR (TMY) ANALYSIS

The general climatic conditions in Cyprus are mostly very sunny with an average solar radiation of 5.4 kWh/m^2 per day on a horizontal surface. This radiation is among the highest in the world and the solar energy input is particularly high during the dry summer. During the rest of the year sunshine duration remains considerable even in the coldest months.

The weather data, contained in the TMY are analysed in respect to the radiation falling on every wall facing the four orientations. Such an analysis, is very useful for designers and is presented here for the first time. Examining the direct beam radiation day by day for most of the months, it is observed that in the morning hours it is usually much greater than it is during the afternoon hours. The pattern emerging shows that usually haze and clouds form in the afternoon blocking the sun. Collective results for the whole year shown in Table 2 indicate that the east wall receives 30% more total radiation than the south wall. The west wall receives only 20% of the beam radiation of the east wall. The diffuse radiation for the afternoon is about the same for all walls. In the morning hours the east wall receives about 75% more diffuse radiation than the south wall. This of course depends on the model used for the contribution of diffuse radiation on a tilted surface. In the case of this study the Reindl model is used which accounts for circumsolar diffuse (an increased intensity of diffuse radiation in the area around the sun) and also includes a horizon brightening diffuse term besides the isotropic radiation. All these factors depend on the amount of beam radiation at the particular time.

Table 2. Collective results of the sun radiation for the morning and afternoon hours

Wall direction	Total radiation (kWh/m^2)			Beam radiation (kWh/m^2)			Diffuse radiation (kWh/m^2)		
	From sunrise to 12 noon	From 12 noon to Sunset	Total	From sunrise to 12 noon	From 12 noon to sunset	Total	From sunrise to 12 noon	From 12 noon to Sunset	Total
South	803	404	1208	408	207	615	395	198	593
East	1488	176	1664	793	0	793	695	176	871
North	338	176	515	43	1	43	295	176	471
West	261	358	619	0	162	162	261	196	457
Horiz.	1114	571	1685	691	324	1015	423	247	670

Examining the sun radiation in the hot months (May to September-Table 3) it is seen that the east wall receives more than twice the total radiation received by the south wall and about 3 times the radiation received by the north and west walls. During this time the west wall receives approximately the same amount of total radiation as the north wall. This is partly due to the sun trajectory. During summertime the sun faces the north wall at sunrise and some time before sunset, therefore a small amount of beam radiation strikes the north wall.

According to the Meteorological Department of Cyprus, because of the heat of the morning hours and the position of Nicosia in the valley of Mesaoria, usually clouds form at around 2 pm., which obstruct the west beam radiation. For the remaining months, south and east walls receive approximately the same total radiation and west and north walls receive only 38% of the radiation of the south wall.

Table 3. Collective results of the sun radiation for the hot (May to September) and cold (October to April) months of the year

Wall direction	Total radiation (kWh/m^2)			Beam radiation (kWh/m^2)			Diffuse radiation (kWh/m^2)		
	Hot months	Cold months	Year total	Hot months	Cold months	Year total	Hot months	Cold months	Year total
South	420	787	1208	165	450	615	255	338	593
East	889	775	1664	442	351	793	447	423	871
North	299	216	515	41	3	43	258	213	471
West	320	298	619	81	81	162	240	217	457
Horiz.	957	728	1685	615	400	1015	342	328	670

An examination of the mean wind velocity is presented in Table 4. As can be seen, during the morning hours this is always smaller than the afternoon hours. The morning wind velocity during the whole year is about 60% of the afternoon velocity whereas during the hot months is reduced to about 50%. The mean direction of the wind is generally SSW.

These peculiarities of the Cypriot weather profile will facilitate the understanding of the thermal load behaviour, in the analysis presented in the following section.

Table 4. Collective results for mean wind velocity and wind direction for the morning and afternoon hours

	Mean wind velocity (m/s)		Mean wind direction (degrees)	
	Morning 5 a.m. –12 noon	Afternoon 12 noon – 7 p.m.	Morning 5 a.m. –12 noon	Afternoon 12 noon – 7 p.m.
All year	2.7	4.7	205 (SSW)	204 (SSW)
Hot months	2.8	5.5	201 (SSW)	223 (SW)

3. MEASURES TO REDUCE BUILDING ENERGY CONSUMPTION

3.1 Effect of Overhangs

Overhangs are devices that block direct solar radiation from striking a window during certain times of the day of the year. These are desirable for reducing the cooling loads and avoid uncomfortable lighting in perimeter rooms due to excessive contrast. To check the effect of the overhang length a number of runs are performed. For these runs the overhang is assumed to be located 0.5 m above the window and extent 1 m from its left and right side. The cooling and heating load of the four zones of the model house, constructed from single walls with no roof insulation for various overhang lengths is indicated in Fig. 2. As it is observed, by increasing the length of the overhangs the annual cooling load decreases but at the same time the annual heating load increases as some useful solar radiation is blocked during wintertime as well. The effect on the cooling load is, as expected, greater for the east and south windows located in Zones 3 and 1, since these windows receive more solar radiation during the year as indicated in section 1. The rate of cooling load decrease shown in Fig. 2 is higher that the rate of heating load increase for every zone.

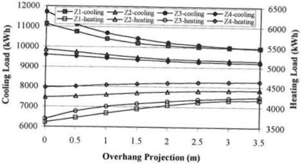

Fig. 2. Annual cooling and heating load of the four zones against overhang length for a model house constructed from single walls with no roof insulation.

The total annual cooling and heating load difference of the model house is presented in Fig. 3. As expected, the greater the overhang projection the greater will be the cooling load decrease. The heating load increases too, since some useful solar radiation is also blocked during the cold days. The difference between the cooling and heating load, increases with the increasing of the overhang length because greater amount of direct and indirect radiation is blocked during summer. Therefore, it is advantageous to use lengthy overhangs that can be retracted during the cold days. Permanent overhangs cannot be lengthy and are aesthetically repulsive; therefore, their length cannot be decided on economic aspects only.

For the model house constructed from walls and roof with 50 mm insulation, the cooling and heating load of the four zones changes in a similar way.

Figure 4 indicates the annual load difference against the overhang length for this type of construction. As it is observed there are about 25% greater savings resulting for the same overhang length, compared to the case above, because of the better insulation of the house.

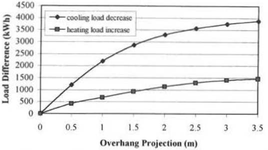

Fig. 3. Annual load difference against overhang length for a model house constructed from single walls with no roof insulation.

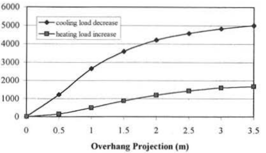

Fig. 4. Annual load difference per year against overhang length for a model house constructed from walls and roof with 50 mm insulation.

The windows of the model house can be replaced with glass doors of the same area (5.2 m2). Such doors have a height of 2.1 m and a width of 2.48 m. The thermal load of the model house is affected slightly as shown in Table 5.

Assuming the overhang to be located 0.5 m above the glass door and extending 1 m from the left and right side, the annual load differences shown in Fig. 5 result, for a house constructed from single walls with no roof insulation.

Table 5. Thermal load variation between a model house with windows and a model house with doors

Model house type	Windows (Model house)		Doors (Shape 1)		Percentage difference in respect to Windows	
	Cooling load (kWh)	Heating load (kWh)	Cooling load (kWh)	Heating load (kWh)	Cooling load	Heating load
Single wall, no roof insulation	42300	16012	42380	16008	0.2%	0%
50 mm roof and wall insulation plus extra lighting	20743	3740	21710	3485	4.7%	-6.8%

Figure 6 shows the results for a model house with doors, constructed from walls and roof with 50 mm insulation. In this case, because of the better insulation of the house, about 25% greater savings result.

The total solar radiation falling on the doors and windows, in respect to their orientation, is indicated in Fig. 7. As it is observed the east and south orientations receive more solar energy during the year. West orientations receive less energy, which is a characteristic of the meteorological year of Nicosia as explained in section 1.

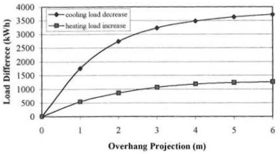

Fig. 5. Annual load difference against overhang length for a model house with doors constructed from single walls with no roof insulation.

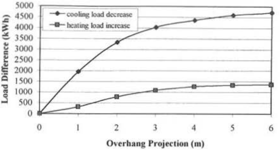

Fig. 6. Annual load difference against overhang length for a model house with doors, constructed from walls and roof with 50 mm insulation.

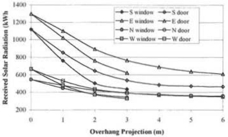

Fig. 7. Total solar radiation falling on doors and windows in respect to their orientation and overhang length.

Generally, assuming an overhang over windows of 1.5 m in length and 3 m over doors, about 7% of the cooling load can be saved for a house constructed from single walls with no roof insulation. The cooling load saving may be about 19% for a house constructed from walls and roof with 50 mm insulation.

3.2 Effect of Building Shape and Orientation

The exposed surface area of a building is related to the rate at which the building gains or loses heat while the volume is related to the ability of the building to store heat. Thus, the ratio of volume to exposed surface area is widely used as an indicator of the speed at which the building will heat up during the day and cool down at night. A high volume to surface ratio is preferable for a building that is desired to heat up slowly, as it offers small exposed surface for the control of both heat losses and gains [3].

In order to examine the effect of the shape and orientation of the building a new model house plan is necessary that increases the wall areas but keeps the same volume. This model, named Shape 2 is illustrated in Fig. 8. Shape 2, has half the width and double the length of the model house resulting in a wall perimeter of 70 m instead of 56 m of the model house used in the preceding analysis.

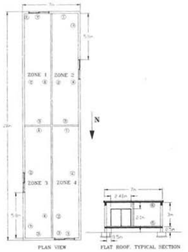

Fig. 8. Shape 2, Model house with glass doors and same floor area and volume as Shape 1.

Table 6 presents the thermal load variation between houses with different shapes. For this analysis two construction types were examined for every shape. These are a) the single wall (type D) model with no roof insulation (type H) and b) the 50 mm wall insulation (type F) model with roof insulation (type J). The results show that the elongated Shape 2 model has about the same cooling load but shows great increase in the heating load, between 8.2% and 26.7% in respect to the model house of Shape 1, depending on the construction type. Therefore the results show that a smaller wall area to volume ratio is preferable.

