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Technical Evaluation of Bids for Nuclear Power Plants

A Guidebook

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1981

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FOREWORD

In continuation of its efforts to provide comprehensive and impartial guidance to Member States facing the need to introduce nuclear power, the International Atomic Energy Agency is issuing this guidebook as part of a series of guidebooks and codes of practice and, in particular, as a necessary supplement to 'Economic Evaluation of Bids for Nuclear Power Plants: A Guidebook', published by the IAEA in 1976 as Technical Reports Series No.175.

The present publication is intended for project managers and senior engineers of electric utilities who are concerned with the evaluation of bids for a nuclear power project. It assumes that the reader has a good knowledge of the technical characteristics of nuclear power plants and of nuclear power project implementation.

Its purpose is to provide the information necessary to organize, guide and supervise the technical evaluation of bids for a nuclear power project. It goes without saying that the technical staff carrying out the evaluation must have prior technical experience which cannot be provided by a guidebook.

The guidebook was prepared by N.A. van Zijl of Motor-Columbus Consulting Engineers, Inc., Switzerland, under a contract with the IAEA. Specific recognition is due to the Advisory Group that met in October 1978 and May 1979 and whose comments and recommendations were very helpful in preparing the manuscript.

CONTENTS

1. INTRODUCTION

The purpose of this guidebook on technical bid evaluation is to help project managers and senior engineers of utilities to organize, guide and supervise such evaluation.

The guidebook has also been written to draw attention to the importance of technical bid evaluation in order that adequate means and time, as well as expertise, shall be made available for it.

Nuclear power plants must achieve high availability factors to justify their relatively high capital costs. Excessive plant outages due to maintenance and repairs can impose very heavy financial burdens on a utility. To minimize these risks the technical aspects of bid evaluation should be treated in considerable depth.

This guidebook has been written mainly for the evaluation of bids for turnkey nuclear power plants and for large turnkey packages (nuclear island, turbine island with or without civil works), but can, in the same sense, also be applied for non-turnkey projects (nuclear steam supply systems and turbo-generator sets).

The guidebook deals with the objectives and the basis for technical bid evaluation as well as with the scope, methods and approaches which can be selected for such evaluation. Detailed guidelines are given for the preparation and organization of the evaluation and how the evaluation should be carried out. Finally, recommendations are given for carrying out technical contract negotiations and on the form and content of technical contract documents.

The technical bid evaluation is a part of the overall bid evaluation, which comprises technical (including safety), economic, financial, contractual, political, organizational and other applicable aspects which have to be considered in the decision-making process of implementing the project and the selection of the supplier(s). The various aspects are schematically shown in Fig.1.

In cases where financing and/or political considerations become overriding factors the danger of technical aspects not receiving sufficient and detailed attention can arise.

It should be kept in mind that the success or failure of a project finally depends on the overall technical performance of the plant. The economical and technical risks of a nuclear power project are so great that those aspects which can influence the technical performance of the plant should under all circumstances receive adequate attention. The engineers responsible for the technical bid evaluation should present the results of their evaluation in a way corresponding to the importance of this evaluation aspect in the overall bid evaluation process.

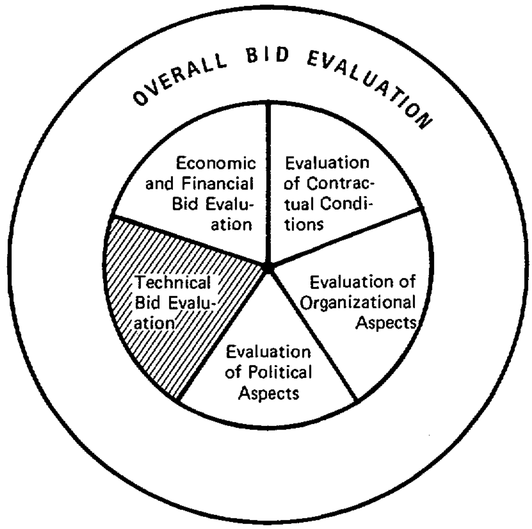

FIG.1. Different aspects of bid evaluation.

2. OBJECTIVES OF TECHNICAL BID EVALUATION

The objectives of technical bid evaluation are to evaluate the bids with regard to scope and limits of supply and services as well as the technical design features of the plant offered. This is so as to determine the costs for deficit and surplus materials and services[1], the technical acceptability of a bid and/or the best technical bid. These objectives are schematically illustrated in Fig.2.

The objectives of the bid evaluation for a particular project depend on the overall objectives set by the utility and the prevailing circumstances. The overall objective of the utility may be to select the cheapest bid which is technically still acceptable or to select the best technical bid, i.e. the bid which gives most assurance of high standards of reliability and safety and which in the long run might prove to be the most economical solution.

Although it is recommendable for a utility to follow the latter case, it is very difficult to determine on a reliable basis the anticipated performance of a plant.

Further, a utility might be forced due to outside circumstances to give other non-technical aspects (costs, financing, political situation, domestic participation, etc.) a higher weight in the decision-making process of selecting the supplier(s). But even in such a case the bid must be technically sound and complete.

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[1] Compared with what was requested in the specifications.

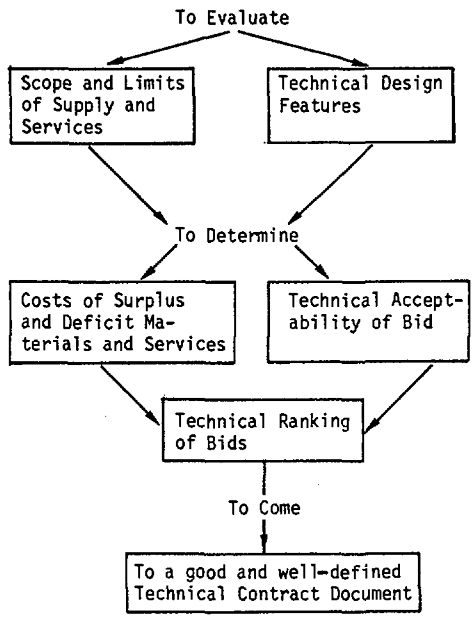


FIG.2. Objectives of technical bid evaluation.

Only in a limited number of countries are the utilities in a position to select the supplier(s) of a nuclear power plant mainly on the basis of technical superiority, so in most instances the objective of the technical bid evaluation is rather to determine the technical acceptability of the bid rather than to determine the best technical bid.

This is in particular the case if there is no open bidding competition (negotiated contract) and in cases where financing of the project is an important prerequisite for its realization.

A bid is technically acceptable if it gives assurance of an adequate standard of reliability and safety. The nuclear power station must be licensable in the country with anticipated known risks of extra costs for additional licensing requirements during construction and should further give assurance of adequate operability and maintainability.

The main aim in evaluating the technical acceptability of a bid is:

- To spot technical inadequate solutions
- To evaluate the risks (in terms of performance and safety) associated with the construction, operation and maintenance of the station.

The evaluation of the scope and technical design features of a bid should get adequate attention by experienced engineers in this field.

3. BASIS FOR THE EVALUATION

3.1. General

The main references for the technical bid evaluation are:

- Bid specifications prepared by the utility and/or its consultant
- Bid documents prepared and submitted by the bidders
- Reference plants
- Preliminary safety analysis report (PSAR) of a reference or generic plant
- Survey of the bidders
- General project situation and related documents.

The best basis for a good technical evaluation is given if detailed bid specifications are available and when the background of the bidders (reference plants, PSAR, survey of bidders) as well as the general project situation is adequately taken into account.

In applying the above references for bid evaluation purposes one has to distinguish between the nature of the various types of information available. Whereas bid specifications and bid documents in most cases contain binding information which will later become part of the contract, the other information serves merely as back-up information unless it will also become part of the contract. This has to be taken into account in evaluating the bids and in using the information which is available on a particular bidder.

The evaluation of a bid or bids without bid specifications is possible, but not recommended. Even in the case of a negotiated contract it is advisable to prepare detailed bid specifications in order to define the functional requirements of the utility. Otherwise no written guides are available for the evaluation engineer to judge the acceptability of the bid(s) and the site-related aspects will most probably not have been sufficiently considered. The contractual basis for the utility is in such a case extremely weak.

3.2. Bid specifications

The bid specifications should contain:

- The technical (including safety), economic, legal and other contractual requirements of the owner and the authorities concerned

- The definition of scope and limits of supply, as well as other responsibilities of the supplier
- The intentions of the utility with regard to the planning and scheduling as foreseen for the project
- All site conditions and other conditions which may affect the work
- Evaluation criteria.

As regards the content and set-up of bid specifications, reference is made to the IAEA publication 'Steps to Nuclear Power: A Guidebook' (Technical Reports Series No.164).

Bid specifications do not only form the basis for the bidder to prepare the bids and for the owner to evaluate the bids but they are also the basis for the contract documents to be developed together with the successful bidder.

Bid specifications are the basis for the whole project as at the preparation of the specifications decisions must be taken as to the type of contract, contracting procedure, reactor type(s), size and location of the plant and many other technical aspects.

In the earlier days of nuclear power, plants were ordered with a very short set of specifications. This was mainly due to lack of knowledge and experience. The present situation is considerably different. It is now usual to prepare functional bid specifications in which the owner spells out in detail what his requirements are as regards tne design, construction, operation and maintenance of the plant. In writing bid specifications, however, attention should be paid to the designs available on the market and to the designs the different bidders prefer to offer.

3.3. Bid documents

The bid documents are the documents which the bidder submits to the utility in response to a bid specification. Bids for turnkey nuclear power stations or large turnkey packages are comprehensive documents comprising often more than ten volumes of which at least 80 to 90% contain technical information which has to be considered in the technical bid evaluation.

The amount of work required in preparing these documents is very great. Nowadays, however, almost all bidders have standard bid documents which only have to be adapted to the special requirements of the corresponding bid specifications.

Depending on the chances of project realization and the chances which the bidders reckon they have of getting the job, they put more or less effort in preparing the bid documents and are more or less prepared to adapt their standard bid document according to the particular requirements of the project.

These standard bid documents facilitate the preparation of specific bid documents considerably, but there is a great danger that they are, when submitted, not sufficiently adapted to the particular project conditions. In evaluating the bids special attention has to be given to this aspect.

3.4. Reference plants

A great help in evaluating bids technically is the presence of similar projects already in construction or operation. Preferably these projects should be of the same size (output) and design as well as being built on sites which are similar to the one under consideration.

Reference plants in operation allow a good evaluation of the risks during construction and operation of the plant and the individual systems and components. However, the design of these stations was made many years ago. These designs are, in view of the technical development in the construction of nuclear power stations, in particular as far as safety is concerned, often no longer representative for the stations offered today. A reference plant which is under construction allows a good definition of the project and evaluation of the risks during construction, including licensability.

Although reference plants are good for evaluating purposes, great care should be taken in using a reference plant as part of the contract. Reference plants have been referred to in contract documents in cases where the utility feels that it cannot define its requirements clearly in the bid specifications. Reference plants can be used in contract documents for different purposes, namely for:

- Reduction of unproven features
- Definition of scope of supply
- Safety standard of the plant
- General architectural finish of the plant.

Safety requirements and regulations change, however, rapidly and the prevailing site conditions often require major design changes to the project, in particular as regards cooling and ventilation systems as well as civil and seismic design. A design technically acceptable on one site is not always acceptable on another site. Due to this, one should be careful in referring to a reference plant in a contract document. Since utilities and/or consultants are nowadays in a better position to make proper bid specifications there is no longer any great need to refer to reference plants in contract documents. It is, nevertheless, still usual to do so, especially to cover items not or not sufficiently dealt with in the contract documents.

3.5. Preliminary safety analysis reports

It is recommended to ask the bidders to provide a preliminary safety analysis report (PSAR) of a reference or generic plant. These PSARs are also very comprehensive documents containing information on design and, in particular, on safety of the corresponding nuclear power plant. The PSAR is in particular useful for safety engineers evaluating the licensability and safety features of the station. If the plant offered is similar to the station for which the PSAR has been issued it might be recommendable to have this reference PSAR as a contract document.

3.6. Survey of the bidders

Before issuing bid specifications for nuclear power stations it is recommended to make a nuclear market study to decide upon the bidders who are considered capable of handling contracts of this size and nature with sufficient experience and background. This is especially the case for utilities with insufficient nuclear experience. It is further advisable to make use of the time between issuing the bid specifications and receipt of bids to pursue the survey of the bidders in a comprehensive way, covering all items which might be important for the implementation of a project. This survey should mainly cover the experience of the bidders as regards the design, construction and operation of the stations where they were involved, but also include items such as local experience, possibilities for financing, liability coverage, general background, potential and organizational structures. The experience of other utilities with certain bidders or systems of bidders should be verified against the information received with the bid and, if necessary, be discussed. The results of the survey of the bidders should be fully used in carrying out the bid evaluation.

3.7. General project situation and related documents

In evaluating the bids adequate attention has to be paid to the general project situation and related project documents, in particular as regards status of technical development in the corresponding country, know-how transfer, domestic participation, site conditions, etc. Generally, these points and others are part of a feasibility study which is, if available, a great help for the technical bid evaluation, in particular, if the persons who made the feasibility study also carry out the evaluation. Matters such as transport of heavy components (reactor pressure vessel, generator stator), and limited production capacities of local suppliers, must be taken into account.

The general project situation is usually or largely reflected in the bid specifications. It is, however, not possible to put everything in the specifications and, therefore, a certain familiarity and knowledge of the general project situation is an important prerequisite for carrying out a proper bid evaluation.

This is an aspect of the bid evaluation in which the utility should be particularly involved, even if the evaluation is largely carried out by a consultant, as the utility is most familiar with the prevailing conditions to be considered for the planning and implementation of the project.

It is very important where a consultant is involved in the bid evaluation that the engineers of the consultant are fully aware of the general project situation and the constraints existing on the realization of the project. This is usually the case if the consultant has also been involved in the preparation of site reports, the preparation of bid specifications, etc.

No proper bid evaluation can be carried out if the general project situation and the site conditions are not well known. This is in particular the case for risks related to earthquakes, flooding and external impacts, but also as regards non-technical issues such as delivery times, licensing situation, language problems, etc.

4. SCOPE OF THE EVALUATION

4.1. General

The scope of the technical bid evaluation depends on:

- The contract approach selected for the project (turnkey or non-turnkey) and the corresponding scope of the bids, including the determination of the balance-of-plant costs
- The definition of technical bid evaluation as part of the overall bid evaluation (including organizational and contractual aspects).

Further, the scope and the depth of the technical bid evaluation are defined by the know-how and experience as well as the corresponding amount of money and time which are available for carrying out the evaluation. In general, one should make ample means available for this work as the size of the projects and the importance of the technical evaluation justifies such an effort. For a comprehensive technical bid evaluation one must reckon with an effort of 100 to 150 man-months over a period of six months, excluding the man-hours required for determining the balance-of-plant costs (see Sections 4.4 and 7.3).

In recent years one has even started to apply system reliability analysis based on component failure probabilities for the most important parts of the bids (e.g. reactor cooling systems, feedheating trains, cooling water systems).

In general, one should aim for a well-balanced technical bid evaluation, giving the necessary attention to all technical aspects of the bids (see Section 4.3).

4.2. Scope of bids

The scope of the bids depends on the contract approach selected for the project (see Appendix 2). One distinguishes mainly between the following types of contract approach:

- Turnkey approach
- Split-package approach
- Multi-contract approach (component approach).

Turnkey approach (see Fig.3)

The term 'turnkey' is used when a single contract is placed covering the whole or almost the whole nuclear power station. It usually implies less involvement on the part of the utility in influencing or approving plant design, so that the responsibility for the design, construction and commissioning of the station is placed upon the contractor. The turnkey approach has almost always been applied for the first nuclear power project in a country (even in the USA) and is still applied to a large extent in Europe.

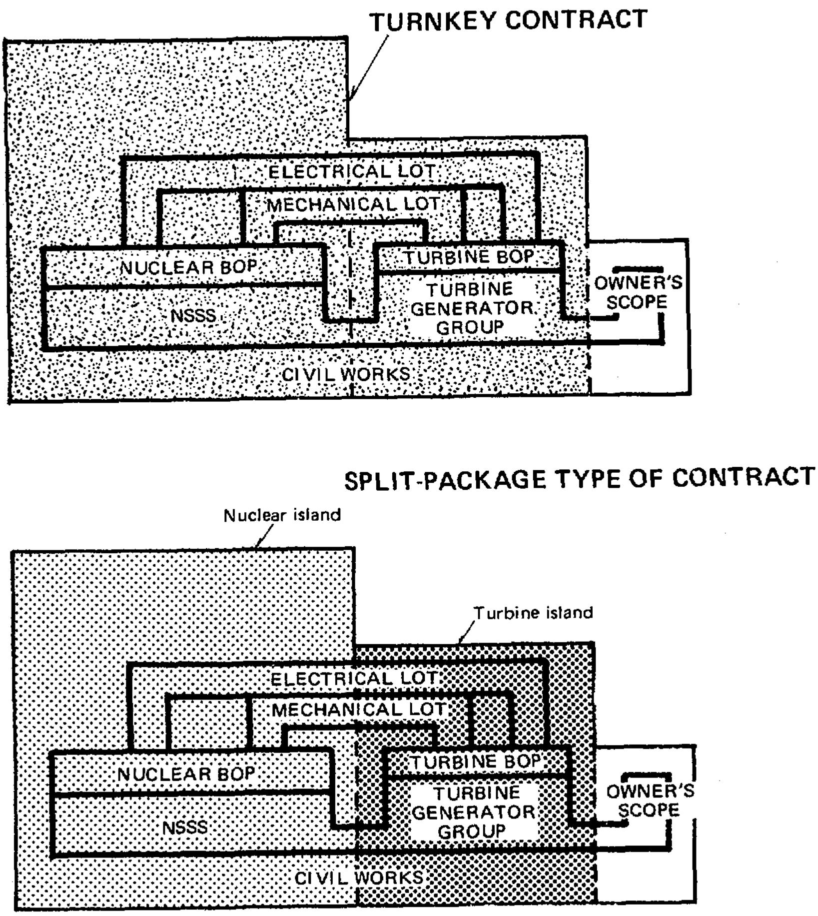
In the case of a turnkey bid the scope of the evaluation work is very comprehensive and time-consuming, although easier than in the case of a split-package approach. The emphasis in the evaluation of turnkey bids is more directed to assure the overall viability of the project, i.e. acceptable design and quality, and to come to a well-defined contract. Also, one has to ensure that the bid is complete and comprises an entire nuclear power station with all accessories and services required.

Split-package approach (see Fig.3)

In case of a 'split-package' approach the total power station is divided into two, three, four or more packages or lots for which separate bids are requested.

The term 'package' is used herein to describe a functionally complete part of a nuclear power station for which a single contractor takes overall responsibility. The split-package approach has been applied to a large extent for the construction of conventional thermal power stations in Europe but until now not so much for nuclear power stations. Basically, one distinguishes mainly between the following types of split-package approach:

- Two-package approach (nuclear island and turbine island)
- Three-package approach (nuclear island, turbine island and civil works)
- Five-package approach (nuclear lot, turbine lot, civil works, electrical lot and mechanical BOP lot).



NSSS – Nuclear Steam Supply System
BOP – Balance of Plant

FIG.3. Scope of technical bid evaluation.

In the case of a split-package approach separate bids for individual turnkey packages have to be evaluated. Usually, first the main packages for the nuclear and turbine island or lots have to be evaluated. After the selection of the corresponding suppliers for these lots, the specifications for other packages or lots are prepared and issued. The scope of the lots includes the design, manufacture, transport, erection, testing and commissioning of the lot, i.e. all engineering and site work is part of the lot. The evaluation of bids for such lots is far more complex than that of bids for turnkey plants, in particular as far as compatibility and interfaces are concerned.

Multi-contract approach

In the case of a multi-contract approach the scope of the bids covers only the nuclear steam supply system (NSSS), the fabrication of the nuclear fuel and the turbo-generator (TG) set, respectively. The total value of the bids for the NSSS and the TG set does not represent more than 30 to 35% of the base plant costs[2] and also most engineering of the station is the responsibility of the owner and/or his architect-engineer (A/E). The multi-contract approach has mainly been applied in the USA and in a few European countries, such as France, Spain and Belgium.

