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THE MODERN CONCEPTS OF QUALITY METHODOLOGY AND TECHNIQUES OF QUALITY CONTROL AND QUALITY INSPECTION[1/]

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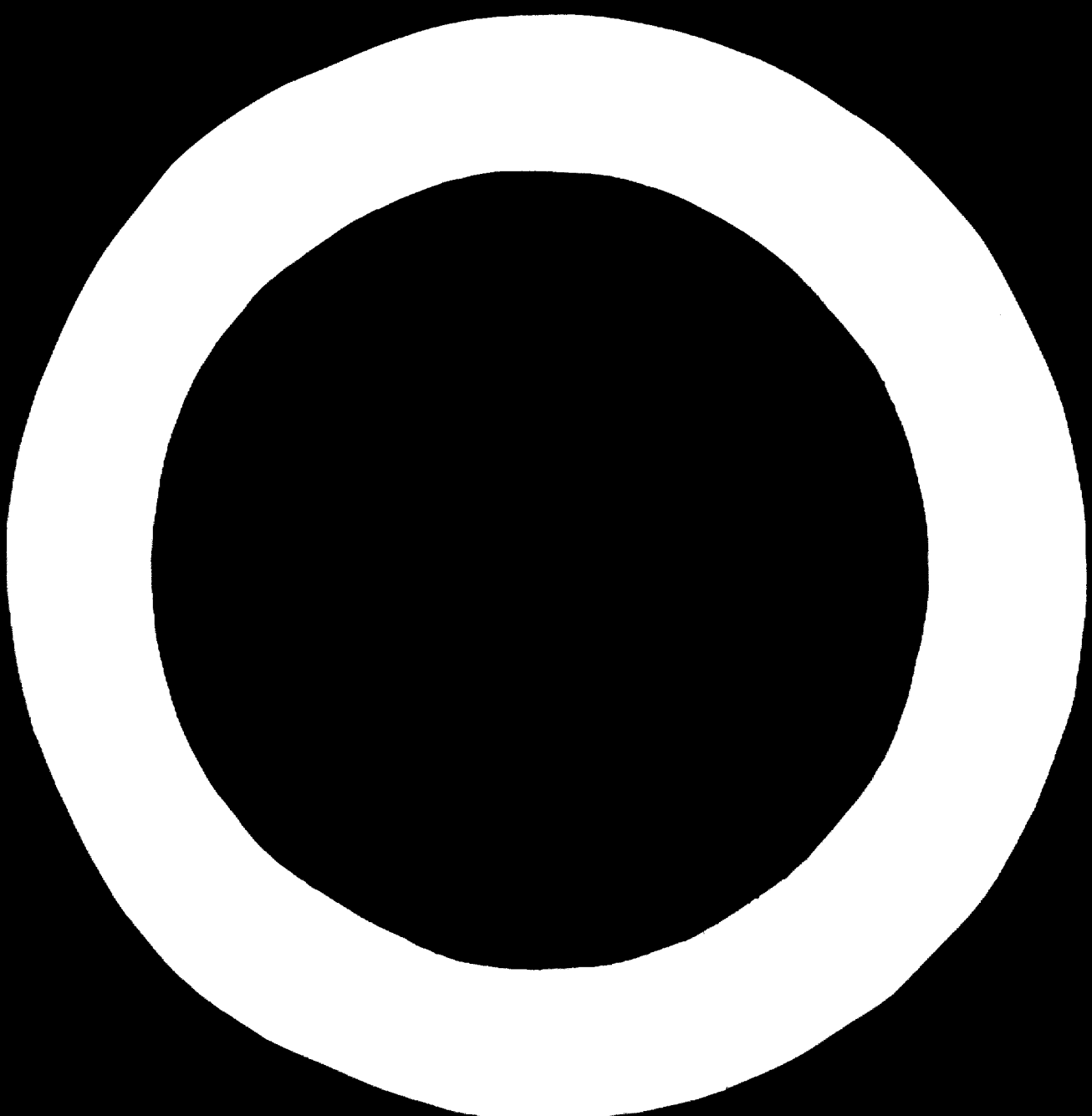

Breadth of Scope

Quality -- its attainment and control, like a precious gem, has many facets -- each contributing to its sparkle and value. There are the in-factory programmes of receiving inspection; raw materials and piece parts inspection; vendor relations; process performance and capability studies; process controls; motivation of employee quality consciousness; failure analysis; reliability, life and environmental testing; instrument calibration and control; maintainability of plant and equipment; final inspection; product warranty and liability; customer relations and analysis of field use data; quality assurance; quality cost analysis; quality of design; management reports; organization for quality, etc.

On a national level there are quality control societies; local, regional and national seminars and conferences; training programmes and certification of practitioners; university degree programmes; publications and literature promotion; product liability legislation and government compulsions for quality; standardization; certification and quality marks programmes; export inspection programmes; etc.

The multi-national companies, bi-lateral and multi-lateral aide programmes, such as the United Nations Industrial Development Organization, and other international organizations carry the in-factory and national programmes over to the international level. The world has seen, first hand, the tremendous economic impact of the transfer of quality technology from one culture to another -- notably the case of Japan.

What is Quality?

As with many concepts as broad as quality there is the necessity for an understanding of terms for effectiveness of application and communication. The term "Quality" alone needs to be understood.

Quality is conformance to a given requirement or specification on a product or service. The term "Quality" by itself does not necessarily mean high quality! It means uniformity, consistency, and conformity to a standard or specification -- a statement of what the user wants and what the manufacturer can provide, i.e. the quality statement or specification should be based on what the existing process can produce with reasonable controls. Therefore the manufacturer and user must cooperate in defining a practical, possible, and economical specification of quality. Such definitions of quality can be developed to account for the following; (1) the degree of national development of a country (2) the buying ability of the consumers and the general economy (3) technical knowledge, labour skill and degree of available machinery (4) the competitive situation among the manufacturers and importers (5) climatic and geographical factors, etc.

Two Aspects of Quality

Concern for quality is often not understood because two distinct aspects of quality are not known or understood. These aspects are "design quality" and "manufactured quality".

We often hear from manufacturers, "quality costs too much"! This statement is almost always based on a misunderstanding of quality and quality control. We should understand this statement to mean that, "a product design of high quality may cost too much". That is, it should be understood that when reference is made to the "high cost of quality", such reference is almost always associated with "design quality" i.e. the quality of the design or product grade. It is, of course, a real cost. A manufacturer of a new product must decide what design (materials, form, appearance, functions, etc.) will appeal to his potential customers, taking into account what it will cost him to produce the product and what the customers will be willing to pay for the product. Design quality, therefore, is an important aspect of quality and must be considered carefully in planning the design, manufacture and marketing of a product.

