

Quality Improvement Manual for Mechanical Equipment in Petroleum, Chemical, and Gas Industries

API RECOMMENDED PRACTICE 683
FIRST EDITION, SEPTEMBER 1993

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005



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Manufacturing, Distribution and Marketing Department

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FOREWORD

This recommended practice is based on the accumulated knowledge and experience of suppliers, contractors, and users of mechanical equipment. The objective of this recommended practice is to facilitate the manufacture and procurement of mechanical equipment for petroleum, chemical, and gas industry service.

The use of this recommended practice in no way is intended to conflict with, supplement, or replace (where applicable) API Spec Q1, *Specification for Quality Programs*, which is concerned with standardization programs.

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Suggested revisions are invited and should be submitted to the director of the Manufacturing, Distribution and Marketing Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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Quality Improvement Manual for Mechanical Equipment in Petroleum, Chemical, and Gas Industries

SECTION 1—GENERAL

1.1 Scope

This recommended practice provides guidelines for improving the quality of mechanical equipment. It is intended to mutually benefit users, contractors, and suppliers and facilitate improved relationships between them by promoting trust, teamwork, and communication. It is not intended to determine certification to or compliance with a particular quality system specification.

A three-part approach for improving the quality of mechanical equipment is described in this recommended practice, consisting of (a) the traditional methods used to help assure quality; (b) techniques that can be used to identify those suppliers who have quality systems so effective that intense user involvement is unnecessary; and (c) suggestions on how users, contractors, and suppliers can work together to improve quality.

Section 2 describes methods by which users prequalify suppliers, prepare comprehensive specifications, conduct communication meetings, audit designs, institute manufacturing quality surveillance, sponsor intensive factory testing, and conduct equipment inspections at the site prior to start-up.

Section 3 (along with Appendix A) contains guidelines for evaluating the type of quality system and effectiveness of the quality system used by a supplier. Emphasis is placed on the commitment of management to the quality system, the structure of the system, relationships with sub-suppliers, training, evidence of continuous quality improvement throughout the organization, and the supplier's performance on recent projects.

Section 4 addresses ways that users, contractors, and suppliers can all work together to improve their quality systems. It includes such topics as uniformity and joint development of equipment requirements, risk sharing, communication, training, and constructive feedback. Users are encouraged to reduce the use of lengthy supplemental specifications and rely more on API standards and data sheets.

This recommended practice is complementary to the referenced standards, but it goes beyond them to address the development and evaluation of systems incorporating continuous quality improvement. This recommended practice is specifically applicable to the mechanical equipment industry.

1.2 Definition of Terms

Some of the terms used in this recommended practice require clarification. The definitions found below will assist

the reader in understanding the contextual meaning of some terms used throughout this recommended practice.

1.2.1 No attempt will be made in this recommended practice to create an original definition of quality. *Quality* may be thought of in terms of a traditional definition accompanied by clarifying statements.

Quality has traditionally been defined with phrases like "fitness for use" (by customers) and "conformance to customer requirements" (by suppliers). Clarifying statements include the following:

- Quality* is understanding who the customer is and what the customer requirements are and meeting those requirements without error, on time, every time.
- Quality* is performance leadership in meeting customer requirements by doing the right things right the first time.
- Quality* is defined by customers; customers want products and services that, throughout their lives, meet customer's needs and expectations at a cost that represents value.
- Quality* is meeting the needs, desires, and expectations of our customers.

1.2.2 A *Quality System* is the combination of activities, procedures, processes, resources, and organizational structure devoted to controlling, assuring, and/or improving the quality of products or services. The quality systems employed by users, contractors, and suppliers may incorporate any or all of the following elements:

- Quality control* denotes the measurement, checking, or testing required to verify and document conformance to a prescribed set of requirements or standards.
- Quality assurance* includes the process and procedures necessary to continually monitor the methods used to control quality and their results to make certain that the methods do, in fact, accurately and correctly verify conformance to requirements.
- Quality improvement* refers to the processes, procedures, and organization devoted to the continuous improvement of quality to all levels and in all functions of an organization.