The technical evaluation of bids for the NSSS and TG set are far less comprehensive and complex than bids for projects with a turnkey or split-package approach. The question of compatibility for NSSS and TG bids is mainly restricted to power output as well as steam and feedwater conditions. The price level of the bids has to be evaluated against the scope offered by the bidders and the balance-of-plant costs, which might be different for the various bidders. The estimate of the balance-of-plant costs and cost differences can be carried out on the basis of reference or generic plant designs.

4.3. Scope and interfaces of technical bid evaluation

4.3.1. General

The definition of technical bid evaluation as part of the overall bid evaluation and the interfaces with the other parts of the bid evaluation (economic, financial, contractual, political and organizational aspects) should be carefully looked at, otherwise it may happen that some important aspects get no or not sufficient attention, or not from the right people.

Generally, the scope of technical bid evaluation includes:

- The checking of the bid for completeness of the information requested
- The checking of the scope and limits of supply and services
- The evaluation of the technical design features of the equipment and structures, as well as the adequacy of the services
- The preparation of questionnaires
- The preparation of evaluation reports, including the identification of problem areas
- The preparation of suitable texts for the technical contract documents

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[2] Including equipment, engineering and erection.

- The supply of the right input for the economic bid evaluation, as well as the evaluation of contractual conditions and organizational matters, such as time schedules and domestic participation.

4.3.2. Scope and limits of supply and services

Careful attention has to be paid to the definition of the scope and limits of supply and services, in particular in cases of turnkey projects or turnkey packages. Apart from systems, equipment and structures which are preferably evaluated with the help of checklists one has to assure that one is also adequately covered as regards:

- Supplies and services during construction and commissioning. These are the so-called non-permanent supplies and services which are necessary for the work on the site
- Packing, transport and insurance of equipment, as well as other direct and indirect costs
- General services and information to be rendered by the supplier:
  - Know-how transfer
  - Design services, including dynamic stress analysis
  - Testing of components and systems
  - Pre-operational testing and commissioning
  - Quality assurance and control (QA and QC)
  - Licensing assistance
  - Provision of drawings, descriptions, calculations and other documentation required for supervising design and construction of the plant, for licensing, for designing and ordering other parts of the plant
  - Training
  - Computer programs for in-core fuel management and other programs required for the operation and maintenance of the plant
- Spare parts and consumables
- Supporting services during operation.

4.3.3. Scope of the evaluation of technical design features

For NSSS and TG bids the evaluation as regards technical design covers mainly the evaluation of design parameters of the components, an appraisal of the operational performance, materials, maintenance requirements, licensability (for NSSS only) and quality assurance and control standards applied, as well as an evaluation of the balance-of-plant costs.

In the case of turnkey projects or turnkey packages a much greater scope of supply and in particular much more technical aspects are involved.

Generally, the scope of the technical evaluation should be carried out on three levels of decreasing complexity, namely:

1st level: Overall technical design evaluation of the station or the package

2nd level: Specific technical design evaluation for systems and main components such as reactor coolant system, feedwater system, reactor pressure vessel, steam generators, steam turbine

3rd level: General technical design evaluation of mechanical and electrical components such as pumps, motors, valves, heat exchangers.

The evaluation of the overall technical design covers items which are of overall importance for the performance and safety of the station, such as:

- Evaluation of overall plant design criteria, including codes and standards
- Evaluation of general operational flexibility and stability
- Evaluation of overall maintenance, refuelling and in-service inspection requirements
- Evaluation of plant layout and layout of individual buildings, their location on the site and all site-related features such as geology, seismology, hydrology, meteorology
- Overall safety evaluation, including normal operation, incidents and accidents which have to be assumed
- Evaluation of the connections of the plant with the surroundings, in particular as regards use of cooling water, fresh water, power supply, ultimate heat sink, waste disposal
- Evaluation of the electrical connection of the plant with the grid, including disturbances and transients which can be expected
- Evaluation of the auxiliary power supply for the users in the plant under normal operating, maintenance and abnormal conditions
- Evaluation of the control and instrumentation techniques applied in the plant
- Evaluation of transport, erection and testing of the equipment, as well as the commissioning of the systems and the plant or package as a whole
- Evaluation of the quality assurance and control standards proposed by the bidder
- Evaluation of environmental impacts.

For the evaluation of specific design features of systems and main components (which is the second evaluation level) one divides the station normally into the following parts:

- Nuclear lot
- Turbine lot
- Electrical lot
- Mechanical lot
- Civil works lot.

The **nuclear lot** evaluation includes the following items:

Reactor system, including reactor vessel, reactor vessel internals (excluding fuel), control rods and drives, reactor coolant system including pumps and steam generators (if applicable) and accessories.

Reactor core and fuel-design

Reactor safety systems, including emergency shutdown or core isolation cooling system; coolant injection and core spray/flooding systems; containment heat absorption/rejection systems; emergency feedwater systems; pressure relief system.

Reactor auxiliary systems, including residual heat removal, reactor coolant receiving, storage and make-up system; coolant charge, volume control, relief, moderator, drain and recovery systems; coolant purification and chemical treatment systems; fluid leak detection systems; auxiliary cooling systems; nuclear fuel handling and storage systems; maintenance equipment and tools.

Radioactive waste treatment and disposal, including liquid waste processing system; gaseous wastes and off-gas processing system; solid wastes processing equipment and storage facilities.

Reactor control and protection systems, including reactor instrumentation and control systems.

The **turbine lot** evaluation includes the following items:

Turbo-generators, including turbine, generator, control systems, exciter system, lubricating system, generator cooling system.

Steam line system, including water separator/reheater, steam by-pass (dumping) system.

Condensing system, including condenser and accessories, condensate and condensate purification system, gas removal system, condenser cleaning system.

Feedheating system, including feedheaters, pumps and tanks.

Turbine auxiliary system, including condensate and feedwater storage, water make-up and storage system; charge, relief, drain and recovery systems; chemical treatment system, auxiliary cooling systems, maintenance equipment and tools.

The evaluation of the **electrical lot** includes the following items:

Main power transmission, from the generator terminals to the switchyard, including generator busbars, generator circuit breakers, main transformers and overall differential protection.

Station auxiliary power supply, including auxiliary and start-up transformers, voltage regulation equipment and corresponding connections to the auxiliary power supply systems.

General station power supply systems, including medium voltage (3–10 kV) power supply system, low voltage (220–660 V) power supply system and the domestic power supply system for the station (AC and DC).

Emergency power supply systems (AC and DC), including battery systems, diesel generator units and accessories, motor-generator sets and inverters.

Domestic electrical systems, including house installations, earthing of the station.

Control and instrumentation, including control room equipment and computer system, plant and system control systems, measuring equipment, environmental monitoring equipment.

Communication and alarm systems, including telephone, wireless facilities, telegraph and telex, public address system and intercommunication systems, fire alarm, security alarm, evacuation alarm and other signal systems.

The evaluation of the **mechanical lot** includes the following items:

Main and service cooling water system, including water intake facilities with water-screening equipment, water-treatment systems; pumps and distribution system to the condenser and other coolers in the nuclear and turbine lot, discharge circuit, cooling towers or ponds, spray ponds.

Air and water systems, including service and instrument air supply systems, domestic and fire protection water systems, water-treatment systems.

Auxiliary heating system, including oil-fired boiler units, or steam or electrically heated boilers with distribution system.

Ventilation and air-conditioning systems

Transport and lifting equipment, including turbine building crane, main reactor building crane, other cranes; hoists, monorails and conveyors; railway equipment, trucks and other vehicles, boats and barges, fuel storage and vehicle maintenance equipment.

Fire fighting and protection systems (mobile and permanently installed equipment).

The evaluation of the civil works lot includes the following items:

Site improvements and facilities, including general site use, water front works, railway and road systems and access, waterway access facilities, air access facilities, if applicable.

Reactor building, including basic building structures, containment shielding and accessories.

Turbine building, including foundation of TG set and accessories.

Other buildings and structures, including reactor auxiliary building, radwaste building, fuel storage building, electrical building, stack, intake and discharge structures, diesel building, administration building, service building, including workshop and stores with accessories.

The third evaluation level is concerned with the general quality of the bulk of components supplied for the plant. It concerns a general technical evaluation of the equipment offered, such as for:

Mechanical equipment, including pumps, heat exchangers, tanks and vessels, piping, valves, supports, insulation.

Electrical equipment, including motors, switches, electrical cables, consoles, panels, racks, cubicles, instrumentation and control equipment.

Architectural finish, including type of walls and roofs, doors and windows; wall, floor and ceiling finish, painting, external finish and other building services (lighting, heating, elevators).

As so many different types of equipment are installed it is clear that this evaluation can only be carried out in a generic way and it is important that the bid specifications contain minimum technical requirements for this general type of equipment and finish. One should, however, try to cover these aspects as much as possible during the bid evaluation phase in order that one knows the quality and type of equipment proposed by a bidder.

4.3.4. Interfaces of the technical bid evaluation

The technical bid evaluation has many interfaces with the economic, financial, contractual and organizational aspects of the bids. The purpose of this Section is to draw attention to these interfaces and to discuss their relation to the technical bid evaluation.

The interfaces with the economic bid evaluation are shown in Fig.4. The technical bid evaluation should give cost estimates for any deficit or surplus

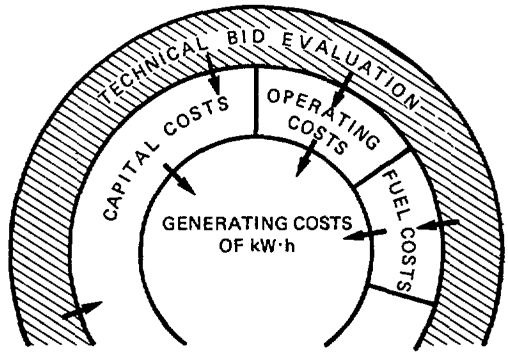

FIG.4. Interfaces of the technical and economic evaluation.

material, as well as evaluation of cost differences due to different technical designs. In general, there are no problems as far as the interfaces between the economic and technical bid evaluation are concerned. The difficulty is mainly that it is not easy and sometimes impossible to express technical design differences in money terms. This matter is dealt with in Section 5.

The interfaces with the contractual conditions are due to the fact that the most important technical aspects are not dealt with in the technical part of the bid specifications and of the bid documents, but in the Terms and Conditions (draft contract) as drafted by the owner or the bidder. Some of the comments of a bidder on a draft contract of the owner are of a technical nature and their evaluation is part of the technical bid evaluation.

The technical matters which are usually dealt with in the draft contract are:

- General definition of the scope of the contract, including an indication of the owner's scope of supply
- The most important technical parameters such as power output, steam and feedwater conditions, generator voltage and power factor
- Information to be supplied to the utility
- Licensability and licensing requirements
- Codes and standards
- Delivery times and contractual dates which have to be met by the owner and the supplier
- Guarantees on design, material and workmanship, performance guarantees, availability guarantee

- Clauses on rectification of defects and deficiencies
- Commissioning requirements, trial run and take-over conditions.

The above points are of a highly technical nature and it is advisable that the person who is in charge of the technical bid evaluation is also responsible for the above points in the main contract document and is a member of the team negotiating the contract with the supplier. If this is the case, there are normally no problems as regards the interfaces between the technical bid evaluation and the contractual conditions.

The organizational and partly technical matters which are usually also dealt with in a draft contract are:

- Responsibilities for co-ordinating the work
- Assignment of work and subcontracting
- Changes to the work
- Training of owner's operational personnel.

These are organizational matters which can only be judged if one has a good technical knowledge, knows what has been the experience with other projects and what could happen in the course of the project. Generally, it is felt that these points are of such importance that a separate group of senior technical people should occupy themselves with them. This is also the case with most of the following points, which are basically of an organizational nature, but could be dealt with by the team responsible for the technical bid evaluation:

- Identification systems of documents and equipment
- Application of different international codes and standards
- Use of different languages
- Project organization of the bidder
- Suitability of selected project approach for the bidder
- Compatibility of companies (in case of a consortium)
- Domestic participation.

It is not so much a question as to whether the above points belong to the technical bid evaluation or not; the main requirement is that that they are properly evaluated. Generally, the team carrying out the technical bid evaluation does not have very much time for items which are merely tangential to their work and, therefore, it is advisable to charge a separate team with the organizational aspects of the project (see Section 7.3).

4.4. Balance-of-plant costs

In comparing bids one has also to evaluate what would be the additional costs required for completing the plant. These balance-of-plant costs are necessary:

- to see if there are any noticeable differences between the bids in this respect
- to determine the total plant costs as an input for the economic bid evaluation.

These balance-of-plant costs are of particular importance if different reactor types are offered, e.g. when light-water reactors (LWR) are compared with heavy-water reactors (HWR) it is important to consider the costs of the heavy water inventory, as well as the costs of the fuel inventory. The differences between power stations with different light-water reactors are much smaller. In any case, it needs much scrutiny and detailed work to compare the bids on an equal basis.

For turnkey projects, the balance-of-plant costs are merely determined to evaluate total plant costs (including owner's costs) and not so much to compare bids. For quasi-turnkey bids, i.e. bids in which civil works and often also the containment structure are not included or not firmly included in the bid price, the costs of the civil works have to be determined on the basis of the layout drawings and other information in the bids. There can be remarkable cost differences in this respect.

In the case of a split-package or a multi-contract approach, only parts of the station are offered, and in order to compare the bids properly, the balance-of-plant costs have to be determined. Balance-of-plant costs can be estimated on the basis of reference plant designs developed for the project or generic cost information available for the reactor types offered. In the latter case one must be careful that the cost information available is compatible, i.e. for power stations developed on the basis of the same design and safety philosophy. Balance-of-plant costs can be remarkably different, particularly due to different building volumes, waste solidification methods, safety philosophies, etc.

For projects on a non-turnkey basis (split-package or multi-contract approach) it is recommended to develop reference plant designs before the specifications for the main equipment are issued. The reference plant designs should be developed for the reactor types one is particularly interested in. For example, if one intends to invite bids for PWRs and BWRs it is advisable to develop reference designs for both reactor types. With the development of the reference designs one can establish the general design and safety philosophy to be applied, taking into account at the same time the specific features of the project and the site. The objective of a reference plant design is to have at an early stage a good definition of the project. It serves also to prepare better specifications regarding site investigations, foundation problems, type of cooling water system, etc. The reference plant design serves further as a basis for estimating the balance-of-plant costs and, once the main supplier(s) has/have been selected, as a basis for the detailed design of the plant.

For the preparation of reference plant designs one should normally call upon the help of a consultant who has standard designs available which can be adjusted according to the wishes of the utility and the requirements of the site. Reference plant designs can be developed within three to six months and the effort involved ranges from 15 to 30 man-months per reference plant design depending on the degree of detail which has to be elaborated.

5. EVALUATION METHOD

5.1. General

The technical evaluation of the bids mainly comprises:

- An evaluation of scope and limits of supply and services
- An evaluation of the technical design features.

The evaluation of scope and limits of supply and services finally results in a cost estimate for any deficit or surplus material and/or services (compared with what has been specified in the bid specification) and gives directly an input into the economic bid evaluation (adjustment of the bid price).

The evaluation of the technical design features can finally result in a cost estimate, but might also be expressed only qualitatively. Design features which *have* a direct influence on station performance such as power output, efficiency, etc., can be and should be expressed in money terms, but features which only *might have* an influence on station performance should be evaluated in a different way.

The evaluation methods which might be applied differ mainly in the way in which differences in technical design features are finally expressed. A quantification of design differences should nevertheless be made in order to estimate the importance of certain aspects of the bid and, in particular, to assess the risks associated with certain design features. This quantification can be made in money or in numerical values. If design features are expressed in money terms, these estimates should be applied in the economic bid evaluation with great caution, as these cost estimates have much bigger uncertainties than, for example, the price quoted by a bidder.

5.2. Evaluation of scope of supply and services

The evaluation of the scope and limits of supply and services is carried out according to the evaluation logic shown in Fig.5.

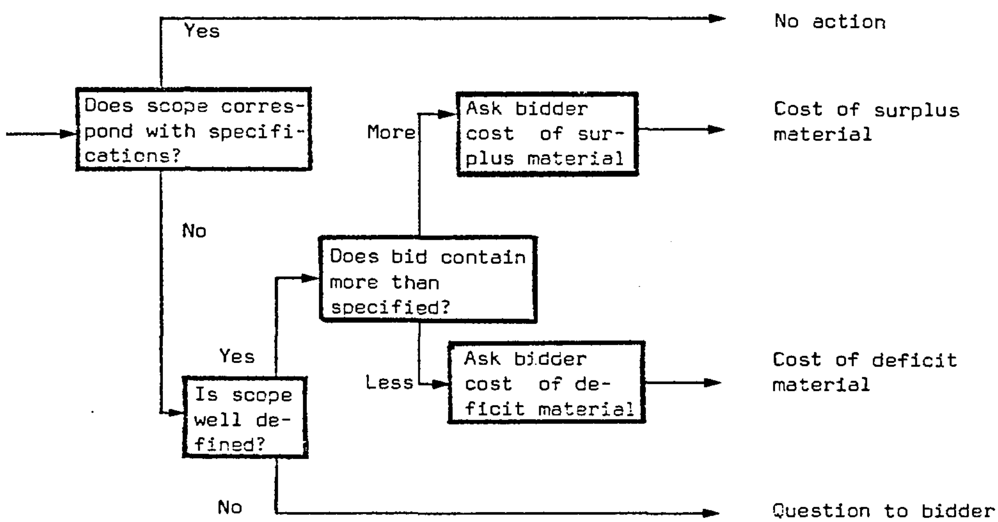

FIG.5. Evaluation logic for scope of supply and services.

This logic is to be applied systematically to each system, component, structure and service to be evaluated. The evaluation has to be carried out by making comparisons with the bid specifications. If the scope offered corresponds with the specifications there is no action.

If the scope is not well defined one should question the bidder. If there are deviations from the requested scope one should try to get the costs for any deficit or surplus material and/or services from the corresponding bidders. If this is not possible, corresponding cost estimates should be made. These estimates should be made on the basis of costs for previous projects adequately scaled, taking into account the particular project and site conditions.

For cost information, reference is made to corresponding reports issued by the United States Nuclear Regulatory Commission (NUREG 0241/0242/0245/ 0246/0247/0248).

For non-turnkey projects on a multi-contract basis the specifications and also the bids for a NSSS are normally quite precise as regards scope of supply and services, specifying in detail all systems and all components belonging to these systems. The scope of supply and services is usually indicated by the bidders in their bids in so-called 'scope lists'. An example of such a scope list is given in Fig.6.

For turnkey projects and projects with large turnkey packages it has also become more and more general practice to define the scope of supply and

ITEM NUMBER	ITEM DESCRIPTION	NUMBER REQUIRED	DESIGN CRITERIA	BASIC DESIGN	DETAIL DESIGN	MANUFACTURE	TRANSPORT	ERECTION	COMMISSIONING

FIG.6. Example of a scope list.

services as accurately as possible. In the earlier days of nuclear power the scope for turnkey projects was only defined in a very general way, such as:

> *"The supplier has to supply everything that is necessary for the construction, operation and maintenance of the unit with the exception of the material and services which are expressly referred to as belonging to the scope of the owner."*

Although such a general definition of the scope is still usual for turnkey projects, the bidders have, nevertheless, started to introduce also the application of detailed scope lists in order to define who is responsible for the supply of the different hardware and software items. In the scope list it is indicated who is responsible for the different aspects, such as:

- Design criteria
- Basic design
- Detailed design
- Manufacture
- Transport
- Erection
- Commissioning.

Although the bid evaluation of turnkey projects or turnkey packages can be carried out on the basis of scope lists, it is very important that the responsibility of the supplier as regards scope of supply is rounded off by general clauses in the contract in the sense as quoted above and by the general functional requirements of the systems as defined by the owner in his bid specification. In the case of turnkey jobs the supplier is responsible for the supply of functionally complete systems and the scope list should mainly serve to indicate in detail what is the scope of the owner. Everything that has not been indicated in the scope list as coming under the scope of the owner should be supplied by the bidder.

