ISO 9000 - The Quest for Quality

By: EMILIO M. MORALES, MSCE

ABSTRACT: Quality in the Construction Industry and the workplace is a necessary ingredient for success. Too often, Quality is neglected sometimes with disastrous results.

As a Professional Design Engineering and Consulting Firm, we realized very early on that we needed to formalize our Quality Control procedures into a single coherent strategy in order to assure consistency and reliability of the Checking, Peer Review and Management Review processes. These activities were necessary not only to assure quality but also to safeguard our reputation and protect the general public by ensuring safe and cost effective designs.

The opportunity came when our biggest client, who was also getting into the ISO 9000 Quality System, required that downstream contractors and service providers also qualify for ISO 9000 Accreditation. We took the challenge and became the First Filipino Engineering Consulting Firm to be accredited under the ISO 9000 System.

This paper describes our quest for ISO 9000 accreditation which we would like to share with the Profession and the Construction Industry. Admittedly, as we shall soon find out, there is not "one single" Quality System for all and that Quality Systems and procedures should be attuned and tailor made to each individual organization's needs. However, it is hoped that conscientious adherence to the ISO 9000 Quality System Guidelines and our experiences which we share in this paper will somehow help our Industry to become one of the most efficient, safest and cost effective sector in our country.

1.0 INTRODUCTION

We got introduced to the ISO System through the backdoor. Our sister Laboratory, *Philippine Geoanalytics, Inc*. just completed accreditation as the First Philippine Laboratory ever to be accredited under **ISO Guide 25**. The quality system was therefore in place in one of our sister organizations, although in this respect ISO Guide 25 is a more stringent system than **ISO 9000** in that it required checking of the technical competency of the personnel to perform Laboratory Testing Procedures.

In addition, and more importantly, we were informed by our biggest client to prepare for ISO accreditation if we are to remain as a service provider for them. This client even sponsored our attendance in their in-house ISO 9000 Briefings and Seminars in order for us to fully understand the quality system and how best to synergize with them. Our client, who was actually on the verge of obtaining ISO 9000 accreditation for most of their plants was the catalyst in speeding up our process for accreditation.

This is not however to be taken as an indication of the lack of desire from within to seek ISO accreditation. For already, we were seeing the positive effects of what ISO Guide 25 was doing for our Laboratory---Morale was up, client satisfaction was at an all time high, income had increased by leaps and bounds, lost records and books have become a thing of the past and order has finally been restored in a very chaotic environment normally found in testing laboratories.

Thus, there was a very strong and compelling reason for us to qualify for ISO 9000 Accreditation.

This paper describes our preparations, documentation process and employee orientation. It is worthwhile mentioning that we undertook this assignment using exclusively our internal resources and manpower. We did not hire a pre audit service nor engaged consultants. This had the advantage that all our employees needed to participate to ensure our success. It was gratifying for us to observe teamwork in action, as our employees were highly motivated to accomplish this task.

How this happened is also discussed in this paper.

2.0 BENEFITS OF THE ISO QUALITY SYSTEM TO THE ENGINEERING ORGANIZATION

Although some of the benefits may not be readily apparent, a Quality System formalized and religiously implemented in an Engineering Organization can confer numerous advantages to it.

Oftentimes, compliance to ISO 9000 may be driven by the desire to comply based on client pressure or requirements. Sometimes it is done in the mistaken belief that ISO 9000 Quality System by itself can increase revenues or can assure quality of products or services.

But what are the true and real benefits of ISO 9000 to an Engineering Organization?

In our case, the ISO 9000 Quality System had given us numerous benefits unimaginable before which are normally the least tangible benefits and these are:

- Substantial improvement in internal operations.
- Elimination of lost or misplaced documents and communications.
- Simplified and formalized procedures for review and quality control of designs
- Reduced time of document retrieval to within 5 minutes.
- Increased employee awareness of the need to preserve quality and reduce errors to a minimum.
- Traceability of design and drafting errors resulting in reduced error counts.
- Increased employee morale because everyone knows their role in the organization and their importance in the maintenance of the Quality System and Procedures.