1.2.3 A *Total Quality System*, in the context of this recommended practice, is defined as a quality system in which all three of the key elements described in 1.2.2 are present. It involves everyone in all functions of an organization and is dedicated to control, assurance, and improvement in quality.

1.2.4 The *user* is the ultimate purchaser and operator of mechanical equipment. It is the user's requirements and expectations for the suitability and reliability of mechanical equipment and related services that contractors and suppliers are dedicated to meet.

1.2.5 The *contractor* provides engineering, procurement, and/or construction services to users. The contractor often acts as an intermediary between user and supplier and is responsible for specifying, purchasing, and installing mechanical equipment.

1.2.6 *Supplier*, in the context of this recommended practice, refers to a manufacturer of mechanical equipment and/or sub-suppliers of equipment components and assemblies.

1.3 How to Use This Recommended Practice

This recommended practice has been structured to assist users and contractors in identifying potential suppliers, evaluating their quality systems, and adopting the most appropriate approach to working together. In 2.2, considerations are outlined that identify a supplier's capability to furnish the equipment required for the intended service or services. Section 3 and Appendix A provide a list of major elements for assessing what kind of quality system a supplier has and how effective it is. This evaluation will enable the user or contractor to determine how best to work with the supplier [for example, by using traditional methods (Section 2) or minimizing user or contractor involvement]. The evaluation material in Section 3 and Appendix A is intended to be used primarily by those experienced with mechanical equipment and familiar with quality systems. Section 4 provides recommendations to help the user, contractor, and supplier move their relationship toward increased reliance on the supplier's internal quality system or systems and continuous quality improvement. Figure 1 is a diagram of the approach to using this recommended practice.

1.4 Referenced Publications

The following standards, codes, and specifications are cited in this recommended practice.

API

Std 617 *Centrifugal Compressors for General Refinery Service*

ASME¹

Boiler & Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"

ISO²

- 9000 *Quality Management and Quality Assurance Standards—Guidelines for Selection and Use* (ANSI/ASQC⁴ Q90)
- 9001 *Quality Systems—Model for Quality Assurance in Design/Development, Production, Installation, and Servicing* (ANSI/ASQC Q91)
- 9002 *Quality Systems—Model for Quality Assurance in Production and Installation* (ANSI/ASQC Q92)
- 9003 *Quality Systems—Model for Quality Assurance in Final Inspection and Test* (ANSI/ASQC Q93)
- 9004 *Quality Management and Quality System Elements—Guidelines* (ANSI/ASQC Q94)

*Malcolm Baldrige National Quality Award Application Guidelines—1991*⁵

MIL⁶

MIL-I 45208A *Inspection System Requirements*

This recommended practice is compatible with the referenced documents and should be used to develop and enhance the concept and practice of continuous quality improvement. It is not intended to substitute for, or compete with, the referenced quality documents.

The ISO 9000 (ANSI/ASQC Q90) series of standards is generic in nature, intended for use with appropriate industry-specific quality assurance standards. This recommended practice is intended to complement the referenced publications to help build a strong foundation for quality systems specific to the mechanical equipment industry.

1.5 Continuous Improvement of This Recommended Practice

Constructive feedback is necessary for the continuous improvement of this recommended practice. Readers are encouraged to use the form in Appendix C, which may be forwarded to the director of the Manufacturing, Distribution and Marketing Department of API.

¹American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

²International Organization for Standardization. ISO publications can be obtained from the American National Standards Institute.

³American National Standards Institute, 11 West 42nd Street, New York, New York 10036.

⁴American Society for Quality Control, P.O. Box 3005, 611 East Wisconsin Ave., Milwaukee, WI 53201-3005.

⁵Malcolm Baldrige National Quality Award. United States Department of Commerce, National Institute of Standards and Technology, Gaithersburg, MD 20899.