For the limits of supply one should be careful to have an exact definition of these limits. For example, it is not enough to say that the limit of supply for piping is 1 m outside the building. One should also specify who is responsible for providing the material for the connection (flanges and bolts), for making the connection and for testing the connection.

In evaluating the scope special attention should be paid to the so-called software items (provision of services and information) referred to in subsection 4.3.2 above. These software items can only be dealt with in a very limited way in a scope list. For example, if a supplier indicates in his scope list that he is responsible for QA and QC, but somewhere else in the bid states that he carries out the QA and QC programme according to company practice, whereas the bid specification calls for a QA and QC programme according to ANSI 45.2, it is necessary to analyse the difference between these two statements and possible consequences to the bid specifications arising out of this deviation.

The scope of supply should therefore not only be evaluated on the basis of scope lists contained in the bid, but on the whole content of the bid documents. Deviations between the scope list and other parts of the bid document need further clarification with the corresponding bidder.

5.3. Evaluation of technical design features

5.3.1. General

The evaluation of the technical design features of a bid is carried out according to the evaluation logic shown in Fig.7.

This logic is applied systematically to the following evaluation criteria which are considered at the evaluation of components, systems and other general technical aspects of the bid:

- Reliability
- Function and Performance
- Safety
- Operation and Maintenance
- Materials.

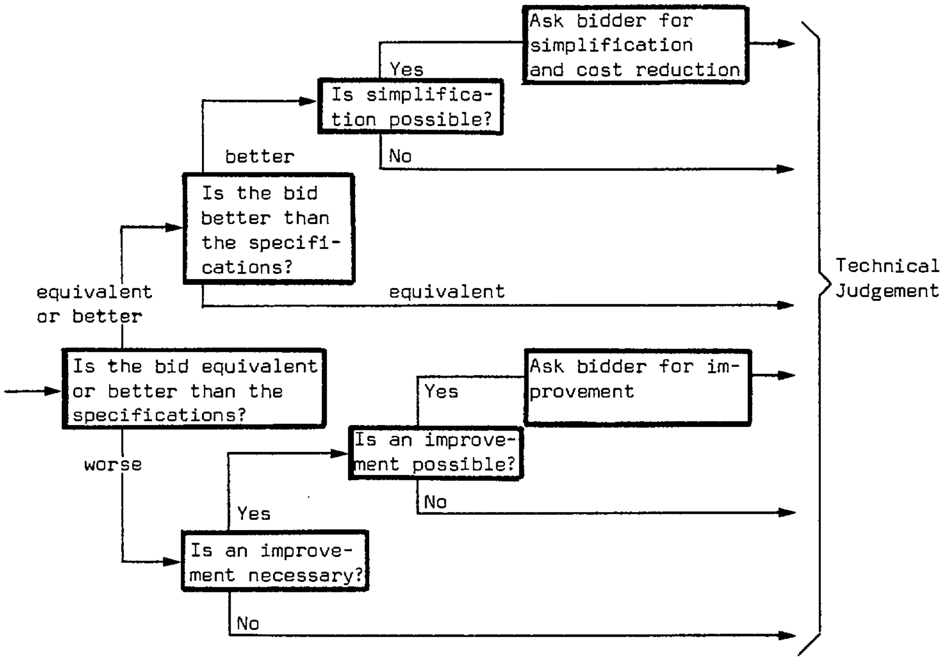

FIG. 7. Evaluation logic for technical design features.

The above evaluation criteria can be applied to any component or system, and to illustrate the meaning and the differences of the above criteria an example is given with regard to the evaluation of the steam generator of a nuclear power station.

Reliability

means: What are the chances of a steam generator failure? How long does it take to repair the steam generator in such a case?

Function and Performance

means: What is the steam production capacity? What is the quality of the steam? How many tubes can be plugged before power needs to be reduced?

Safety

means: How good is the steam generator as regards safety? What codes and standards have been used for its design? What are the design margins as regards over-pressurization?

Operation and Maintenance

means: Does the steam generator have sufficient manholes at good locations? Is the instrumentation sufficient? How difficult is it to plug tubes?

Material

means: What is the material of the shell, tube-plates and tubes? What is the danger of corrosion and erosion?

Before starting the evaluation, the scope of the evaluation has to be divided into a number of items which shall be evaluated on the basis of the above evaluation criteria. The selection of these items shall be made on the basis of the importance of these items to the overall performance of the plant. The items to be evaluated can be components, systems, structures, buildings, or technical aspects such as layout, licensability, operational flexibility, codes and standards, (see subsection 4.3.3). For the latter aspects other evaluation criteria have to be applied whenever the criteria mentioned before are not applicable.

The main distinction in the evaluation methods applied is the way in which differences in design and technical judgements are considered in the overall bid evaluation. The technical judgement can be made either qualitatively or quantitatively, i.e. in the former case one highlights the positive and negative features of a design and gives a qualitative judgement, whereas in the latter case one tries to quantify the technical design differences either in monetary or other numerical values. These approaches will be dealt with in the following subsections.

5.3.2. Qualitative evaluation

The aim of the qualitative evaluation is mainly to determine the technical acceptability of a bid and to evaluate the positive and negative features of a design. Each component, system or technical aspect which is felt worthwhile to be evaluated is examined against the requirements of the specifications according to the evaluation logic shown in Fig.7.

If a certain evaluation criterion (e.g. reliability) of a component, system or technical aspect is considered worse than specified, one should investigate whether it can nevertheless be accepted. If this is the case no further action is required and one can make a technical judgement with regard to the positive and negative features of this component, system or technical aspect, as far as its reliability is concerned. If, however, it is not considered acceptable one has to investigate if an improvement is possible or not (question to/or discussion with the bidder). If it is possible one has to consider the consequences of the change (technical and economic) and make a recommendation and corresponding technical judgement regarding the new solution. If an improvement is not possible this component, system or technical aspect is, as far as its reliability is concerned, not acceptable, and the judgement should explain why this solution is not acceptable and what kind of consequences might arise if such a component, system or technical aspect were nevertheless adopted.

If the reliability of a component, system or technical aspect is considered equivalent to what has been specified no action is required other than making a technical judgement indicating the positive and negative features of this item regarding its reliability. If the reliability aspect is considered better than specified one can investigate if a simplification is possible and recommendable to get a cheaper design.

Generally, this does not pay off in matters which are related with reliability, but this could well be considered for matters related with performance, operation and maintenance, as well as material (e.g. less tank or pumping capacity, smaller coolers, cheaper materials, less automation, etc.). If a simplification is *not* possible or recommendable, one gets a better design than specified, which has to be expressed in the technical judgement accordingly. If a simplification is possible, one should make a recommendation in adopting this modification or not and highlight the positive and negative features of this item as far as its reliability is concerned. In general one should be extremely careful in asking for design changes. One must be fully aware of the consequences of certain design changes. In this respect one has to bear in mind that the bidder has generally more knowledge and background information with regard to designs applied by him than anybody else.

Each component, system or technical aspect evaluated is dealt with five times according to the evaluation logic shown in Fig.7, in evaluating namely: reliability, function and performance, safety, operation and maintenance, and materials of the corresponding component, system or technical aspect.

The summary evaluations of each component, system or technical aspect are then grouped for a number of components, systems or technical aspects, listing in particular the technically unacceptable features, as well as the additional costs and cost reductions which are required to bring, if possible, the group of items to the standard as requested in the bid specifications.

Also, an overall summary shall be made for each group of items evaluating, in a general way, the aspects of reliability, function and performance, safety, operation and maintenance, as well as materials.

Finally, an overall evaluation of the bid is made for all groups of components, systems and technical aspects in the same way as for a particular group of items as described above, i.e. giving an overall opinion on the technical acceptability of the bid, indicating all additional costs and cost reductions needed to bring the bid to the standard as requested in the bid specifications and highlighting, in a general way, the main positive and negative features of the bid.

An example of a division of bids for nuclear lots with light-water reactors into components, systems and technical aspects which can be evaluated invidually according to the above procedure is given in Appendix 1.

5.3.3. Quantitative evaluation

The quantitative evaluation is carried out in the same way as the qualitative evaluation, with the only exception that one quantifies the positive and negative features of a design in order to come to a clear technical ranking of the bids. The quantification can be either made in monetary or other numerical values.

This evaluation method is required if one would also like to determine, besides the technical acceptability of the bids, the best technical bid and how much better that bid is. It is clear that there are many design features which can easily be expressed in money. These are, in particular, items which have a direct influence on station availability and performance such as refuelling times, auxiliary power requirements, start-up times from cold and hot standby conditions, operating staff required, etc., etc.

In an evaluation with a quantification of design features in *terms of money* one quantifies positive and negative design features in an anticipated gain or loss of energy assuming a certain value of the kW·h produced and anticipated gains and losses in operating and fuel costs. For example, if the bid allows a faster start-up from the hot standby condition than specified, it can be determined how many operating hours can be gained assuming a certain number of hot standby conditions per year.

In order, however, to do the quantification correctly, one has to quantify *all* positive and negative features of the items evaluated, considering the criteria of reliability, function and performance, safety, operation and maintenance, as well as materials. As there are, however, many aspects with great uncertainties (e.g. how to quantify operating experience, differences in technique and design) one limits in practice the quantification mainly to the areas which can easily be quantified and all other items are only evaluated in a qualitative way. There are even uncertainties associated with the items which can easily be quantified. For example, if on the basis of the evaluation one comes to the conclusion that with a design of one bidder one can perform a refuelling in three weeks and with a design of another bidder in four weeks, it is, nevertheless, doubtful whether one should penalize the latter for one week less availability, as the actual down-times for refuelling might not necessarily be determined by the refuelling, but by repairs or in-service inspection tests.

As any penalties or bonuses due to anticipated loss or gain of availability have a very strong influence on the costs of nuclear power plants, one might well come to wrong conclusions due to the fact that anticipated losses or gains in reality are not so important and are largely offset by other factors which cannot be quantified.

Differences in output and efficiency of the units offered are always converted into money terms, also in case of a qualitative bid evaluation, and are, therefore, not considered herein as specific to a quantitative bid evaluation.

Another quantitative bid evaluation method is the application of a *numerical bid evaluation* scheme which is shortly described hereafter. This method is also based upon the qualitative bid evaluation scheme, whereby the technical judgements resulting from this scheme are *converted* in numerical values. All items to be evaluated have, to the extent possible, to be judged with regard to the following evaluation criteria:

- Reliability
- Function and Performance
- Safety
- Operation and Maintenance
- Materials.

The judgements of the above aspects are made qualitatively on the basis of the positive and negative features of the component or system evaluated. The qualitative judgements are made using the following categories: very good, good, satisfactory, doubtful, inadequate, bad.

These judgements are for the numerical evaluation converted into numerical values. These numerical judgements are taken into account to the extent that the corresponding component, system or technical aspect is considered important for the operation and safety of the station.

Qualitative judgement	*Quantitative judgement*
Very good	10
Good	8
Satisfactory	6
Doubtful	4
Inadequate	2
Bad	0

For example, the overall technical judgement of a certain system for various bidders could be as shown in Table I.

The relative importance of that main component, system or technical aspect within the overall plant design is determined by the consequences arising out of component or system failure with regard to plant availability and risks to the public and the operators. The importance of an item for operation is determined on the basis of its failure probability and on the basis that this item can cause a plant outage or power restriction. This can be evaluated in terms of equivalent full power day outages. Outage ratings to be established for the different items can range from outages of more than one year down to less than a few hours.

TABLE I. QUANTITATIVE EVALUATION OF EMERGENCY CORE COOLING SYSTEM

Emergency core cooling system	Bidder				
	a	b	c	d	e
Reliability	6	8	6	8	8
Function and Performance	6	4	6	6	6
Safety	6	6	4	6	8
Operation and Maintenance	6	6	6	6	6
Material	6	6	6	6	6

The judgement on risks to the public and the operator is made according to the importance of that main component or system to the overall safety of the station and the corresponding safety classification of this equipment.

In order to come to an overall bid evaluation, corresponding weighting factors have to be introduced for the evaluation criteria applied, as well as for the different group of systems and general technical aspects evaluated. The establishment of weighting factors should be guided by the importance of the evaluation criteria and the group of systems or general aspects within the lot evaluated (in terms of operation and safety) and the costs and possible implications of that item. The application of weighting factors is the most difficult part in this numerical bid evaluation scheme and needs a lot of experience and know-how. Depending on the experience of the company which is doing the bid evaluation, simpler or more sophisticated bid evaluation schemes might be applied.

Numerical bid evaluation schemes can be carried out with the assistance of computer programs in order to determine relatively easily the results of the calculations and the sensitivity of the results when certain judgements and/or weighting factors are changed. An example of such a numerical bid evaluation scheme is described in an article in Nuclear Engineering International, February 1976.

5.4. Conclusions and recommendations

The evaluation methods described herein have all been applied in practice and differ only in the way in which the technical judgements on the design features of the bids are finally expressed; either in words (qualitatively) or in monetary or other numerical values (quantitatively).

If one merely likes to determine the technical acceptability of the bids it is sufficient to limit the evaluation to words only, whereas if one would also like to determine the ranking of the bids, it is necessary to apply a quantitative bid evaluation method. The evaluation method to be applied does, however, not only depend on the aims of the evaluation but also on the experience of the evaluating team and the information available.

Whatever method is applied, clear technical judgements and recommendations should be forwarded to the decision makers. These judgements and recommendations can be equally well in verbal, numerical or monetary terms if adequate attention is paid to what these words or figures mean (risk analysis).

In the case of a quantitative evaluation expressed in money terms, careful attention has to be paid to distinguishing between cost figures of different quality (uncertainty margin). One should not just add estimated bonuses or penalties for certain kinds of design features to binding prices of bidders, as these cost figures have different certainties. One should indicate for any cost estimate which is made during an evaluation the possible uncertainties involved. In such a way one gets for each bidder cost figures with which an adequate risk analysis and a proper comparison can be made.

The numerical bid evaluation method permits a very distinct and objective judgement of the bids. The method also allows a quantitative appraisal to be made on matters such as proven design, experience with components and systems, differences in techniques, etc. It is emphasized that numerical bid evaluation still needs an interpretation of figures and a corresponding risk analysis for problem areas detected and that it is merely intended to be a tool for giving a more objective overall judgement of the bids and to be a help for pinpointing weaknesses of design.

The quality of the bid evaluation does, however, not depend on the method applied, but on the ability and experience of the engineers performing the evaluation, as well as the means available for carrying out the evaluation. The quality of the evaluation depends also on the depth to which the different evaluation criteria are investigated.

6. EVALUATION APPROACH

6.1. General

The evaluation approach is the procedure followed by the utility to evaluate the bids, e.g. if a detailed evaluation is carried out on one bid, on a limited number of preferred bids, or on all bids received.

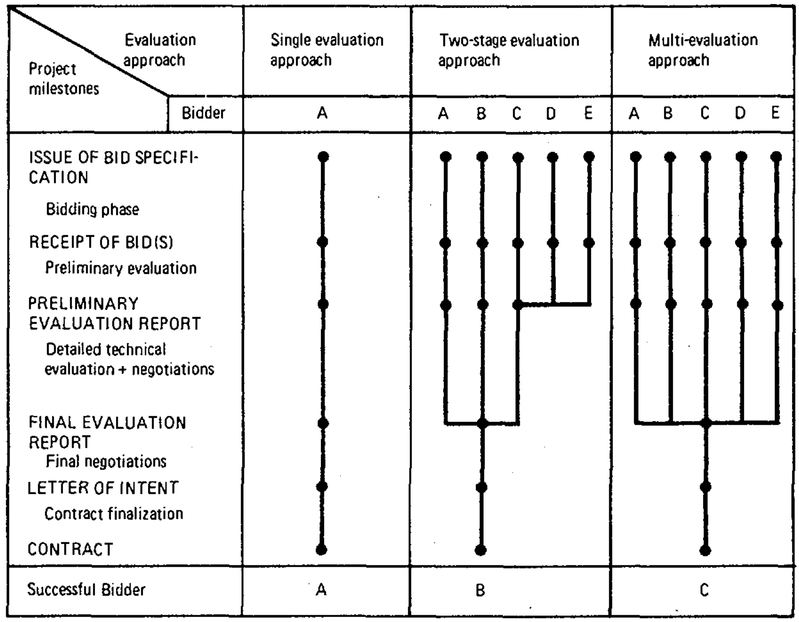

FIG.8. Schemes of evaluation approaches.

One distinguishes basically the following three types of evaluation approach which are applied for the technical evaluation of bids for nuclear power stations:

- Single evaluation approach
- Two-stage evaluation approach
- Multi-evaluation approach.

These schemes are illustrated in Fig.8.

The above evaluation approaches differ mainly in the number of bids which are evaluated in detail. The single evaluation approach is applied in the case of a negotiated contract approach with one particular bidder who, for technical and financial and/or political reasons, has been selected as the potential supplier for the station. The two-stage evaluation approach is applied in connection with an open or limited bidding competition whereby, after a first evaluation dealing only with the important features, if possible, a short-list of one to three bidders is made, who are then evaluated in more detail. A multi-evaluation approach is applied in connection with an open bidding competition and it means that all bids which have been received are considered and evaluated to the same extent.

In the following, the above evaluation approaches are described in more detail, dealing in particular with why and how a certain evaluation approach is applied.

6.2. Single evaluation approach

The reasons for a negotiated contract with a single evaluation approach can be manifold. In most instances this approach is selected for subsequent units as the utility likes to stay with the product of a certain supplier as the experiences with the supplier and/or with his product have been good, as well as for ease of operation and maintenance of the units. Operators as well as maintenance personnel can be easily exchanged between identical or similar units; the stock of spare parts need not be as large as in the case of two different units and also one can expect increased domestic participation. In the case of identical units on the same site, the technical bid evaluation is rather limited and confined to the interfaces with the previous unit(s), the parts of the unit which cannot be identical to the former one(s), scope of supply and services, as well as specific adaptation aspects due to increased safety requirements, as well as possibly differing subsoil and site conditions. Where the unit size of the subsequent unit is different from the previous one(s), other factors have also to be considered, such as layout differences, differences in equipment size and rating, as well as safety implications. Nevertheless, the technical evaluation of a bid for a subsequent unit from the same supplier on the same site can be relatively short and easy.

The evaluation of an identical or similar unit on a different site is by far more comprehensive and difficult in view of the necessary site adaptation aspects, which may require the application of different layouts, cooling water systems, foundations, seismic design criteria, etc. In such a case, the technical bid evaluation involves considerable effort, in particular as regards whether the specific site conditions have been sufficiently taken into account. This applies less to NSSS bids which are not so site-dependent, except for items such as seismicity.

In most developing countries, however, the utilities enter into a negotiated contract with a certain supplier mainly for long-term fuel supplies, or for financial or political reasons. The utility has in such a case mostly no long-standing business relationship with the supplier and does not know the technology offered by the supplier very well. These facts are basic warning signals to the utility to be very prudent and to evaluate the bid technically with great care and scrutiny in order to find out what it is buying and what might be the expected performance of the station. In the case of a certain supplier being politically acceptable and/or being able to provide financing for his supply and services, the utility should pay great attention to the bid to find out if the bid is technically acceptable or could be made acceptable and to determine that the organizational set-up for the implementation of the project is sound. Finally, the success of a project depends mainly on the technical performance of the station and its timely completion.

Depending on the circumstances, different paths can be pursued in carrying out a negotiated contract approach. However, in general, it is recommended, before starting negotiations with one vendor, to do a market survey including visits to manufacturing facilities and operating plants which are of particular interest, and to get memos of understanding with the vendors one is particularly interested in as regards costs, contract conditions, technical design features of the plant and the technology transfer they intend to offer. Any contract should then be negotiated with one of the vendors on the basis and within the framework of the corresponding memo of understanding. For such negotiations the assistance of a consultant with wide contracting experience and preferably experience with the vendor in question is recommended if the utility has had no experience with the corresponding vendor before.