Table 6. Annual thermal load variation between houses with different shapes

Case	Model house type	Shape 1		Shape 2		Percentage difference in respect to Shape 1	
		Cooling load (kWh)	Heating load (kWh)	Cooling load (kWh)	Heating load (kWh)	Cooling load	Heating load
A	Single wall, no roof insulation (types D and H)*	42300	16012	43526	17323	2.9%	8.2%
B	50 mm wall and roof insulation (types F and J)*	21710	3485	21665	4417	-0.2%	26.7%

* Characteristics of walls and roofs shown in Table 1

In a similar way as for all measures examined, it is observed that the better the house is insulated, the bigger the percentage effect is, since the same amount of solar energy is blocked or added by every measure.

To examine the effect of building orientation for the climatic conditions encountered in Nicosia, Cyprus, the models are rotated from their normal orientation, in a clock-wise direction every 45° through 180°. Figure 9 shows the cooling load difference presented by the models for different orientations.

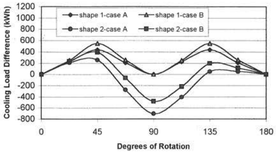

Fig. 9. Annual cooling load difference against degrees of rotation of the models.

Shape 1, presents the lowest cooling load at normal position and at every 90 degrees rotation because of the symmetry of its four sides. Depending on the construction type, an extra load of 400 kWh to 600 kWh results at a peak position of 45 degrees.

Shape 2, presents the lowest cooling load at 90 degrees rotation because at this position the east wall area, which has the biggest load contribution, is minimised. Depending on the construction type, an extra maximum cooling load of 900 kWh can result, if the model is rotated from its minimum load position.

Figure 10 shows the heating load difference presented by the four models during rotation. Shape 1, presents the lowest heating load at no rotation as it happens with its cooling load.

Depending on the construction type, an extra load of 125 kWh to 150 kWh results at a peak position at 45 degrees. Shape 2, presents the lowest heating load at about 75 degrees. Depending on the construction type, an extra maximum heating load of 200 kWh can result, if the model is rotated from its minimum load position. Therefore, the best position for a symmetrical house is to face the four orientations and for an elongated house to have its long side facing south. Of course architects cannot always orient the buildings at the best position since orientation is mainly dictated by the plot shape and location in respect to roads.

4. CONCLUSIONS

This paper presents an analysis of the TMY of Cyprus and the results of measures taken for improving the thermal behaviour of a model house. The analysis of the TMY shows that clouds are formed during the early afternoon hours and therefore the east wall receives the highest total radiation compared to the other orientations.

Overhangs can result in savings of 2000 kWh to 3000 kWh depending on the construction of the model house. Overhangs may have a length over windows of 1.5 m and 3 m over doors. In this way, about 7% of the load can be saved for a house constructed from single walls with no roof insulation. The savings are about 19% for a house constructed from walls and roof with 50 mm insulation.

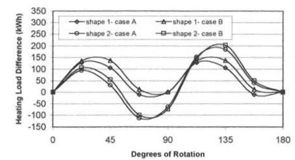

Fig. 10. Annual heating load difference against degrees of rotation of the models.

The shape of the building affects the thermal load with a smaller wall area to volume ratio to perform more economically. The results show that the elongated Shape 2 model has about the same cooling load but shows great difference in the heating load, which is between 8.2% and 26.7% in respect to the model house of Shape 1, depending on the construction type. The heating load difference in this case is about 1000 kWh.

Referring to orientation, the best position for a symmetrical house is to face the four cardinal points and for an elongated house to have its long side facing south. For a symmetrical house, depending on the construction type, an extra cooling load of 400 kWh to 600 kWh may be added at a peak position at 45 degrees. An elongated house exhibits an increase in its cooling load of as much as 900 kWh. A symmetrical house presents the lowest heating load at the same building orientation as that applied for its minimum cooling load. Depending on the construction type, an extra heating load of about 150 kWh is added at a peak position of 45 degrees. The elongated house may have a maximum increase in the heating load of 250 kWh, if rotated 45 degrees from its minimum load position.

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REVIEW OF SIGNAL PROCESSING TECHNIQUES USED IN THE FIELD OF DIAGNOSTICS.

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1. Introduction

In recent years diagnostics can be referred to as the identification of defect types and prediction of their development [7]. It is also known that diagnostic systems in order to be effective require the maximum possible amount of information which can be derived by the analysis of signals namely from noise and vibration signals. The reason is that the vibration signal of a device contains not only detailed information about the dynamic behaviour of the system but also about its structural components (rigidity) as these contribute to the overall transfer function of the system. Many applications in different fields of the industry have shown that from the vibration signature of a system, a reliable diagnosis of the condition of the device (system) may be obtained.

A signal processing technique is an important tool used for diagnostics since it is used to enhance the patterns caused by existing faults. That is why a careful selection of the appropriate method will ensure a reliable diagnosis of the problem. There are many signal processing techniques used for fault diagnosis purposes. In this article an attempt is made to study some of these techniques [4], which can be divided into five groups as shown in Table 1 below:

TABLE 1

Statistical measuring methods	**Statistical comparison methods**	**Frequency analysis**	**Time-Frequency analysis**	**Wavelet decomposition**
Mean	CPD graph	Fourier Transform (FFT)	Spectrogram	Wavelet Transform
Variance	Correlation	Spectral Analysis	Wigner Distribution	Daubechies Series
Standard Deviation		Cepstrum	Pseudo-Wigner Distribution	Harmonic Wavelets
Kurtosis				
Crest Factor				
Form Factor etc				

It should be emphasised that there are many other signal processing techniques. However the ones tabulated above, have been already successfully applied in many areas of industry in order to identify faults or monitor the condition of a system.

2. Statistical Methods

Statistical methods in processing of vibration signals can be used either for direct analysis of the data collected or by comparison of the vibration signals. The method to be followed basically depends on the form and nature of the signals.

2.1 Mean

For a discrete series it is defined as:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} Xi$$

2.2 Variance

The variance value estimates the width of a distribution by indicating the average variability of the values around the mean value. It is defined as:

$$Var(x_1 \_ x_N) = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2$$

2.3 Standard Deviation

It estimates the mean squared deviation of x from its mean value giving also an indication of the spread of data around its mean value. It is defined as:

$$\sigma(x_1 \ldots x_n) = \sqrt{Var(x_1 \_ x_n)}$$

2.4 Skew

It is a non-dimensional quantity, which identifies the degree of asymmetry of a distribution around its mean value. It can be defined as:

$$Skew\ (x_1 \ldots x_n) = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{x_i - \bar{x}}{\sigma}\right]^3$$

2.5 Kurtosis

The Kurtosis number gives the relationship of relative flatness or peakedness of a distribution with that of a normal distribution.

$$Kurt(x_1 \ldots x_n) = \{ \frac{1}{N} \sum_{i=1}^{N} \left[\frac{x_i - \bar{x}}{\sigma} \right]^4 \} - 3$$

2.6 Crest factor

This number is usually valid for long vibration signatures and basically compares the peak value with the signal's *RMS* value. It can be defined as:

$$CF_{peak} = \frac{\max(|x_i|)}{X_{RMS}} \text{ where } X_{RMS} = \sqrt{\frac{\sum_{i=1}^{N}(x_i)}{N}}$$

2.7 Form Factor

It is a measure describing the waveform of a signal by comparing the signal's *RMS* value to its *mean absolute* value.

$$FF = \frac{X_{RMS}}{\frac{1}{N}\sum_{i=1}^{N}|x_i|}$$

3. Statistical comparison methods.

3.1 CPD graph.

The Cumulative Probability Distribution graph represents the way in which a signal is distributed since inherent in this characteristic is the *mean value* and *standard deviation*. It is a useful tool in cases where no means of estimating the future value of a random vibration signal are available. In order to establish the CPD graph the following method is used:

3.1.1 Quantisation of recorded sample values.
3.1.2 Estimation of probability of measurement in each level of quantisation $P = n/N$
3.1.3 Plot a graph of probability *P vs* *Quantisation level* in the form of a bar chart.

3.2 Correlation

Is a measure of the way in which one signal depends on another (cross-correlation) or the way in which one part of a signal depends on another part of the same signal (auto-correlation).
For discrete signals cross- correlation is given by:

$$R_{xy}\left[k\right] = Limit\ \frac{1}{2N}\sum_{i=0}^{N} X_i Y_{i+k}$$

and auto-correlation

$$R_{xx}\left[k\right] = Limit\ \frac{1}{2N}\sum_{i=0}^{N} X_i X_{i+k}$$

4. Frequency Analysis Methods

In the previous sections the amplitude and time domain characteristics of signals have been examined where the information extracted from the signals was embodied in the time histories which were observable and required some suitable mathematical operation on the time data. The interpretation of the extracted information sometimes requires some care but the mathematical processes particularly in discrete form are relatively straightforward. When considering however frequency characterisation some 'strange' mathematical procedures are invoked but often result in providing information which can be more readily interpreted than for previous methods. It should be however pointed out that there is no more information available by looking at the frequency characteristics of a signal. It is just an alternative method of displaying information.

4.1 Fourier Transform

Vibration analysis using frequency distributions is based on Fourier Transform.

$$X(j\omega) = \int_{-\infty}^{\infty} X(t) e^{-j\omega t}\, dt$$

The transformation from time to frequency equation enables any time signal to be represented by a frequency component or a set of frequency components depending on the nature of the signal. It is important to note that if the Fourier series is to represent a function *X(t)*, then *X(t)* must meet the Dirichlet conditions [1] stated below:

4.1.1 The function *X(t)* must be defined and single valued.
4.1.2 The function *X(t)* must be continuous or have a finite number of finite discontinuities within a periodic interval.
4.1.3 The function *X(t)* and *X'(t)* must be piecewise continuous in the periodic interval.

It should be stated also that the frequency resolution achieved by the above method is inversely proportional to the period of the time series, and the frequency ranges from 0 to half of the sampling frequency.
In order to study non-periodic vibration signals the idea of using the Fourier series cannot be applied. In that case by using the Fourier transform, the discrete equivalent has been developed, the so-called Discrete Fourier transform (DFT).