⁶Department of Defense. Obtain from Commanding Officer, Naval Publications Forms Center, Attn: NPFC 105, 5801 Tabor Avenue, Philadelphia, PA 19120.



Documents

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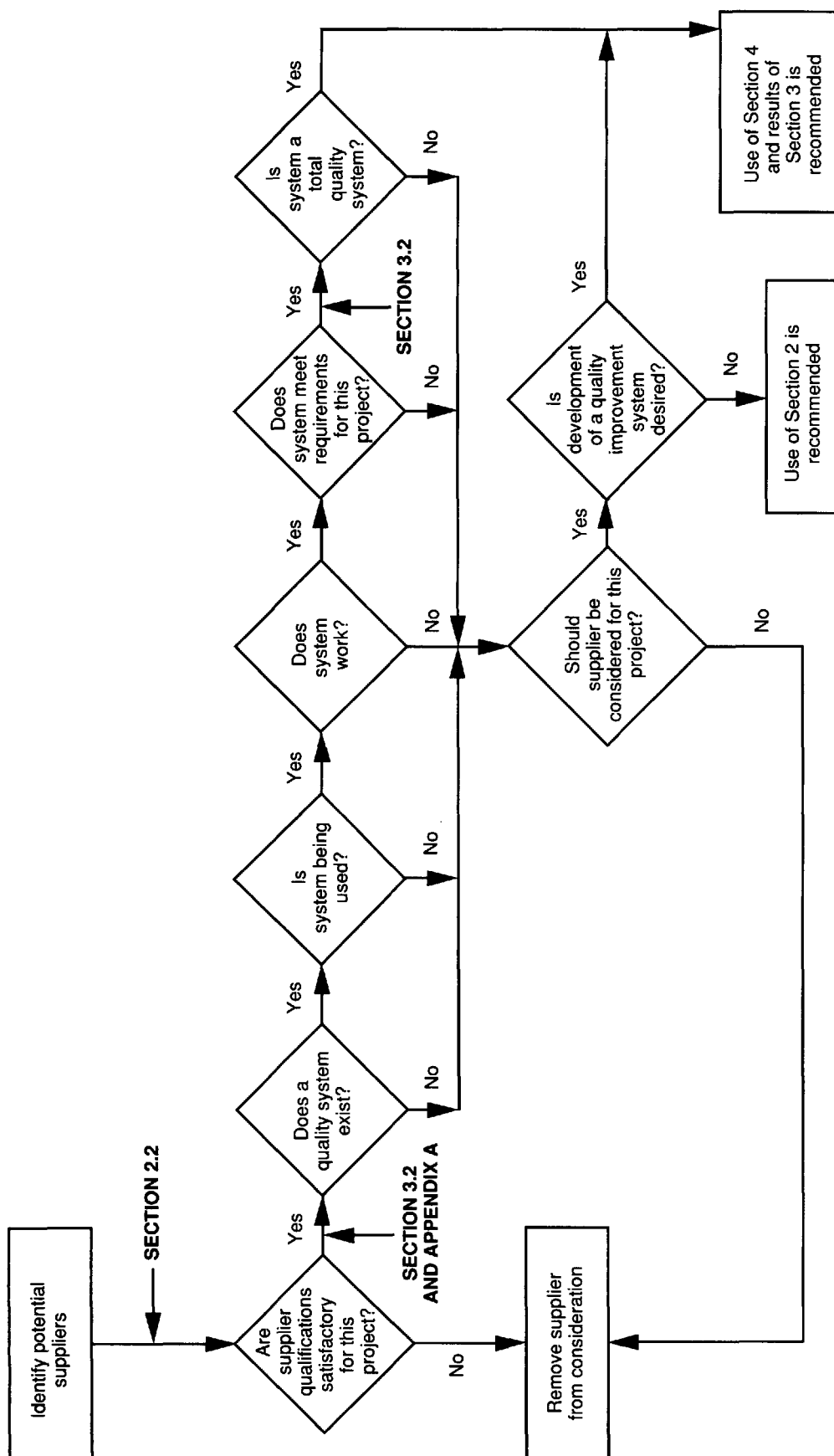