The foregoing may not be readily apparent to an organization seeking accreditation for the first time and it was to us a pleasant surprise that these came **free** with the package.

To us as Professional Designers, the foregoing are more important than the more often Touted Benefits because of the need to increase client satisfaction and also reduce our liability exposure.

There have been cases in our experience where our preservation of certain documents had saved us from costly litigation and claims. This would not have been possible without a fool proof document Archiving/Retrieval System that the ISO 9000 guidelines suggest.

The other more common benefits are of course the following:

- Increased competitive advantage due to enhanced efficiency in procedures.
- Customer preference for ISO 9000 companies with established Quality Systems.
- Global acceptability of the ISO 9000 accredited company.
- Orderly conduct of company business governed by procedures.

If we are to be asked what is the best benefit that has resulted from our seeking ISO 9000 accreditation, it is this:

> *We have reduced the chances for errors remaining undetected before implementation. Although errors cannot be entirely eliminated due to human factors or computer glitches, our formalized Quality Control system gave us the assurance and feeling of confidence that somehow we will find these errors before they can do some harm or cause loss of reputation.*

As a matter of fact, it is not a sin in our organization to commit an error. However, it is a cardinal sin for everyone and anyone if we let an error go undetected through our various checks and counterchecks, as outlined in our Quality System. Somehow, this has given our employees High Morale.

3.0 BASIC UNDERSTANDING OF THE ISO 9000 SYSTEM

3.1 Background

The ISO 9000 standards originated from the IOS which is located in Switzerland . IOS is the acronym in French of the *International Standards Organization*. The ISO standards had its roots during the Second World War where methods of assessment of quality of wartime suppliers was very critical. This evolved into the MIL Standards and their Civilian Counterparts. Countries in the EU began to accept the values of a single standard for quality management systems resulting in the publication in 1987 of the ISO 9000 Series of Standards.[1]

3.2 What is ISO 9000?

ISO 9000 is a set of international standards for a Basic Management System of Quality Assurance. It is intended to equalize Quality Systems between companies and countries. [1]

The following are the unique characteristics of the Quality System:

Flexibility -the requirements of the system are guides only and could be changed if the practices within an organization do not exactly match the requirements.

Wholistic - the standard looks at how the whole organization assures the quality of its products and services.

---

[1] Clement, R.B. "Quality Manager's Complete Guide to ISO 9000". 1993 Prentice Hall Inc., N.J.

Focus on Quality Process - the standard do not focus on the final results but rather on the procedures for assuring quality.

Global - the standards have worldwide application and acceptability.

Broad Application - the standards can be applied to all aspects of business or operational procedures.

3.3 The ISO 9000 Family

The ISO 9000 Standards has five parts or is really a set of Five (5) Standards as defined[1] below:

ISO 9000 - *"Quality Management and Quality Assurance Standards – Guidelines for Selection and Use"* is written to help companies determine which of the three standards to adopt or apply for registration.

ISO 9001 - *"Quality Systems – Model for Quality Assurance in Design/Development Production, Installation and Servicing"* is the standard for companies engaged in all aspects of manufacturing or of the development and delivery of a service.

e.g. A consulting Engineering Firm with a fully integrated Design Engineering function.

ISO 9002 - *"Quality Systems – Model for Quality Assurance in Production and Installation"* – is for companies that perform functions except the design and development of products and services.

e.g. A manufacturer that builds to prints and designs of a customer. A general contractor who builds based on plans supplied by the owner's engineers.

ISO 9003 - *"Quality System – Model for Quality Assurance in Final Inspection and Test" –* is intended for non manufacturing companies such as distribution or warehousing entities. ISO 9003 is applied less and less and is expected to be dropped in the future.

ISO 9004 - *"Quality Management and Quality System Elements –Guidelines"* – is an overview of the themes and intent of the standards.

The key word in all of the foregoing titles is "*Model"* because the standards represent models of quality assurance rather than compulsory standards. Companies need only to match as closely and as economically, and as practically as possible the guidelines. This means that companies need not dramatically change their methods of quality assurance to meet the ISO 9000 Standards.