4.2 Spectral Analysis

This technique describes a vibration signature in terms of all its frequency components within the Nyquist theorem. Faults can be detected by visual comparison between 'good' and 'faulty' spectrums. Of course this technique is not sufficiently robust to reliably detect and diagnose all kinds of faults. That is due to the fact that the vibration components from some types of faults are localised, hence when transforming the whole time series, the fault contribution is overshadowed by the rest of the signal [2,3]. However this technique can serve as the basis for describing how different faults affect the vibration spectrum. Moreover it can form the basis of other fault diagnosis methods such as cepstrum and time-frequency decompositions (spectrogram).
The spectral analysis relies solely to Fourier Transform. Today there are many algorithms available to perform the Discrete Fourier Transform (DFT) of a signal and one of them is the Fast Fourier Transform (FFT). The following equation shows the digitised version of the Fourier integral and can be used for the analysis of the vibration signals:

$$X(k) = \frac{1}{N}\sum_{n=0}^{N-1} x(n) e^{-j\frac{2\pi\kappa n}{N}}$$

4.3 The Cepstrum Analysis

It is considered to be a direct extension of the pure spectral analysis and focuses on the detection of harmonic components in a time series. It works by performing the inverse Fourier transform of the logarithm of the Fourier transform of an input sequence. This technique has two variations: the complex cepstrum and the real cepstrum.
The complex cepstrum the complex logarithm is used after the input series is Fourier transformed. It can be used in cases where phase information of the input signal needs to be retained.
In the real cepstrum the logarithm of the magnitude of the input signal Fourier transform is evaluated. It is simpler than the complex cepstrum but in this case it ignores and discards the phase information in the time series. A formal definition of the real cepstrum and its inverse is given below:

$c(n) = IDFT(log|DFT(x(n))|)$ and $\hat{x} = IDFT(exp|DFT(c(n))|)$ where

$c(n)$ is the real cepstrum of the input signal $x(n)$ and $\hat{x}(n)$ is the inverse real cepstrum. The DFT is the Discrete Fourier Transform and IDFT is the inverse Discrete Fourier Transform.

The output of cepstral analysis will be a signal in the cepstral domain. It is commonly shown as a plot similar to spectral plot but with quefrency instead of frequency in the x-axis. The unit of quefrency is $[Hz]^{-1}$.

5. Time- Frequency Analysis.

This type of vibration analysis aims to model a signal by describing which frequencies were present at which instants in time. The output of this technique is a three dimensional map, containing time information, frequency information and energy content. Two of the most common techniques met in the vibration analysis field are the spectrogram and the Wigner-Ville Distribution.

5.1 The spectrogram

This method is also known as Short-Time Fourier Transform and it works by viewing segments of the time domain data through windows. It then transforms these segments to frequency domain, representing the energy distribution of the signal over the frequency domain at every instant of time.
The correct choice of a window function (Gaussian, Hamming, Hanning, rectangular etc) plays an important role in this method. For example if a window is chosen so that it focuses on time resolution (narrow window in time domain) then once the Fourier Transform is performed the window function will have low frequency resolution (wide window in frequency domain). Therefore it cannot be used to analyse signals with large and small patterns simultaneously.
In order to analyse how the spectral contents of a vibration signal varies with time, a window is positioned on each particular time and the FT of the windowed signal is performed. This process is repeated for each instant of time of the signal. So if $x(\tau)$ is the time data series to be analysed and $h(\tau)$ is the window function used in STFT. The windowed signal Xw is:

$X_w(t,\tau) = x(\tau)h(\tau-t)$ where

t is the time instant of the window center and τ represents time.
By applying FT on the windowed signal the following definition is obtained:

$$X(t,f) = \frac{1}{2\pi}\int_{-\infty}^{\infty} x_w(t,\tau)e^{-i\omega t}dt = \frac{1}{2\pi}\int_{-\infty}^{\infty} x(\tau)h(\tau-t)e^{-i\omega t}dt$$

The spectrogram is defined as the Power Spectral Density PSD of $X(t,f)$ and it is given as:

$$S_w = |X(t,f)|^2$$

5.2 The Wigner Distribution.

This technique works by adding up pieces made up of the product of the signal at a past time multiplied by the signal at a future time, the time into the past being equal to the time into the future. There are several variations on the Wigner Distribution namely the Wigner-Ville or the Pseudo-Wigner etc [6].

The Wigner Distribution (WD) produces a plot similar to spectrograms showing how the spectral content of a signal varies with time. Like spectrograms this technique also uses the Fourier Transform Algorithm but in this case the time resolution is better. However this method suffers from a different problem that of the cross-term interference from different signal components. This interference can be minimised by the application of the Wigner Distribution of the analytic signal (Wigner-Ville distribution) or by means of a sliding window function (Pseudo-Wigner distribution) Various applications of WD in analysing different vibration signals have proved that this method can be used for both stationary and non-stationary signals. It applies best in cases where signals contain amplitude and frequency modulation enabling the user to clearly observe between carrier and modulating frequencies and the modulation level. Also WD has the ability to filter out white noise or random interference in the signal to be processed.

The Wigner Distribution of a real signal $x(t)$ is defined as:

$$WD(t,f) = \int_{-\infty}^{\infty} x\left(t+\frac{\tau}{2}\right)x\left(t-\frac{\tau}{2}\right)e^{-2\pi f\tau}d\tau$$

The Wigner-Ville Distribution of a real signal $x(t)$ is defined as:

$WD(t,f) = \int_{-\infty}^{\infty} \tilde{x}\left(t+\frac{\tau}{2}\right)\tilde{x}^{*}\left(t-\frac{\tau}{2}\right)e^{-2\pi f\tau}d\tau$ where $\tilde{x}$ is the analytic signal of x and can be found by: $\tilde{x}(t) = x(t) + \frac{i}{2\pi}\int_{-\infty}^{\infty}\frac{x(n)}{t-n}dn$

Finally the Pseudo-Wigner Distribution is defined as:

$PWD(t,\omega) = 2\int_{-\infty}^{\infty} \tilde{x}(t+\tau)\tilde{x}^{*}(t-\tau)h(\tau)h^{*}(-\tau)e^{-4i\omega\tau}d\tau$ where the asterisk denotes complex conjugate.

6. Wavelet Analysis.

The Wavelet Analysis is considered to be a versatile mathematical technique, which can break down a signal into its constituent parts. Wavelets can be seen as a family of functions composed by translations and dilations of a single function (the mother wavelet). The set of products of all the dilated and translated wavelets with an arbitrary function is called the Wavelet Transform.

The translation of the 'mother wavelet' allows for the analysis of the signal at different instants in time while the dilation has the effect of narrowing or widening the time window depending on the frequency. This enables the analysis of very short-lived transients coupled to longer-lived transients in time domain.

The main idea behind the wavelet transform is to decompose a signal $x(t)$ into its wavelet components called levels and are numbered from –1 upwards. The addition of these wavelet levels leads back to the original signal.
The actual shape of the decomposed components depends on the signal under analysis and on the analysing wavelet. This wavelet can be a family of functions which are the translation and dilation of a unique valued function $\Psi(t)$.
This is defined as:

$WT(t,s) = \int_{-\infty}^{\infty} x(\tau)\sqrt{s}\psi(s(\tau - t))d\tau$ where $\Psi(t)$ is the wavelet, t is the time and s is the scaling factor.

From this it follows that a wavelet family can be developed by:

$\left(\sqrt{s}\psi(s(\tau - t))\right)$ for $(t,s) \in \Re$

The reconstruction of the signal can be obtained from:

$$x(t) = \sum_t \sum_s WT(t,s)\sqrt{s}\psi(s(\tau - t))$$

6.1 Orthogonal Wavelets

These wavelets include the Daubechies Series and the Harmonic Wavelets. The main characteristic of the orthogonal wavelets is that the number of levels (L) resulting from the wavelet transform is related to the number of points in the data series to be transformed [5]. This relation is expressed as $L = n + 1$.
Orthogonal wavelets come from a special case of the wavelet family. This special case is met only if the following condition exists:

$\left(\sqrt{s}\psi(s(\tau - t))\right) = \sqrt{2^j}\,y\left(2^y\left(t - 2^{-j}n\right)\right)$ for $(j,n) \in Z$ so the orthogonal wavelet is defined

$WT_0(t,s) = \int_{-\infty}^{\infty} x(t)\sqrt{2^j}\psi\left(2^j t - kT\right)dt$ and from which a signal can be reconstructed by:

$X(t) = W_0 + \sum_{j=0}^{\infty}\sum_{k=0}^{2^j-1} w_{2^j+k}\psi\left(2^j t - kT\right)$ where $W_0 = \int_0^T x(t)dt$

and $w_{2^j+k} = \int_0^T x(t)\psi\left(2^j t - kT\right)dt$.

7. Conclusions

It is quite obvious that there is not a 'magic' formula to immediately select the appropriate signal processing technique for every fault diagnosis problem. That is due to the fact that this selection depends on many parameters like the form and nature of the signal, the sampling frequencies, the presence of noise etc. However it will be helpful for one to study the application of all the above methods for the analysis of a specific vib:ation signal and derive important information as far as the validity and usefulness of each method is concerned. This will eventually lead to the selection of the appropriate signal processing technique that will ensure an effective solution of a fault diagnosis problem.

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UB 200 Θερμομονωτικό τούβλο.

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Το UB 200 είναι Θερμομονωτικό τούβλο που προσφέρει άριστη μόνωση σε τοιχοποιίες καλύπτοντας τις αυξημένες σύγχρονες απαιτήσεις θερμομόνωσης και ηχομόνωσης. Είναι κατάλληλο τόσο για κατοικίες όσο και για δημόσια κτίρια.

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- **Ηχομόνωση**
  Το UB 200 απορροφά τους ενοχλητικούς διάχυτους θορύβους χάρη στη δομή του και στη σχέση της ακαμψίας του με το φαινόμενο βάρος του.
- **Σταθεροποίηση της θερμοκρασίας**
  Ο τοίχος που είναι κτισμένος με UB 200 εξασφαλίζει την επιθυμητή ισορροπία θερμοκρασιών αφού μετατρέπει τις μεγάλες ημερήσιες εξωτερικές μεταβολές της θερμοκρασίας σε μικρές διακυμάνσεις στο εσωτερικό του χώρου και συγχρόνως επιβραδύνει την αλλαγή της θερμοκρασίας στο εσωτερικό του τοίχου. Η μετατόπιση των φάσεων που επιτυγχάνεται είναι 12 ωρών (τα ιδανικά όρια κυμαίνονται μεταξύ 10-14 ωρών).
- **Μεγάλη θερμοχωρητικότητα**
  Το UB 200 έχει την ιδιότητα όταν θερμαίνεται να αποθηκεύει θερμότητα και να την αποδίδει στο περιβάλλον σε περίπτωση που η θέρμανση διακοπεί
  έτσι ώστε ο χώρος να μην ψύχεται γρήγορο
- **Υγροαπορροφητικότητα**
  Απορροφά υγρασία λιγότερη από τα κοινά τούβλ
  και έχει υγροαπορροφητικότητα <1%.
- **Πυροπροστασία**
  Παρουσιάζει μεγάλη πυρανάσχεση δηλαδή μεγάλ
  χρόνο αντίστασης στη φωτιά.
- **Αντοχή στον παγετό**
  Οι κυψέλες του UB 200 δε γεμίζουν σε περίπτωσ
  βροχής και σε περίπτωση παγωνιάς λειτουργούν ω
  θάλαμοι εκτόνωσης.
- **Χαμηλό συντελεστή διάχυσης υδρατμώ**
  Υγιεινό περιβάλλον.
- **Εύκολη τοποθέτηση εγκαταστάσεων**
  Άνοιγμα καναλιών, τοποθέτηση δικτύου καλωδιώσεω
  στήριξη σωμάτων. Μπορεί να τρυπηθεί με τρυπάν
  να κοπεί με τροχό ή να τοποθετηθούν βίδες κ
  καρφιά στην επιφάνεια του.
- **Οικονομία στο χρόνο και στο κόστος**
  Οικονομία στο χρόνο και στο κόστος κατασκευή
  καθώς και στην κατανάλωση ενέργειας για θέρμανσ
  και ψύξη.
- **Εξασφάλιση μεγάλης διάρκειας ζωής**
  Χωρίς απαιτήσεις συντήρησης.