Figure 1—How to Use This Recommended Practice

SECTION 2—TRADITIONAL METHODS TO ASSURE QUALITY

2.1 General

2.1.1 The traditional approach, that is, the use of detailed specifications and monitoring by inspection, may be chosen for many reasons. The purchaser or user may not want to relinquish methods that have been successful. The purchaser or user may not have the time to audit a supplier's quality system or may have audited the system and deemed it to be inadequate. The purchaser or user may have reviewed a supplier's quality system and found it to be adequate but may want to oversee a test of the system to be sure that it works for the contract in question.

2.1.2 With the traditional approach, the need for proper communication cannot be overemphasized. There are several layers within a user's organization, a contractor's organization, and the supplier's and subsupplier's organizations that are involved from the conception of the requirements to the completion of the specified product, its installation, and its implementation. The organizations involved in each activity must be informed of, adhere to, and produce the intent of the specification.

2.1.3 The following are broad categories of major areas that must be addressed when the traditional approach is used and must be considered for the transition approach as well. Although all these areas may not pertain to everyone involved in a project, several of them are involved with everyone's scope of a project.

- a. Supplier qualifications.
- b. Comprehensive specifications.
- c. Communication meetings.
- d. Design audits.
- e. Manufacturing quality surveillance.
- f. Factory testing.
- g. Field inspection prior to start-up.

2.2 Supplier Qualifications

2.2.1 APPROVED BIDDERS LIST

The most commonly used method for assuring that quality equipment will be purchased—whether for an entire plant, an expansion of facilities, or the revamping of existing facilities—starts with an approved bidders list. This list may be an existing list provided by the user and based on the user's own experiences and preferences; it might be one that the contractor has used successfully; or it could be one that is jointly developed by both user and contractor as the equipment required becomes better defined. The list may be suitable for worldwide competition or because of user

preferences or project financing, be limited to one or more specific source countries, depending on the equipment involved and its availability throughout the world.

In the final configuration of the approved bidders list, when it is ready to be used for a specific inquiry, the bidders list should contain only names of acceptable, qualified suppliers. It need not contain the names of *all* suppliers of quality equipment, because any one of several commercial considerations could disallow bidding by an otherwise qualified supplier. The list should not, however, contain the name of any unqualified supplier.

2.2.2 SOURCES FOR EVALUATING SUPPLIER QUALIFICATIONS

A number of sources are available to both users and contractors for evaluating the qualifications of both suppliers and subsuppliers and for determining which of these will be placed on a particular approved bidders list. The most useful of these available sources are experience, supplier reference lists of operating installations, and feedback from the suppliers regarding their own experiences with subsuppliers.

2.2.2.1 Experience

Experience is the most useful basis upon which either a user or a contractor will decide whether a particular supplier is qualified for placement on a list of approved bidders. It is important that the experience upon which judgement is made be recent experience, preferably gathered within the past 3 to 5 years and, if possible, for the life of the equipment from its initial start-up to its present condition. The term *recent* is used here because equipment is designed, produced, tested, delivered, installed, and operated by people, not by corporations. In an era when corporate changes are common, it is important to know the effects of such changes on product quality. It is possible for a corporation to change its name and its organization while maintaining the same people and product quality level it has had for years. It is equally possible for a corporation whose name has been unchanged for generations to have undergone drastic changes in both personnel and product quality.

Experience may be either first-hand, based on equipment that the user or contractor purchased and is now operating, or acquired via contact with other users and contractors. In either case, the evaluation of that experience ought to be as objective as possible. If the experience is other than first-hand, contacts should be with people that have been directly responsible for the start up, operation, and maintenance of the equipment and if time permits, with others who may have participated in the original specification and shop testing of the equipment.