But "design quality" is not the only aspect of quality. After a product has been designed and placed in manufacture we find that the manufacturing process does not always produce each unit of product in conformance to the design -- defects in materials, parts, sub-assemblies, assemblies, and in final product are seen to arise. These defects, of course, may be related to the design and their correction or reduction may call for a redesign of the product. But all too often these defects are the result of an incomplete, inadequate, poorly planned and/or poorly controlled manufacturing process. The products produced, which fail to perform their intended design, resulting in customer dissatisfaction; the defective materials, parts, assemblies, and finished products which are discarded during the manufacturing process; the lost time and effort in producing these defective parts and products; the loss of business resulting from delays in delivery; and other associated ills of poor quality product are the consequence of "manufactured quality" i.e. the quality of conformance to the design.

Manufacturers often fail to make the distinction between these two aspects of quality -- "design quality" and "manufactured quality". Making this distinction is particularly important, because with a correct understanding of these aspects of quality, the extremely important fact is realized that "good quality and low cost" can be achieved simultaneously. Higher design quality or product grade usually means higher cost, but higher manufactured quality or quality of conformance usually means lower cost. This is illustrated for emphasis as follows:

Design Quality (Quality of Product Design)	Manufactured Quality (Quality of Product Conformance)
Higher Quality ↓ Higher Costs	Higher Quality ↓ Lower Costs

What is Quality Control?

The manufacturer is responsible, and he will find it to his benefit, to make a product to the stated requirements, that is, to achieve good "manufactured quality". As mentioned above, the established manufacturing process does not always produce product units which conform to the design. Defectives in materials, parts, assemblies and finished product, lost time and effort, lost business due to failures in product or in deliveries, etc. are manufacturing costs which can be reduced or even avoided. Quality Control principles and methods have been developed and have proved effective in bringing about these cost reductions as well as improved quality and greater productivity (of good quality units).

The real users of Quality Control are those who have discovered that it doesn't cost money, but on the contrary, it saves money.

Of course, Quality Control as with almost any concept, can be applied incorrectly. Its principles and techniques are very flexible -- simple enough for the most humble processes and products, yet sufficient enough for the most complex processes and products. With this wide range of application its implementation can be overdesigned or underdesigned. How effective it is in reducing overall costs, including savings resulting from improved quality and greater production, is a reasonable measure of the correctness of its application. If it is costing more than it is saving -- it is improperly applied.

Quality Control has many aspects and several good definitions have been set forth. Its techniques are statistical (most of which are simple to understand and apply) and its motivation is the responsibility of top management. It has been said, "No advance has ever been made in quality without statistical methods nor without the interest and labour of top management". One useful definition is as follows.*

> THE STATISTICAL CONTROL OF QUALITY IS APPLICATION OF STATISTICAL PRINCIPLES AND TECHNIQUES IN ALL STAGES OF DESIGN, PRODUCTION, MAINTENANCE AND SERVICE, DIRECTED TOWARD THE ECONOMIC SATISFACTION OF DEMAND.

Two Important Aspects of Quality Control

Quality Control is more than a set of principles and techniques. It is an attitude of mind that is concerned with using the principles and techniques to achieve the benefits of improved quality, reduced costs and greater production.

There are two important aspects to Quality Control. One pertains to the procedures used routinely in the manufacturing process in an attempt to achieve uniformity of quality and prevent too many defective products. The other aspect of Quality Control pertains to procedures and techniques for achieving specific improvements in manufacturing processes where quality and production difficulties are apparent. The first aspect is concerned with "control of quality" while the second is primarily

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* See reference 1.

concerned with "improvement of quality". They are closely related and complementary.

There is no general rule as to which aspect of Quality Control should be applied first. This will vary with the process and the product. Applying the procedures to achieve control of quality may reveal places where improvement of quality (and associated costs) are needed and possible. On the other hand, application of techniques to improve quality will often reveal places where procedures of control are necessary.

Control of quality can be achieved by considering the following areas. The degree of attention to each area depends on the size and nature of the production process.

(1) Control of Manufacturing Information -- careful instruction and training of production workers, understandable drawings and process instructions, and good communication of design and production changes are essential elements of quality manufacture. They are often implemented by simple management directives.

(2) Control of Purchases and Storage of Raw Materials -- obtaining the correct materials of defined quality from suppliers and the storage of these materials to prevent deterioration of quality are essential elements of uniform quality manufacture. Often simple checks and periodic random inspections of these supplies will achieve the results. Maintaining good relations and communications with suppliers is important.

(3) Control of Manufacturing Process -- preventing the fabrication of defective products, maintaining equipment and production facilities, motivating production employees, etc. are essential to quality and low cost manufacture. Clear and decisive management directives, routine simple checks on important process steps, planned maintenance, and good employee relations are important to achieve results. Simple statistical techniques as control charts and sampling plans are useful.

(4) Control of Finished Product -- some verification, by means of adequate tests and criteria, that finished product meets the expected quality is an essential step in quality manufacture. Feedback of information from this "final inspection" is also important to maintaining the production process. Simple sampling plans are useful.

(5) Control of Measuring Instruments and Test Equipment -- where applicable, calibrations and periodic maintenance of test and process equipment for adequate control is essential.

(6) Control of Corrective Action -- a systematic use of information from control areas (1) through (5) above is necessary to assure that deficiencies effecting quality are promptly detected and corrected.

Improvement of quality (with associated reduction in costs) has been achieved by the application of some simple steps that have proven useful in initial small scale as well as large scale studies of manufacturing processes for the purpose of identifying and correcting causes of trouble.* These steps are as follows:

(1) Determine the magnitude of defectives, rejections, rework, repair, or other appropriate characteristics of undesirable conditions.

(2) Separate or break-down the data on these characteristics by obvious comparisons involving production paths, such as

   a. Different products or qualities of product.
   b. Different shifts or teams of employees.
   c. Different machines or operators.
   d. Different days or intervals within days.

(3) Critically analyze the defectives, units requiring rework, etc.

   a. Are they actually defective?
   b. Can they be categorised according to severity?
   c. Is the same defect or many defects present?
   d. Can causes of defects be assigned?

(4) Form ideas as to the causes of the undesirable conditions using the information from steps (1) through (3).

(5) Collect data for more detailed process studies.

(6) Upon learning the causes of difficulty - Take the necessary corrective action.

Simple statistical techniques are very useful in carrying out the control and improvement of quality of manufactured product. Among these are control charts, capability studies, Pareto charts, cause and effect diagrams, sampling plans, designed experiments, etc.

What are the Benefits of Quality and Quality Control?

Statistical Quality Control, correctly applied with an awareness of the importance of quality, can provide the active ingredient needed to achieve domestic and export quality and the resulting good reputation for products made "anywhere". SQC is now widely used in almost every type of industry in most countries of the world. It has proved to be most effective (1) in improving the quality of products, (2) in raising the productivity of manufacturing processes and (3) in reducing manufacturing and other costs.