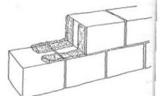
ΟΔΗΓΙΕΣ ΕΦΑΡΜΟΓΗΣ

Η τοποθέτηση UB 200 είναι ίδια με αυτή των κοινώ
τούβλων, με μοναδική διαφοροποίηση στην τοποθέτησ
των αρμών ώστε να μην περιορίζονται
θερμομονωτικές ιδιότητες του. Το κτίσιμο του UB 2
ο συνδετικός πηλός τοποθετείται δεξιά και αριστερ
σε δύο παράλληλες ευθείες, συνεχίζοντας κ
κατακόρυφα όπως φαίνεται στο πιο κάτω σχήμ
Με αυτό τον τρόπο επιτυγχάνεται εύκολα και γρήγορ
κτίσιμο αλλά και υγρομόνωση, αφού το κενό π
δημιουργείτε εμποδίζει τη μεταφορά της υγρασίας α
το εξωτερικό στο εσωτερικό επίχρισμα.

Τυπικές Ιδιότητες

ΥΨΟΣ: 200χιλ		
ΠΛΑΤΟΣ: 250χιλ [πάχος τοιχοποιίας]		
ΜΗΚΟΣ: 300χιλ		
ΠΟΣΟΤΗΤΑ ΓΙΑ 1μ² ΤΟΙΧΟΥ: 16 τεμάχια		
ΣΥΝΤΕΛΕΣΤΗΣ ΘΕΡΜΙΚΗΣ ΑΓΩΓΙΜΟΤΗΤΑΣ λ	0,214	W/m°K
	0,184	kcal/mh°C

• *Πιστοποιητικό μέτρησης συντελεστή θερμικής αγωγιμότητας από* **ΙΝΣΤΙΤΟΥΤΟ ABAKUS ΓΕΡΜΑΝΙΑΣ**



DESIGN OF A SPRAY-TYPE SEAWATER EVAPORATOR

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ABSTRACT

The objective of this work is to design a low cost evaporator. The new type of evaporator suggested here is of the spray-type, i.e., spay the seawater into fine droplets in order to evaporate the water. The cost of this type of evaporator is comparatively low because no heat exchangers are required. The evaporator is designed based on the theory of cooling towers. The system is modeled and optimized using heat and mass transfer relations. With proper design the spray-mode of evaporation is superior to both pool boiling and thin film evaporation.

It is shown in this paper that the rate of evaporation is influenced mainly from the droplet size and temperature. i.e., the evaporation is enhanced by having small diameter and high temperature water droplets. A limitation of the suggested system is that either good filtration equipment needs to be used or the droplet size could not be low enough. Also it is desirable not to operate the systems with temperatures higher that 70°C, temperature that can easily be obtained with comparatively cheap flat plate solar collectors. Typical expected results are presented in this paper, which prove the viability of the proposed system.

INTRODUCTION

Many parts of the earth are suffering from water shortage problems. When the technical and economic conditions are favorable governments often resort to desalination. The cost of water produced from desalination systems depend on the initial expenditure required and the running cost of the systems. The initial cost is very important because it needs to be available right from the beginning of a project. If no money is available Governments often turn to external funding in the form of low-interest loans. Also countries like Cyprus, which depend entirely on energy imports for their energy needs, should utilize as much as possible the renewable energy sources which are also non-polluting.

The objective of this work is to design a low cost evaporator. Such an evaporator should use as low heat transfer areas as possible. The heat exchangers in the boiling section of the evaporators are usually manufactured from corrosion resistance alloys and metals like copper-nickel, stainless steel or titanium and constitute one of the major cost items of thermal evaporation systems.

The new type of evaporator suggested here is of the spray-type, i.e., spaying the seawater into fine droplets will evaporate the water. Spray has been used in other types of evaporators, like the multiple effect stack-type. In that case however, the spray of water was used mainly to create a thin film of water on the evaporator tubes, thus enhancing the evaporation, and therefore the size of water droplets was not very small. The proposed system has a very small number of heat exchangers, employed mainly in the condensation side. These heat exchangers are usually made from carbon steel pipes, as they are not exposed to the highly corrosive sea water/acid-agent mixture. The cost of this type of evaporator is therefore comparatively low.

SPRAY EVAPORATOR DESIGN

A schematic diagram of the evaporator is shown in Fig. 1. As seen the seawater passes first through the condenser tube where water evaporated in the evaporation section of the unit is condensed preheating at the same time the seawater. Subsequently the seawater is directed either to a heater or to a solar collector made from plastic tubing so as to avoid blocking and then it is directed to a set of nozzles where it is sprayed. The water remaining at the bottom of the evaporator section is directed to the collector where it is further heated and redirected to the nozzles.

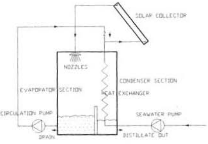

Fig. 1. Schematic of the spray-type evaporator.

A model unit constructed as part of this project was made from Perspex so as to be able to visually check the various effects taking place within the evaporator.

The design of the evaporator is based on the cooling tower theory developed by Baker and Shryock [1]. There is however one difference; the main function of cooling towers is to cool the water whereas the main function of the evaporator is to evaporate as much water as possible. Fig. 2 shows schematically, one water droplet and the processes of heat and mass interactions that occur. The bulk water is at temperature t surrounded by the bulk of air at dry bulb temperature ta having enthalpy ha and humidity ratio Wa. The interface is assumed to be a film of saturated air with an intermediate temperature t", enthalpy h" and humidity ratio W". Assuming a constant value of specific heat of water c_p, the total energy transfer from the water to the interface is:

$$dq_w = m_w c_p \, dt = K_w \alpha (t-t")dV \quad \text{or} \quad \frac{dt}{dV} = \frac{K_w \alpha (t-t")}{m_w c_p} \qquad (1)$$

The heat transfer from interface to air is:

$$dq_s = K_a \alpha (t"-t_a)dV \qquad (2)$$

The diffusion of water vapour from film to air is:

$$dm = K' \alpha (W"-W_a)dV \qquad (3)$$

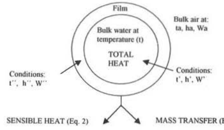

Fig. 2. Heat and mass transfer representation of a water bulb into air.

The humidity ratio W can be obtained from [2]:

$$W=0.62198\frac{P_{ws}}{1-P_{ws}} \qquad (4)$$

where:

P_{WS} = saturation pressure given by:

$$Ln(P_{WS})= -6096.938(1/t)+21.240964-2.71119x10^{-2}t+1.67395x10^{-5}t^{2}+2.43350Ln(t) \qquad (5)$$

The heat transfer due to evaporation from film to air is:

$$dq_L = r\,dm = r\,K''\,\alpha\,(W'-W_a)\,dV \qquad \text{or} \qquad \frac{dm}{dV} = K'\,\alpha\,(W''-W_a) \qquad (6)$$

As can be seen in the above relations the rate of energy or mass transfer is directly proportional to α, i.e., the area of interface. Therefore enhanced evaporation can be achieved with droplets of small diameter.

The process will reach equilibrium when $t_a = t$, and the air becomes saturated with moisture at that temperature.

Under adiabatic conditions, equilibrium is reached at the temperature of adiabatic saturation or at the thermodynamic wet-bulb temperature of the air. This is the lowest attainable temperature in the evaporator. The circulating water rapidly approaches this temperature when a low temperature of the spray water exists and vice versa. The process is the same when the spray water is at elevated temperature, but the air enthalpy increases as it moves through the evaporator so the equilibrium temperature increases progressively.

The Lewis relationship can be assumed to be equal to one in combining the transfer of mass and sensible heat into an overall coefficient based on enthalpy difference as the driving force, i.e. [3]:

$$K_a / (K'\,c_{pm}) = 1 \qquad \text{or} \qquad K_a = K'c_{pm} \qquad (7)$$

where:
c_{pm} = humid specific heat of moist air on a dry air basis (J / kg K).

Equation (7) also explains why the wet-bulb thermometer closely approaches the temperature of adiabatic saturation in an air-water vapour mixture. Setting water heat loss equal to air heat gain yields:

$$m_w\, c_p\, dt = m_a\, dh = K'\, \alpha\, (h''-h_a)\, dV \quad \text{or} \quad \frac{dt}{dV} = \frac{K'\alpha(h''-h_a)}{m_w c_p} \tag{8}$$

This equation considers the heat transfer from the interface to the air stream, but the interfacial conditions are intermediate. If the film resistance is neglected and the overall coefficient K' is postulated, based on the driving force of enthalpy h' at the bulk water temperature t, equation (8) becomes:

$$m_w\, c_p\, dt = m_a\, dh = K'\, \alpha\, (h'-h_a)\, dV \tag{9}$$

or

$$\frac{K'\alpha V}{m_w} = \int_{t_1}^{t_2} \frac{c_p}{h'-h_a}\, dt \tag{10}$$

and

$$\frac{K'\alpha V}{m_a} = \int_{h_1}^{h_2} \frac{dh}{h'-h_a} \tag{11}$$

It should be noted that the integrated value of Eq. (10) can also be referred as the number of transfer units (NTU) of the evaporator. This value gives the number of times the average enthalpy potential ($h'-h_a$) goes into the temperature change of water (ΔT) and is a measure of the difficulty of the task. Thus one transfer unit has the definition of $c_p\Delta T / (h'-h_a)_{avg} = 1$.

The above equations are not self-sufficient and are not subject to direct mathematical solution. They reflect mass and energy balance at any point in the evaporator and are independent of relative motion of the two fluid steams. Mechanical integration is required to apply the equations, and the procedure must account for relative motion. The integration of Eq. (10) gives the NTU for a given set of conditions.