2.2.2.2 Suppliers' Reference Lists

2.2.2.2.1 Advantages

The supplier's own reference lists are another useful source of information available to both users and contractors when evaluating a supplier's qualifications. The amount of detail on such lists varies widely. Some lists are fairly comprehensive; others are almost worthless. Most, however, provide sufficient information to enable a user to proceed with the qualification process. The supplier should be asked to provide any missing information needed for a proper evaluation. Dates are very important. Installation and start-up dates are more important than shipping dates or order entry dates, but the latter may be the only ones for which the supplier has any first-hand information. Installation lists should contain the names of both users and contractors to facilitate contact with either. Most lists also provide model designations or frame sizes as well as some detail on the operating parameters of the equipment.

By itself, a reference list cannot usually provide clear evidence of a supplier's qualifications. Actual operating conditions may be significantly different from those originally specified. Follow-up contacts with users and contractors familiar with the referenced installations are normally required. On the other hand, a reference list can provide sufficient evidence regarding lack of current experience to justify exclusion of a particular supplier from an approved bidders list. The source of the referenced equipment is equally important. Many of today's suppliers have licensees or joint venture companies in foreign countries. Careful consideration must be given before the experience of one source is credited to any of the others.

As with the user's own experience, it is important that pertinent entries on a supplier's reference list also be sufficiently current if they are to be considered as evidence of a supplier's present-day qualifications.

2.2.2.2.2 Reference List Limitations

A supplier's reference list cannot demonstrate to the user or contractor the supplier's success rate in designing and building equipment for operating conditions well beyond those with which the supplier has had experience. Some suppliers have invariably done better than others in this regard, and the user or contractor, as part of his own risk management techniques, must find ways to evaluate this measure of success. Lacking any first-hand experience, the user or contractor can contact other users or contractors for this type of feedback: the more such feedback is positive, the more willing a user might be to assume some of the risks involved. Some extremely well-qualified suppliers have had fewer start-up and operational problems with prototype equipment than other less-qualified suppliers have had with "near-duplicate" equipment.

2.2.2.3 Supplier Feedback

Major equipment packages for process plant installation often contain a considerable amount of both raw materials and finished products that the primary supplier does not produce but purchases directly from subsuppliers. It is quite common for users and contractors to limit the source of much of this content, thereby assuring themselves that their own minimum quality levels are being maintained in certain areas. This is normally done by including, as part of the equipment specifications, lists of acceptable subsuppliers. These lists may cover such commodities as instruments, motors, bearings, and seals. In general, the lists do not cover sources for unfinished materials, such as castings and forgings, nor certain nonmetallic materials. For these items the principal source of information regarding quality is feedback from the primary supplier. Although a supplier may not be in a position to identify specific sources before a purchase commitment is made, it should be possible to obtain a listing of several probable sources for each major subsupplier purchase that would be required for the equipment involved. Such lists are rarely produced by a user or contractor, but to the suppliers they are the equivalent of a user's approved bidders list.

2.2.3 TECHNICAL ASPECTS

Beyond a supplier's proven ability to manufacture and deliver a quality product, there are a number of technical and commercial requirements that both the user and the contractor should see satisfied as part of their supplier qualification efforts. It should be noted that the user and contractor have a great many objectives in common, but they do have slightly different agendas and the supplier is expected to accommodate both. The user and contractor both are interested in the supplier's design tools, the supplier's in-house inspection and testing capabilities, and the field performance of the equipment produced. Both wish to see the equipment delivered and installed on time and within budget. In the engineering phase, while both are interested in scope of supply and compliance with specifications, the contractor normally takes a deeper interest in the scheduling and quality of the supplier's preliminary and certified drawings, particularly those affecting the progress of the contractor's civil, piping, electrical, and instrument design work. In the erection and start-up phase, while both may be interested in the completeness of installation and operating sections in the supplier's instruction manual, the user is more interested in those sections covering such topics as maintenance, special tools, and spare parts.