However, many developing countries have yet to promote, utilize and benefit from SQC on a national scale. Most are receiving some assistance and interest is developing. Understanding the concepts set forth above and placing them in proper perspective will surely help. It must also

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*See reference 2

be understood that the commonly heard resistances to quality implementation such as, "our problems are different", "it will cost too much", "management will not accept it", etc., have been voiced before most successful applications -- regardless of degree of development and/or scope of application.

For example, in Thailand it is conceded that price dominates the domestic market for many products at present. However, Thai consumers, bolstered by a relatively loose control on quantities of imports, continue to spend huge amounts (price plus large custom taxes) for quality imports. If Thai manufacturers are to capture a greater share of this capital, they will have to shift their emphasis to quality -- at the lowest possible price. "Buy-Thai" movements are underway but they are mostly promotional. In addition to the domestic market, the export market continues to demand quality products -- although they don't always get them as evidenced by the many and varied complaints, requests for controls, etc. SQC can provide the substance needed to make these programmes effective.

Thailand, like many developing countries around the world, stands on the threshold of rapid industrial development. If this development is to be successful in achieving domestic and export acceptance of locally made products; quality, price and delivery must be placed in proper perspective and continually improved. Management personnel in government departments, private industry, management and industry associations, academic institutions, etc. must develop a genuine and growing interest in the use of Statistical Quality Control to achieve these results.

Education, Training and Implementation are Essential

Training cannot be over-emphasized. In one U.S. factory of approximately 4000 employees some 23,000 man hours of quality control training was conducted for personnel from top management to inspectors and key shop workers in a period of seven years. This was during a concentrated period of process studies using quality control principles and techniques (1952-1958). Over this same period savings in production waste and excessive inspection amounted to $27 million.* The above factory was visited by many Japanese industrial study teams in the mid-to-late fifties.

As alluded to earlier, Statistical Quality Control has been emphasized in Japan's rise to international recognition as a manufacturer of quality products. It is estimated that the total number of participants in SQC courses in outside company training reached more than 100,000 for the period from 1949 to 1968.** With the in-company training programmes, several million have been trained. In more than 2000 companies, training has been completed for all employees including top management and workers. The Japanese Standards Association, since 1953, has been conducting seminars on Quality Control and Standardization. Every year the association holds 17 seminars of about 160 hours duration each. Above 1,100 attendants were trained in 1972 and more than 18,000 in total.

An effective training format which has been used successfully in many countries is a programme consisting of (1) an initial seminar period of classroom exposure to the fundamentals of quality control including how

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* See reference 3.
**See reference 4.

to begin a process improvement study, (2) a period of time when each participant begins to apply the techniques to a problem within his own factory and (3) an additional classroom period to report and review the initial applications and develop further topics.* This approach motivates direct implementation of the training and could be very useful in Thailand to initiate widespread quality control applications.

As with training, management support and action also cannot be over-emphasized. Dr. W. Edwards Deming, honored by the Japanese for his lectures and consultations on statistical quality control, has said, "I am firmly of the opinion that nothing can happen in the improvement of quality or in economy of production without active support and continued interest of management. Moreover, people in management must learn something about their own responsibilities. I find in my own practice here (U.S.) that management too often takes refuge in other problems as soon as they learn from the charts that they themselves must take some action to reduce the common causes. Management in Japan was different: they listened, learned, observed, and did something about common causes when they were indicated".**

This quotation sums up the action necessary to reap the benefits of statistical quality control. Most of the developing countries have advanced to the point where a vigorous programme of quality control, supported by industry, government, academic and other professional groups, will yield economic prosperity.

Standardisation, Certification and Quality Assurance

In Japan's rise in quality reputation, resulting in economic prosperity, one phase of Quality Control to be established was a programme of quality certification whereby licenses to use the JIS (Japan Industrial Standard) quality mark were issued to 10,919 factories (as of 31 March 1972).***In 1949 the Industrial Standardization Law was established. One of the key characteristics of this law was the certification labeling system (the JIS mark). By the law, through Statistical Quality Control audit, the Ministry of International Trade and Industry permitted manufacturers to put JIS certification marks on their products indicating conformance to Japanese standards. This programme, together with an extremely active programme of Quality Control education (outlined above), implementation and public promotion, is credited with giving Japan its major thrust in industrial and economic leadership.

Historically, in the earlier developed industrialized countries, national certification marks programmes proceeded (or are proceeding) from already mature standardization efforts.**** It took (or is taking) many years to achieve the overall benefits of standardization together with the implementation of standards through a certification programme. The developing countries, have an excellent opportunity to shorten the the period to achieve a significant degree of industrialization, of quality goods appreciated on the international and domestic market, by simultaneously developing their standardization, certification and quality control programmes.

Turning to Thailand as an example, The Thai Industrial Standards Institute (TISI) supported by the Industrial Products Standards Act of

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* See reference 5.
** Personal correspondence with the author. See also, reference 6.
*** See reference 7.
**** See reference 8.

1968 and the governing Standards Council has launched the standardization and certification programmes which can greatly assist the acceleration of quality industrialization. Of course, these programmes will need broad and active industry and government support if they are to achieve their potential.

One of the principle purposes of TISI's Certification Marks programme, in conjunction with its standardization efforts, is to encourage and assist the manufacture of quality products in Thailand -- a prelude to economic growth and stability. In this, TISI recognized the importance and need for manufacturers to establish and/or maintain an adequate programme of Quality Control and Assurance. In the preliminary investigation -- for initial grant of licence, as well as in the surveillance inspection and testing -- for continuance of licence, TISI will determine, "if the factory(ries) has(have) an adequate programme of control of production so as to assure continued conformity to the standard(s)".

In this, as in the sixth area on the control of quality above, reference is to an "assurance" function which may be defined generally as follows:

> QUALITY ASSURANCE IS A SYSTEM OF ACTIVITIES WHOSE PURPOSE IS TO PROVIDE AN ASSURANCE THAT THE OVER-ALL QUALITY CONTROL IS IN FACT BEING DONE EFFECTIVELY.

The system involves a continual survey of the adequacy and effectiveness of the quality control programme so as to correct it if necessary. For a specific product or service, this involves verification audits and the evaluation of the quality factors that affect the specification, production, and use of the product or service.

Quality Assurance has to do with making sure that Quality Control is doing what it should. Such an effort should be organized within a manufacturer's plant and motivated by the management.

In a somewhat broader scope than manufacturer's efforts, Certification by TISI as with other standards bodies or other agencies provides an independent, 3rd party form of Quality Assurance. In general, Certification is assurance by a competent organization, independent of trading interest, that goods are being manufactured in conformity with a standard. However, it is not a guarantee! The quality of manufactured product is primarily the responsibility of the producer. Since it is economically impractical to provide for 100% assurance, a system has to be devised, product by product, which will provide the desired assurance within practicable and economic limits. This can be achieved under a system of Quality Control and Assurance at the manufacturing plant, backed by regular inspections by an independent inspectorate and independently verified tests. TISI's Certification programme has the following objectives:

*Implementation of Industrial Standards with Their Many Production Benefits.