3.4 What It Is and What It Isn't

The ISO 9000 Quality System is a set of Guidelines that is flexible.

It does not dictate the procedures to be practiced nor does it require a company to change its way of doing Quality Assurance if it is logical and effective. However, it provides a set of coherent guidelines to enable companies to meet minimum standards in the Global marketplace.

The ISO 9000 Standard is a requirement for a management system, not the structure of a quality department within an organization. There is not one correct Guideline and Procedure to follow. Each must be tailor made to suit the particular company's operations and Quality Assurance procedures.

As a minimum, the standards provide a general pattern to follow. However, deviations or omission can and do occur depending on the company's specific way of doing business which may be unique and requiring special procedures.

- **Common Misconception**

  It is sad to note that there are still lingering misconceptions about the ISO 9000 System and the quest to get there. These misconceptions should be clarified and erased before an organization can start its travel towards ISO 9000 accreditation. Some of these misconceptions are:

  ** It is very difficult to comply with the standards.
  ** The standards are rigid and inflexible.
  ** It would take a long time to successfully comply.
  ** It is very expensive to obtain and maintain.
  ** It must be prepared by a consultant
  ** It must be prepared and packaged by the management because employees would look at the standards with bias.
  ** Employee compliance must be mandated from the top.
  ** The quality system process must be management driven all the way.
  ** It is not necessary provided you know what you are doing.
  ** The documentation process is a waste of time and resources.

4.0 ESTABLISHING THE QUALITY COMMITTEE

Some of the major misconceptions in ISO 9000 accreditation are:

- The process should be management driven.
- You need a consultant to prepare the procedures and quality system.
- Employees should be handed the complete procedure for their compliance.

The foregoing are quaranteed paths to failure because more than anything else, employee direct involvement is crucial to the success of any quality system. The effort should therefore be employee driven with the full logistical and moral support of top management.

We realized this very early on and we created a Total Quality Committee drawn from rank and file, tasked to prepare the company for accreditation. The Chairman of the Total Quality Committee in our case was a Lady Middle Level Engineer at that time and the following as representatives:

Management Representative	-	Technical Manager and Senior Partner
Engineering Representative	-	Junior Engineer representing Design Group And CAD Group
Admin Representative	-	Senior Clerk representing Admin and Non Technical Group
Q.C. Engineer	-	Full time **Independent** member of the Committee Designated as such.

The Total Quality Committee (TQC) spearheaded the company's program for ISO 9000 Accreditation. It independently set the goals, milestones and work objectives of the company. Top management interference was unheard of and the main function of management was to keep the activities focused and monitor progress to attain a fixed deadline we have mutually agreed upon during the formation of the TQC.

The members were free to make the necessary suggestions and draft the procedures pertinent to their areas of operation. They were given blanket authority to draw upon any company resource or personnel in order to attain the objectives set by the TQC.

Directly under the TQC but not its members were two (2) Archive and Documentation Clerks. They received guidelines and instructions on the filing and records retrieval system being evolved and undergoing dynamic revision throughout the life of the TQC. These clerks were on full time assignment and were aided by our clerks and secretaries. They were not part of the mainstream operations as their job was to compile, catalog, file and debug the system. Little did we know that this decision saved us a lot of time and was partly instrumental in clinching the accreditation for the company.

As can be seen, the TQC was employee driven and this was very crucial not only to the preparation of the Quality System and Procedures but also in the subsequent implementation and maintenance of the Quality System.

The procedures, having been originated by the employees themselves were widely accepted and embraced by all. In other words, the procedures were not rammed down the throat of rank and file but were prepared, polished and nurtured by them.

This to us is the single most crucial decision leading to the success of our Quest for ISO 9000 Accreditation.

5.0 PREPARING FOR ACCREDITATION

The Total Quality Committee established the necessary documentation requirements and the procedures needed to be documented. It also set out the guidelines for the archival and retrieval system.

The Quality Manual was reviewed and continually revised to contain new procedures or revised/eliminated/ outdated/superseded procedures.