2.2.3.1 Compliance with Specifications

Both users and contractors often will judge a supplier's qualifications by the supplier's comments and exceptions to



the applicable specifications. Comments may be nothing more than correct interpretations of the specifications, in which case the comments may be readily acknowledged. Comments by the supplier that are incorrect interpretations of the specifications require clarification, after which the comments may or may not be noted as exceptions. Exceptions to the specifications fall into three broad categories: (a) those taken of necessity because a supplier's basic design differs from that specified, (b) those taken because the specification violates some mandatory code or safety regulation, and (c) those taken for purely economic and competitive reasons. Item a usually requires a decision by the user regarding whether or not the particular design difference is acceptable. Item b normally requires that the specification be rewritten to eliminate the conflict. Item c simply makes it more difficult to evaluate competing proposals and raises questions about the supplier's overall qualifications. A preferred approach to Item c would have the supplier include the cost of compliance in the proposal and offer a comment on the savings and effects on quality of the alternate offering.

2.2.3.2 Design and Analysis Capabilities

Users and contractors alike expect that every supplier on their approved bidders list will have the in-house capability to design and produce the equipment they propose. This would include not only the technical and engineering design talent required but also the state-of-the-art analytical tools and software necessary for meeting today's demand for shorter schedules and sophisticated designs of components, assemblies, and systems. This requirement (that is, in-house capability) is particularly important when the equipment required by new process technology has not been built before and some of the risks associated with unproven equipment can no longer be avoided.

2.2.3.3 Machine Tools and Plant Layout

Physical plant equipment and its layout are commanding more of the users' and contractors' attention. Electronic numerical controls on properly maintained machine tools can substantially eliminate or at least reduce human error in the machining of equipment components. Modern plant layout complements these advanced machining techniques by facilitating such innovative practices as the manufacturing cell concept and just-in-time inventory control. These concepts are usually not addressed in any user or contractor specification or standard but are reviewed in most current shop surveys.

2.2.3.4 Inspection and Test Facilities

Until all acceptable bidders are fully committed to the quality management process, both users and contractors will continue to review and rate their suppliers' inspection and

test facilities. Shop inspection and shop testing, whether mandatory or optional, are primarily the suppliers' responsibility. Nevertheless, both users and contractors continue to find it necessary to periodically visit suppliers' shops to review documentation and to observe or witness certain parts of the test procedures as they are performed. The extent to which such surveillance is found necessary is often inversely proportional to the extent to which the supplier involved has implemented a total quality process.

2.2.3.5 Field Service

Perhaps no other facet of a supplier's overall operations can do more than the supplier's field service organization either to damage or to enhance the supplier's reputation in the eyes of the user. Ideally, a supplier should have extremely qualified field service personnel, conveniently located service facilities, and a minimum number of service calls that bear directly on equipment quality. The size of a supplier's service department depends on the nature of the equipment involved. Suppliers who furnish large, complex equipment packages often are required to have qualified field personnel available for routine erection and start-up services as well as for the training of customer personnel in the operation and maintenance of such equipment.

A quality service organization stays in touch with its customers, keeping them informed of design improvements and any recall for hidden defects that might compromise safety.

2.2.3.6 Spare Parts

The contractor's involvement with equipment spare parts normally involves capital spares only, such as spare rotors for major compressors or steam turbines or spare tube bundles for critical unspared exchangers. On certain projects, the contractor may be responsible for commissioning or start-up spares. Rarely, the contractor may be required to purchase spare parts for the first year or two of operation. Lead times for the manufacture of spare parts is seldom a problem. The user, however, is concerned about the availability of spare parts throughout the life of the equipment, especially their availability in an emergency. For this reason and for the reasons stated in 2.2.3.5, the user's rating of a supplier's qualifications will place more emphasis on spare parts and field service than will the contractor's rating of the same supplier's qualifications.

2.2.4 COMMERCIAL ASPECTS

Although the commercial aspects of a supplier's qualifications may not appear to be as critical as the technical ones covered in the preceding paragraphs, certain commercial aspects are extremely important to both user and contractor.