As the water is sprayed from the top of the evaporator and the opening of the air towards the condenser is at the top, as depicted in Fig. 1, a counterflow condition is encountered.

The relationships giving mass exchange coefficient (K') and the heat exchange coefficients (K_w, K_a) as a function of the air flow rate (m_a) and water flow rate (m_w) are [4]:

$$K' = \frac{2.09\, m_a^{0.11515}\, m_w^{0.45}}{\alpha} \quad \text{and} \quad K_w \text{ or } K_a = \frac{5900\, m_a^{0.5894}\, m_w^{0.169}}{\alpha} \tag{12}$$

As is already shown the air-film heat transfer coefficient and the mass transfer coefficient on the air-water interface are coupled by the Lewis relation (see Eq. 7).

For the estimation of the rate of the hourly water evaporated a computer program was developed. The program is called SPRAY, is written in BASIC computer language and employs the above relations for the necessary calculations. The flow chart of the program is shown in Fig. 3.

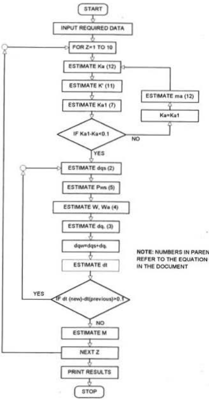

Fig. 3. Program SPRAY flow chart.

By running the program for a range of values of inlet sea-water temperature and the area of interface the graph shown in Fig. 4 was constructed. As can be seen the amount of water evaporated per hour increases with increasing inlet temperature and with decreasing buddle diameter, i.e., increasing the area of interface. It is thus desirable to keep the inlet temperature as high as possible and the bubble diameter as small as possible.

The inlet temperature is limited by the type of scale inhibitor employed and the bubble size is limited by the possible operational problems of nozzles when very small droplets are produced, unless a very good filtration system is employed. Additionally it is desirable that the inlet temperature is kept low so as to be able to use low-cost solar collectors to supply the required heat energy. It is also desirable not to evaporate the sea water completely as salt crystals may be formed which can be carried out to the condenser section thus deteriorating the distilled water produced. Therefore a compromise between the two needs to be made. The second constrain needs to be decided after experimenting with the unit for a considerable time and actual size can be decided by the frequency of maintenance required.

A complete system employing a collector area of $1m^2$ constructed with plastic tubing, is modeled with TRNSYS [5] and the typical meteorological year (TMY) of Cyprus [6]. The annual production of such a unit was found to be 11.2 m^3, which is a satisfactory value [7], much better than the best enhanced solar still.

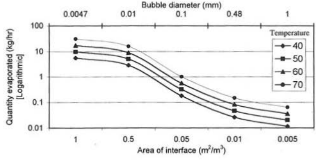

Fig. 4. Quantity of water evaporated against the bubble size or area of interface for various seawater temperatures.

CONCLUSIONS

The objective of this work is to design a low cost spray-type evaporator. The design of the unit was based on the theory of cooling towers. It is shown in this paper that the rate of evaporation is influenced mainly from the droplet size and temperature. i.e., the evaporation is enhanced by having small diameter and high temperature water droplets. The annual production of a unit with a collector area of $1m^2$ is 11.2 m^3, which is a satisfactory value. An experimental unit, which will be used for validation of the above results, is under construction.

NOMENCLATURE

α = area of interface (m^2/m^3)
c_{pm} = humid specific heat of moist air on a dry air basis (J/kg K)
ΔT = temperature difference (°C)
K_a = unit conductance sensible heat transfer from interface to main air stream (W/m^2K)
K_w = unit conductance heat transfer from bulk water to interface (W/m^2K)
K' = unit conductance mass transfer from interface to main air stream (kg/s m^2)
M = quantity of water evaporated (kg/s)
m = mass transfer rate from interface to air stream (kg/s)
m_a = air mass flow rate (kg/s)
m_w = inlet water mass flow rate (kg/s)
P_{ws} = saturation pressure
q_L = rate of latent heat transfer from interface to airstream (W)
q_s = rate of sensible heat transfer from interface to air steam (W)
q_w = rate of total heat transfer from bulk water to interface (W)
r = latent heat of evaporation (constant) (kJ/kg)
V = cooling volume (m^3)
W_a = humidity ratio of air (kg/kg)
W'' = humidity ration of interface (film) (kg/kg)

ACKNOWLEDGEMENT

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CERTIFICATION WITH ISO 9000 Vs ACCREDITATION TO ISO 17025

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ABSTRACT
The management of Calibration or Testing Centers should desire to maintain a Quality assurance system to go for ISO 9000 certification or consider and proceed with accreditation with ISO 17025(ISO/IEC 17025:2000, Requirements for the competency of testing and calibration laboratories). The aim of this project is to help managers to get familiar and understand the differences of the too standards, and help them to decide what to adopt in accordance with the requirements explained in this article. This joint research project which lasted 18 months investigate and identify the requirements and resources required for ISO 17025 accreditation. In the investigation each section of the ISO 17025 was correlated against ISO 9002(ISO 9002:1994) and ISO 10012-1 (ISO 10012-1, Quality Assurance requirements for measuring equipment), which are the most commonly used standards for similar cases. Where there is no conformance between the standards the requirement was copied into the text otherwise the matching sections were identified and recorded. An economic assessment, when possible, was also made in collaboration with the management of a specific laboratory. The reported costs are summarized on general, people and document for short and long term implementation.

The investigation revealed that the new ISO 17025 standard is far beyond the requirements and the scope of the ISO 9000. The latter is covering only a small amount of the 17025 requirements and a lot of affords need to taken prior to proceeding to accreditation.

KEYWORDS
Laboratory accreditation, Calibration laboratories, ISO 9000 Vs ISO 17025, ISO/IEC Guide 25:1990, Standards

INTRODUCTION
It is of crucial importance that calibration laboratories are accredited by a "notified body". The requirements are described in the internationally agreed documents ISO /IEC Guide 25 and EN 45001 or the new standard ISO 17025, General requirements for the competence of testing and calibration laboratories, (Guide 25 1990 and ISO 2000).

Very recently the new international accreditation standard ISO 17025 [International standard; General requirements for the competence of testing and calibration laboratories] was issued. As it was announced this will supersede both ISO/IEC Guide 25 and EN 45001 (UKAS Update, 1999). More than that UKAS will move to assessment against ISO 17025 and not the M10 publication.

This new international accreditation standard contains all the requirements that testing and calibration laboratories have to meet if they wish to demonstrate that they operate a quality system, and are technically competent in respect to personnel, equipment, premises, procedures and reports. It also assesses the laboratory on its capability reference to equipment and personnel, impartiality, independence, integrity and legal identity. The laboratory will then be able to generate technically valid results that the market can have confidence in. "Notified bodies" that assess test and calibration laboratories will use this new international standard as the basis for their accreditation. It is well understood that 17025 is far beyond to ISO 9000 certification.

This investigation is offering valuable information to Calibration Centers Management about the new standard ISO 17025 as well as what is required if they decide to go from ISO 9000 to ISO 17025.

QUALITY SYSTEM STANDARDS

Quality does not happen by chance. It has to be managed at every stage of the life of the product or service. A Quality System is a mechanism by which an organisation can organise and manage its resources to achieve, sustain and improve quality economically. A quality system harmonises the effort all groups in an organisation towards a focus on the quality at what it produced and what factors might prevent it from satisfying customers. Such standards are the ISO 9000 series, the set of special ISO/IEC Guides, the EN 45000 series and many others.

Conformity to a certain Quality System Standard indicates that the object of standardisation (product of process) complies with the most advanced knowledge and experience (state of the art) and therefore represents a fairly complete form of quality.

Benefits

The primary purpose of an effective quality system is to inspire confidence among customers in a contractual situation. It is also of immense value to the suppliers themselves, because it enables them to achieve customer satisfaction cost effectively. If all tasks were carried out correctly the first time, there would be no waste, costs would be minimised and profit maximised. Implementing a quality system based on ISO 9000 can help transform an ad hoc method of quality control into an organised and cost-effective quality-management system. By combining high quality with low cost, this can give the company a tremendous competitive advantage (Lal, 1996).

Limitations

ISO 9000 series, as every other Quality Management System approach, is emphasised on the writing of formal procedures and work instructions to guide employees. The expectation is that all employees will comply with the procedures in order to ensure that the work is done properly. The focus is, therefore, on the technical system and the way it operates.

ISO 9000 series is a statement about how quality is managed and one implication of this is that the products or services are constantly made to consistent standards whatever these standards are. In general ISO 9000 series of standard assure the quality of a process producing a specific product or offering a service with consistency and not the outcome (product or service) (Lal, 1996).

THE VALUE OF CALIBRATION

The aim of calibration is to ensure that Test and Measuring Equipment (TME) is capable of fulfilling its intended purpose. This is achieved by calibrating TME at specified time intervals against Measurement Standards that have accuracy traceable to National or International Measurement Standards.

The importance of regular calibration of instruments and measuring equipment cannot be emphasized enough. Organization effectiveness and the quality and reliability of its products rely on an efficient calibration system. Without such a system the product very quickly becomes fourth rate. Calibration is also required by clause 4.11 of ISO 9002.

Calibration laboratories are a special category of test laboratories. They provide calibration of test and measuring equipment, assuring the necessary accuracy by evaluating the uncertainty and traceability to primary measuring standards.

Benefits of accreditation

The Laboratory accreditation is a visible proof that it has been thoroughly assessed by independent technical experts. Buyers and specifies look for the accreditation mark on reports and certificates, so that they can be sure that work has been done to agreed specifications. More than that the accreditation process aims to ensure consistency and reliability.

Finally the accrediting body exerts influence to see that such certificates are accepted worldwide to further world trade.

Introduction to the international standard ISO 17025

The Draft International Standard ISO/IEC DIS 17025 was published in July 1998 and the comments received were considered at the meeting of the ISO/CASCO working group in March 1999. The standard will eventually supersede both ISO/IEC Guide 25 and EN 45001 and the final form was published at the end of 2000. The new standard considered the operating existence gained over the ten or so years since the previous standards were published. It contained all the requirements that testing and calibration laboratories have to meet if they wish to demonstrate that they operate a quality system are technically competent and are able to generate technically valid results.

Accreditation bodies that recognise the competence of testing and calibration laboratories will use this International Standard as the basis for their accreditation.