Numerous working copies were reprinted for comments by employees as soon as these have undergone revisions- each revision being issued a Revision number. Thus, everyone got involved in the process of rewriting the procedures manual. The paper generated by the preparations was humongous but it was well worth the effort and time.

We also acquired several books on the ISO System which served as reference and guide for our efforts. Our books were the poor man's substitute to a Consultant to assist in the accreditation process.

As part of our preparations and to serve as "Dry Run" to the *Pre Audit* and *Audit* activities ahead, we conducted internal audits using the checklist published in these references.

There was a compelling need to ensure that the system is thoroughly checked and debugged as external audits are expensive. In our case the Pre Auditor came from Austria and the Auditor from India. Both have to be billeted in Five (5) Star Hotels and their airfares paid for in addition to the Audit Fees charged by their company.

Thus, we can not afford failing in both audits and no room or allowance for non-compliance reaudits, and the rallying cry for the TQC is **"Hit it one Time"** this battle cry had a double meaning to us because HIT is our acronym for:

H - Personal **H**onesty
I - **I**ntegrity
T - **T**echnical Excellence

We aimed for single pass *Pre Audit* and *Audit* and got it, saving us a lot of anxiety and plenty of hard earned money.

Dedicated as they were, the TQC members were driven by the Chairman who almost worked full time developing and coordinating the standards preparation. To add to the incentive, the Chairman was promised and got an all expenses paid trip to Hong Kong for getting accreditation in one pass. To get accredited in one audit was to us hard earned divine providence. The Internal Audits and Dry Runs were repeated until we were very satisfied that our system met ISO 9000 Standards. The personnel were in high state of morale and eager to get it over with.

We were ready!

6.0 THE DOCUMENTATION PROCESS

The main task in the ISO 9000 Accreditation Process is to ensure adequate Documentation of Procedures and Quality Systems. This also involved creating Document Filing, Archiving and Retrieval system to ensure the traceability and retrievability of all documents that need to be stored and that meant everything except junk mail.

No project document or communication was considered unimportant as not to be logged and stored in the archives.

The archived files consisted of Project Files which in our specific case involved:

- Project Communications
- Project Calculations
- Project Plans & Drawings *(Hard Copy, CD and Bernoulli Disk Files)*
- Project Specifications
- Project Contract File
- Estimates & Quantity Take Off

All these project files were interlinked and coded to assure fast retrieval and filing.

It is worthwhile to note that as a result of systematizing our document archiving and retrieval system, we can retrieve any project document within **five minutes** after the request for each documents is initiated. This includes travel time from the groundfloor to the third floor of our office.

In addition, lost document or lost files have become a thing of the past.

7.0 THE ISO 9000 QUALITY SYSTEM

7.1 ISO 9000 Elements

The ISO 9000 Quality System sets out Guidelines for companies to consider in the preparation of their Quality Systems and Procedures. It identifies vital elements that may comprise the system.

Note that in this definition, there are no mandatory statements such as **"required" "shall"** etc. Instead the words or phrases such as **"consider" "may comprise"** and that the provisions are **"Guidelines".**

What this suggests is that the ISO 9000 is totally flexible and does not prescribe how the system should be done. It must completely suit each individual companies product or processes.

In our case, we evaluated the Guidelines element by element, and we adopted or incorporated those elements or sub elements related to our operations.

The following are the Elements for ISO 9001:

1) Management Responsibility
2) Quality System
3) Contract Review
4) Engineering Design Control
5) Document and Data Control
6) Purchasing
7) Control of Customer Supplied Product
8) Product Identification and Traceability
9) Process Control
10) Inspection and Testing
11) Inspection, Measurement & Test Equipment
12) Inspection and Test Status
13) Control of Non Conforming Product

14) Corrective and Preventive Action
15) Handling, Storage, Packaging, Preservation and Delivery
16) Control of Quality Records
17) Internal Quality Audits
18) Training
19) Servicing
20) Statistical Techniques

In our specific instance, we deemed all the twenty (20) Elements as necessary for our system but with a lot of modifications in order to suit our way of doing business and conducting our work.

