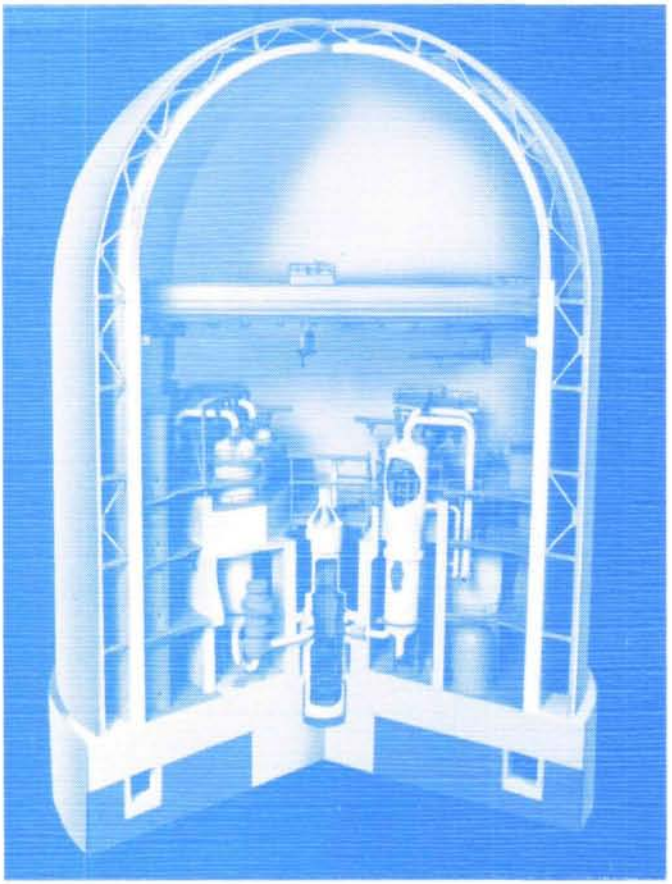

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Bid Invitation Specifications for Nuclear Power Plants

A Guidebook

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1987

BID INVITATION SPECIFICATIONS FOR NUCLEAR POWER PLANTS

A GUIDEBOOK

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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FOREWORD

In 1986, about fifteen per cent of the world's total electricity was produced by nuclear power. There were 533 nuclear power reactors in operation or under construction in 33 countries. It is expected that nuclear power will remain a viable option for energy production, if the construction schedule and costs of power plants are effectively controlled and if the plants are operated in a safe, reliable and economic way. Not only will the share of electricity generation by nuclear power be increased in those countries which already have nuclear programmes, but also there will be additional countries in which new nuclear power projects are launched. These new nuclear units will be acquired from suppliers, in most cases through a formal competitive bidding process. This is initiated by the future plant owner who prepares bid invitation specifications as a basis for the preparation of bids by the suppliers.

In response to the special needs of the developing countries and in particular those countries which intend to launch nuclear power programmes, the Division of Nuclear Power of the IAEA has produced a series of technical guidebooks. These provide information and advice on the principal activities involved in the planning and implementation of nuclear power projects, as well as on the infrastructure requirements and development needs for the successful implementation of a nuclear power programme. In particular, for the process of plant acquisition the following Guidebooks have already been published in the IAEA Technical Reports Series: Technical Evaluation of Bids for Nuclear Power Plants (TRS No. 204, 1981), Guidebook on the Introduction of Nuclear Power (TRS No. 217, 1982) and Economic Evaluation of Bids for Nuclear Power Plants, 1986 Edition (TRS No. 269, 1986). The present Guidebook constitutes a complement to these.

The Guidebook on Bid Invitation Specifications for Nuclear Power Plants is primarily directed to the managers and senior professional staff of plant owner organizations intending to launch a call for bids for a first nuclear power plant. However, the Guidebook should also be of some value for experienced owners who are about to acquire a follow-up unit. The purpose of this Guidebook is to give advice on the kind of information to be provided by the prospective plant owner to the prospective suppliers.This information should enable them to have a clear conception of the owner's wishes, of his requirements and preferences, the conditions and circumstances under which the tasks should be performed, and the detailed data and information requested of them. The presentation of this information should be such that bid evaluation and contract negotiations are facilitated.