Calibration laboratories that comply with ISO 17025 also operate in accordance with ISO 9002 and are able to implement a single quality system meeting the requirements of both International Standards 17025 and 9002 if they so wish. It should be noted, however, that laboratories, which obtain only certification to ISO 9002, would not be able to demonstrate that they are technically competent and can produce technically valid testing and/or calibration results. On the other hand, accreditation is not the same as being certified against ISO 9002.

Update

In the UKAS Newsletter, edition 14-summer 1999(Update, 1999) it was announced that once ISO 17025 is published UKAS will cease to assess against M10. A transition period for accreditation bodies and accredited laboratories to move using the new standard will be given. This is unlikely to be less that one year but probably not more than two. The idea is to give time for the analysis of the new version of the standard published by ISO and for laboratories and accreditation bodies to adjust to any changes in requirements. UKAS will move to assessment against ISO 17025 and not M10.

This important announcement by UKAS has lead the authors to conduct the exercise based on the new standard and advise laboratories management to aim accreditation against the new international standard ISO 17025 and not M10, M10 supplement and M11 of UKAS (M10, M10 Supplement., M11, M3003, NAMAS).

CERTIFICATION VERSUS ACCREDITATION

Calibration laboratories may choose to be either certified or accredited against a quality management system. The most common quality management systems employed by Calibration Laboratories are the ISO 9002 and the ISO/IEC Guide 25 (ISO 9002:1994, ISO/IEC G25:1990).

But first, let us examine what certification and accreditation are:

- Certification is the procedure by which an impartial third party body gives written assurance that a product, process or service conforms to specified requirements. That the quality management system of a calibration laboratory meets the ISO 9002 is one example. That a product meets, say, the relevant British Standard is another.

To be sure that this certification is of full worth or value, accreditation comes into play.

- Accreditation is the procedure by which an authoritative body gives formal recognition that a body, organisation or person is competent to carry out specific tasks. The competence of a body to pronounce a pressure vessel as safe is one example. The competence of a laboratory to calibrate instruments in accordance with ISO/IEC Guide 25 is another.

An ISO 9002 certified calibration laboratory, is emphasized on the writing of formal procedures and work instructions to guide employees; it gives a statement about how quality is managed and one implication of this is that the service (or product) is constantly made to consistent standards, whatever these standards are! ISO 9000 Series is therefore a standard for managing a quality organization rather than a standard for product or service.

On the other hand, laboratory accreditation to ISO/IEC Guide 25 is specifically designed to assess the laboratory on its capabilities (equipment and personnel), impartiality, independence, integrity and legal identity. Further the requirements of the technical competence are also determined to conduct calibrations and tests in a technically competent and impartial manner and thus be able to issue valid reports and certificates in which the market can have confidence.
To determine this capability, three key elements are assessed:

- The impartiality of the laboratory.
- The technical confidence of the staff, the suitability of the equipment and environment and the validity of individual test methodologies.
- The effectiveness of the organisations management system.

Figures

ISO/IEC Guide 25	ISO 9002
The accreditation is granted based on the requirements of ISO/IEC Guide 25 by technically competent and expert inspectors or team.	The certification is based on the requirements if ISO 9002 by mainly local trained auditors
The ISO/IEC Guide 25 establishes a quality system with key elements not included in ISO 9002.	
The assessment is determined to establish the technical competence of the personnel in relation to the relevant activity.	The auditors may not be familiar with the activities they audit.
The assessment also involves the validity of test methodologies and suitability of equipment and material.	Therefore it is practically impossible to assess the technical competence of the personnel.
The systematic review, maintenance and calibration of test equipment, the traceability of measurements and the uncertainty are important elements of the accreditation.	Only clause of the standard is dealing with these activities
The accreditation requires the correct implementation of confirmation methods by the personnel. Something that only special expert inspector may evaluate.	Not included
The authoritative bodies issue detailed and explanatory publications in support to the requirements of the standard.	Not provided
The laboratory shall participate in an inter-laboratory comparison programme.	Not required by certification bodies
Laboratories are accredited for specific test and measurement parameters based on established methods of calibration	Certified organisations are assured for process, scope or service conformity to specified requirements.

Figures 1. Comparison betweem ISO/IEC Guide 25 and ISO 9002

It is this third element that is comparable with ISO 9000 certification. An effective management system is important, but it is only one of the elements necessary to gain laboratory accreditation..

In Figure 1 the ISO/IEC Guide 25 is compared with the ISO 9002 with respect to their scope and application.

CROSS-REFERENCE OF ISO 9002:1994 and ISO/IEC 17025

In the next pages a detailed cross-reference of the ISO 17025 against the international standards ISO 9002 and ISO 10012-1 is carried out for those who are now at the stage to decide what is expected by the new standard if the decide to follow the route for accreditation (ISO 17025, ISO 9002:1994, ISO 10012-1).

The ISO 17025 consists of two major sections; the Management requirements comprising 14 clauses and the Technical requirements consisting of 10 clauses. Both sections will be covered in the following paragraphs. Each paragraph in ISO 17025 will be correlated against ISO 9002 and ISO 10012-1. Where there is no conformance the whole paragraph will be copied in italics as is printed in ISO 17025. In cases where there is a conformance between the standards, the exact paragraphs numbers, codes and the headings will be identified and recorded only, since the content of the 19 requirements of ISO 9002 are well known to the majority of the readers.

In the main survey report only (Constantinou, 1999), at the end of a clause and when it was necessary, a more elaborated explanation was given of how this standard can be applied in the majority of calibration laboratories.

SECTION A: CROSS REFERENCE OF ISO 17025 CLAUSE 4 "MANAGEMENT REQUIREMENTS" AGAINST ISO 9002:1994 AND ISO 10012-1

➢ **ISO 17025: clause 4.1 "Organisation and Management"**

- 4.1.1: *"The laboratory or the organisation of which it is part shall be an entity that can be held legally responsible."*
- 4.1.2: *"The laboratory shall be organised and shall operate in such a way that it meets the requirements of this International Standard whether carrying out work in its permanent facilities, at sites away from its permanent facilities, or in associated temporary or mobile facilities."*
- 4.1.3: *"If the laboratory is part of an organisation performing activities other than testing and/or calibration, the responsibilities of key personnel in the organisation that have an involvement or influence on the testing and/or calibration activities of the laboratory shall be defined on order to identify potential conflicts of interest."*
- 4.1.4(a) *"The laboratory shall have managerial and technical personnel with the authority and resources needed to carry out their duties and to identify the occurrence of departures from the quality system or the procedures for performing tests and/or calibrations, and to initiate actions to prevent or minimise such departures."*
- 4.1.4(b): *"The laboratory shall have arrangements to ensure that its management and personnel are free from any undue internal and external commercial, financial and other pressures that may adversely affect the quality of their work."*
- 4.1.4(c): *"The laboratory shall have policies and procedures to ensure the protection of its clients' confidential information and proprietary rights, including procedures for protecting the electronic transmission of results."*
- 4.1.4(d): *"The laboratory shall have policies and procedures to avoid involvement in any activities that would diminish confidence in its competence, impartiality, judgement or operational integrity."*
- 4.1.4(e): *"The laboratory shall define, with the aid of organisational charts, the organisation and management structure of the laboratory, its place in any parent organisation, and the relationships between management, technical operations, support services and the quality system."*

- ISO 17025:4.1.4(f) as per ISO 9002:4.1.2.1 Responsibility and Authority
- 4.1.4(g): *"The laboratory shall provide adequate supervision of testing and calibration staff, including trainees, be persons familiar with the test and/or calibration methods and procedures, with the purpose of each test and/or calibration, and with the assessment of the test and/or calibration results."*
- ISO 17025:4.1.4(h) as per ISO 9002:4.1.2.2 Resources
- ISO 17025:4.1.4(i) as per ISO 9002:4.1.2.3 Management Representative
- 4.1.4(j): *"Appoint deputies for key managerial personnel such as the quality manager."*

➤ **ISO 17025: clause 4.2 "Quality System"**

- ISO 17025:4.2.1 as per ISO 9002:4.2.1 Quality System General
  and ISO 9002:4.2.2 Quality System Procedures
- ISO 17025:4.2.2 as per ISO 9002:4.1.1 Quality Policy
  and ISO 9002:4.2.2 Quality System Procedures
- ISO 17025:4.2.3 as per ISO 9002:4.2.1 Quality System General
- 4.2.4: *"The quality manual shall define the roles and responsibilities of technical management and the quality manager including their responsibility for ensuring compliance with this International Standard."*

ISO 17025: Clause 4.3 "Document Control"

- ISO 17025:4.3.1 as per ISO 9002:4.5.1 Documentation and data control
- ISO 17025:4.3.2.1 as per ISO 9002:4.5.2 Document and data approval and issue
- ISO 17025:4.3.2.2 as per ISO 9002:4.5.2 Document and data approval and issue
- 4.3.2.3: *"Quality system documents generated by the laboratory shall be uniquely identified. Such identification shall include the date of issue and/or revision identification, the total number of pages or a mark to signify the end of the document and the authority for issue."*
- ISO 17025:4.3.3: as per ISO 9002:4.5.3 Document and data changes

➤ **ISO 17025: clause 4.4 "Review of request, tender or contract"**

- ISO 17025:4.4.1: as per ISO 9002:4.3.1 Contract review – general
  and ISO 9002:4.3.2 Review
  and ISO 9002:4.3.3 Amendment to a contact
  and ISO 10012-1:4.5 Planning
- ISO 17025:4.4.2: as per ISO 9002:4.3.4 Records

➤ **ISO 17025: clause 4.5 "Subcontracting of tests and calibrations"**

- ISO 17025:4.5.1: as per ISO 9002:4.6.2 Evaluation of subcontractor
- 4.5.2: *"The laboratory shall advise and obtain approval from the client, preferably in writing, when the laboratory intends to subcontract to another laboratory specific tests and/or calibrations."*
- ISO 17025:4.5.3: as per ISO 9002:4.6.2 Evaluation of subcontractor
  and ISO 9002:4.6.4 Verification of purchase product
  and ISO 10012-1:4.13 Use of outside products
- ISO 17025:4.5.4: as per ISO 9002:4.6.4 Verification of purchased product
- ISO 17025:4.5.5: as per ISO 9002:4.6.2 Evaluation of subcontractor

➤ **ISO 17025: clause 4 6 "Purchasing services and supplies"**

- ISO 17025:4.6.1: as per ISO 9002:4.6.3 Purchasing data
- ISO 17025:4.6.2: as per ISO 10012-1: Use of outside product and services
  and ISO 9002:4.6.4 Verification of purchased product

- ISO 17025:4.6.3: as per ISO 9002:4.6.3 Purchasing data
- ISO 17025:4.6.4 as per ISO 9002:4.10.2 Inspection and testing
- ISO 17025:4.6.5: as per ISO 9002:4.6.2 Evaluation of subcontractors

➤ **ISO 17025: clause 4.7 "Service to the client"**

- 4.7 *"The laboratory shall afford clients inform or their representatives co-operation to facilitate clarification of the client's request and to monitor the performance of the laboratory in relation to the work performed."*

➤ **ISO 17025: clause 4.8 "Complaints"**

- 4.8: *"The laboratory shall have a policy and procedure for the resolution of complaints received from clients or other parts. Records shall be maintained of all complaints and of the investigations and corrective actions taken by the laboratory."*

➤ **ISO 17025: clause 4.9 "Control of non-conforming testing and/or calibration work"**

ISO 17025:4.9:	as per	ISO 9002:4.13 Control of non-conforming product
	and	ISO 10012-1:4.9 Non-conforming equipment.