*Encouragement of Quality Manufacture, Exports and Imports.

*Protection of the Consumer from Misrepresentation of Product Quality.

*Protection of the Producer from Improper Competition.

*Reduction in the Multiplicity of Quality Certificates. (Which reduces sampling, testing, time, and costs)

*Assistance to the Producer's Advertisement and Marketing.

*Improving the quality of the Standards by locating errors and/or outmoded practices for feedback to technical committees or the Standards Council for revision of Standards.

Certification Marking Procedures (TISI)

To assist manufacturers in understanding the Certification Programme, the steps in making application, undergoing a pre-license factory inspection, receiving and maintaining the license and undergoing factory surveillance inspection, a number of procedures have been prepared. These are included as exhibits at the end of the paper to serve as examples for the development of similar programmes. They are as follows:

Exhibit A Certification Marking Procedures -- General (English)

Exhibit B Certification Marking Procedure/Scheme for Surveillance Inspection and Testing -- Sample.

Exhibit C Minimum Programme of Factory Surveillance Inspection -- Procedures.

Some Observations on Testing Programmes for Certification

The following observations based on TISI experiences are recorded here for information in the consideration of developing and implementing testing programmes for certification.

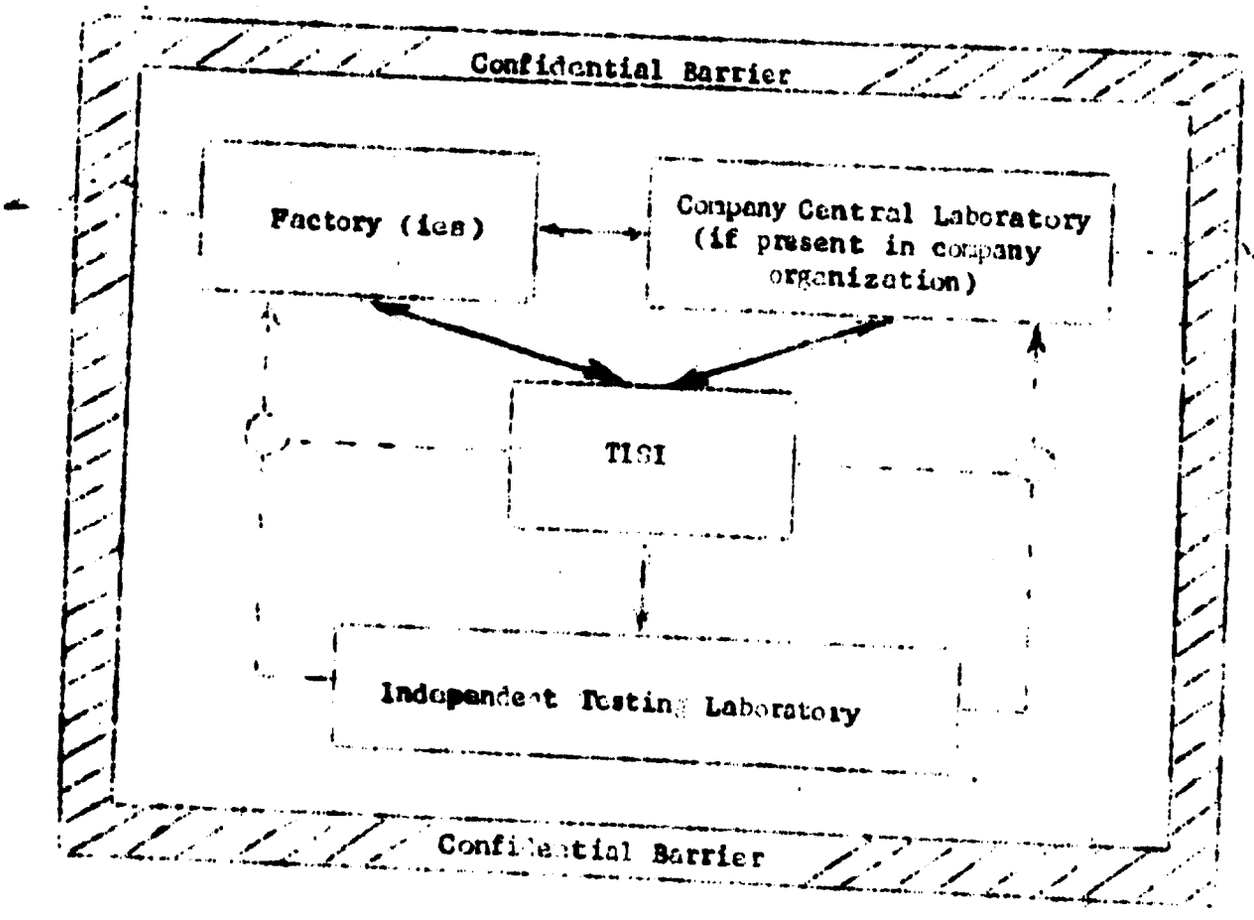
Implementation of the certification programme is dependent on accurate and competent tests of product quality characteristics at the factories and at the independent testing laboratories used by TISI to carry out tests on their samples. This is an extremely important part of the overall programme and requires a great deal of cooperation and attention by all parties concerned.

TISI is in the middle of the certification programme between the factory and the independent testing laboratory. Therefore, measurements supplied to TISI on the quality characteristics of the applicable standard must be as complete as possible. Average values or calculated quantities are generally not adequate.

TISI must have detailed test information as part of its overall evaluation of the quality (which includes variability as well as average value) of the manufactured product. This is especially important in the event of any discrepancies in measured values between the factory tests and the independent testing laboratory tests. It should not necessarily be considered unusual for some discrepancies to occur. There are many causes of differences in measurement, namely, different test equipment, different methods of calibration, different test methods, and even minor techniques of preparing and handling the test specimens. Possible errors in calculation and even in transcription from rough test notes to test notebooks can not be ignored.

Especially during the early stages of the certification programme, close cooperation in testing should be maintained between the factory, TISI, and the associated test laboratory. Each can learn from the other -- resulting in greater knowledge and understanding of the tests and more accuracy in test values. Test personnel from test laboratories might accompany the TISI certification team during the factory inspection visits to become more familiar with the factory procedures of testing.

Close cooperation involves an open sharing of test results, test methods, test equipment, etc. Confidentiality of testing needs to be understood. Tests are confidential only with respect to an unethical sharing of such results with a company's competitor, organizations, or persons using the results contrary to the interests of the factory under investigation. The following diagram illustrates the nature of the cooperation, communication and confidentiality of the testing programme.



The solid lines represent the main flow of communication between the parties. TISI deals directly with the factory(ies) and/or a central company laboratory (if such exists). TISI also deals directly with the independent testing laboratory engaged by TISI to carry out the tests and report the results.