The Guidebook was prepared in the Division of Nuclear Power, under the responsibility of B.J. Csik; J. Coll and K.F. Schenk shared this responsibility since 1985. In the preparation of the various drafts, valuable contributions were provided by C. Held, N.A. Van Zijl and, in particular, by P.J. Meyer and M. Krejci.

Appreciation is expressed to all those who participated in the preparation of this Guidebook and also to the Member States who sent experts to assist the IAEA in this work.

CONTENTS

INTRODUCTION 3

Part 1. INFORMATION PROVIDED BY THE OWNER 11

1. Invitation letter 11

2. Administrative instructions 11

3. General information 15
   - 3.1. Project description 15
   - 3.2. Site information and data 16
   - 3.3. Electric grid system 18
   - 3.4. National infrastructures 18

4. Technical requirements and criteria 19
   - 4.1. Codes and standards 20
   - 4.2. Design 22
   - 4.3. Construction and commissioning 23
   - 4.4. Operation and maintenance 23
   - 4.5. Safety and licensing 24
   - 4.6. Quality assurance 25
   - 4.7. Training 27
   - 4.8. Project schedule 28
   - 4.9. Documentation management 29

5. Scope of supply and services 30

6. National participation and technology transfer 33

7. Bid evaluation criteria 35

8. Draft contract: Terms and conditions 36
   - 8.1. Introduction 37
   - 8.2. Elements of the draft contract 37
   - 8.3. Definitions 38
   - 8.4. General clauses 39
   - 8.5. Object of the draft contract 39
   - 8.6. Planning and execution of the work 40
   - 8.7. Information, inspection, testing and control 40
   - 8.8. Assignment of the work and subcontracting 41

8.9. National participation and technology transfer 41
8.10. Training of personnel 42
8.11. Changes and additional work 42
8.12. Transport and customs clearance 43
8.13. Risks and transfer of title 43
8.14. Liability 44
8.15. Insurances 44
8.16. Quality assurance 44
8.17. Licensability and licensing 45
8.18. Delivery times 45
8.19. Documentation 45
8.20. Spare and wear parts, consumables and special tools 46
8.21. Alternatives and options 46
8.22. Guarantees or warranties 47
8.23. Take-over 47
8.24. Prices, price adjustments and terms of payment 48
8.25. Force majeure 48
8.26. Termination and suspension of the contract 48
8.27. Guarantee of title and proprietary information 49
8.28. Execution of the contract 49
8.29. Applicable law 49
8.30. Arbitration 50

9. Commercial conditions 50

Part 2. INFORMATION REQUESTED FROM THE BIDDERS 53

1. General information 53
1.1. Legal and commercial documentation 53
1.2. Relevant experience of the bidders 53
1.3. Reference plant 54
1.4. List of main subcontractors 54
1.5. Summary of the bid presentation 55
1.6. Overall schedule of the project 55
1.7. Summary of technical description and scope of supply 55
1.8. Organization of the project 56

2. General technical aspects 60
2.1. Design 60
2.2. Construction and commissioning 61
2.3. Operation and maintenance 61
2.4. Safety and licensing 62
2.5. Documentation 63

3. Technical descriptions 63
3.1. Nuclear island 63
3.2. Nuclear fuel and nuclear fuel cycle 64
3.3. Turbine-generator plant 65
3.4. Balance of plant 65
3.5. Electrical systems 66
3.6. Instrumentation and control 66
3.7. Civil works 67
3.8. Spare and wear parts and consumables 67

4. Scope of supply and services 67

5. Alternatives and options 71

6. Quality assurance programme 72

7. Training 74

8. Project schedule 74

9. National participation and technology transfer 75

10. Guarantees and warranties 76

11. Deviations and exceptions 76

12. Commercial conditions 77
12.1. Prices, price breakdown and currency 77
12.2. Price adjustment 81
12.3. Terms and schedule of payments 82
12.4. Financing 84

APPENDICES

Appendix A. IAEA Account System for Nuclear Power Plants 87
Appendix B. Technical Questionnaires 115
Appendix C. Abbreviations 157

Bibliography 159

List of Participants 163

INTRODUCTION

INTRODUCTION

The decision to acquire a nuclear power plant — whether it is the first plant or a subsequent unit of a country — is based on the results of previously performed planning, feasibility and siting studies. In these studies the advisability of acquiring the plant and the principal characteristics of the project are investigated and the results constitute the background of the project. Throughout the preparatory studies the prospective plant owner can express his wishes and intentions, and he can decide where the plant is to be built. He can also choose the contractual mode and analyse the supply market. At the end of the preparatory studies the owner starts a competitive bidding process, unless he has chosen only one supplier for policy or political reasons or has preselected a supplier and decided to proceed with direct negotiations. The first stage of the competitive bidding process is the preparation of bid invitation specifications (BIS).