In the case of a negotiated contract approach it is just as necessary for the utility to develop bid specifications as it is in open bidding competitions in order to specify what it really wants and to protect itself contractually. These specifications should preferably already be available during the first contacts with the vendor in order that the memo of understanding can partly be based on these specifications. The bidder should then submit a comprehensive bid on the basis of these bid specifications. The quality and content of such bids are generally much better, as the vendor has much more interest in the project than in the case of an open bidding competition. Due to this and the fact that only one bid is available, the utility and/or its consultant can make a much more detailed and in-depth bid evaluation, which is beneficial to the project. If a proper procedure is followed the utility knows very well what it is buying in the case of a negotiated contract approach.

The success of a negotiated contract approach depends, however, on the willingness of the parties involved to co-operate and fairness in not taking advantage of the non-competitive situation.

6.3. Two-stage evaluation approach

This evaluation approach has two distinct stages, namely a preliminary and a detailed bid evaluation phase. Upon completion of the preliminary bid evaluation phase a preselection of preferred bidders (short list) is made and a certain number of bidders are eliminated. In the detailed bid evaluation phase the preferred bid(s) is (are) evaluated in detail and in greater depth, and negotiations with the preferred bidder(s) take place. At this stage all commercial, contractual and technical matters in connection with the preferred bid(s) are evaluated and clarified so that at the end a letter of intent can be given to the successful bidder.

The two-stage evaluation approach is the normal procedure followed in the case of an open or limited bidding competition. The main reason for following this approach is to concentrate the bid evaluation on those bids one is really interested in. With this approach the preliminary bid evaluation phase is a very important phase of the evaluation period. In this case, the preliminary bid evaluation phase is concluded with a report which is conclusive as regards the selection of the preferred bid(s). This means that the bids must have been compared and evaluated with regard to all main commercial, contractual and technical conditions. The technical evaluation of the bids at this stage must cover:

- General compliance with the bid specifications and adequacy of the information provided with the bid
- Scope of the bids
- Main design parameters
- Experience of the bidders and the operating experiences with units built by the bidders
- Main new and unproven features and equipment included in the bid
- General safety philosophies applied
- Willingness regarding transfer of technology
- Problems related to the fuel cycle.

The main outcome of this preliminary technical evaluation is a judgement on which of the bids are technically acceptable, and which ones are evaluated as the preferred bids. Further, the scope of supply and services must be checked in order to compare the bid prices. This first phase of the evaluation might take one to two months from receipt of the bids, as a minimum.

The detailed technical bid evaluation of the preferred bid(s) is the more comprehensive part of the bid evaluation, in which all details of the bid are evaluated according to the evaluation logics on scope and technical design as outlined in Section 5. This part of the evaluation includes also the issue of questionnaires, the evaluation of answers to questionnaires, as well as the negotiations with the preferred bidder(s), and the preparation of a final evaluation report. This second phase might take five to six months, as a minumum, so that the total time required for the bid evaluation might take at least six to eight months.

The number of preferred bids retained for detailed evaluation might range from one to three depending on the circumstances and the results of the preliminary bid evaluation. If only one bid is retained for detailed evaluation, one comes very close to a bid evaluation as in the case of a negotiated contract approach. An advantage is that on one hand great attention can be paid to the evaluation of this bid, whereas, on the other hand, one loses some bargaining power, in particular, as regards costs and contractual conditions. This can, however, only be done if the preliminary bid evaluation shows clear advantages for one particular bid. In most instances this preselection is not so clear and, generally, it is preferable to retain two or three bids for detailed evaluation.

6.4. Multi-evaluation approach

The multi-evaluation approach is applied in the case of an open bidding competition if no preselection or elimination of bids can be decided upon after the preliminary bid evaluation phase. In this case, all bids are evaluated in detail and kept in the running during most of the bid evaluation period, possibly even up to the point of the issue of the letter of intent to the successful bidder.

The reasons for a multi-evaluation approach can be the following:

- The preliminary bid evaluation does not show meaningful differences between the bids.
- The financial plans are still not settled, i.e. no firm financing plans are available.
- Uncertainty as regards political acceptance of the bids and involvement of local industry and engineering.

It is clear that meaningful differences, either in costs, schedules or technical features must be determined during the preliminary bid evaluation phase in order to eliminate bids. Since the costs involved in the preparation of bids are quite considerable a certain fairness should exist on the side of the utility to perform a proper evaluation before a bid is excluded. In cases where the differences between the bids are not great, it might be justified to keep all bids at least during a part of the detailed bid evaluation phase in the running. It is, however, recommended to limit the number of bids for detailed bid evaluation as much as possible, in order not to divert all means and efforts for this evaluation on too many bids.

Long-term fuel supplies, financial and political reasons are, in developing countries, the most important reasons for applying a multi-evaluation approach. These are, however, mainly non-technical reasons which can be avoided if the matter is taken up and studied, if possible, beforehand. The utility might then well come to the conclusion that it is not worth while to have an open bidding competition but to have a limited bidding competition of preferred bidders who are selected on the basis of the financing terms they can offer, their political acceptability and their willingness to co-operate with local industry and engineers, as well as the technical features of their plant design.

The multi-evaluation approach has also a preliminary and a detailed evaluation phase as in all other cases, but the differences is that in this case all bids are retained for detailed bid evaluation. It is obvious that, if one would like to get to the same detail and depth, much more time, money and manpower must be made available for a multi-evaluation approach.

6.5. Conclusions and recommendations

The single and two-stage evaluation approach allow a more detailed bid evaluation than the multi-evaluation approach. The questionnaires can be much more thorough, which leads to a better defined contract with fewer extras at a later date. Further, the bidders know very well that they are going to be asked for extra design features, or for cost reductions, or both, during the negotiations, and they enter these negotiations with a pretty clear picture of what is negotiable. Experience shows that a well-prepared negotiator can get advantageous conditions even in a single evaluation approach. It is probable that the bidder will put much more effort into answering a questionnaire fully and satisfactorily if he knows that he has a real chance of a contract, than if he knows he is only one of half a dozen being asked similar questions. Further, in the case of a two-stage evaluation approach, the utility has also the possibility, if one bidder does not negotiate to the satisfaction of the utility, to concentrate more on another bidder.

The main question of the two-stage evaluation approach is whether within a relatively short time (one or two months) after receipt of the bids a meaningful selection from the bidders can be made. It can be difficult, in particular, in cases where financing and political aspects play an important part in the final selection of the bidders. If no clear arrangements or decisions have been made with regard to these aspects beforehand, it might be obligatory to consider almost all bidders for further detailed evaluation and negotiations.

All evaluation approaches, but in particular the multi-evaluation approach, require a comprehensive involvement of the utility and its consultant during the evaluation and negotiation time. To obtain low prices and more willingness to meet the special wishes of the owner it is better to keep sufficient competition up to the letter of intent stage. On the other hand, this is a more time-consuming procedure and it may lead to less well defined contracts because the attention of the utility is devoted to more than one bid.

The recommendation is to apply, if possible, a two-stage evaluation approach and to limit the detailed evaluation and negotiations to two, at the most three, bids. If a utility has to go in for a single evaluation approach, this could be, under certain circumstances, just as good but in this case it would be desirable to engage a consultant who is technically and contractually very familiar with bids and contracts of the corresponding supplier for other projects.

7. PREPARATION AND ORGANIZATION

7.1. General

The technical bid evaluation has to be planned as part of the overall bid evaluation and as part of the overall project schedule.

The work required to prepare and organize the technical evaluation of bids for nuclear power projects comprises:

- Establishment of the evaluation method and approach
- Preparation of a time schedule for the whole evaluation period
- Preparation of an evaluation form and other standard forms
- Organization and instruction of the evaluation team.

The problems related to the establishment of the evaluation method and approach have been described in the previous Sections, 5 and 6. The other topics are dealt with in the following subsections. Also, the use and set-up of a bid evaluation manual is discussed which is a guide for all persons engaged in the evaluation of the bids.

Further, the use of consultants is discussed, as for this important and difficult task consultants are often asked to carry out or to assist the utility in the bid evaluation and the negotiations with the bidders.

It is important that for the preparation and organization of the bid evaluation sufficient time is available and that one can start with the evaluation as soon as the bids have been received. The time required for this preparation depends very much on the experience available but is at least two months. The survey referred to in Section 3.6, and which is also considered as a preparation for the actual bid evaluation, should be carried out over the whole time that the bidders prepare their bids.

7.2. Scheduling of the bid evaluation

The time required for the technical bid evaluation, i.e. the time from receipt of the bids up to the submission of a final evaluation report, amounts, at least for a turnkey bid, to six to eight months and for a NSSS bid to four to five months. Utilities in countries which are rather remote from the countries of the bidders and/or which are rather new in the field (first nuclear project) must recognize that they need more time, even if they have the backing of a well-experienced consultant. Depending upon the circumstances it might well be that the times referred to above need to be extended by two to four months. This is, in particular, valid in cases in which a multi-evaluation approach is applied (see Section 6.4).

A typical time schedule for a bid evaluation for a turnkey project is shown in Fig. 9.

The evaluation of the economic and contractual aspects may need more time, in particular in cases where the negotiations with the preferred bidder(s) are difficult or outside circumstances (political, financial or other) delay the completion of final negotiations.

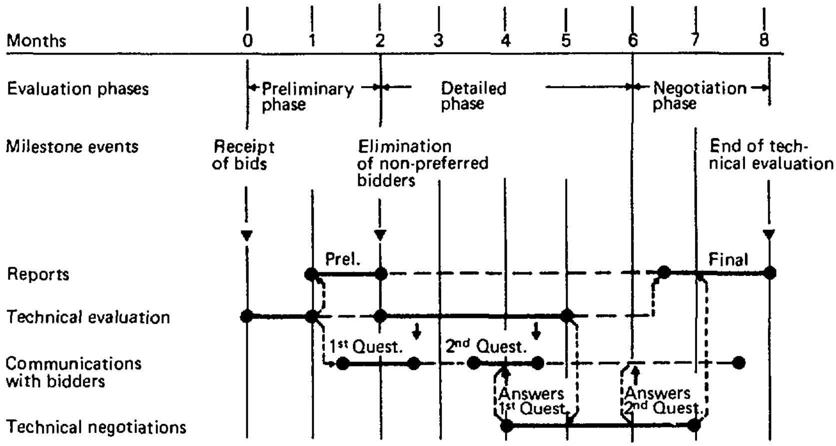

FIG.9. Typical time schedule for a technical bid evaluation for an experienced utility.

The above schedule is drawn up for an eight months' evaluation period which is felt to be realistic if the evaluation itself is well prepared and organized and if the bidders can respond to the questionnaires within six weeks as indicated above and are sufficiently available for the negotiations at the end of the evaluation period. A six months' schedule can only be obtained if the utility has already sufficient experience from previous projects and the preferred bidders react reasonably fast. The bidders have, in general, an interest to get a letter of intent on conditions which leave sufficient scope for interpretation. It is more in the interest of the owner than the bidder to agree upon things before the letter of intent. Therefore, in most instances the bidders are not prepared to commit themselves as regards the most crucial items of the negotiations too soon, in the expectation that the utility, under the pressure of schedules and other commitments, will place a letter of intent before the most important items have been settled. The utility should, in this respect, make it clear to the preferred bidder what conditions should be met and settled before a letter of intent can be issued. It is in particular the negotiation phase of the overall bid evaluation period which carries most uncertainties as regards timely completion. It needs, for this phase, a very rigid programme of meetings planned sufficiently in advance with clear agendas in order to keep the schedule.

For utilities who have complicated purchasing procedures and/or need governmental approval for placing a letter of intent, appropriate time provisions must be made to cope with these constraints and adequate planning must be done to limit the consequences of such constraints.

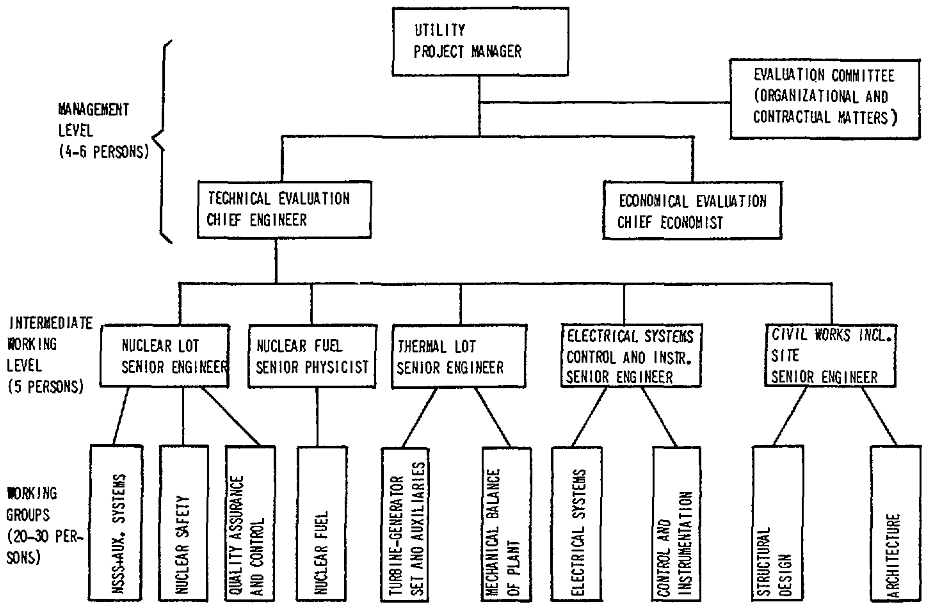

FIG.10. Organizational set-up of an evaluation team for a turnkey project.

Bid evaluations for NSSS require a comparative total plant evaluation to determine the technical features of the unit offered which determine overall plant costs. For this reason the total time required for the evaluation will be similar to that for the turnkey project.

7.3. Organization and manpower requirements

The organizational set-up for implementing the bid evaluation must be as clear as possible. An example of such an organization for the evaluation of bids for a turnkey project is shown in Fig. 10.

The composition of the evaluation team should be a suitable mixture of engineers, physicists, economists and lawyers, whereby the persons at the management and intermediate level (about ten) should have sufficient experience on similar large-scale industrial projects.

The evaluation team consists of a number of working groups, each responsible for a part of the bid evaluation. The responsibility of each group must be well defined and, in particular, the interfaces and interrelationships between the groups. Each group must be headed by a group leader who is responsible for the work within his group as well as for the co-ordination of the work with other groups.

In addition to the working groups referred to above, one can have so-called evaluation and purchasing committees judging the work carried out by the corresponding evaluation groups and which must approve the proposals made by the groups as to how to proceed and whom to select.

The composition and size of these working groups has to be adapted to the disciplines and work load to be covered. At the management level it is important that people of different disciplines and professions are represented. This is especially the case in the evaluation committee, which could deal with organizational and contractual matters in which engineers, lawyers and economists should participate.

The engineers at the intermediate working level have more co-ordinative and general project-oriented tasks. Next to the co-ordination of the working groups they are also responsible for the evaluation of aspects which are of a more general nature which cannot properly be covered by one of the more specialized groups, such as overall station layout, scope of supply and services, as well as balance-of-plant costs. These engineers could also be responsible for the organizational aspects as described in subsection 4.3.4. For the latter, one can, however, also use members of the evaluation committee who report directly to the project manager. This solution is generally preferred but it depends on the personnel available for this work.

In the group for the economic bid evaluation, an engineer should participate who also plays a major role in the technical bid evaluation.

The number of personnel involved in a bid evaluation depends on the time available for carrying out the evaluation, the number of bids and scope of the bids, but also on the experience of the personnel available and the depth to which this evaluation is carried out. The total number of personnel required can be limited to 30 to 40 people. Eight to ten persons would be fully devoted to this work during the whole bid evaluation period, twelve to fifteen persons during 50 to 60% of the time, whereas the rest would be involved less than 30% of the time. The total man-power involvement for a comprehensive turnkey bid evaluation amounts to 100–150 man-months if the total bid evaluation period, including the time for the negotiations, can be kept to a six to eight months' schedule. The manpower involvement for the evaluation of bids for a part of the plant, such as a NSSS or Nuclear Island, is smaller, but if one takes the total effort involved in evaluating all the bids required for a multi-package approach or a split-package approach, as well as the additional costs for estimating the balance-of-plant costs, one ends up with figures which are considerably higher than for a turnkey project.

The composition of the bid evaluation team should cover the following disciplines:

- Twelve to fifteen mechanical engineers of whom three or four should have at least ten years' industrial experience

- Five or six civil engineers of whom one or two should have at least ten years' industrial experience
- Eight to ten electrical engineers of whom two or three should have at least ten years' industrial experience
- Two or three physicists with five years' experience in the nuclear field
- Two to three experienced economists
- One or two lawyers with wide-ranging industrial experience.

The organizational set-up of evaluating teams for non-turnkey projects is largely the same as presented for a turnkey project with the difference that, depending on the scope of the bid, some of the technical groups would drop out, whereas on the other hand a particular group for the determination of balance-of-plant costs might be created, as this is a much bigger task in the case of a non-turnkey project. The number of people on most of the groups might, however, be reduced, depending on the scope of the bids.

7.4. Division of work and basic responsibilities

In order to define exactly the scope of work of each working group, as well as of the individual persons working within these groups, one has to divide the lot into items which can be evaluated and which are judged to be important enough to be evaluated independently by individual persons or small groups of persons.

In this context, reference is made to subsection 4.3.3, in which the different items and levels of the evaluation are described and indicated. An example of a division of work for a nuclear lot is shown in Appendix 1.

In the division of work one has to indicate the person(s) who is (are) basically responsible for a main part, as well as for the individual items of the bid evaluation. Each person who is responsible for a certain aspect of the evaluation must study the bids in this respect and complete bid evaluation forms for the different bids considered for detailed evaluation.

The number of individual items into which the bids are divided depends on the scope of the bids and the degree of division, but in the case of bids for turnkey projects one has normally 100–150 items, and for a nuclear lot only approximately 40–50 items.

7.5. Bid evaluation form and other standard forms

Standard bid evaluation forms and other forms should be prepared in such a way as to facilitate a co-ordinated and consistent approach for the different persons working on the evaluation. An example of such a bid evaluation form is to be found in Appendix 3.

The bid evaluation form must be worked out very carefully, to assure that it covers all aspects of the evaluation in sufficient depth and that the form is well understood and properly used. The forms are used for all important components and systems of the bid, as well as for all general technical aspects of the bid which are evaluated. The form shall be filled in by the engineer(s) responsible for the detailed evaluation of the corresponding component or system and be reviewed and approved by a supervising engineer who forwards the forms to the engineer carrying the overall responsibility for the technical bid evaluation.

The bid evaluation form must provide sections for the following:

- The information in the bid reviewed and evaluated
- A general summary of the evaluation
- The comments of the bidder on the bid specifications
- Comments regarding the scope and limits of supply and services
- Comments regarding the compliance of technical design with the bid specifications (including risk assessments)
- Co-ordination matters.

The bid evaluation form must contain also a section on overall system evaluation, in which the evaluation engineer has to assess the importance of the system or component with regard to overall plant operation and plant safety. Further, an overall judgement should be made on the reliability, performance, safety and other features of the object evaluated. Further, the bid evaluation form should include a section where recommendations can be made with respect to possible design changes. The form should also have a section where questions can be put with regard to the corresponding main component or system and which will be the basis for the preparation of the questionnaire for the corresponding bidder. In some cases it might be required that the evaluation engineer make proposals for a revision of the bid specifications owing to the peculiarities of the main component or system offered.

Other standard evaluation forms which might be developed are:

- Forms to check if the bids include all the information requested in the bid specifications
- Forms to check if the scope of supply and services offered is the same as requested in the bid specifications
- Comparative tables for technical data to be included in evaluation reports
- Forms for questionnaires, attendance lists, etc., etc.

7.6. Bid evaluation manual

Bid evaluation procedures are best summarized in a manual to inform each person involved in the evaluation about his basic responsibilities and to give him the necessary background information, in order that the work is done in an appropriate and expeditious manner. The bid evaluation manual is a guide to be used by all engineers involved in the bid evaluation. At the same time, it is a checklist for the persons responsible for the evaluation that all necessary aspects have been organized and prepared.