It would be necessary to acquire references and guides such as the books mentioned in our references in order to have a clear and concise **General** Guide in preparing the Quality Manual and Procedures.

Emphasis is placed on the word *"General"* because the system and procedures are unique to the individual company's operations.

The biggest temptation, is to copy some other company's manual. This is a big mistake and a shortcut to failure due to lack of immersion and voluntary participation of rank and file.

7.2 ISO 9000 Levels of Documentation

The ISO 9000 Guidelines is relatively flexible in terms of document structure. However, it is necessary to have several levels of documentation mutually supportive of each other in order to have a fully Integrated Quality System. In our case, we adopted the Document Structure Pyramid [2] commonly used by a lot of companies as shown below:

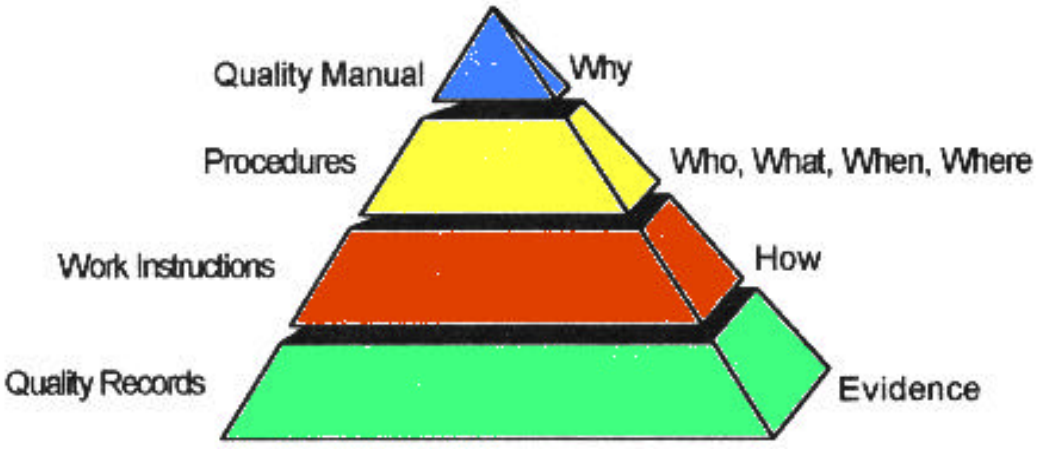

Figure 2-1 Document Pyramid

[2] Novack, J.L. "The ISO 9000 Documentation Toolkit". 1987 Prentice Hall, Inc., N.J. pp.20

From the above, the documentation levels or hierarchy can be easily seen as follows:

LEVEL 1 Quality Manual - the Quality Manual answers the question: **why?** It is a company's statement of philosophy and approach to quality. The Quality Manual discusses in general terms how the company complies with each element of the standard, it also includes the company's quality objectives *(such as "Zero Defects"),* gives an overview of the company's processes and contains the quality philosophy of the company.

The Quality Manual is the Bible for Quality for the company.

LEVEL 2 Procedures - The procedures document the company's Quality Plan and defines the implementation strategy. It indicates compliance to the ISO 9000 Standards, demonstrate the processes and ensures that there are no loopholes in the system.

The procedures are process oriented and covers:

- The Tasks: **What?**
- The Responsibility: **Who?**
- The Frequency: **When?**
- The Department: **Where?**

Necessarily, the procedures should be written by the people who will use them. **Not by a Consultant.**

Because the procedures are process oriented, we decided to Flow Chart our procedures. This had the advantage of:

- Making it easily understandable by anyone reading it even without prior knowledge of flow charting.
- Saving a lot of manhours and pages of paper during the preparation.
- Enabling in thorough checking of the process as it was Graphical and easily checked.
- Expdediting the audit procedures enabling us to get accredited.

We saw the need to include 12 Flow Charts defining our operations.