The dashed lines inside the confidential barrier indicate the possibility of the independent testing laboratory dealing directly with the factory(ies) and/or the central company laboratory -- but only with knowledge and approval of TISI. Such contacts may be necessary to calibrate equipment, check methods of tests, calculations, etc. to achieve the greatest possible accuracy of results. These contacts may

also be necessary for carrying out the tests on company owned equipment, when not available elsewhere. In this respect, it is recognized that tests for one company's product may have to be carried out on equipment owned by another company (and probably a competitor) by personnel from the independent testing laboratory. In these cases extra care must be taken to guard the confidentiality of the results.

The dashed lines outside the confidential barrier represent the company's right to share the quality of their product with others as they may choose.

Some specific practical steps which should be implemented by the Certification Marking group in their preparation for submitting samples for test to a test laboratory are as follows:

1. The CM group should confer and agree on interpretation of the standard with respect to the necessary quality characteristics, preparation of the test specimens, test methods, etc. Technical and grammatical errors in the standard should be noted. (There are almost always some points of ambiguity or vagueness in the standard that need to be clarified.). They should list the items requiring clarification and the errors in the standard which will need to be communicated to the test laboratory when submitting the request and sample for test.

2. List the tests to be performed by the testing laboratory. Communicate any special instructions in the preparation of the test specimens and the conduct of the tests which are not covered in the standard. Special practices in carrying out the tests may be learned at the factory during the factory inspection by the TISI staff. Advance coordination with the independent test laboratory, which will carry out the tests for T I S I, will enable one of the testers to accompany the TISI team on the factory inspection to observe the test practices and methods. This is highly recommended for implementation on factory visits.

3. In conjunction with the tests listed in 2. above, list the measurements, test values, and computations from the measurements and test values that are to be reported by the test laboratory for each of the test specimens. In communicating requests for tests to the test laboratory, emphasis should be placed on the necessity for the individual test values and any supplementary measurements used in the tests. Direct and clear communication can be achieved on this item by designing a data sheet for the test results, sending this with the samples, with instructions for completion of the data sheet by the test laboratory.

4. Develop a programme of cooperation with the test laboratories to establish a closer and less formal communication between TISI and the labs on Certification testing. It must be understood by all that in the event of failures in the product, testing difficulties, etc., TISI certification staff will have to conduct further investigation into the nature of the failures, contact the factory with the information for their cooperation and action, draw additional samples, and resubmit these samples for testing. Defective test specimens must be

retained for inspection and evaluation in this investigation. The whole process of product evaluation will be made more effective and efficient if arrangements are made with the test laboratory to immediately notify TISI when product failures are found in testing.

For TISI, and its associated testing laboratories to be the certifier of manufactured quality for industrial firms desiring certification, it will be necessary to give assurance that the quality of the test and evaluation process is held high and subject to controls and improvements itself. In factory visits to date we have been met with an open atmosphere of cooperation and willingness to examine and improve, if necessary, the quality of products. In several instances quality improvements have been necessary and work on these has been fast and effective. This type of cooperation must be continued and extended to all organizations involved in the certification programme.

The testing programme associated with TISI certification will grow rapidly and to large proportions. In planning for this, it is feasible that Thailand should seriously consider the formation of a testing and calibration working committee consisting of top-level representatives from some of the main testing laboratories, from TISI and even from interested industries to map out a programme of users and coordination of testing facilities. In such planning, it may be recognized that certain laboratories concentrate on testing in certain major fields, eliminating the duplication of the very expensive testing apparatus, and raising to a high performance level, the tests within these major fields. Coordination of deliberate overlapping of tests for scheduling purposes can be planned. Coordination of calibration can also be planned. It is perhaps possible that the cooperative work of such a group may be more successful in obtaining equipment grants from the various sources.

This should have high priority in Thailand, as in other developing countries, and actively supported by industry and government leaders!

Certification -- Some Limitations

Certification, as carried out by a national standards body or similar agency, has been presented here as an adjunct to a broader programme of quality control and assurance. This deserves further emphasis. While statistical quality control is an essential part of a certification programme, we must be careful that we are not lulled into thinking that certification is quality control. As indicated earlier, in Thailand, as in other countries of the world, there needs to be a parallel programme to complement and supplement the Certification Marks Programme in motivating and achieving the manufacture of quality products at economical costs. There are at least two major reasons why application of quality control principles and techniques cannot be limited to a certification programme.

1. Certification (as carried out in most developing countries) itself is an adjunct to a national standardization programme. It is therefore limited to those products for which standards are prepared and published. SQC is not so limited. Standards preparation is often a relatively slow process. Then too, (even without the usual limited resources) standards cannot be prepared on all products simultaneously -- lower priority products are bound to be delayed. Furthermore, the application of statistical quality control to the manufacture of products,

before on during the preparation of national standards on those products, can improve the standard by an inherent improvement in the quality of the products.

2. Not all products (processes, procedures, etc.) for which standards are required are suitable for certification. Yet statistical methods may be employed to improve and/or control these products, processes, procedures, etc.

Quality Control Programmes in Developing Countries

Many papers have been written on quality control in developing countries.* All of them include, at least in part, the following recommendations for developing an effective quality control programme.

1. Establish strong national leadership and a national plan. This implies the formation of a group to spearhead the quality movement. This need not be a Q.C. Society, per se, but should be well organized, influential, and active. Develop a quality consciousness and concern for quality in key governmental, industrial, commercial, financial and academic leaders. This may be done by arranging for an internationally known expert to conduct a seminar for such leaders to emphasize the importance of quality in a developing economy -- perhaps using the success of another country. (Japan can serve as an excellent example).

2. Create government and commercial compulsion for reasonable levels of quality via quality requirements in purchase contracts, building specifications, standardization and certification, export inspection programmes, etc. Some quality requirements need enforcement from an organization or program with a broader perspective than the manufacturer himself or his immediate customer. (For example, the higher cost of electricity or even the cost of a fire from poor quality electrical cable is most often not borne by the manufacturer of the cable or by the construction contractor -- without some independent enforcement of such quality, they may be tempted to cut their individual costs by supplying a low grade cable). There are at least two levels of compulsion which may be created. One can be referred to as a "subtle compulsion" obtained by the politico-technical activity of convincing responsible authorities to specify or require quality in products and services. The other may be referred to as "hard core compulsion" obtained by the politico-technical-legal activity of decreeing by law that imported and/or manufactured products must conform to a given standard -- with associated liabilities.

3. Establish a media for exchange. Promote industrial applications. Hold seminars and publish transactions and journals in the local language. Develop training manuals, texts, standards, etc. in the local language. Develop study groups to study applications in other countries. Request and implement local projects funded by outside aid. Direct these projects in accordance

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* See, for example, reference 9.

with the national plan. Develop local practitioners, lecturers, teachers, etc. for more intensive training.