➤ **ISO 17025: clause 4.10 "Corrective Action"**

ISO 17025:4.10:	as per	ISO 9002:4.14.1 Corrective and Preventative Action
	and	ISO 9002:4.14.2 Corrective Action

➤ **ISO 17025: clause 4.11 "Preventative Action"**

ISO 17025:4.11:	as per	ISO 9002:4.14.1 Corrective and Preventative Action
	and	ISO 9002:4.14.3 Preventative Action

➤ **ISO 17025: clause 4.12 "Records"**

ISO 17025:4.12.1:	as per	ISO 9002:4.16 Control of Quality Records
	and	ISO 9002:4.2.3 (h) Quality Planning
	and	ISO 9002:4.17 Internal Quality Audits
ISO 17025:4.12.2:	as per	ISO 9002:4.10.5 Inspection and Test Records
	and	ISO 10012-1: 4.8 Records

- 4.12.2.2: *"Observations, data and calculations shall be clearly and permanently recorded and identifiable to the specific job at the time they are made."*
- 4.12.2.3: *"When mistakes occur in records, each mistake shall be crossed out, not erased, made illegible nor deleted, and the correct value entered alongside. All such alterations to records shall be signed or initialled by the person making the correction. In the case of computer-collected data, similar measures shall be taken to avoid loss or change of original data."*

➤ **ISO 17025: clause 4.13 "Internal Audit"**

ISO 17025:4.13.1:	as per	ISO 9002:4.17 Internal Quality Audits
	and	ISO 9002:4.1.22 Resources
	and	ISO 10012-1:4.4 Periodic Audit and Review of the Confirmation System

- 4.13.2: *"When audit findings cast doubt on the effectiveness of the operations or on the correctness or validity of the laboratory's test or calibration results, the laboratory shall take timely corrective action, and shall notify clients in writing if investigations show that the laboratory results may have been affected."*

- ISO 17025:4.13.3 as per ISO 9002:4.17 Internal Quality Audits

➤ **ISO 17025: clause 4.14 "Management Reviews"**

- ISO 17025:4.14 as per ISO 9002:4.1.3 Management Review

SECTION B: CROSS REFERENCE OF ISO 17025 CLAUSE 5 "TECHNICAL REQUIREMENTS" AGAINST ISO 9002:1994 AND ISO 10012-1

➤ **ISO 17025: clause 5.1 "General"**

- ISO 17025:5.1 as per ISO 9002:4.9 Process Control

➤ **ISO 17025: clause 5.2 "Personnel"**

- 5.2.1: *"The laboratory management shall ensure the competency of all who operate specific equipment, who perform tests and/or calibrations, evaluate results and sign test reports and calibration certificates. When using staffs, who are undergoing training, appropriate supervision shall be provided. Personnel performing specific tasks shall be qualified on the basis of appropriate education, training, experience and/or demonstrated skills, as required."*

● ISO 17025:5.2.2	as per	ISO 9002:4.18 Training
● ISO 17025:5.2.3	as per	ISO 9002:4.9 Process Control
	and	ISO 9002:4.18 Training
	and	ISO 10012-1: 4.18 Personnel
● ISO 17025:5.2.4	as per	ISO 9002:4.1.2.1 Responsibilities and Authority
● ISO 17025:5.2.5	as per	ISO 9002:4.18 Training
	and	ISO 9002:4.9 Process Control

➤ **ISO 17025: clause 5.3 "Accommodation and Environmental Conditions"**

● ISO 17025:5.3.1 and 5.3.2	as per	ISO 9002:4.9 Process Control
and		ISO 9002:4.11.2(g) Control Procedure
	and	ISO 10012-1:4.17 Environmental Conditions

- 5.3.3: *"There shall be effective separation between neighbouring areas in which there are incompatible activities. Measures shall be taken to prevent cross-contamination."*
- 5.3.4: *"Access to and use of areas affecting quality of tests and/or calibrations shall be controlled."*
- 5.3.5: *"Measures shall be taken to ensure good housekeeping in the laboratory. Special procedures shall be prepared where necessary."*

➤ **ISO 17025: clause 5.4 "Test and Calibration Methods including Sampling"**

● ISO 17025:5.4.1	as per	ISO 9002:4.10.1 Inspection and Testing
	and	ISO 9002:4.11.1 Control of Inspection MTE
	and	ISO 9002:4.2.3 Quality system
	and	ISO 10012-1:4.3 Confirmation System
● ISO 17025:5.4.2:	as per	ISO 10012-1:4.7 Documented Confirmation
	and	ISO 9002:4.11 2(a) and (c) Control Procedure

- 5.4.3: *"Introduction of test and calibration methods developed by the laboratory for its own use shall be a planned activity and be assigned to qualified personnel equipped with adequate resources. Plans shall be updated as development proceeds and shall ensure effective communication amongst all personnel involved."*
- 5.4.4: *"When it is necessary to employ methods not covered by standardised methods, these shall be subjected to agreement with the client and shall include a clear specification of the clients requirements and the purpose of the test and/or calibration. The method developed shall have been validated*

appropriately before use, and be available for examination by the client and other authorised recipients. New test and/or calibration methods and procedures should be produced prior to the tests and/or calibrations being performed and should contain at least the following information:

a) Scope
b) Description of the type of item to be tested or calibrated
c) Parameters or quantitatives to be determined
d) Apparatus, equipment, reference material required
e) Environmental conditions required and any stabilisation period.
f) Description of the procedure including:
  - *Affixing identification marks, handling, transporting, sharing of items*
  - *Checks to be made before the work is started*
  - *Checking that the equipment if working properly, and where required, calibrating and adjusting the equipment before each use*
  - *Methods of recording the observations and results*
  - *Any safety measures to be observed*

g) Criteria and/or requirements for approval/rejection.
h) Data to be recorded and method of analysis and presentation
i) Uncertainty or procedure for estimating uncertainty."

- **ISO 17025:5.4.5 "Validation of methods"**

  5.4.5.1 *"Validation is the confirmation by examination and the provision of effective evidence that the particular requirements for a specific intended use are fulfilled".*

  5.4.5.2 *"The laboratory shall validate non-standardized methods, laboratory designed/developed methods, standardized methods used outside their intended range and amplifications of standardized methods to confirm that the methods are fit for the intended use. The validation shall be as extensive as is necessary to meet the needs in the given application or field of application. The laboratory shall record the results obtained, the procedure used for validation and a statement as to whether the method is fit for the intended use."*

  5.4.5.3 *"The range and accuracy of the values obtained from validated methods (e.g. the uncertainty of the results, detection limit, selectivity of the method, linearity, limit or repeatability and/or reproducibility, robustness against external influences and/or cross-sensitivity against interference from the matrix of sample/test object) as assessed for the intended use shall be relevant to the clients needs."*

- ISO 17025: 5.4.6 Best Measurement Capability

  5.4.6.1 *"A calibration laboratory shall have procedures to calculate its best measurement capability. These calculations shall be available for specified ranges and for all quantitives/measurements in its scope."*

- ISO 17025:5.4.7 Estimation uncertainty of measurement

5.4.7.1 and 5.4.7.2:	as per	ISO 9002: 4.20 Statistical Techniques
	and	ISO 10012-1: 4.6 Uncertainty of Measurement
	and	ISO 10012-1: 4.16 Commutative effect

  5.4.7.3: *"When estimating the uncertainty of measurement, all uncertainty components which are of importance in the given situation shall be taken into account using accepted methods of analysis."*

- ISO 17025:5.4.8 Control of data

5.4.8.1	as per	ISO 9002:4.5 Document and Data Control
	and	ISO 9002:4.10.4 Final Inspection and Testing
5.4.8.2	as per	ISO 9002:4.11.1 Control of Inspection, MTE

➤ **ISO 17025: Clause 5.5 "Equipment"**

● ISO 17025:5.5.1	as per	ISO 9002:4.6.1 Purchasing – General
● ISO 17025:5.5.2:	as per	ISO 9002:4.6.4 Verification of Product
	and	ISO 9002:4.10.2 Receiving Inspection
	and	ISO 9002:4.11.2 (a), (b), (c) Control of MTE
	and	ISO 10012-1:4.2 Measuring Equipment
● ISO 17025:5.5.3:	as per	ISO 9002:4.1.2.2 Organization – Resources
	and	ISO 9002:4.18 Training
	and	ISO 10012-1:4.18 Personnel
● ISO 17025:5.5.4:	as per	ISO 9002:4.11.2 (e) Control of MTE
	and	ISO 10012-1:4.8 Records
● ISO 17025:5.5.5	partly by	ISO 10012-1: 4.8 Records

"Records shall be maintained of each item of equipment significant to the tests and/or calibrations performed. The records shall include at least the following:

- *a) Identity of the item of equipment*
- *b) Manufacturers name, type identification and serial number*
- *c) Checks that equipment complies with the specification (see 5.5.2)*
- *d) Current location, where appropriate*
- *e) The manufacturers instructions, if available, or refer to their location*
- *f) Dates, results, and copies of reports and certificates of all calibration adjustments, acceptance criteria and due date for next calibration.*
- *g) Maintenance carried out to date and the maintenance plan.*
- *h) Damage, malfunction, modification or repair of the equipment.*

● ISO 17025:5.5.6:	as per	ISO 9002:4.11.2 (e), (f), (h), (i) Control of MTE
	and	ISO 10012-1:4.3 Confirmation
	and	ISO 10012-1:4.14 Storage and handling
● ISO 17025:5.5.7:	as per	ISO 9002:4.11.2 (f) Control of MTE
● ISO 17025:5.5.8:	as per	ISO 10012-1:4.9 Non-conforming equipment
● ISO 17025:5.5.9:	as per	ISO 9002:4.11.2 (d) Control of MTE –
	and	ISO 10012-1:4.10 Confirmation labeling