Before the preparation of bid invitation specifications, it is advisable for a country launching a nuclear power programme to contact the prospective suppliers and to investigate in advance the financial and political constraints of the project in order to establish acceptable conditions for both the owner of the plant and the prospective suppliers as well as for the relevant authorities.

PURPOSE AND SCOPE OF THE BIS

The fundamental purpose of the BIS is to provide information to the bidders (the prospective suppliers). The prospective plant owner (in the following called owner) informs the bidders of his wishes and requirements, the conditions and circumstances under which the supplier will have to perform his tasks, the information required, the form of presentation of this information in the bids and the basis on which the bids will be evaluated. The owner also makes proposals for contractual arrangements with the successful bidder.

It is in the interest of the owner to provide complete and precise information since this will facilitate the preparation and subsequent evaluation of the bids. It is also in the interest of the owner to promote competition and to encourage each bidder to prepare and present his best possible offer. This means that the owner should provide comprehensive relevant information on all aspects which may affect the project and that he should clearly express his requirements, conditions and wishes or expectations. On the other hand, the owner should refrain from being too restrictive in his demands and from making the scope of the BIS too extensive by including detailed

technical descriptions or basic information which is common knowledge. The quality of the BIS is measured by its contents, not by the number of pages.

PURPOSE AND SCOPE OF THE GUIDEBOOK

The present Guidebook on Bid Invitation Specifications for Nuclear Power Plants has been prepared within the framework of the series of technical guidebooks of the Division of Nuclear Power published by the IAEA in the Technical Reports Series (TRS) (see Bibliography). It complements in particular the "Guidebook on the Introduction of Nuclear Power" (TRS No. 217), the "Technical Evaluation of Bids for Nuclear Power Plants: A Guidebook" (TRS No. 204), and the "Economic Evaluation of Bids for Nuclear Power Plants, 1986 Edition: A Guidebook" (TRS No. 269). These Guidebooks contain information, advice and recommendations relevant to the subject area treated in the present Guidebook.

One of the basic recommendations for the preparation of the BIS is to avoid repetition and overlap. In the present Guidebook, repetitions are avoided as far as practicable without losing coherence. The reader is advised to consult the above-mentioned Guidebooks as well as other IAEA publications in general and those which are referred to in the text.

It is the purpose of all IAEA technical guidebooks to provide information, advice, recommendations and basic guidance and, to a certain extent, to give examples which are useful for the management and staff of nuclear power plants mainly in developing countries when performing relevant tasks and activities. In particular, this Guidebook is directed to managers and senior staff of prospective owner organizations in developing countries embarking on their first nuclear power project. It is this group of persons who have no prior experience in acquiring nuclear plants which can profit most from this kind of objective guidance. The Guidebook may also be useful to experienced owner organizations who wish to acquire follow-up units.

The main contractual approach covered by this Guidebook is the turnkey approach. This is not only the most complete contractual approach but also the one most likely to be chosen by countries starting a nuclear power programme. To a certain degree, the guidance given here is also applicable to the split package approach for large functionally complete portions of the plant. Major differences between the split package approach and the turnkey approach are indicated where appropriate. The preparation of the BIS within the multiple package approach is beyond the scope of this Guidebook, since an owner who has the experience and technical capability to take on the responsibility of managing a nuclear power project under such a contract hardly needs the advice and assistance offered here.

It has been attempted to provide technically meaningful guidance which goes beyond statements of the obvious and the expression of generalities. The experience of developing countries has been used largely in this Guidebook.

ORGANIZATION, STAFFING AND EFFORT NECESSARY FOR THE PREPARATION OF THE BIS

The owner of a nuclear power plant has the full responsibility for the preparation of the BIS and for its contents. He can delegate certain tasks, obtain assistance and use as much advice as he needs or wishes, but he cannot delegate the general responsibility nor can he share it with anyone. The owner first has to establish a basic organizational unit which is in charge of the preparation of the BIS and he has to select competent persons for this unit. If he is unable to do this, it is questionable that he is at all ready to proceed with the work for the acquisition of a nuclear power plant.