2.2.4.1 On-Time Delivery

Most qualified suppliers make an honest effort to quote realistic lead times for the delivery of their equipment and specified software; some, however, fail repeatedly to meet these commitments. Technically, their equipment may meet the most stringent requirements in terms of design, performance, reliability, and efficiency, but it seldom ships on time. On some projects this may pose no problem; on others it could be catastrophic. To qualify such a supplier, the user or contractor might consider automatically increasing the quoted lead time by some appropriate amount. If this is done, the supplier should be notified so that he may take corrective action on future proposals. Liquidated damages are sometimes used to remedy this problem but are seldom sufficiently punitive and tend to foster an adversarial relationship between user and supplier. The same situation described above can arise and the same remedial action can be taken regarding lead times for the submittal of drawings and other software required by either the user or the contractor.

It is important to remember that in evaluating any supplier's on-time delivery record, care must be taken to distinguish between delays caused by the supplier and those caused by the user or contractor. The former usually occur when the supplier fails to properly schedule his own engineering, procurement, and manufacturing operations or fails to properly oversee the quality and scheduling of the major subsuppliers. The latter normally occur if the user or contractor delays commitment well beyond the time slots anticipated by the supplier, makes significant changes in design or scope long after commitment, or fails to approve or comment on a supplier's drawings and data on a timely basis.

2.2.4.2 Terms and Conditions

Since users, contractors, and suppliers all have their own preferred terms and conditions for governing purchase orders, it is often necessary to compromise. For users and contractors wishing to qualify specific suppliers, the best approach is to develop overriding agreements well in advance of any particular project or purchase order. In the course of reviewing a supplier's terms and conditions, it is recommended that the supplier's financial status be checked via a third party agency.

2.2.4.3 Payment Terms

A supplier's proposed payment terms may have little to do with the quality of the equipment, but they often have a significant effect on cost. Progress payments vary widely in terms of percentages and lead times, and if possible, the payments should be negotiated and evaluated along with terms and conditions during evaluation of the supplier's overall qualifications. From the purchaser's point of view, progress payments should be tied to measurable milestones that can be readily verified.

2.2.4.4 Warranties

Mechanical warranty clauses are normally spelled out in the terms and conditions governing an order. If an overriding agreement with a particular supplier exists, the mechanical warranty clause is already agreed upon and need not be addressed further; the performance guarantee, however, will depend on the nature of the equipment and designated operating conditions. Guarantees relating to performance (such as efficiency or power consumption) or to acceptance criteria for test results (such as maximum leakage rates or maximum vibration or noise levels) should be covered in the technical specifications or data sheets and clearly identified as guaranteed levels.

A supplier of quality equipment often will go well beyond written guarantees after his equipment is put into service. The supplier does this by exhibiting a genuine interest in the actual field performance of the equipment, by keeping the user informed of any design improvements, and by readily issuing a recall notice involving any hidden design defects that, if ignored, could compromise the safe operation of the equipment.

2.2.4.5 Labor Agreements

The expiration of the current labor agreement should be defined as well as any labor disputes that may adversely affect the negotiation of a new contract.

2.3 Comprehensive Specifications

2.3.1 USER REQUIREMENTS CLEARLY STATED

A key item in the communication of a project requirement is the production of a written specification that clearly defines the commercial and technical aspects of the project. Specifications should be clear and concise so that the readers do not have to rely on references or interpretation of intent. The following are guidelines for specifications.

2.3.1.1 Standard Industry Specifications

Wherever possible, widely accepted industry standards, such as API standards, ASTM⁷ standards, ASME codes, and ANSI standards, that have a broad base of distribution, understanding, and acceptance should be relied upon.

2.3.1.2 Standard Data Sheets

Where users, contractors, or suppliers are required to add specific information regarding a project, standard data sheets, such as API data sheets, that are easily recognized by all parties should be used.

⁷ASTM, 1916 Race Street, Philadelphia, PA 19103-1187