The manual should cover the overall bid evaluation, including commercial, contractual, organizational and technical matters. It is necessary that the evaluation manual be worked out together with all parties and key personnel involved in the bid evaluation.

The bid evaluation manual should cover the following information:

- A list of the bids which will be received with a short description of the scope requested in the bid specifications
- A brief description of the evaluation method and approach which will be applied
- The organizational set-up for carrying out the evaluation
- The overall schedule for the evaluation of the bids with an indication of the time at which various reports, questionnaires, etc. need to be ready
- A list and brief description of the documents which shall form the basis for carrying out the technical evaluation
- An explanation and, if possible, an example of the bid evaluation form which will be applied for the technical evaluation
- The division of work and basic responsibilities for carrying out the evaluation.

All items to be covered in the manual have been described in the previous sections of this guidebook. One basic requirement for organizing and preparing the evaluation is to know how many bids will be received and for what type of equipment. For this purpose it is usual to ask the potential bidders within one month after receipt of the bid specifications to confirm if they will submit a bid or not. The bidder could give, at that time, also the standard information normally available.

An important aspect also is the formation and instruction of the evaluation team. In preparing the manual and setting up the organization of the team adequate attention has to be paid to the availability of the personnel at the time that this is required. The evaluation manual is the main tool for instructing people carrying out the bid evaluation. The instructions required depend on the experience of the team doing the bid evaluation, and if the evaluation method applied is well-known or not. As the number of bid evaluations carried out by most organizations is rather limited and the work itself will never become a routine job, it is necessary that sufficient attention is paid to informing and instructing the people involved.

7.7. Use of consultants

In judging the need for a consultant one has to evaluate own in-house engineering capability, experience and availability at the utility, as well as the importance and weight one gives to this activity. The means and efforts which should be made available for doing a technical bid evaluation should be in line with the costs of such projects. If one handles a project of costs equivalent to 1000 million US$, one should realize the size and risks of such projects and give corresponding weight to the bid evaluation activity. Also, the in-house engineering know-how should be evaluated accordingly.

In most cases, the utility will call upon the help of a consultant who has wide knowledge of the designs and services being offered by the corresponding bidders. If the utility has a few engineers with sufficient experience in the nuclear field, it might be recommendable to include those engineers in the team of the consultant in order that they get full inside knowledge as to the way in which such an evaluation is organized and to what kind of depth the technical evaluation has been carried out. The learning effect, if these engineers of the utility work in the team of the consultant, is certainly very great and is a good basis for assisting in or carrying out the technical negotiations with the bidders. If no nuclear experience is available at the utility, it might be that the utility is restricting itself to a supervisory role and checks the work of the consultant. Alternatively, in such a situation it may be better for the utility to conduct its own evaluation in parallel with that of the consultant and to compare its results with those of the consultant.

The basic requirements for a consultant appointed for bid evaluation purposes and in general for preliminary engineering services on a nuclear project (from preliminary studies up to the conclusion of the main contracts) are the following:

- Wide nuclear experience on different reactor types and with different bidders in his own country and abroad
- Sufficient and good references as regards such preliminary engineering services
- Good knowledge of different safety regulations and philosophies followed in different countries
- No ties nor relations with particular bidders which could interfere with an objective judgement.

Apart from the above references, it is important to evaluate the qualifications of the professionals who the consultant can assign to the job, as any consulting service depends more on the persons than on the corresponding consulting engineering company engaged for the job.

If a utility has experience from a sufficient number of earlier projects, it might decide to do the evaluation largely itself and to call upon a consultant for specialized assistance or for a review of the evaluation work carried out by the utility. The assistance which will be given in such cases will mainly be on new or particular features of some bids or on the evaluation of a bidder whom the utility does not know very well. Also, very experienced utilities call, from time to time, upon the assistance of a consultant for the evaluation of main systems with the help of system reliability analysis methods which certain consultants have developed.

The use of consultants is generally recommended for this important project activity, even in cases where nuclear experience is available within the utility. Generally the number of bid evaluations and negotations with bidders carried out by utilities is very limited and in order to counterbalance the ability and experience of the bidders, who go from one bidding to another, it is advisable to call upon an experienced consultant who knows the market situation, as well as having been involved in a sufficient number of other projects.

Utilities with no nuclear experience should not try to do the evaluation and related project engineering work themselves, as this 'learning by doing' means 'learning by mistakes'. Nuclear projects are simply too large and too costly for mistakes to be affordable. The utility should largely rely upon the services of an experienced consultant and follow the strategy of 'learning by reviewing', and closely working with the consultant in order to learn as much as possible from his work and from discussions with him and the bidders.

For utilities with some nuclear experience the utility and the consultant could form a common evaluation team, where the lead could be either with the utility or the consultant, depending on the personnel available and the experience gained in earlier projects.

In the long run the utility should develop sufficient engineering know-how to carry out the evaluation largely by itself. Any consultancy assistance would only be required in certain areas as referred to above.

An important aspect is also *where* the evaluation is carried out. It can be either in the offices of the consultant or of the utility. In cases where the consultant is largely responsible for the work it should be in the offices of the consultant, as it would be too costly and too difficult to relocate too many persons. Further, the quality of the evaluation suffers if the work is not carried out in the offices of the consultant as expertise from other persons cannot so easily be asked for. In such cases staff of the utility should be sent to the offices of the consultant to be directly involved in the work. It must be emphasized that this personnel must receive meaningful responsibilities.

In the case of a common effort between utility and consultant one should perhaps agree upon one working place for the whole evaluation team, as this is necessary for the day-to-day co-ordination which is required. If this is not possible, one should make a division of work which will enable the work to be carried out at different places. Experience with this kind of arrangement shows, nevertheless, that this is generally not so good either for the quality of the work, or from the point of view of the learning effect which the utility likes to obtain. In deciding upon a common working place, the relative location as regards distance and communications with the bidders has also to be taken into account. For utilities with experience in conventional power stations it would be meaningful to carry out the turbine lot evaluation at the utility and the nuclear lot evaluation at the consultant's offices.

Consultancy on special matters can be carried out at the offices of the consultant with occasional visits to the utility or could, depending on the work and time involved, be directly carried out in the offices of the utility.

8. IMPLEMENTATION OF THE TECHNICAL BID EVALUATION WORK

8.1. General

The technical bid evaluation starts with the receipt of the bids and ends with the final evaluation report. The most important activities during the bid evaluation phase are the following:

- Receipt and opening of the bids
- Preliminary bid evaluation and preparation of preliminary bid evaluation report
- Detailed bid evaluation
- Preparation of questionnaires
- Negotiations
- Preparation of input data for the economic bid evaluation including balance-of-plant (BOP) cost estimate
- Preparation of final evaluation report.

The above activities are discussed in detail in the following subsections, with the exception of the negotiations, which are dealt with separately in Section 11. The intention has been to describe 'what is done by whom' during the evaluation phase and to indicate 'how it should be done'.

Although some guidance is given for carrying out the evaluation, it cannot be the aim of this Section to give detailed technical instructions for making a technical bid evaluation. For a detailed technical evaluation one needs a team of experienced engineers covering all engineering fields of the bids.

8.2. Receipt and opening of bids

The bids are usually received sealed and packed at a certain address before the bid closing date or any other date agreed upon with the bidders. The number of copies of the bid document as requested by the utility are usually provided by the bidders free of charge, i.e. all costs associated with the preparation and submittal of the bid are for the account of the bidder. It is recommended to ask for a sufficient number of copies taking into account the number of people involved during the evaluation. The number of copies usually asked for ranges from six to ten sets of bid documents. Each set may comprise 10–15 volumes so that the total number of volumes received per bid amounts, on average, to approximately 100. In order not to mix these documents it is necessary that all bid documents are marked by set and volume in order that they can be clearly identified. It can also be useful to renumber the pages of the bids with simple consecutive numbers throughout the different bid volumes in order to facilitate the identification of individual pages as the page numbering systems applied by the bidders are sometimes difficult and misleading. The latter must, however, be done very carefully and is not absolutely necessary.

The available sets of bid documents are then distributed to the key persons involved in the evaluation who should sign for receipt and be responsible for these bid documents. It is recommended to keep at least one or two sets of bid documents in reserve and untouched in order to have always reference documents which one can use later if one is not sure about the completeness of a document or if there is a real need for another copy. The persons who receive a set of bid documents should confirm with their signature the receipt of these documents and should acknowledge the confidential nature of such documents and pledge themselves not to copy these documents nor disclose the content of these bids to third parties.

A similar confirmation should also be obtained from all persons having access to these documents as the confidential nature of these documents should be preserved. This is an obligation of the utility towards the bidder.

It is usual that bid prices, payment conditions and other important commercial conditions are submitted under a separate sealed cover and, unless it is a custom of the utility to open these covers in public, it is not recommended to inform the engineers working on the technical bid evaluation as regards the bid prices. It is in the interest of the utility to keep the price information as secret as possible in order not to disturb the technical bid evaluation and future negotiations. Access to bid prices should not be the basis for ranking at the bid opening, as evaluation factors will likely change the course of the evaluation.

8.3. Preliminary bid evaluation

The purpose of the preliminary bid evaluation which takes place in the first four to eight weeks (minimum) after the receipt of the bids is to get a good picture of the bids within a reasonably short time. The aims of this first evaluation are, however, partly dependent on the kind of evaluation approach selected for the evaluation.

In the case of a single or multi-evaluation approach (see Section 6) the aims of this evaluation phase are to scan the bids as regards the completeness of the information submitted with the bid, to check the scope of supply and services and to evaluate the main design features of the unit offered. This preliminary evaluation is carried out to see if the bid complies in general terms with the bid specifications, what kind of information has still to be asked from the bidders and if revisions as regards scope of supply have to be requested.

In the case of a two-stage evaluation approach the results of this evaluation phase must be much more conclusive, as the number of bids which are considered for further evaluation must be reduced, i.e. a number of bids must be eliminated. For the two-stage evaluation approach one has in addition to the points mentioned before for the single and multi-evaluation approach to include the following points during the preliminary bid evaluation phase:

- An evaluation of the licensability of the reactors, an estimate of any significant cost increases which would be involved in ensuring licensability, and an evaluation of any licensing doubts which might remain when a contract is awarded and which might, therefore, affect the schedule
- An evaluation of the novelty of the design, the extent to which it is based on previous proven designs, the experience of the manufacturers and, derived, from these factors, a view on the reliability and availability of the plant
- An identification of any significant costs involved in modifying the plant to meet important requirements of the utility
- Problems related to the fuel cycle.

In the case of different bids for the reactor and the turbine plant, any significant incompatibility between the reactor and turbine bids must be identified. In such a case, an overall economic evaluation must be made, whereby reference plant designs (see Section 4.4), developed by the utility before the bidding competition, should be a help to define station designs for each combination of a reactor bid with a reference turbine. An estimate is then made of the costs of the civil works and all other equipment not included in the bid. An overall corrected station capital cost is thus defined and used to compute the relative economic merits of the bids. In this case more time is required for this activity.

In parallel to the preliminary technical evaluation, a preliminary economic and contractual evaluation is carried out as well. Based on the preliminary economic, contractual and technical bid evaluation, together with other main aspects such as long-term fuel supplies, financing, political aspects, as well as domestic participation, the bids should be ranked in order of attractiveness and the differences examined to see whether likely differentials in such factors as expected availability, potential licensing or other delays, the bidder's known practices in demanding reimbursement of cost extras, etc., are liable to change the ranking. If this process identifies bids with important drawbacks compared to the others, then these bids should be eliminated and not be considered any more for a more detailed evaluation.

The preliminary bid evaluation is carried out by the senior engineers of the evaluation team, whereas the other engineers of the team use their time to get acquainted with the bid and give support as required. The number of key persons involved is limited to six, maximum eight, who cover all aspects of the bid. In case specialized expertise is required, experts in the field are asked to give their opinion on specific aspects. This preliminary evaluation permits the senior engineers also to guide and supervise the detailed evaluation in a more effective manner. As they conduct this preliminary evaluation they will become quite familiar with the content of the bids, the scope of supply and services as well as design features offered.

8.4. Preliminary bid evaluation report

The results of this first phase of the evaluation are laid down in a preliminary bid evaluation report – also referred to as bid opening report – which for the two-stage evaluation approach should contain the following information as regards the technical aspects of the bids:

- Basis, objectives and scope of the report
- Background information on bidders
- Technical summary of each bid, including any unproven features, if any
- Conformity of the bids with the bid specifications
- Scope and limits of supply and services, as well as a costing of deviations
- Main technical data of the bids
- Conclusions and recommendations.

For the two-stage evaluation approach one has to issue also a preliminary report on the commercial and contractual items in order to be able to eliminate a number of bids.

In the case of non-turnkey projects also the compatibility of the nuclear lot or nuclear island bids with the turbine lot or turbine island bids has to be dealt with in the report.

The section on background information of the bidders should deal with the information collected in the survey of the potential bidders (see Section 3.6) and should give special emphasis to those points which are doubtful and which must still be clarified.

The technical summary of the bids should only highlight the most important aspects, such as comments on output, new design features, layout, safety standards and regulations, containment design and fuel. The evaluation as regards the conformity of the bids with the bid specifications is mainly to spot deviations from the bid specifications and missing information in the bid. This can be carried out with detailed checklists in which all information is listed which has been asked for in the bid specifications. Also the scope of supply and services is checked in a general way in order to be able to compare mainly the bid prices. This preliminary evaluation of the scope of supply and services can be carried out with checklists. If no time and information is available for costing surplus or deficit materials accurately, it might be sufficient, at this stage of the evaluation, to classify these items by estimating only the order of magnitude of the corresponding costs, e.g.:

Low class:	below \$ 0.2 million
Medium class:	between \$ 0.2 to 1 million
High class:	above \$ 1 million.

Only for items belonging to the high class should a preliminary estimate of the actual costs be made. Mostly there are many items in the bid which should be included in the scope but which cannot be explicitly identified as being included. These so-called undefined items might in total represent higher costs than the total cost deviations established by estimating the deficit and surplus items. One has to be extremely careful in this respect and it is therefore recommended to make also a preliminary estimate of undefined items in order to see how they compare with the other cost corrections made for the deficit and surplus materials. In the case of an undefined item one should, in a first instance, always assume that it is a deficit item and verify with the bidder if this is the case or not.

The main technical data which are compared in a preliminary evaluation report are at least the following:

– Power output of the core and the reactor

- Gross and net electrical output of the power station
- Power consumption of the auxiliaries
- Heat rate
- Steam conditions (flow, pressure, temperature and moisture content)
- Feedwater conditions (flow, pressure and temperature)
- Water inventories
- Number of main items (number of loops, control rods, fuel assemblies, steam generators, turbines, LP casings, feed heaters, feedwater pumps)
- Reactor core data (fuel enrichment, burn-up, power density, heat flux)
- Turbine speed
- Condenser pressure
- Feed pump drive
- Nominal rating of generator
- Power factor
- Short-circuit ratio.

It is important to indicate in the report how the bidder has qualified in his bid the information supplied, i.e. if the data are guaranteed, binding, preliminary or given for information only. This is not only important for the technical data provided, but also for all other information submitted with the bid.

In the case of a two-stage evaluation approach, the report should also contain the points specifically referred to in Section 8.3, i.e. an evaluation of the licensability of the reactors, a view on the reliability and availability of the plant and any significant costs involved in modifying the plant to meet important requirements of the utility.

The preliminary evaluation report is made on the basis of a first review of the bids received. The outcome of this preliminary evaluation largely depends on the familiarity of the persons involved in this work with bids of the bidders, in having general knowledge of the background and the organization which has been preparing the bid and in knowing the plants which have been constructed and/or engineered by the bidder.

The evaluation logics referred to in Section 5 are only applied in general terms during the preliminary bid evaluation phase. The detailed application of these logics as well as of the bid evaluation forms for main technical aspects, systems and main components, is only foreseen for the detailed evaluation of the bids.

8.5. Detailed bid evaluation phase

Stage two of the evaluation consists of a very careful and detailed evaluation of the preferred bids or the bids still under consideration. The aim of this stage is to get a better understanding of the bids allowing a proper judgement to be made on the anticipated performance and to spot inadequate design features and uncertainties as regards the scope and limits of supply and services.

The detailed technical bid evaluation is to be carried out according to evaluation logics shown in Figs 5 and 7 of Section 5 and the division of work and basic responsibilities as laid down for this evaluation (see Section 6.4). This phase of the work lasts at least three to four months and involves a large number of persons. During this phase questionnaires to the bidders are prepared and issued and first answers are received. Towards the end of this phase the technical negotiations with the bidders start. For this work it is advantageous to make use of a bid evaluation form and other standard forms prepared for this purpose.

The detailed technical evaluation of the design features of the equipment offered covers in particular the following items:

Compliance with bid specifications

- Evaluation as to whether the requirements of the bid specifications can be met by the design offered in the bid, particularly in view of evaluation criteria referred to hereafter. Careful attention has to be paid to that section of the bid which is dealing with the exceptions which the bidder is making with regard to the requirements of the utility as indicated in the bid specifications.

Reliability

- Whether the design is likely to provide inherent reliability
- Spare capacity and redundancy features
- Design margins and features of components
- Proven components and systems.

System function and performance

- System capacities and flows, etc., and the resulting functional performance
- Comparison with similar systems by the same bidder on other projects
- Suitability of systems for all operating modes, i.e. start-up, shut-down, part and full-load operation, normal and abnormal load changes

- Control of systems
- Effects of possible faults on other systems.

Safety considerations

- Investigations whether the system or item is related to nuclear safety with the corresponding component classification (quality group and safety classification)
- Comments on physical separation and redundancy features
- Any areas of non-compliance with licensing authority requirements
- Protection against internal and external impacts, such as missiles, flooding, etc.
- Seismic design considerations
- Other safety aspects, including fire protection and potential hazards to operating staff
- Items of current concern.

Operation and maintenance

- Accessibility for removal and repair
- Operation and maintenance considerations including in-service inspection
- Personnel exposure to radiation
- Radioactivity levels and releases
- Logic of layout, considering pipework and cable runs
- Testability
- Interference with neighbouring equipment.

Material

- Suitability for the application
- Any corrosion, corrosion product and/or erosion difficulties during design life
- Experience with the materials on other projects
- Radiation resistance.

Codes and standards

- Examination of the codes and standards which the bidder has indicated in his bid for the structure, component or system to be evaluated
- Review of compliance of the codes and standards with the general requirements as specified in the bid specifications.

Testing

- Review of the extent of testing proposed by the bidder and a check if this is in compliance with the bid specifications.

Interface aspects

- Check of all interfaces between the system or component and other lots, considering physical and functional aspects.

Upon completion of the detailed evaluation of a system or main component the evaluation engineer shall summarize his findings in such a way that these can be incorporated in an overall evaluation report. This summary is intended to give concise information on the main components and systems to the engineers who are responsible for the negotiations with the bidders. The summaries to be prepared should cover the following aspects:

- Overall judgement whether the main component or system evaluated is good, satisfactory, etc.; these overall judgements should be based on the separate evaluation of the different technical aspects dealt with before, bearing in mind the relative importance of the different aspects considered
- Statement whether the design is typical or unusual, bearing in mind the practice of this and other bidders
- Indication of any major deficiencies
- Statement if the evaluation has been limited by a lack of information in the bid, highlighting any particular areas where further information would be required
- Any recommendations which can be made to the owner on improvement or simplification of design
- Proposals for adapting bid specification.

All these summary evaluations of the different main components and systems must be taken up in the evaluation report, which will be the basis for the final selection of the successful bidder.

The evaluation of the scope and limits of supply is carried out on the basis of the scope lists provided in the bid, as well as other technical documentation included in the bid according to the guidelines given in Section 5.2.

Cost estimates must be made on any deficit or surplus items compared to the scope and limit of supply as specified in the bid specifications.

In evaluating the scope and limits of supply it is advantageous to make use of comprehensive check lists in the format of the scope lists (see Fig. 6 in Section 5) and to make, in particular, for comprehensive and turnkey contracts a division into:

- Supplies and services during construction
- Permanent supplies and services
- Other services and documents
- Limits of supply
- Alternatives
- Options.