These are:

1) Proposal Preparation: New Clients Procedure Flow Chart
2) Awarding of Contract: New Clients Procedure Flow Chart
3) Awarding of Contract: Old Clients Procedure Flow Chart
4) Engineering Production Flow Chart
5) Design Verification/Validation Procedure Flow Chart
6) Design Changes Flow Chart
7) Control of Client Provided Info/Data Procedure Flow Chart

8) Isuance of Documents and Books Procedure Flow Chart
9) Purchasing Procedure Flow Chart
10) Handling of Documents Procedure Flow Chart
11) Internal Audit & Reviews Procedure Flow Chart
12) Handling Client Request Procedure Flow Chart

LEVEL 3 Work Instructions - The work instructions answer the question **How?** They are the step by step instructions specific to the company's procedures. Work instructions includes direction for doing specific tasks such as Checking and Peer Review, Document Storage and Retrieval, Handling of Complaints, etc.

In our case, and for the same reasons above, we have integrated these into a procedures Flow Chart indicating the process, the documents needed or generated and the persons responsible.

The Quality Documents or Forms we generated are as follows:

- Transmittal Letter
- Project Summary Sheet
- Request Form
- Confirmation of Documents Received
- Checkprint Report
- Internal Project Bulletin
- Internal Quality Audit
- Complaints Form
- Purchase Order
- Quality Control Checklist
- Weekly Project Monitoring
- Zero-Defects Score Card Form
- Statistical Record of Defects
- Checklist of Client Inputs Form

LEVEL 4 Quality Records - The quality records provide evidence of the company's compliance. They are the ongoing objective evidence of the system and evolve from the company's procedures. The standards does not specify exactly which records to keep because the individual company has to define this depending on its process. However, most elements of ISO 9000 require Quality Records.

The records that we decided we needed to keep as a minimum are as follows:

- Project Files
  - Hardcopy Plans
  - Electronic Plan Files *(CD Format & 3.25 Floppy Diskettes)*
- Communications (Incoming & Outgoing)

- Log Books
  - ** General Incoming Logbook
  - ** General Outgoing Logbook
  - ** Contract Transaction Logbook
  - ** Request Logbook
  - ** General Software Logbook
  - ** Document Retrieval Logbook *(Project File)*
  - ** Drawings/Plans Withdrawal Logbook
  - ** Specs/Design Computation/PF Retrieval Logbook
  - ** Document Retrieval Logbook *(Electronic File)*
  - ** Complaint Log

In the generation of documents, it is necessary to focus on the company's actual needs and the procedures that it implements. Some procedures may overlap and therefore can be joined into one detailed procedure.

The key thing to remember is to limit documentation to what is really essential to the Quality System defined procedures. More documents mean a larger number to manage (or neglect), fewer documents may mean larger and crammed individual documents which may decrease usefulness or reduce understanding.

In addition, our Quality Manual included the following:

- Quality Committee Table of Organization
- Company Table of Organization
- Amendments Record
- Official Company Quality Policy Statement

8.0 PREPARING FOR THE PRE AUDIT AND FINAL AUDIT

In order to obtain proof of compliance that the ISO 9000 System is functional and being implemented within the company, a Third Party Independent Auditor (TPA) normally ISO certified as such would need to be engaged.

The TPA would need to conduct a Pre Audit Review and as many audits as necessary until you run out of money or you obtain compliance.

Because Third Party Audit is **expensive,** it would be necessary and imperative that the Quality system and procedures are fully debugged internally prior to Audit. Otherwise, non compliances could stretch the time and be very costly and demoralizing to both rank and file.

The Pre Audit

The pre audit is an audit conducted by the TPA in order to check:

- Completeness of Quality Systems and Procedures (Elements involved)
- Adequacy of Documentation to cover the company' processes
- Cursory evidence of implementation of the Quality System
- Archived Documents and Document Retrieval system
- Top Management commitment to the Quality System

We prepared for the pre audit as though it was our final audit. This involved at least 3 months of preparations and weekly staff orientation meetings.

Each individual staff was given his own copy of the Draft Quality Manual which required voluminous printing of documents. Internal audits and peer audits were required at every step of the process.

The pre audit required two (2) days to complete and to our relief, only minor non compliances were observed.