4. Establish an extensive programme of training. This can be organized and sponsored by the [illegible] society and/or other organizations such as management associations, industry associations, government departments, etc. especially for managers and practitioners. Academic institutions should be encouraged to develop courses for inclusion in key curricula. In-company training should be encouraged and assisted.

5. Establish and actively support and publicize a national standardization effort. The adjunct of a quality certification programme with a publicized and recognized quality mark backed up by a sound programme of initial factory inspections, product testing, surveillance inspections and testing, etc. is highly desirable. The development of a national capability in metrology and calibration is a necessary programme to support the certification efforts and industrialization in general.

6. Develop a programme to promote public awareness of quality, safety, etc. Public media such as radio, TV, newspapers, magazines and journals, even movies should be used in this effort. Consumer organizations for representing consumer groups in negotiating better quality from monopolies, informing the public, etc. should be established.

Summary

The modern concepts, methodologies, and techniques of quality and quality control have advanced to a great extent over the last thirty to forty years. Successful applications abound. Yet total recognition and implementation has the potential. Greater promotional and instructional efforts are needed in developing, as well as developed countries.

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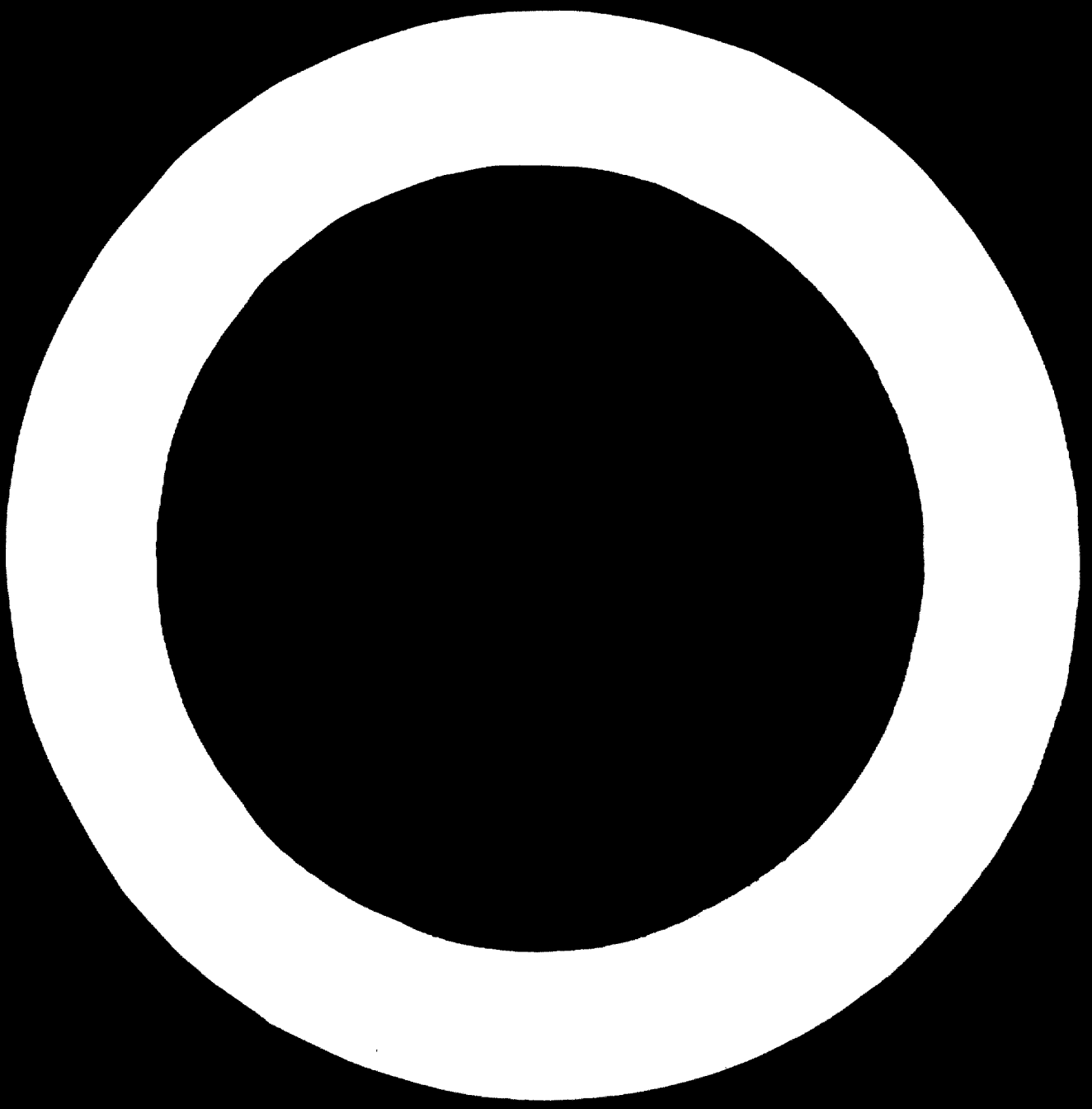


Exhibit A

Thai Industrial Standards Institute

Certification Marking Procedures ---- General

Certification by means of the TISI Standards Mark is regulated by the Industrial Product Standards Act, B.E. 2511, published in the Government Gazette, Vol. 85, part 121, dated 31st December, 2511 (1968), pp. 1023 - 1045. It is further regulated by Ministerial Regulations 1 - 4, B.E. 2515, published in the Government Gazette, Vol. 89, Part 55, dated 4th April, 2515 (1972), pp. 50 - 62. Other Ministerial Regulations and notices particularly those dealing with Inspection and Testing fees to carry out the certification programme, will be published in the Government Gazette. Royal Decrees with notifications of compulsory standards will be issued as the need demands.

Procedures ancilliary to and in clarification of the Act and Ministerial Regulations are presented here to assist interested parties in applying for - and receiving - a license to use the Standards Mark. Questions concerning this and other documents pertaining to the certification programme should be directed to the Certification Officer of TISI, Ministry of Industry, Rama VI Street, Telephone 815830. Copies of the IPS Act and Ministerial Regulations as published in the Government Gazette are available from the Royal Institute, Na Phrathatu Road and also from TISI. Copies of Product Standards, information pamphlets and this and other documents pertaining to standardization and certification are available from TISI.

I. Marking Application

1. Application forms are available from TISI, Ministry of Industry, Rama VI Street. The application fee is Bht. 5 (per Ministerial Regulation No. 3).

2. The completed application in triplicate and supporting materials per Ministerial Regulation No. 1 should be submitted to the Director of TISI, Ministry of Industry, Rama VI Street. The fourth (yellow) copy should be retained by the applicant.

3. A preliminary inspection fee (to be published in the Government Gazette) shall be paid as required by TISI. This fee will cover the product testing necessary to determine conformity to the appropriate product standard(s) for initial granting of license. TISI may instruct the company to pay this fee directly to one or more testing laboratories which have carried out the testing.