The results of the detailed technical evaluation should be checked by supervising engineers and be submitted in a clear and uniform way (bid evaluation forms and other standard forms) to the engineers responsible for co-ordination and direction of the technical bid evaluation. The results are required to prepare the following:

- Second questionnaire
- Final evaluation report
- Input data for the economic bid evaluation.

The results of the detailed technical bid evaluation are further a basis for the responsible engineers to start the negotiations with the bidders and to initiate any co-ordination required between the different technical groups and other groups of the bid evaluation team.

8.6. Questionnaires

Questionnaires are prepared by the evaluation team during the bid evaluation period covering commercial and technical matters. The aims of the questionnaires which are sent to the bidders are:

- To clarify any uncertainties in the bid as regards scope, technical design features and conditions of contract, clarifying at the same time the position of the utility on the most important aspects

- To suggest to the bidder that he improves or simplifies his design, whenever appropriate

- To ask the cost of deficit or surplus material or any options or alternatives the utility would like to consider
- To ask the bidder to provide missing and/or supplementary information.

One should try to combine the questions to the bidders in a limited number of questionnaires which are sent to the bidders at regular intervals during the bid evaluation period.

The first questionnaire is usually issued directly after the preliminary bid evaluation phase. This questionnaire, which can be ready in six to eight weeks after the receipt of the bids, deals mainly with requests for additional information, matters of scope of supply and services and more general technical matters.

The questionnaires need to be prepared with care in order not to ask things which are clearly described in the bid or which are irrelevant. Questionnaires should be prepared on an individual basis (not necessarily the same questions to all bidders).

One should bear in mind that the kind of questions put forward will indicate the qualification of the evaluation team with regard to its ability and experience in doing a bid evaluation and that this may have some effect on the attitude of a bidder in subsequent negotiations. The utility should, however, ask all questions to assure clarification of all important issues.

The questionnaire should be on a standard form with an indication on each page of the lot, bidder and date of questionnaire. A typical example of such a form is shown in Fig. 11. The questions should further be grouped in the way they will probably be treated by the bidder. Each question should have its own number and references should be made in each question to the corresponding parts in the bid specifications and in the bid documents.

Answers to the questionnaires can be expected within four to six weeks after they have been sent to the bidders. It is necessary that written answers are given by the bidders in order that the answers can later be used as a basis for negotiations and contract formulation. An additional oral presentation of the answers can also be useful to see if the questions were satisfactorily answered and if the answers are well understood. The answers to the first questionnaires should be available in the course of the detailed bid evaluation so that they can be fully taken into account during this phase of the work and the first technical negotiations.

Subsequent questionnaires can only be made available in the latter half of the detailed bid evaluation phase, with all the questions which have come up during the detailed evaluation. These are much more comprehensive questionnaires with many technical questions on the individual aspects of the bids. The answers to these questionnaires will only be available towards the end of the bid evaluation period and can thus most of the time not be considered by the individual engineers for completing their bid evaluation forms. The answers should, however, be available when the final bid evaluation report is written and during the last technical

Nuclear Lot Bidder: A		Type: PWR	Date......
References			
Specs.	Bid	No.	Questions to the Bidder
			<u>SAFETY SYSTEMS</u>
			<u>Emergency Core Cooling System</u>
PTSC-NL PWR 2.2.1 to 2.2.3	Vol.2 Sect. 6.1, 6.2	48	State the level of redundancy provided in the passive injection subsystems of each injection train; i.e. are one or two accumulators required?
"	"	49	Provide further detailed information indicating the performance of the safety injection system, using as a calculation basis the latest US NRC evaluation model. Provide in particular: a) water level versus time, and b) peak fuel and fuel cladding temperatures. These should relate to loss of coolant accidents with various break sizes, and should be based on the minimum number of ECCS components being operational.
			<u>Containment Spray System</u>
PTSC-NL PWR 2.2.1, 2.2.2, 2.2.4	Vol.2 Sect. 6.4	50	Provide a family of containment pressure versus time curves, for the post-accident situation, showing the effect of different combinations of spray and fan cooling. These should include the cases with minimum number of components of either system operating.
"	"	51	Indicate the effect on containment pressure of inadvertant containment spray actuation in a non-accident situation.

FIG.11. Example of a questionnaire.

negotiations. The purpose of these questionnaires is to provide more certainty as to what one is buying (to receive confirmations), to get good documentation for writing the technical contract documents and to obtain the necessary cost information.

No letter of intent or any other commitment should be made by the utility until the questionnaires have been satisfactorily answered by the corresponding bidder(s).

8.7. Final evaluation report

The results of the detailed technical evaluation are laid down in a final evaluation report on the lot which should contain a conclusive answer as to what is (are) technically considered the best bid(s), what features need to be improved or carefully watched during construction and commissioning and what are the recommendations for coming to a satisfactory technical contract document. The report should further contain the input data for the economic bid evaluation. Separate reports should be made for each lot and the nuclear fuel.

The report should give a technical ranking of the bids evaluated with possibly an indication how much better one bid is compared to the others. (What is the expected higher availability, better performance, etc.)

The main sections of the report deal with:

- Summary and conclusions
- Basis and method of the evaluation
- Evaluation of the scope of supply and services
- Evaluation of the general aspects
    - operation and maintenance
    - safety
    - quality assurance and control
    - codes and standards
    - testing and commissioning
- Evaluation of the systems and main components
- Evaluation of general electrical and mechanical equipment
- Evaluation of technical guarantees
    - design, material, workmanship
    - performance guarantees
- Special problem areas and exceptions to the bid specifications
- Overall evaluation of the bids.

The input data for the economic bid evaluation are normally dealt with in the section on the overall evaluation of the bids. This section should contain a summary of the costs for deficit and surplus material, as well as indications of any other items which are required for the economic bid evaluation. This data should already have been given to the group doing the economic bid evaluation beforehand, and the incorporation of this data in the final report serves merely for the records.

The other input data which have to be given for the economic bid evaluation depend on the scope of the bids, but in general cover the following items:

- General technical input data
  - net electrical output of the plant
  - anticipated operational availability of the plant over its whole economic lifetime
  - balance-of-plant costs
- For anticipated operating and maintenance costs
  - staffing of the plant
  - costs for maintenance, consumables and spare parts
- For the fuel cycle costs
  - refuelling schedule with quantities of fuel, enrichments and burn-ups for the first core and a number of reloads.

The final bid evaluation report should give an all-inclusive picture of the evaluation work carried out listing all documents issued by or on behalf of the utility during the bid evaluation. Reference should also be made to other documents which are only partly related to the bid evaluation work, such as site reports, reference plant design reports and other project-related documents in order to see what background documentation is available.

The extent to which the different items are dealt with in the report depends on the judgement of the engineers responsible for writing the report. Final bid evaluation reports are quite comprehensive documents of several hundreds of pages and it is difficult to keep these reports sufficiently digestible. General guidelines for writing a final bid evaluation report are the following:

- Use a uniform format for each section of the report.
- Use comparative tables as much as possible not only for technical data, but also for the evaluation itself.
- Use the division of work (see Appendix 1) for the table of contents of the detailed technical evaluation part of the report.

The text of a section on a particular aspect may comprise a separate summary evaluation for each bidder on that aspect (with a reference to where the matter in the corresponding bid was described) plus a comparative assessment at the end

BIDDER	A	B	C	D
Important Deviations from Bid Specifications	None	Excessive interconnection No (n-2 option)	Inadequate performance No (n-2) option	None
Reliability	Good Good redundancy (n-2), pumps can be maintained with reactor on power. Proven components	Doubtful Only (n-1) redundancy so failure of some components may cause reactor shutdown. Proven components. However extensive interconnection on suction side.	Good Only (n-1) redundancy but pump can be replaced quickly. Proven components.	Good Only (n-1) redundancy but pump can be replaced quickly. Proven components.
Function and Performance	Satisfactory This judgement should be confirmed for small breaches when safety report available. Otherwise margins should be good.	Good Fuel temperature margins should be good	Doubtful Fuel temperature margins less than specified.	Satisfactory Adequate fuel temperature margin.
Safety	Good As a result of a combination of reliability and performance and excellent separation.	Doubtful Not very good redundancy or separation of loops. Extensive interconnection on suction side.	Doubtful Doubts about performance, otherwise satisfactory for (n-1) redundancy. See comment under W.	Satisfactory Three independent trains supplied but only (n-1) redundancy because one will be lost with the faulty loop.
Operation and Maintenance	Satisfactory Adequate access appears to be provided for maintenance but more details are required.	Satisfactory All components are removable.	Good All components easily renewable.	Good All components easily renewable.
Materials	Satisfactory Mainly stainless steel.	Satisfactory Stainless steel, alloy steel, carbon steel.	Satisfactory Mainly stainless steel.	Satisfactory Little information available.
Main Advantages	Excellent redundancy and separation.	Well-tried system with good performances and 3 water sources.	Well-tried system with 3 independent trains.	Well-tried system with 3 independent trains.
Main Disadvantages	Use of suppression pool as only water source.	All pumps have complex interconnections on the suction side. Reliability therefore doubtful.	Barely adequate performance. (n-2) obtainable only by rapid replacement of failed components not by true extra redundancy.	(n-2) obtainable only by rapid replacement of failed components not by true extra redundancy.

FIG.12. Example of a comparative assessment: summary evaluation.

BIDDER	UNIT	A	B	C	D
High-Pressure Pump(s)					
Type	-	Triplex piston pumps	Vertical centri-fugal	Centrifugal	Vertical centri-fugal
Number	-	4	1	3	3
Design flow rate	m3/h	81	421 + 1,419	130	182
At a head of	bar	80	87.6 + 29	71	78.7
Power consumption at shaft	kW	230	2,237	-	-
Speed	min^{-1}	-	1,500	-	-
Low-Pressure Pump(s)					
Type		Centrifugal	Vertical centri-fugal	Vertical centri fugal	Vertical centri-fugal
Number		4	3	3	3
Design flow rate	m3/h	150	1,419/1,649	225	318
At the head of	bar	10	22.4/8.62	13	17.6
Power consumption at shaft	kW	450	1,192/650	-	-
Speed		-	1,500	-	-
Refuelling Water Storage Tank					
Number	-	Not applicable	Not applicable	3	1
Volume (min.)	m3			600	1,400
Accumulators					
Number	-			3	3
Volume (water)	m3			26	35
Condensate Storage Capacity	m3	Not used for ECCS	568	Not applicable	Not applicable
Suppression Pool	m3	3,000	3,759	Not applicable	Not applicable

EXAMPLE

FIG.13. Example of a comparative assessment: technical data.

of the section. The write-up, which should be kept as short as possible, can be completed with comparative tables as referred to above and illustrated in Figs 12 and 13.

The evaluation of the technical guarantees is partly a technical and partly a contractual matter. The technical evaluation should consider how far the guarantees given in the bid are realistic and adequate. The guarantees cover usually the most important plant data, such as gross electrical output, auxiliary power consumption and heat rate. For the main performance guarantees the general operating conditions, design and measuring tolerances, as well as the procedures (how and when) for measuring these values, are important points to be considered during the evaluation. The measurements should be made in accordance with relevant codes. Should a bidder have indicated extremely large tolerances on gross output and auxiliary power, it might well be justified to lower the net electrical output which is used in the economic bid evaluation.

Technical guarantees should generally be given on all items which can be very detrimental for the utility if not performing well, also including use of consumables, radiation levels, noise and vibration levels. Also, performance figures of many auxiliary systems, such as radwaste systems, water make-up systems, etc., should be guaranteed.

The overall evaluation of the bids should cover a comparison of the main plant characteristics and parameters, summarizing the most important positive and negative features for the main aspects of the bids, emphasizing specially the problem areas related to the bids. Finally, recommendations on the selection of a bidder should be given, together with points which still need to be verified or improved during the negotiations and points which need a close follow-up during construction and/or commissioning of the plant.

The final evaluation report can be made available depending on the scope, method and approach of the evaluation within a minimum of four months after the receipt of bids for NSSS and TG lots and eight months for turnkey lots. Negotiations with the preferred bidders can start in parallel with the preparation of the final evaluation report, upon receipt of answers to the questionnaires, three to four months after receipt of the bids. The results of these negotiations should be taken into account at the preparation of the final evaluation report.

9. PROBLEM AREAS

9.1. General

The problems encountered during a technical bid evaluation are manifold. The intention of this section is to deal with those problem areas which are considered very important and to give some guidance in treating these problems.

The following points are particularly dealt with:

- Technical acceptability of a bid
- Different safety standards and philosophies
- Bids for power stations with large differences in power output
- Domestic participation
- Spare parts
- Specific technical issues.

The guidance and recommendations given hereafter can be only of a general nature, as each project has its own particular conditons and circumstances, which have to be adequately taken into account in dealing with the matter.

Any problem area needs in each particular case a project-oriented and individual treatment and can only be solved satisfactorily if all salient aspects are properly considered. The purpose of this section is not so much to give guidance in dealing with these problem areas, but to draw the necessary attention to those points which need special treatment or which may create difficulties.

Another important problem area is the interface aspects of the station with the nuclear fuel, which will be treated in Section 10.

9.2. Technical acceptability of a bid

The question if a bid is technically acceptable or not cannot always be answered by yes or no and depends a lot on the circumstances, the evaluation criteria and the judgement of the engineers doing the bid evaluation. The reason for a bid being unacceptable is generally non-compliance with the bid specifications in one or more of the following areas:

- Safety standard does not correspond to the requirements.
- Bad or unproven design features which could seriously affect the performance of the station.
- Scope of the bid deviates seriously from what had been requested.
- Information in the bid is inadequate.

If a bidder cannot or is not willing to improve within the time stipulated by the utility a serious deficiency in his bid there is strong reason to reject this bid. The above reasons for rejection are not all equally important. It is clear that a bid must comply with the safety and environmental regulations and requirements in the buyer's country. Important areas where the bid may not comply in this respect are:

- Safety regulations considered are not the ones requested in the bid specifications and/or design is not licensable in the country of origin.
- Design does not fully meet seismic design criteria or other relevant design criteria (external missiles and impacts).
- Proposed codes and standards are other than specified.

The safety regulations and requirements in a country are not always well known but if the bid specifications were prepared in close consultation with the authorities and the bid does not meet the requirements therein, it is clear that there is a great risk for the utility to accept such a bid.

The other reasons for rejecting bids are not safety-related and depend only upon the utility and the engineers responsible for the evaluation. They have to evaluate if a certain risk is still acceptable to the utility or not. This is obviously a subjective judgement which, depending upon the circumstances, is different from utility to utility and from country to country. Utilities in countries which are rather remote from the supplier's country and which do not have a highly developed industry should not accept new or unproven features which could seriously affect the performance of the station. The risks of components or systems with known problems can in this respect be evaluated better than the risks of unproven features.

In the case where a bidder likes to supply much more or much less than what has been specified in the bid specifications, it is up to the utility to decide if this is acceptable or not. If a bidder offers a turnkey power station, whereas he has been asked to prepare only a bid for a nuclear island, it is questionable if this is acceptable, whereas if he has been asked to offer separate bids for a nuclear and turbine island, it may be acceptable. Often it is recommendable to adapt the scope of supply to the scope offered by the bidders, as this is the usual scope offered and supplied by the bidder, unless it is clear that the bidder wishes to reduce his responsibility or that the supplementary items could be just as well manufactured in the country itself. Differences in scope of supply are normally no reason for rejecting a bid.

In the case of a serious lack of information in the bid the same cannot be evaluated properly and the utility does not know what it is buying if it accepts the bid. This is a strong reason for rejection if the bidder does not improve the situation within the time stipulated by the utility.

9.3. Different safety standards and philosophies

The safety standards implicit in the regulations of most supplier countries are very similar, but licensing procedures differ markedly either in details of the regulations or even in the basic regulatory philosophies. There are also different design interpretations of the regulations by different suppliers, even within a single country. To further complicate matters, safety regulations have been evolving rapidly in recent years, so that older designs no longer comply with all current regulations.

The evaluation of the safety standards of bids received in an international bidding competition is thus a very difficult task and requires a broad and comprehensive knowledge of the regulations valid in the corresponding countries at the time of the bid evaluation and of the designs offered by the bidders. It requires also a certain familiarity with the development of the safety standards as regards the possible changing of existing regulations in different countries.

For a more global evaluation and for determining the acceptability of a bid it is sufficient to compare the main safety features and general safety philosophies followed by the bidders in the designs proposed with the existing regulations in the country of the utility.

A question often asked by a country starting its first nuclear power station is what safety regulations to apply in the country. The following basic approaches are now or will be in future most practical:

Either

- require compliance with US regulations or a safety level equivalent to US requirements;

or

- require compliance with the regulations in the country of the bidder;

or

- require the achievement of a safety level equivalent to international (IAEA) safety regulations.

The regulations issued by the US Nuclear Regulatory Commission (USNRC) are currently the most extensive available in written form, and for this reason, as well as the early predominance of the USA in the commercial nuclear field, the first of the above approaches has been adopted by many countries. This approach would provide a sound base for any country. However, it has been noted that some of the detailed regulations specified by the USNRC may be specific to the USA situation, and if applied too literally could lead to unnecessary expense, without any increase in safety, in countries where situations may differ.

The second alternative, namely, specifying regulations as in the bidder's country, will require work on the part of the regulatory authority in the buyer's country to ensure that it understands and is prepared to accept the safety standards implied in those regulations. The utility must take the initiative to ensure that this alternative will be acceptable to his country's regulatory authority before specifying it in his bid specification.

The third alternative, e.g. use of IAEA regulations, is not available at the time of writing this guidebook. However, since 1975 the IAEA has carried out a programme for establishing codes of practice and guides on the safety of nuclear power plants (the Nuclear Safety Standards or NUSS programme) which is aimed at making available to Member States recommendations to provide a basis for regulatory developments and to serve as a standard frame of reference for safety analysis, review and assessment.

No matter which alternative is followed, some modification of the chosen reference regulations may be appropriate to cater for specific situations in the buyer's country. However, it is not advisable to make any significant changes, nor to attempt to combine regulations of different countries. Since many of the regulatory systems have evolved in a complex but integrated manner, there is a risk of inadvertently missing out some important feature if such a route is attempted.

In the longer run, the country may well choose to establish its own comprehensive set of regulations. These are likely to be based on the reference regulations chosen for their early stations, and this factor may also influence which of the above alternatives they choose.

A further potential problem is to evaluate the probability that the reference regulations will change over the time of construction of the station and, further, what consequences such changes may have on the schedule and cost of the station. To evaluate this, and the differences between the bidders as regards their safety-oriented design features, a detailed safety evaluation must be carried out on the bids submitted.

This safety evaluation should cover the following items:

- Compliance with the safety regulations specified for the project
- Incidents and accidents as well as external impacts considered for the design of the station
- Comparison of containment designs and concepts
- Redundancy and separation philosophies applied.

In addition to the above general aspects, each system and main component need to be evaluated in detail as far as safety is concerned covering the points listed in Section 8.5.

Particular problem areas for a safety evaluation are:

- Bids not complying with the safety regulations specified or not complying with the latest safety regulations in the bidder's country
- Judgement and risks of different containment concepts (dry containment versus pressure suppression containment)

– Design, rating and fabrication of fuel (see also Section 10)

– Radiation levels and releases and radiation doses to the environment as well as operating and maintenance personnel

– Evaluation of external impacts, in particular as regards flooding, earthquakes, missiles, aircraft crashes, as well as sabotage.

For the evaluation of bids not complying with the safety regulations specified or not complying with the latest safety regulations in the country of the bidder, close co-ordination with the safety authorities is required. Furthermore, it has to be determined if it is possible to improve the bids to the safety standards required and what are the costs and other consequences.

Most bidders propose codes and standards applied in their country. This is particularly a problem area if suppliers from different countries work on the same project.

It is recommended to apply as far as possible international codes and standards such as IEC and IEEE and other internationally accepted national codes and standards.

9.4. Bids for power stations with large differences in power output

The power output of the nuclear power stations offered today range from 600 to 1300 MW(e). Nuclear power stations for a smaller output are under development in different countries, but are still not commercially available, with a few exceptions.