● 5.5.10 *"When, for whatever reason, equipment goes outside the direct control of the laboratory for a period, the laboratory shall ensure that the function and calibration status of the equipment are checked and shown to be satisfactory before the equipment is returned to service."*

● ISO 17025:5.5.11:	as per	ISO 17025:5.4.8
● ISO 17025:5.5.12	as per	ISO 9002:4.11.2 (c) Control of MTE –
	and	ISO 10012-1:4.11 Intervals of confirmation

● 5.5.13 *"When calibrations give rise to a set of correction factors, the laboratory shall have procedures to ensure that any copies (e.g. in computer software) are correctly updated."*

● ISO 17025:5.5.14:	as per	ISO 9002:4.11.2. (I) Control Procedure
	and	ISO 10012-1:4.12 Sealing for Integrity

➤ **ISO 17025: clause 5.6 "Measurement Traceability"**

● ISO 17025:5.6.1	as per	ISO 9002:4.11.1 Control of MTE – General
	and	ISO 10012-1:4.3 Confirmation system

● ISO 17025:5.6.2 Specific requirements

5.6.2.1	as per	ISO 9002:4.11.2 (b) Control Procedure
	and	ISO 10012-1:4.15 Traceability

5.6.2.2

- ISO 17025:5.6.3: Reference Standards and Materials
  5:5.6.3.1 and 5.6.3.2 as per ISO 17025:5.6.2.1
  5.6.3.3: *"Checks needed to maintain confidence in the calibration status of reference, primary working standards and reference materials shall be carried out in accordance to defined procedures and schedules."*
- ISO 17025:5.6.3.4: as per ISO 9002:4.11.2 (b) Control Procedure
  and ISO 10012-1: 4.14 Storage and Handling

- ISO 17025: clause 5.7 "Sampling"
- 5.7.1 *"The laboratory shall have a sampling plan and procedure for sampling when it carries out sampling of substances, matrices, materials or products for subsequent testing or calibration. The sampling plan as well as the sampling procedure and shall be available at the location where sampling is undertaken."*
- 5.7.2 *" Where the client requires deviation, additions or exclusions from the documented sampling procedure, these shall be recorded in detail with the appropriate sampling data and included in all documents containing test and/or calibration results, and shall be communicated to the appropriate personnel"*
- ISO 17025:5.7.3 as per ISO 9002:4.10.4 4.10.5 Inspection and testing

➢ **ISO 17025: clause 5.8 "Handling and Transportation of test and cal items"**

● ISO 17025:5.8.1	as per	ISO 9002:4.7 Control of customer supplied product
	and	ISO 9002:4.15 Handling storage, packaging, preservation and delivery
	and	ISO 10012-1:4.14 Storage and Handling
● ISO 17025:5.8.2	as per	ISO 9002:4.8 Product Identification and traceability
	and	ISO 9002:4.10.2 Receiving inspection and testing
	and	ISO 10012-1:4.14 Storage and Handling
● ISO 17025:5.8.3	as per	ISO 9002:4.10.2 Receiving inspection and testing
● ISO 17025:5.8.4	as per	ISO 9002:4.10.3 In process inspection and testing
	and	ISO 9002:4.11.2(b) Control procedure
	and	ISO 10012-1:4.14 Storage and handling

➢ **ISO 17025: clause 5.9 "Assuring the quality of test and calibration results"**

● ISO 17025:5.9:	as per	ISO 9002:4.9 Process control
	and	ISO 9002:4.10.4 Final inspection and testing
	and	ISO 9002:4.20 Statistical techniques

- ISO 17025: clause 5.10 "Reporting of Results"
- ISO 17025:5.10.1 as per ISO 9002:4.10.5 Inspection and Test Records
  and ISO 10012-1:4.8 Records
- 5.10.2 and 5.10.4 *"Unless the laboratory has exceptional reasons for not doing so, each calibration certificate shall include at least the following information:*
  a) A title (e.g. "Calibration Certificate"
  b) Name and address of laboratory and location of tests carried out
  c) Unique identification of the calibration certificate (such as serial number), and on each page identification in order to ensure that the page is recognized as a part of calibration certificate
  d) Name and address of the client placing the order
  e) Description and unambiguous identification of the item(s) tested or calibrated
  f) Date of receipt of calibration item(s) and date(s) of performance of the calibration where relevant to

the validity and application of the results

g) Calibration results with units of measurement

h) Reference to sampling procedures used by the laboratory

i) The name(s), function(s) and signature(s) or equivalent identification of person(s) authorizing the calibration certificate

j) Where relevant, a statement to the effect that the results relate only to the items calibrated. In addition Calibration certificates shall include the following:

a) Identification of the standard specification used or a brief unambiguous description of the method

b) The conditions (e.g. environmental) under which the calibrations were made

c) The uncertainty of measurement and/or a statement of compliance with an identified metrological specification or clauses thereof:

d) Evidence that the measurements are traceable."

- 5.10.4.2 *"The Calibration certificate shall relate only to metrological quantities and the results of functional tests and shall specifically state which clauses of the specification are met or not met." When a statement of compliance with a specification is make omitting the measurement results and associated uncertainties, the laboratory shall record and maintain those results for possible further reference. When statements of compliance are made the uncertainty of measurement shall be taken into account."*
- 5.10.4.3 *"A calibration certificate (or cal label) shall not contain any ecommendation on therecalibration interval except this has been agreed with the client."*
- 5.10.5 *when opinions and interpretations are included in the report, the laboratory shall be able to show that it has documented the basis upon which his opinions and interpretations have been made."*
- 5.10.6 *"When the report contains results of tests performed by subcontractors, these results shall be* clearly identified. When a calibration has been subcontracted, the laboratory performing the work shall issue the calibration certificate to the contractor."
- ISO 17025:5.10.7 as per ISO 17025: 5.4.8
- 5.10.9 *"Material amendments to a test report or calibration certificate after issue shall be made only in the form of a further document, or date transfer, which include the statement "Supplement to Calibration Certificate, Serial Number...," or an equivalent form for wording. Such amendments shall meet all the requirements of this standard. When it is necessary to issue a complete new test report or Calibration Certificate, it shall be uniquely identified and shall contain a reference to the original that it replaces."*

THE COST OF THE ACCREDITATION

The cost of calibration services is generally admitted to be high, so high is expected to be the cost for achieving accreditation. What follows is a short and a long-term financial analysis of the estimated resources required in order to achieve ISO 17025 accreditation standards.(see Figure 2 and 3). The required resources are grouped into three categories. The first category lists the General expenses as specified by accreditation bodies (UKAS Update, 1999). The second lists the People requirements and finally the third one the Document requirements roughly estimated for a specific calibration laboratory with 15 employees working with ISO 9002 certification for almost 6 years (Cyprus Calibration Centre (CCC) Limassol, Cyprus). Where was possible the exact costs were drawn. In some other areas, the best possible estimation was made in collaboration with the management of the calibration laboratory. Please note that the amounts quoted in Figures 2 and 3 are in British pounds and refer to expenses and costs estimated at the end of 1999, when the article was firstly written.

SHORT TERM					
GENERAL	COST	PEOPLE	COST	DOCUMENT	COST
UKAS application fees	£620	Review Terms of Reference	£600	Review Quality Manual and Quality Instructions	£3000
UKAS pre-assessment fees	£2820	Training of Authorized Signatories	£3000	Amend Documents issued by the CCC	£600
UKAS on site assessment fees	£5640			Review IHCP and uncertainties estimation	£3000
UKAS post assessment fees	£2820			Produce Records for Test Equipment	£1000
Re-organisation of the laboratory	£2000				
Subtotal	£13900		£3600		£7600
				Total	£25100

Figure 2 Short Term Financial Resources

LONG TERM					
GENERAL	COST	PEOPLE	COST	DOCUMENT	COST
UKAS Annual Surveillance	£2980	Appoint Quality Manager and Deputies	£12000/ year	Update / Amend Procedures	£3000
UKAS 4th Anniversary Assessment	£5960	Employ Calibration Technician	£15000/ year	Update / Amend Quality Manual and Instructions	£2000
Inter-Laboratory Audit	£2000	Additional Labour hours	£2000/ year	Update / Amend all quality documents	£2000
Audit Measurement Program	£2000	Training Courses	£10000		
Subtotal	£12940		£39000		£7000
				Total	£58940

Figure 3 Long Term Financial Resources

EPILOGUE

The continuously changing and competitive environment of today, together with the vital requirement to meet our customer's needs, dictates the necessity to become more effective and efficient in our methods of operation. Some Calibration Centres gained the most in the recent past few years by achieving the BS EN ISO 9002 certification. This has established an effective management quality system combining high quality at a relatively low cost for all calibration methods. Thus, giving them a competitive advantage.

However, this is just not enough today. It is more than necessary to achieve compliance with accredited methods of calibration, if the laboratory wants to maintain and improve its competitive edge. It is wise to seek accreditation against the new international standard ISO 17025. As it was clearly reported before (apart from the differences in scope, use and application) the certification with the ISO 9002 is covering or fulfilling only a small amount of the ISO 17025 requirements. Specifically there are approximately 34 non-conformances out of 86 requirements of ISO 17025 witches are not covering by ISO 9000. As it was written before the article was firstly written end of 1999 when the ISO 17025 was in its draft form. At the same time the new ISO 9000:2000 was in its draft form. Both standards were published end of 2000. So it was impossible to compare two draft standards, that is why the new ISO 17025 was considered the base of comparison with an existing standard (ISO 9000:1994)and because this is the standard laboratories will seek accreditation. The old ISO 9000:1994 can be used until December 2002. After that deadline all should comply or certified with the new ISO 9000:2000

The implementation of this new international standard, ISO 17025, will therefore require a tremendous effort by any personnel laboratory. The resources and other requirements needed in order to implement and comply with this quality system have already examined and identified. Of course these requirements varies from laboratory to people in accordance with what they have got and achieved till today.
Nevertheless, laboratories are more than technical systems. Apart from anything else, they are also social systems. They are about the way people behave and interact with each other. A quality process can only be developed through attention to this social system. The technical system, set up by this new international standard, need to be interacted with the social system in order to built the correct quality culture.

Through this report, the management of Calibration Laboratories will have the valuable data and ideas as to what is expected of them if they ever decide to proceed with the accreditation. Given this information, that has been scientifically collected, they can now base their decision and implement it with their staff.

REFERENCES

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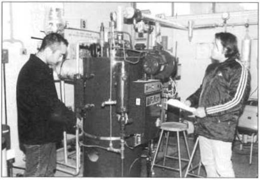
Experimental work in the Plant Engineering Laboratory



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