4. Applications for a substitute license (IPS Act. Section 23), moving of establishment (IPS Act, Section 24), and/or transfer of license (IPS Act, Section 25) shall be made in accordance with the indicated sections of the Act using the application forms which will be published in the Government Gazette and made available from TISI.

5. Applications for addition of new varieties, inclusion of other factories, compliance with an amended standard (IPS Act, Section 27 - 2), etc. shall be dealt with in the same manner as an original application.

II. Preliminary Investigation - To Evaluate Initial Grant of Licence

1. Applications received will first be examined for completeness by the TISI Certification Officer and rectified where necessary.

2. Arrangements for a visit to the factory(ies) by a TISI competent official(s) will be made shortly after receipt of the completed application.

3. The factory visit(s) will be directed toward determining if the current production is in conformity with the applicable standard(s) as well as determining if the factory(ies) has an adequate programme of control of production so as to assure continued conformity to the standard(s) This determination will be made by a review of the overall manufacturing process, inspection and checking points (including equipment, its use and maintenance, adequate well kept records, etc.) and the programme of quality control. In addition, a sample of completed product and/or materials as specified in the standard will be drawn by the TISI official for independent testing of the quality characteristics specified in the standard(s). This testing will be conducted in an authorized laboratory, e.g. the Department of Science. It is recognized, that in some cases certain tests may be carried out using factory equipment observed by TISI or authorized laboratory official(s).

4. The results of the factory visit(s) and the tests on the product sample(s) will be carefully studied by the TISI Certification staff for preparation of a report to the Standards Council.

   (a) If the results are satisfactory, a report together with a recommendation for granting of license will be submitted to the Standards Council.

   (b) If unsatisfactory (excessive failure of sample units, inadequate inspection equipment, inadequate programme of quality control to assure continued conformity to standard(s), etc.), the TISI certification staff will prepare a recommendation of improvements needed for the [illegible] certification. This recommendation will be submitted to the applicant with a copy to the Standards Council.

   (c) The TISI official(s) will revisit the factory(ies) upon notification of corrections or, where desirable and possible, to assist in implementing the recommendations. Upon satisfactory evidence of corrections, a report together with a recommendation for granting of license will be submitted to the Standards Council.

   (d) If after a reasonable period of time (not to exceed six months), no or unsatisfactory action is taken on the recommendations of improvements, a report together with a recommendation for turning down the application for license (IPS Act, Section 26) will be submitted to the Standards Council. The application fee and preliminary inspection fee are forefeited by the applicant.

III. Grant of License and Surveillance

1. Upon approval of his application, the applicant will be so informed by the Director of TISI.

2. The applicant will also receive from TISI the Scheme for Surveillance Inspection and Testing for his product(s). This document will contain the specific procedures to be followed by the applicant and TISI in its continual audit of the applicant's conformity to the Standard(s). It will include periodic factory visits, as well as samples for testing drawn from the factory and from the market, or in transit from the factory to market.

3. A license to use the Standards Mark on the designated product will be issued to the applicant upon receipt of the license fee (500 Bht. per Ministerial Regulation No. 3) and evidence of payment of the preliminary inspection fee as directed by TISI. Subsequently, fees for surveillance inspection and testing, as they are incurred, will be billed to the company for payment. These inspection fees, on a product unit basis, will be published in the Government Gazette. To permit fiscal company planning, TISI will establish and publish a maximum fee, not to be exceeded on an annual basis.

4. The licensee then prepares the TISI Standards Mark for marking his product according to Ministerial Regulation No. 2.

5. Information obtained by TISI during its preliminary investigation and surveillance is treated as confidential.

IV. Loss of License and Penalties for Mis-Use

1. Conditions under which a license expires, is suspended, or is revoked are described in the IPS Act, particularly Sections 27, 37, 39, 40, 41, 42, and 43.

2. Penalties for mis-use of the license and Standards Mark are also described in the IPS Act, particularly Sections 44(2), 46, and 48 thru 57.

Exhibit B

SAMPLE

Thai Industrial Standards Institute
Certification Marking Procedure
Scheme for Surveillance Inspection and Testing
XYZ Company, Ltd.

1. This procedure applies to TISI's certification of (name of product), manufactured by the XYZ Company's (location of factory), factory in conformity with the Standard TIS (number of TISI standard). License to use the Standards Mark was approved by the Standards Council on ... (date of approval) .... following a satisfactory preliminary investigation of the factory by TISI.

   1.1 Certification by means of the TISI Standards Mark is regulated by the Industrial Product Standards Act, B.E. 2511. It is further regulated by Ministerial Regulations 1 thru 4, B.E. 2515 and future Regulations.

   1.2 This procedure regulates the continuance of certification including surveillance inspection and testing and thus supplements the Standard and other related documents.

2. The factory laboratory, where the tests are carried out, shall be maintained, equipped, and staffed in at least its present approved condition in order to continue to determine the products conformity to the Standard.

   2.1 Records of tests shall be kept on suitable forms as attached.

   2.2 Copies of any test records or charts that may be required by TISI shall be made available at any time on request. Information obtained by TISI will be treated as confidential.

3. (In this and its sub-paragraphs a detailed programme of final product testing to be carried out by the manufacturer is outlined. The tests included are designed to verify that the final product meets the requirements of the standard. Each company and factory is considered separately in developing the programme of tests).

4. It is recommended that, as far as possible, statistical quality control (SQC) methods shall be used for controlling the quality during production. These same methods may result in reduced costs and increased through - put of production.

   (In the associated sub-paragraphs a detailed programme of in-process controls to be carried out by the manufacturer is outlined. The specified controls are designed to assure that the products are consistently made to meet the requirements of the standard. In many instances these process controls will be those already carried out by the manufacturer, prior to certification. Otherwise additional or alternative procedures will be specified with emphasis on defect prevention, and thus cost reduction and increased good production, and improved quality).

5. The TISI Standards Mark shall be printed on each (unit of product) as per Ministerial Regulation No. 2 B.E. 2515, provided always that the product conforms to the requirements of the Standard.

   (In the associated sub-paragraphs additional marking requirements as set forth in the standard are specified. An approved marking layout incorporating the TISI mark is often included).

6. A separate record shall be maintained giving information relating to the rejection of production lots which do not conform to one or more specifications of the Standard. The disposition, action taken, and/or method of disposal of this product shall be indicated clearly. Tests as required by the Standard, shall be completed so as to make it possible to take corrective action on non-conforming product prior to its marking with the Standards Mark.

7. If at any time, there is some difficulty in maintaining the conformity of the product to the specifications, or the test equipment goes out of order, or if advised to do so by TISI, the marking of the product shall be ceased. The marking may be resumed as soon as the defects are removed or when TISI advises to do so. The information regarding resumption of marking shall also be sent to TISI.