As the scaling effect with nuclear power stations is very important (i.e. larger units are not much more expensive than smaller units), there is a very strong economic incentive to go to larger units. For example, for a nuclear power station supplying 50% more power output the cost increase is not more than 10 to 20%.

This is the reason why utilities in many instances ask for a complete bid in the lower power range (e.g. 600–700 MW(e)) as well as an option for a larger unit (e.g. 900–1000 MW(e)). In this respect it is recommended that the utility conduct a power system expansion study in order to determine the feasibility of adopting the larger sizes before going out for bids. Such a study is normally part of a feasibility study for the project. It can also occur that a utility asks only for a unit in the lower power range and that one or more bidders offer a larger unit as they do not have a smaller unit or they feel the larger unit to be more competitive.

If the utility has asked for power stations in the range of 600–700 MW(e), and the bids are all in this range, it is not necessary to make any distinction between the bids. The bids can be compared on the basis of the estimated generating costs which can be achieved with the stations offered by the bidders. If one or more bids should be of a substantially larger output, e.g. 800 to 850 MW(e), one should decide if such a bid is technically acceptable.

If under certain circumstances such larger units could be technically acceptable one has to study the increased risks and special measures required to install such a unit. In such a case the grid expansion study has to be verified against the actual data of the bid.

Although it is very attractive on a unit cost basis for a utility to go for a larger unit, one has to realize fully the disadvantages related to it, which are mainly:

- Increased risks (financially and technically)
- Possibly higher costs for grid expansion
- More reserve power may have to be installed
- Possibly less domestic participation in equipment.

9.5. Domestic participation

The domestic participation is the share of national engineering companies and local industry in the planning and implementation of a nuclear project. The aims of the utility in this respect are normally outlined in the bid specifications. The time available for preparing the bids is normally too short for this matter to be adequately dealt with by the bidder in his bid. This is in particular the case for a foreign bidder with no previous experience in the corresponding country.

The evaluation of the domestic participation for the first project in a country can only be done properly if the following prerequisites are met:

- A thorough study has been made beforehand regarding the kind of services and equipment that could be provided from the buyer's country.
- The requirements of the utility in this respect have been dealt with in a complete and understandable way in the bid specifications.
- The bid corresponds in detail to the requirements of the utility as regards domestic participation.

The problems encountered in evaluating this aspect are the different ways in which this matter is normally dealt with in the bids, and the priorities set by the utility in carrying out the project.

Domestic participation always means a compromise of the utility as regards possible guarantees for delivery times, costs and station performance. Domestic participation is dependent on the project approach selected. It is clear that in the case of non-turnkey projects the aims as regards domestic participation are easier to achieve than in the case of turnkey projects. Maximizing domestic participation in the case of turnkey projects means less stringent guarantees as regards timely completion, costs and performance.

Nevertheless, some bidders who are well experienced and qualified to accept a large portion of domestic participation can still maintain a large part of their guarantees. In fact if a bidder has an adequate knowledge of the domestic market he might include a large share of domestic participation without diminishing guarantees on performance and timely completion. As regards costs, one possibility is to ask for a detailed costing of the power station and to give the supplier the right to adjust the price if local manufacture is more expensive than the costs foreseen in the bid for the corresponding type of services or equipment.

The time for bid preparation normally does not allow the inclusion of costs for services and equipment of domestic suppliers, and in such a case the final share of domestic participation remains uncertain and mainly depends on the willingness of the supplier to consider in time possible domestic supplies. The bidders under consideration will have different records regarding domestic participation on previous projects, which have to be adequately taken into account in evaluating this matter.

To protect the utility as regards an adequate share of domestic participation one should agree upon a final price which is partly paid in local currency corresponding to the share of work foreseen to be carried out domestically. In such a case there is a very strong incentive for the supplier to spend at least the agreed share in local currency for domestic services and supplies.

The bids to be evaluated in this respect can be of a very different standard, depending on the experience of the bidders in the corresponding country and the experience of using different subcontractors for different projects. The main question is often if the bidders have adequately taken into account the delivery times of local supplies in their overall project time schedule.

9.6. Spare parts

The bidder is usually requested to include in his bid spare parts which are required to enhance the availability of the plant. In the case of bids for a NSSS or a turbo-generator unit, the bidder is certainly able with this restricted scope of supply to offer spare parts, as most of the equipment will be manufactured and supplied from the bidder's own factories or from suppliers with whom the bidder has previous relationships. In the case of more comprehensive bids or even turnkey bids, the scope of supply is so large that it will be difficult for the bidder to offer with the bid a complete set of spare parts for the total scope of supply. Even should the bidder try to conform with the bid specifications, the list of spare parts will be incomplete.

On the other hand, the requirements for spare parts may be quite different from country to country, depending on the circumstances. It is clear that in very remote countries with no highly developed industries the needs for spare parts are different from those in highly industrialized countries. It also depends on the care of operators of the station so that no really uniform approach can be taken concerning the scope of spare parts to be bought with the station.

The bids received for spare parts are, therefore, very different, depending on the interpretation by the bidder of the needs and his knowledge of the costs of spare parts for the total scope of supply. Normally, not very much time and experience is available during the bid evaluation phase to judge the completeness and necessity of the spare parts offered and, therefore, it is recommended to exclude spare parts from the technical bid evaluation. For comprehensive contracts and turnkey contracts it is further recommended to exclude any total bid prices for spare parts in the cost comparison of the bids as it is unlikely that the cost of spare parts is very different from one station to another. For budgetary purposes the total costs of spare parts have to be estimated as at least 3 to 5% of the total equipment costs, not including consumables such as fuel boxes, in-core instrumentation, pressure vessel sealing rings.

Once the bidder is selected, the evaluation of the need for spare parts should be made by comparing stocks of spare parts of utilities which already have operating experience with a reactor or turbine from this bidder or with similar type of equipment and by discussing the matter with such utilities. This is a vital question for the operation and maintenance team of the station and it should be one of the first jobs of this team to evaluate the need for spare parts.

In order not to pay unnecessarily high prices for spare parts it is recommended. to ask the bidder in the bid specifications to include in his bid for the power station unit prices for the main spare parts for his basic scope of supply, and to order these spare parts only after the evaluation has been carried out in the sense as described in the previous paragraph.

9.7. Construction time schedules

The team evaluating the technical features of the nuclear power station has to check also that proposed time schedules are realistic. A short construction time proposed by one bidder will – when the bids are economically evaluated – place his bid in a favourable position, if the bid price is the same as for other bids. The evaluating team has to check that this short construction time is possible and could also investigate why other bidders need a longer time.

The time schedule proposed by a bidder is based on the condition that equipment and services to be provided by the utility or by other suppliers are available at times specified in the schedule. Even for turnkey contracts including civil works there are some services that have to be provided by the utility. Most common are access roads and other transportation facilities, connection to the electric grid, water supply, and sometimes water and sewage treatment plants. Those services have to be available at specified times, otherwise the supplier can claim that he has been delayed, with the consequence that plant completion can be delayed and that the utility has to compensate the supplier for the extra costs.

In a large number of cases the start-up of nuclear power plants has been delayed because the necessary licences for construction or operation have not been issued as expected. Usually it is the responsibility of the utility to obtain those licences. A construction permit may be based on the approval of a PSAR, provided by the reactor supplier. A reasonable time has to be allocated in the time schedule for the review of this PSAR. Operating licences may authorize a step-wise increase in reactor power, where the results of tests at each power level have to be reviewed by the authorities before the power can be increased to the next level. Again, the time schedule must permit a certain time for reviews by the authorities.

In the case of contracts on a split package basis, there are still more time limits to be met. The evaluation team has to verify that the time schedule from each supplier gives sufficient time for other suppliers to perform their work. One example is that a turbine supplier may be able to finish all testing necessary to increase the turbine-generator power from zero to full power in a matter of weeks – provided that the reactor can supply the steam. The reactor supplier may need several months for the corresponding power increase – sometimes determined by the licensing procedure. Should the civil works be excluded from the main contracts there are numerous points of interaction and the time schedule has to be very detailed in order to avoid disputes as the work proceeds.

The evaluation of a time schedule may not be considered as part of a technical bid evaluation, as it influences mainly the economy of the project. However, the technical evaluation team is the most competent one to judge if the schedule is realistic and to check where there are interactions with other suppliers. It is, therefore, recommended that a review of proposed time schedules should be part of the technical bid evaluation.

9.8. Specific technical items

There are many specific technical problem areas in the bids which have been items of concern in the past and which have still not been fully solved.

In the following an attempt is made to list these items of concern so that they get the necessary attention in future bid evaluations. It is clear that the selection given is incomplete and will need some adaptation in the future, as perhaps new items of concern will appear. Nevertheless, it is felt worthwile to pinpoint a number of items which may not be overlooked during technical bid evaluations of nuclear power stations:

- Definition of the auxiliary power consumption and the way how the auxiliary power consumption is determined
- Containment design, single or double containment, pressure-suppression containment concepts of BWRs
- Steam generator tube failures in PWRs
- Fuel failures, hydride damage, fuel shrinkage
- Core vibration problems
- Degree of instrumentation and automation
- Fire prevention and protection
- Radiation levels in the plant and releases to the atmosphere
- In-service inspection of the reactor pressure boundary
- Refuelling procedures and refuelling downtimes
- Flexibility of start-up, load changing and shut-down
- Layout of the buildings and access of the operating personnel for operation and maintenance
- Steam bypass or blow-down operation
- Condenser tube failures
- Condensate clean-up system and chemical treatment of the feedwater
- Seismic design of buildings, structures and equipment
- Spent-fuel storage in the plant
- Radwaste solidification systems
- Radwaste storage on the site
- Off-gas treatment systems.

10. NUCLEAR FUEL

10.1. General

The evaluation of the bids for the manufacturing of fuel assemblies is a highly specialized activity, particularly the technical aspects related to this evaluation. The general guidelines given for the evaluation of the power station, however, also apply to the fuel assemblies, i.e. the technical evaluation covers also an evaluation of the scope of supply and services and technical design features as described in Section 5. Other important aspects are the contractual conditions and, in particular, the guarantees for the fuel assemblies.

The bids for the nuclear fuel cover normally only the fuel assembly manufacturing services, i.e. the utility takes the responsibility for delivering the required quantities of fuel in the right chemical and physical composition to the supplier and the supplier delivers the required number of fuel assemblies ready for loading into the reactor. The scope of bids for the manufacture of fuel assemblies includes normally also the associated in-core fuel management services. Bids for consumable items such as fuel boxes, control rods, in-core instrumentation, burnable poison, should be included either in the fuel or plant bid.

For developing countries there might be an incentive to extend the scope to other parts of the fuel cycle.

The nuclear fuel may be offered either as part of the bid for the nuclear power station, or separately. The bidders tend to favour separate bids as the fuel divisions of the bidders often belong to another management or even to another company. Also, for the utility it might be preferable to have finally separate contracts for the station and the fuel, as the contractual conditions and the duration of the contracts are different (fuel contracts generally last much longer). In such a case it is important that the compatibility and interfaces of the nuclear fuel and the nuclear lot are carefully evaluated and contractually well defined.

The economic evaluation of the fuel cycle comprises an evaluation of the total fuel cycle, i.e. uranium, U_3O_8, conversion, enrichment where applicable, fabrication, storage and/or reprocessing and consumable items discussed above. In the case of heavy-water reactors the heavy-water inventory and the loss factors must be considered. The aim of the following sections is to draw more attention to the technical aspects of the nuclear fuel evaluation.

10.2. Technical evaluation of the nuclear fuel

For the technical evaluation of the fuel, the same evaluation criteria are considered as for the equipment of the power station, namely:

Evaluation criteria	*Special features*
Reliability:	fuel integrity
Function and Performance:	burn-up, heat flux, linear power and other performance features
Safety:	Safety margins and possible radioactivity release from the fuel
Operation and Maintenance:	operational flexibility, refuelling schedules, possibilities of repair and insertion of third-party fuel
Materials:	use and behaviour of cladding materials and other materials (spacers, upper and lower supports, fuel boxes, etc.).

Fuel can be the source of radioactivity problems, which are one of the main concerns of the operators of nuclear power stations. Therefore, one of the main aims in evaluating the fuel is to assess the expected integrity of the fuel assemblies and fuel rods. The integrity can be improved by good and conservative designs, conservative operational limits and careful manufacturing procedures.

The points which are evaluated in this respect are:

- Degree of fission gas release within the fuel rod
- Pressurization of the fuel rods
- Cladding material, dimensions and properties
- Chemical composition of the fuel, pellet density, form and dimensions
- Gap between cladding and pellet, temperatures and cladding/pellet interactions
- Safety margins and operational limits
- Manufacturing as well as QA and QC procedures applied
- Other items of current concern, e.g. probability of primary hydride damage.

The burn-up figures quoted by the bidders can be compared with each other, and previous projects, to judge how confident one can be that these figures will be reached. These figures are mostly backed up by guarantees given by the bidders. Due to the complexity of such guarantees and the increased experience with nuclear fuel there is a tendency to limit the fuel guarantee to a design, material and workmanship guarantee in terms of a mechanical integrity guarantee per fuel assembly related to a certain burn-up. Any burn-up guarantee limits the freedom of the utility in operating the power station as due consideration has to be given to the conditions under which such burn-up guarantee is given.

Operational flexibility with the nuclear fuel is an important aspect of the fuel evaluation. This flexibility should correspond to the flexibility of the nuclear lot and to the needs of the utility. The speed with which power changes are required needs to be carefully evaluated against the increased risk of fuel failures.

Nuclear fuel is generally not designed and a nuclear power station is generally not very suitable as a load-following unit for daily load changes. Nevertheless, a certain amount of load-changing (weekly power reductions) is certainly within the range of possibilities for nuclear power stations and certain reactor and fuel designs are better than others in coping with this kind of operation. The operational flexibility as regards start-up and load changes at the end of each fuel cycle needs to be evaluated as well. In reactors with enriched fuel this flexibility can, however, be improved by having higher initial enrichments or by reducing the feedwater temperature and, consequently, having higher reactivity reserves towards the end of a fuel cycle. This gives also the possibility of stretching the fuel cycle length further than would be normally the case, although at some economic penalty.

The evaluation of the nuclear fuel not only covers fuel design, but also reactor core design, i.e. the arrangement of the fuel assemblies within the reactor vessel and associated equipment and means of start-up and control (neutron sources, control rods, burnable poison). The evaluation of the reactor core design should cover:

Main core data:

rated core thermal power, number of fuel assemblies and zones, weight of fuel (U, Tr), initial enrichments and discharge enrichments, burn-up, number of control rods, active core length, equivalent core diameter, peaking factors, linear power ratings, power densities, boron concentration.

Thermo-hydraulic characteristics:

coolant flow, core inlet and discharge conditions, void fractions, coolant velocities and pressure drop, core temperatures, heat transfer surface, heat fluxes, minimum critical heat flux ratios (CHFR) or departure of nucleate boiling (DNB).

Nuclear data:

moderator/fuel volume ratio, core reactivities, shut-down margins, ranges of reactivity coefficients.

Control rods:

negative reactivity values, shape, absorber materials, pitch, active length and other dimensions, design life, weights.

Neutron sources:

number, material, activity, lifetime.

In-core instrumentation.

From the above it is clear that there is a strong interaction between the fuel and the nuclear lot. The following subsection deals, in particular, with the aspect of compatibility and interfaces of these two items, as this is generally a problem area in evaluating bids for a nuclear power station.

10.3. Compatibility and interfaces with the nuclear lot

The fuel must be physically and functionally compatible with the other parts of the nuclear lot and vice-versa. There are dimensional ties with the reactor vessel and the vessel internals and functional ties with almost all other parts of the nuclear lot. In the case of separate contracts for the fuel and the nuclear lot, it is extremely important that the supplier is fully responsible for the compatibility and interfaces of the two contracts and that in each contract reference is made to the other contract.

The compatibility of the fuel with the nuclear lot concerns, in particular, the following items:

- Reactor vessel internals and, in particular, the reactor core structures
- Primary cooling system
- Control rods and other neutron absorbing systems (e.g. boron control system)
- Core cooling systems and other safety systems
- Fuel handling systems, including new and spent fuel facilities, and power refuelling machines if applicable, storage capacities, pool cooling and cleaning systems.

The design values and effectiveness of the above systems must correspond to the requirements of the fuel with a certain amount of flexibility, namely, that in the course of the life of the power station, fuel assemblies with other design characteristics (e.g. other enrichments, plutonium fuel, etc.) can be applied. Also, assurance should be given by the fuel bidders that in the case of a contract all necessary design data and drawings will be given to the owner to allow the possible application of third-party fuel in order not to become fully dependent on the supplier of the first fuel charge.

The main functional interface aspects of the fuel with the power station are the following:

- Power level
- Safety aspects, including safeguards, radiation doses and environmental release of radioactivity
- Operational flexibility
- Fuel storage capacities.

The power level of a nuclear power station is determined by the power which can be produced within the reactor core. With a fixed number of fuel assemblies in the reactor core and predetermined operational limits or safety margins for the fuel, the power which can be produced within the reactor core is fixed. If the predetermined power level of the reactor core cannot be reached with the operational limits and safety margins required, the power station will not be able to reach its guaranteed power output. The evaluation of the operational limits and safety margins for the fuel is thus extremely important, as more stringent requirements from the authorities in this respect lead automatically to a power reduction of the power station.

The radiation doses received by operating and maintenance personnel and the activity releases from the station will be strongly affected by the quality of the fuel. The activity levels which are partly responsible for the radiation doses of the personnel are the ones in the primary cooling and reactor auxiliary systems (clean-up systems, radwaste systems and ventilation systems). Although the radiation doses received by the personnel can be reduced by appropriate design and layout features, it is nevertheless better to keep the activity levels in the systems as low as possible by having the best possible fuel with minimum leakages and fuel failures. Serious fuel failures can contaminate the systems to such an extent that premature refuelling could be required with economic consequences both in terms of lost fuel burn-up and incremental cost of replacement electricity during the outage, if required.

Radiation doses received by personnel from direct radiation of the fuel when handling spent fuel assemblies or when working in the neighbourhood of the reactor core can be reduced by appropriate design and layout features of the station.

The activity releases to the environment are partly dependent upon the fuel and partly dependent upon the design of the radwaste systems. For a certain station design the activity releases are, however, directly proportional to the performance of the fuel, so that also in this respect the fuel can have serious consequences for the operation of the power station.

TABLE II. EXAMPLE OF A REFUELLING SCHEDULE

Operating cycle		Loaded fresh fuel			Unloaded irradiated fuel				
Number	Length (efph)[a]	Number of assemblies	Uranium (kg)	Assay (% U-235)	Number of assemblies	Uranium (kg)	Assay (% U-235)	Fissile Pu (g/(kg U initial))	Average burnup (MW·d/kg)
1	9000	500	89 000	1.94					
2	6500	157	27 946	2.75	(157)[1]				
3	6500	108 (+157 re-inserted)	19 224	2.75	180 (+85)[2]	31 358	0.82	4.4	14.9
4	6500	111 (+85 re-inserted)	19 758	2.75	196	34 075	0.76	4.5	16.4
5	6500	108	19 224	2.75	108	18 724	0.67	4.7	18.6
6	6500	115	20 470	2.75	115	19 768	0.85	5.3	25.4
7	6500	113	20 114	2.75	113	19 390	0.84	5.4	26.8
8	6500	111	19 758	2.75	111	19 041	0.82	5.4	27.1
9	6500	112	19 936	2.75	112	19 210	0.80	5.4	27.1
10	6500	112	19 936	2.75	112	19 208	0.80	5.4	27.2

[a] efph. – equivalent full power operating hours.

The fuel is one of the limiting aspects as regards the operational flexibility of a nuclear power station. This is the case with regard to start-up and power changes and, in particular, towards the end of each fuel cycle in the case of reactors with off-load refuelling procedures. This is, however, a plant design feature and not related to the fuel.

Spent-fuel storage capacities within the power station have become one of the interface aspects with the fuel which needs to be considered and evaluated carefully in view of the existing uncertainty as regards the fuel cycle and the limited fuel reprocessing facilities available. A strategy has to be developed by the utility as to what to do with the spent fuel, and each power station design has to be evaluated with respect to its features to cope with this strategy, according to the requirements in the bid specifications.