Management and the TQC were briefed by the TPA on the deficiencies to prepare for the final audit.

To our great relief we were told that we were ready for the final audit.

The Audit

More intense preparations were made to include training and retraining of staff in the implementation of the system.

The audit, aside from being more rigid, would require individual interviews of staff chosen at random by the TPA. Everyone therefore must know the system by heart.

Aside from the more detailed checks on the pre audit items, the following were done:

- Interview of top management to determine level of participation or involvement in the quality process.
- Meeting with the TQC to gage its inner workings and level of commitment
- Individual staff interviews to determine level of understanding of the Quality System
- Checking of Office Procedures
- Checking that Software is validated
- Test of the Document Archiving and Retrieval System

In this specific instance, several projects were randomly chosen by the TPA and related Files were requested to be presented. The retrieval time was monitored.
Also, as an example: a project was chosen and the work order and minutes of coordination meeting were requested to be exhibited.

Checkprints were asked to be displayed and compared with final plans to see whether all corrections were implemented.

The audit was conducted for three (3) straight gruelling days, and all office functions were directed towards the audit. Other activities not related to the Audit ground to a halt. That was how important the audit was to us. The TPA was crucial to us.

Besides, it would be very expensive for us not to pass the audit as the TPA had to be billeted again in a 5 Star Hotel and the Airfares (from Europe or elsewhere) had to be paid in addition to his man day rates.

9.0 COMPLIANCE AT LAST

It was a combination of very hard and dedicated work and the grace of God the Almighty that we successfully handled the audit and obtained acceptance of the company's Quality System with a few minor comments in **one pass.** There was a feeling of general relief and satisfaction for a job well done.

We got our accreditation on **June 14, 1996.**

We had a reception to honor the members of the TQC and it also gave us the opportunity to thank our clients and announce to the world that our Quality System is at par with the World's Best.

True to our promise, the Chairman of the TQC was given a 3 day Holiday in Hong Kong.

Morale was very high and everyone had a feeling of pride and accomplishment for a job well done!

10.0 MAINTAINING AND SUSTAINING THE SYSTEM

The effort does not stop at accreditation time. Yearly audits by the TPA are mandatory to retain Accreditation and Certification.

But to us, the incentive in maintaining the system is because we have seen that the system really works for us and has given us a very competitive advantage over peer companies.

To us, at least and to potential clients, *"we are more equal among equals"*. Whether this is true or not, is not the question. In our minds and our hearts we know that we are because we have a formalized system that works.

In closing, we wish to state that in this difficult times, an engineering company can survive or survive better with a formalized and working Quality System and as forces realign, the ISO 9000 accredited company is better positioned to meet a more discriminating and quality conscious client.

REFERENCES

1) Clement, R.B. *"Quality Manager's Complete Guide to ISO 9000"*. 1993 Prentice Hall Inc., NJ.

2) Novack, J.L. *"The ISO 9000 Documentation Toolkit"*. 1987 Prentice Hall Inc., N.J. pp.20

3) TQC *"Quality Manual"*. March 15, 1996 *(Revision 1.0)* EM²A & Partners & Co.

ABOUT THE AUTHOR

Emilio M. Morales took up his Master's Degree in Civil Engineering at the Carnegie Institute of Technology, Carnegie-Mellon University, Pittsburgh, PA. USA in 1981. He is formerly a Senior Lecturer of the Graduate Division, College of Engineering, University of the Philippines, Diliman, Quezon City. Presently, he is the Principal of EM²A Partners & Co., Technical Manager of Philippine Geoanalytics, Inc. and Technical Director of PGA Calibration & Metrology Laboratory. Committee Member, TC-11, Bureau of Product Standards Technical Committee on Steel Products. He is currently Chairman of ASEP Geotechnical Committee.

He can be contacted at: EM²A Partners & Co., 17-C Scout de Guia corner Scout Reyes Streets, Diliman, Quezon City. Telephone Nos. 371-18-06 / 410-29-23 to 24 Telefax No. 924-98-94; E-mail: em2apart@mozcom.com