8. The licensee shall supply, free of charge, from his factory or go downs the samples required by TISI for its certification surveillance. (Provision for samples taken from the open market will also be specified).

9. The licensee shall send to TISI a statement of quantity produced, marked and exported by him and the trade value thereof during the half year ending .... and ..... This statement is required to be forwarded to TISI on or before the ..... and ..... for the preceding half year.

10. TISI's surveillance inspection and testing will include periodic factory visits, as well as samples for testing drawn from the factory and from the market, or in transit from the factory to the market. Testing expenses, as they are incurred, shall be paid by the company. To permit fiscal company planing, the maximum expenses under normal quality are not expected to exceed ... . Excellent quality performance, as demonstrated on subsequent audits, will reduce the inspection frequency and ensure an expense considerably lower than the expected maximum.

Exhibit C

Thai Industrial Standards Institute

Minimum Programme of Factory Surveillance Inspection Procedures

The following is designed to supplement the Certification Programme Procedures -- especially with regard to Surveillance Inspections.

Upon issuance of a license to use the Quality Mark, after a successful preliminary factory inspection and product tests, the certification programme calls for periodic surveillance inspections of factories including sampling and testing of finished product. This is designed to provide a continuous motivation to the manufacturer to produce a quality product in conformance to the applicable Thai Standard.

Each surveillance inspection, based on the findings of the last previous inspection and/or pre-license inspections, can be made very efficient in time and effort. It need not be as thorough as the pre-license inspections. However, for effectiveness of the certification programme, surveillance inspections should include the following minimum programme which can serve as a guide to certification officials and factory personnel.

1. Review the process control section of the surveillance inspection scheme with responsible factory personnel for their conformance to the programme of process control. Review process control records to observe if tests are being made at the agreed upon frequency and if the product or subproducts are meeting prescribed specifications. Note any discrepancies or alternative procedures adopted since the last inspection (including pre-license investigation). If necessary, observe the process for execution of the process controls.

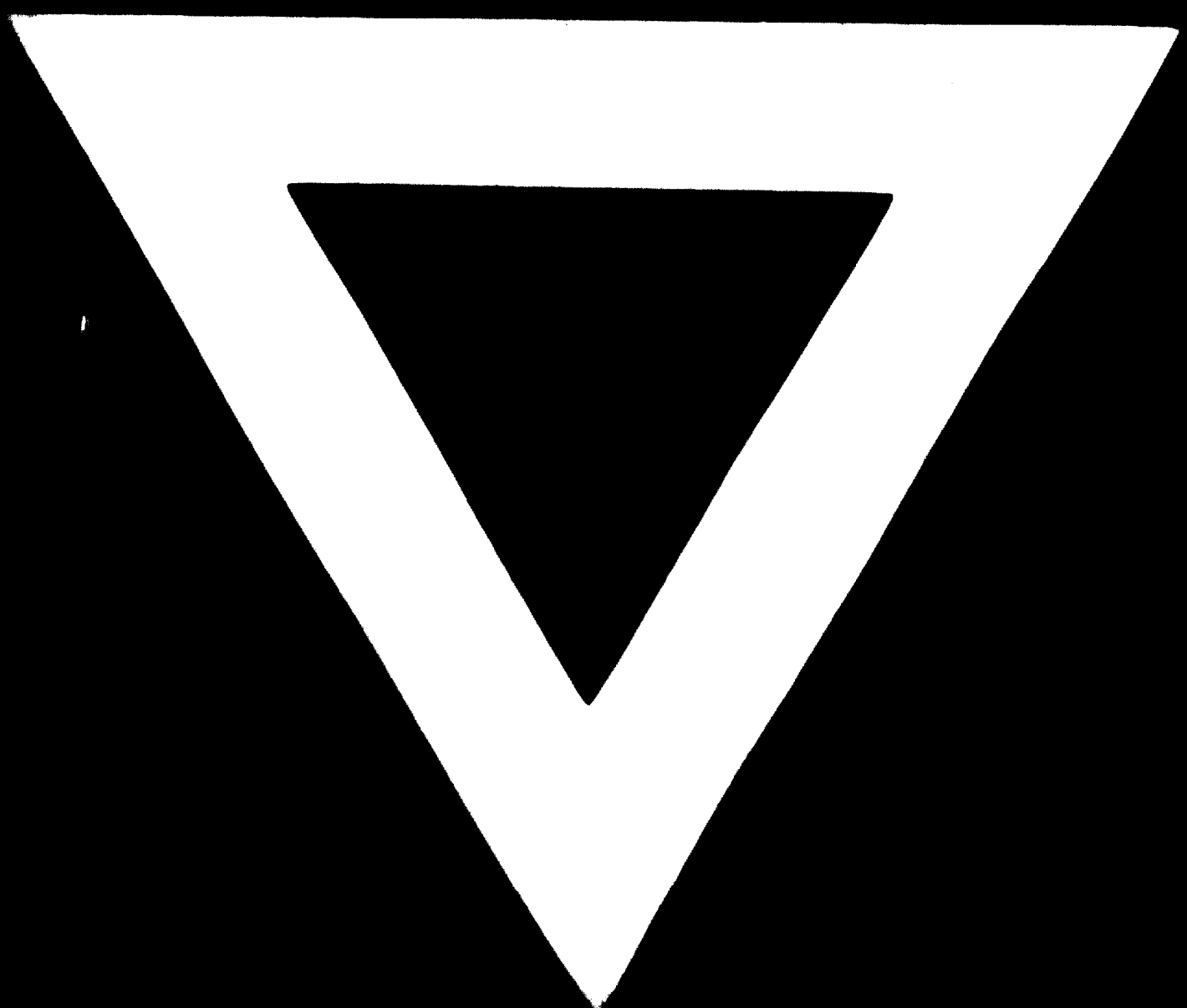
2. Review the finished product section of the surveillance inspection scheme with responsible factory personnel. Look for conformance to this programme and review factory testing records at least covering the time period from the present back to the last inspection visit. Note if final product has been meeting the requirements of the Standard. Particularly note periods of non-conformance and actions taken to control substandard product.

3. Review the marking of the final product in accordance with the marking section of the surveillance inspection scheme. Note any discrepancies or modifications.

4. Obtain a sample of the finished product representative of current production over at least several hours (or days) of production by sampling, if possible, finished product being produced during the visit as well as final product in the factory's immediate go-downs. This may require recognition of a factory's production pattern and scheduling of the surveillance visit (but still unknown to the factory) to include periods of production.

5. Review overall results of surveillance inspection visit with TISI certification officer and arrange for testing of the finished product sample. Analyse test results (observe tests if necessary) and note approval or prepare recommendations for improvements. Communicate findings with responsible factory personnel.

6. Maintain an up-to-date file on each license, containing materials from the pre-license inspections, the surveillance inspection and other materials which will be helpful in carrying out subsequent inspections.



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