There are many other interface aspects, such as reactor core control and instrumentation and reactor coolant flow properties, which are all important for the performance and behaviour of the fuel. All these aspects have to be evaluated to the extent they differ from one bidder to another and depending on their importance for the fuel and the power station in general.

10.4. Refuelling schedules

The refuelling schedules for off-load refuelled reactors provided by the bidders in their bids need to be evaluated to see that they correspond to the requirements of the utility as regards energy production, first cycle length, refuelling periods and end-of-cycle reactivity. The schedules provide further basic input data for determining the fuel cycle costs and data for an overall fuel evaluation (number of fuel elements, amount of fuel, burn-ups, enrichments, loading time in the reactor, etc.). A typical refuelling schedule for a BWR reactor is shown in Table II. The data are normally indicated for the first core and a number of reloads up to a time that a basic equilibrium is reached in the reactor core. The bidder should be requested to provide modified schedules if the refuelling schedules do not correspond to the requirements of the utility or do not contain all information required to do a proper fuel cycle cost calculation.

If no modified schedules are supplied in time, the fuel cycle cost calculations can be carried out on the basis of the original schedules supplied with an estimate of the evaluation engineer of missing information and/or what corrections should be made for taking into account other design input data. It is advantageous to have technical data and cost data for a large number of reloads (say up to 10) even if it is not the intention of the utility initially to order a large number of reloads.

The burn-up values quoted in the refuelling schedules have to be evaluated as to the credibility and probability that these figures are met without undue risks of fuel failures. The experiences on other projects and the values quoted by other bidders with similar reactor and fuel designs are important tools for this evaluation. If doubts arise, corresponding questions should be put to the bidder and more emphasis has to be placed on corrective measures or penalties in the contract if the guaranteed figures are not met.

11. TECHNICAL NEGOTIATIONS AND CONTRACT DOCUMENTS

11.1. General

Technical negotiations with the preferred bidders are required to clarify any uncertainties in the bids in order to get a better understanding of the overall scope and of the technical designs offered. At the same time, special wishes of the utility with regard to any design modifications can be discussed and agreed upon. Further, the aim of the technical negotiations is to obtain a clear basis for the preparation of the technical contract document which will form the basis for the fulfilment of the contract. The basis for the technical negotiations is the bid specifications, bid documents, questionnaires, answers to the questionnaires, and any evaluation reports available at the time of the negotiations.

The technical negotiations can start as soon as answers have been received to the first questionnaire, which can be within three to four months from the receipt of the bids. They last until the final technical contract document with the selected bidder has been agreed upon.

11.2. Technical negotiations

It is advantageous, in particular for utilities which are relatively new in the nuclear field, to organize the negotiations on a rather broad basis and to reserve sufficient time for these negotiations. The negotiations are normally carried out in three phases, namely:

- Preliminary negotiations which take place after receipt of the answers to the first questionnaire
- Negotiations before placing a letter of intent
- Negotiations with the selected bidder for final technical contract formulation.

The preliminary and subsequent negotiations can be carried out with one or more preferred bidders, whereas the negotiations for final contract formulation are carried out with the selected bidder only. The negotiations need to be organized in a very distinct way and the parties and people involved need to know very well the objectives and matters to be discussed at each particular meeting.

The preliminary negotiations are preferably held with all preferred bidders in order to hear views of different bidders, to estimate the willingness and thoroughness of the bidders in examining the questions and wishes of the utility and to have a better chance of becoming familiar with different bids and techniques available on the market. Preliminary negotiations may be started by a general presentation of the bidders of their companies and the equipment or station they offer. This is in general a good basis for starting the negotiations but one should be careful not to devote too much time for this purpose. The main objectives of these preliminary technical negotiations are to discuss:

- Scope, costs and major deviations from the bid specifications
- Major technical doubts on the adequacy and acceptability of the bids
- Site adaptation aspects of the bids
- Missing information
- BOP implications in the case of non-turnkey projects.

The duration of such preliminary negotiations may take three to five days per bidder.

In order to limit the effort involved in these negotiations and to concentrate on the bids which are of real interest to the utility, subsequent negotiations should be held only with those bidders who at this phase of the bid evaluation are still seriously considered as potential suppliers. These negotiations should not only be conclusive for the utility to finalize the evaluation of the bids, but also for reaching basic agreement with the bidders on the scope, costs and design features of the work in the case of a contract award. All major points need to be agreed upon at these negotiations and a good basis should be available at the end to place a letter of intent with any one of the bidders with whom these negotiations are held.

These negotiations may take five to ten days for each bidder, but this depends largely upon the competence of the negotiators, the competitive situation and the experience, flexibility and willingness of the bidders to deal with the outstanding questions. It might be necessary to hold these negotiations in two to three rounds of meetings in order to give the negotiators the opportunity to discuss major outstanding points with their management.

The technical negotiations on different detailed technical matters should be held by relatively small groups of people with specialists of the utility or its consultant on one side, and specialists of the bidder on the other side. It is important that these detailed technical negotiations are led by a member of the utility or a consultant who has good general project experience and who can understand the relative importance of the questions discussed and negotiated.

Representatives of the utility or its consultant will prepare protocols of these negotiations which are agreed upon with the corresponding bidder and which form the basis for preparing and issuing the technical contract document.

The number of people involved in the meetings should be limited in order to avoid confusion and the danger that the points on the agenda are not properly dealt with. It might be advantageous each time to start the negotiations in a big common introductory meeting where the objectives of the negotiations are laid down whilst the negotiations themselves are held in smaller, more specialized groups of people.

For finalizing the technical contract documents after the letter of intent, a number of meetings are required to agree upon the text of the documents. The negotiations required for this should not be difficult if a proper basis has been laid for the basic content of these documents before the letter of intent. In such a case this matter can largely be dealt with by the corresponding project engineers of the utility and the supplier. In many cases, however, the final negotiations, prior to the letter of intent, do not reach the status of a full agreement on the supply and services to be provided by the supplier, as well as the exact terms for the scope and services, so that not only the wording but partly still the content of the contract document has to be agreed upon. In such cases these negotiations are more difficult and they may lead to delays in signing the contract and in starting the project.

A number of important technical points such as licensability, changes, guarantees, rectification of defects and failures are not dealt with in the technical specifications, but in the terms and conditions of contract. The negotiations required in coming to an agreement on those points are consequently not dealt with during the technical negotiations, but during the negotiations on these terms and conditions. The engineers dealing with the technical specifications and negotiations should, therefore, know the content of these terms and conditions in order that no time is lost during the technical negotiations in dealing with matters which are already covered elsewhere. The negotiations on the terms and conditions of contract with the exact wording of these terms and conditions should be completed and agreed upon prior to placing a letter of intent. These negotiations should only be carried out with bidders with whom one is also entering into final negotiations, i.e. negotiations on terms and conditions only start towards the end of the evaluation period. The time required for these negotiations is at least two months, during which three or more rounds of meetings of one or two days can take place. The time in between the meetings is used to prepare the text of modified proposals and to hold internal meetings to determine the targets to be reached during the negotiations. No negotiations should be required on the basic terms and conditions after the letter of intent as these should be fully agreed upon before such a letter is given.

11.3. Technical contract documents

For contracts of the size and nature of a nuclear power station it is recommended to prepare a contract specification in which all agreements reached during the negotiations are incorporated in a clear and understandable way. The contract specification, the content of which is basically agreed upon before the letter of intent, is finalized after the supplier is selected. This document is to be agreed upon by the parties involved before signing the contract. The basis for preparing the contract specification is the original bid specifications, the comments of the successful bidder to the bid specifications, the questions put forward to the bidder during the evaluation and the answers received, as well as the protocols of the negotiations on mutually agreed deviations from the bid specifications.

The basic technical contract documents comprise:

- The contract specification
- The bid documents
- The PSAR of a reference plant, if applicable
- Other documents agreed upon as technical contract documents.

The contract specification should have priority over the bid documents in order to protect the utility, in the course of construction and commissioning the station, with regard to any matters which have not been sufficiently dealt with in the bid documents of the corresponding bidder.

The contract specification gives the utility also the necessary legal power during the guarantee period to claim for rectification of technical deficiencies if the performance of the station does not comply with the requirements in the contract specification.

Appendix 1

EXAMPLE OF A DIVISION INTO GENERAL TECHNICAL ASPECTS, SYSTEMS AND COMPONENTS FOR BID EVALUATION PURPOSES

(Bids for nuclear lots with light water reactors)

1. GENERAL TECHNICAL ASPECTS

1.1. Basic design criteria
1.2. General operational flexibility and stability
1.3. Maintenance, refuelling and in-service inspection requirements
1.4. Layout of individual buildings
1.5. Safety evaluation, including normal operation, incidents, and accidents which have to be assumed
1.6. Quality assurance and control
1.7. Codes and standards
1.8. Transport, erection, testing and commissioning
1.9. Technical guarantees
1.10. Interfaces with other lots

2. REACTOR SYSTEMS

2.1. Reactor vessel and auxiliaries
2.2. Reactor vessel internals
2.3. Reactor core design (co-ordination with fuel) (physics, thermodynamics)
2.4. Control rods and drive mechanisms (mechanical aspects)
2.5. Reactor coolant system (pumps, drives, piping, valves, etc.)
2.6. Steam generators (PWR)

3. SAFETY SYSTEMS

3.1. Emergency (auxiliary) core cooling systems
3.2. Containment spray system
3.3. Emergency shutdown cooling system
3.4. Auxiliary feedwater system (PWR)
3.5. Reactor core isolation cooling system (PWR)
3.6. Primary coolant pressure relief system (BWR)
3.7. Boron injection system (BWR)

4. REACTOR AUXILIARY SYSTEMS

4.1. Shutdown cooling and residual heat removal system
4.2. Reactor water clean-up system (BWR)
4.3. Chemical and volume control system (PWR)
4.4. Primary make-up water system (PWR)
4.5. Nuclear fuel handling and storage system
4.6. Steam generator blow-down system (PWR)
4.7. Chemical addition system (PWR)
4.8. Service equipment and tools
4.9. Penetrations
4.10. Fingerprint – test equipment

5. WASTE TREATMENT SYSTEMS

5.1. Solid waste systems
5.2. Liquid waste systems
5.3. Gaseous waste systems

6. NUCLEAR VENTILATION SYSTEMS

6.1. Containment ventilation system
6.2. Auxiliary buildings, ventilation system
6.3. Shield building, annulus exhaust system
6.4. Shield building, annulus heating, cooling and circulation system
6.5. Standby gas treatment system (BWR)
6.6. Supplementary leak collection system
6.7. Drywell cooling system (BWR)
6.8. Drywell purge system (BWR)
6.9. Drywell containment atmosphere mixing system (BWR)

7. MISCELLANEOUS SYSTEMS

7.1. Spent fuel pool(s) cooling and cleaning system
7.2. Refuelling water system
7.3. Closed cooling water system
7.4. Sampling system
7.5. Vents and drains
7.6. Sump systems

8. COMPONENTS

8.1. Mechanical components (pumps, valves, heat exchangers, piping supports, hangers, etc.)
8.2. Electrical components (motors, switchgear, cables, control and instrumentation equipment, racks, cubicles, etc.)

Appendix 2

TYPES OF CONTRACT APPROACH FOR NUCLEAR POWER PLANTS

1. INTRODUCTION

Nuclear power stations have been built in a wide variety of different ways. At one extreme, a single contractor has been given complete responsibility to design, build and commission a complete nuclear power station, handing it over to the owner only when it is running. At the other extreme, the owner has bought only the basic hardware of the nuclear steam supply system (NSSS) from the reactor vendor, designing the rest of the power station and buying all of the other equipment himself.

Basically, there are three different types of contract approach which have been applied so far for nuclear power stations, namely:

(1) *Turnkey approach,* where a single contractor or a consortium of contractors takes the overall responsibility for the whole works.
(2) *Split-package approach,* where the overall responsibility is divided between a relatively small number of contractors, each building a large section of the works.
(3) *Multi-contract approach,* where the owner or his architect-engineer (A/E) assumes overall responsibility for engineering the station, issuing a large number of contracts.

So far, for a first nuclear power station in a country almost always – even in the USA – a turnkey contracting approach has been followed. Today, however, the different types of contract approaches have matured considerably, particularly in the countries where they are most frequently used and are much better understood. Therefore, the risks of going non-turnkey are no longer as great as they were ten years ago and a non-turnkey approach could be considered today, even for a first nuclear power station. A final selection of the contract approach should, therefore, be made once all salient factors have been carefully evaluated. These factors are:

- potential vendors and their particular experiences and attributes;
- standardization and proven quality;
- government and industrial relationships;
- competitive and economic considerations;
- foreign financing possibilities;
- guarantee and liability considerations;
- planning and implementation of the project and subsequent projects;
- availability of qualified project management, co-ordinating and engineering manpower;
- development of national engineering and industry capability.

The objectives of most utilities entering the nuclear field are:

- to build a station to the required schedule which will produce electricity reliably over a long period of time at a price as low as is consistent with adequate safety and an acceptable environmental impact;
- to make the maximum reasonable use of domestic resources in construction;
- to gain experience from the project so that future stations can, if necessary, be better adapted to the needs of the country and depend less on foreign expertise and hardware.

The latter two points determine the amount of technology transfer that can be obtained in building nuclear power stations.

The contract types which can be considered for a nuclear power station have been summarized in the following sections.

2. TURNKEY CONTRACTS

Basically, one distinguishes between the following types of turnkey approaches:

- super turnkey
- normal turnkey.

Super turnkey

This term is used when a single contract is placed covering the whole nuclear power station. It also usually implies that the prime responsibility for the success of the project and, therefore, also for the design of the plant, is placed upon the contractor. This approach is particularly suitable for utilities with limitations in manpower resources and/or experience in the nuclear field, as has been the case in the past in Germany, Austria, Switzerland and Holland and in less well developed countries. The degree of utility involvement and approval rights is negotiable and should be written into technical bid specifications and the contract. Experience in developed countries shows that a high degree of utility involvement is negotiated, as utility expertise and manpower resources increase.

Normal turnkey

This term is used to describe a contract placed for a nuclear power plant where the utility supplies all peripheral items of the plant (10–20% of the plant costs). It is usual for owners with nuclear experience or greater competence in conventional power stations to wish to influence and approve the design of the plant to a greater extent than for the super turnkey contracts, as well as taking full responsibility for the owner's scope themselves. The owner's scope can, however, differ substantially depending on the engineering capability within the utility. This approach means a closer involvement of the owner in the detailed engineering of the station and possibly increased local participation coming under the owner's scope.

3. SPLIT-PACKAGE CONTRACTS

The term 'package' is used herein to describe a functionally complete part of a nuclear power station where a single contractor takes the overall responsibility for the design, supply, construction and setting to work. The split-package approach has been applied to a great extent for the construction of conventional thermal power stations in Europe, but until now not so much for nuclear power stations.

Basically, one distinguishes between the following types of split-package approaches:

- two-package approach
- three-package approach
- five-package approach

(a) The two-package approach

With this approach, the two main contracts (excluding the owner's scope) are for a nuclear island and a turbine island. By dividing the main plant into two packages, a higher degree of competition and technical choice can be affected. This approach has, however, two main difficulties. One is the problem of harmonizing the interfaces and the other problem arises from the problem of having two civil contractors close to one another. This can be avoided if each bidder is asked to select his civil contractor later by a sequential bidding technique. The bidding for the civil contractor is for both halves of the station.

(b) The three-package approach

This approach separates the civil works from both the nuclear and turbine islands and makes them a separate contract placed directly by the owner. This approach has, apart from the problem related to civil work, the same positive and negative features of the two-package approach, i.e. it does not ease the problem associated with the interface between reactor and turbine. Considerable engineering and interfacing experience by the utility is required.

(c) The five-package approach

In this approach the problems associated with the matching of the interface between the nuclear island and thermal island are reduced by the owner taking direct responsibility for much of the mechanical and electrical equipment which links them. The initial bidding is then for nuclear and thermal lots each with reduced extents of supply compared with the corresponding island. When the two main plant contractors have been chosen, the owner (or his architect-engineer) issues appropriate bid invitations for civil, mechanical and electrical lots to complete the power station. In practice the electrical and mechanical lots may be treated as a number of separate contracts over an extended period of time.

4. MULTI-CONTRACT APPROACH

The multi-contract approach is now the normal way of contracting in the USA and the same approach is also adopted in France, Spain, Belgium and some other countries. The customer, or more usually his architect-engineer, invites bids for a NSSS and turbine-generator and fuel, selects the preferred bids, places contracts and then designs the balance-of-plant around this equipment. The A/E will provide experienced and readily available staff, which acts on the orders of the utility. The utility or its A/E will produce a very large part of the safety report and supervise construction, usually erecting the plant themselves. This option clearly gives the maximum opportunity to the owner to select the plant which suits him and to influence the design as he would wish. It also allows him, if his architect-engineer is a good one, the best chance of having a minimum-cost plant. On the other hand, it gives him or his A/E the maximum amount of work and responsibility and the minimum protection if things go wrong, if completion of the station is late or if it does not perform well.

In this regard, the financial and technical liability of the A/E is very limited since he works exclusively on utilities' orders, usually on a cost-plus basis, for his engineering and management services.

5. CONCLUSIONS

The selection of the type of contract is one of the basic decisions to be taken concerning the realization of a nuclear power station. It should, therefore, receive great attention and be based on a careful analysis of all aspects.

Generally, it is recommendable to settle the project approach before going out for bids, but in some instances it might be necessary to leave it open until the main vendor(s) has (or have) been selected.

Technical Reports Series No. 204

TECHNICAL EVALUATION OF BIDS
FOR NUCLEAR POWER PLANTS

A Guidebook

CORRIGENDUM

On page 91 the title of Appendix 3 should read:

EXAMPLE OF
A BID EVALUATION FORM

The Contents list should be amended accordingly, and the italic words in parenthesis on page 91 should be deleted.

Appendix 3

NUMERICAL BID EVALUATION SCHEME FOR NUCLEAR POWER PLANTS

(reprinted with permission from Nuclear Engineering International, February 1976)

MIDDLETOWN NUCLEAR PROJECT

BID EVALUATION FORM

Form Ref. No.:

BIDDER:

SYSTEM/COMPONENT:

REACTOR TYPE:

ENGINEER:

SPEC. REF.:

COMPANY:

1. INFORMATION REVIEWED AND EVALUATED

References (Bid Volumes, Chapters, Pages, Drawing Nos., Diagram Nos.) for:

a) Descriptive information:

b) Bidders comments to the specifications:

c) Scope and Limits of Supply:

d) Diagrams and Drawings:

2. GENERAL SUMMARY OF THE EVALUATION

3. COMMENTS OF THE BIDDER TO THE SPECIFICATIONS

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4. <u>COMPLIANCE OF SCOPE AND LIMITS OF SUPPLY WITH SPECIFICATIONS</u>

a) Deficit Items

b) Surplus Items

c) Comments

5. <u>COMPLIANCE OF TECHNICAL DESIGN WITH SPECIFICATIONS</u>

a) Reliability:

b) System Function and Performance:

c) Safety Considerations:
- *Nuclear safety*

d) Operation and Maintenance:
(Layout)

e) Materials:

f) Codes and Standards:

g) Testing:

h) Interface Aspects:

6. COORDINATION

Is any coordination required?

7. COSTS

Estimated Costs of Deviations from the Specifications with regard to Scope and Limits of Supply

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8. OVERALL SYSTEM EVALUATION

a) Importance of System for overall plant reliability and safety:

Outage Rating		Safety Rating	
1 [ ]	4 [ ]	Safety Class 1	[ ]
2 [ ]	5 [ ]	Safety Class 2	[ ]
3 [ ]	6 [ ]	Safety Class 3	[ ]
		Class 4	[ ]

b) Overall Judgement:

	very good	good	satisfactory	doubtful	inadequate	bad
Reliability						
Function and Performance						
Safety (nuclear safety only)						
Operation and Maintenance						
Materials						

c) Recommendations:

9. QUESTIONS

10. PROPOSAL FOR ADAPTING SPECIFICATIONS (if necessary)

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