The usual criteria for project management organizations should be applied to the owner's basic organizational unit. The authorities and responsibilities as well as the lines of communication should be well defined. This basic organizational unit should have direct access to the highest level of decision-making capability within the owner's overall organization. The organizational unit should have easy access to outside expertise for assistance and advice in a wide range of special topics. The internal structure of this unit can be simple; there should be a project manager, an assistant project manager and a team of 15–25 competent professionals with efficient administrative support.

In the case of a first nuclear project, the owner can choose the staff for the organizational unit from two groups: (1) practice-oriented professionals with experience in the preparation of bid invitation specifications for conventional thermal power plants or large industrial plants, and (2) persons who have been involved in the feasibility study for the nuclear project and who have received specialized training in subjects relevant to nuclear power. The core of the team should preferably be formed by persons selected from the owner's staff. The owner should resist the temptation to turn to research-oriented nuclear scientists.

It is generally advisable for the owner to obtain assistance from well qualified consultants or architect/engineers (A/E) who have the experience and specialized knowledge that may be lacking in the owner's team. Consultants or architect/engineers should, however, always have an advisory function.

The overall effort required for preparing the BIS for a nuclear power plant under a turnkey contract is of the order of 10–20 professional man-years (including the basic team and outside assistance) and the time needed is about 6–8 months. For a split package project, considering the main packages, the overall effort and time needed may be somewhat higher but should be of a similar order of magnitude as those for a turnkey project.

CONTENTS OF THE BIS AND PREPARATION PROCEDURES

The purpose of the BIS determines its contents. The BIS should contain all the information needed by the bidders for the preparation of their bids, in response to the invitation of the owner and according to his requirements. This information should be structured in such a way as to facilitate the subsequent bid evaluation.

There are many ways of structuring the contents of the BIS so that it has a logical sequence. The approaches and practices vary and there are different opinions as to which is the best approach. As long as the BIS is complete, precise, clear, unambiguous, consistent and comprehensive, any reasonable internal structure and sequence is acceptable. In this Guidebook, the approach adopted and presented is to divide the contents of the BIS into two main parts. Part 1 contains the information provided by the owner and Part 2 includes the information requested from the bidder. In each part, the different aspects and subject areas are treated separately, in a sequence which can facilitate the work; repetition and overlap which may lead to confusion are avoided.

Regarding the procedures for the preparation of the BIS, special attention should be given to the following points:

- Basic policy questions, such as the overall approach to plant acquisition, project implementation, national participation, technology transfer, the fuel cycle and financing, should be decided beforehand and laid down in a written statement which can be used during the preparation of the BIS.
- Comprehensive site and site-related data and information should be available before starting the preparation of the BIS.
- Reference material, such as specifications for other projects (nuclear or conventional) and technical descriptions of nuclear power plants, should be obtained for consultation.
- Adequate office space in a central location as well as administrative support should be provided for the project manager and his core team. The budget for this work should be adequate.
- The BIS should be prepared in a language suitable for both the owner and the bidder. The necessary translations should be done by specialized translators.
- The work of different groups for the major subject areas of the BIS should proceed in parallel, with constant co-ordination and interface control.
- If the services of an outside consultant or an A/E are required, the selection should be made with special consideration of the following points: relevant experience in developing countries, preferably in the owner's country; experience in the scope of the work; reputation; impartiality regarding prospective suppliers; and qualifications of the staff of the consultant or A/E.
- If consultants or A/E firms are involved in any major capacity, the owner should constantly supervise and control their work.

— Prospective bidders should be asked to give the owner relevant information, in particular on their experience, and to provide technical descriptions of their standard designs.
— The regulatory body of the owner's country should be consulted regarding aspects of nuclear safety and licensing contained in the BIS.
— Representatives of other national authorities or organizations of the owner's country who participate in the decision-making process or who have to approve the BIS should be involved in the BIS preparation, at least in defining the basic policies.

In principle, no effort should be spared in the preparation of the BIS, since it constitutes the basis of the project. The owner should keep in mind that the final objective of the process which starts with the BIS is to produce energy at the lowest possible cost, in a safe and reliable plant. He should state clearly and precisely all his conditions, requirements, preferences and wishes, but he should also use common sense so that a reasonable compromise can be achieved.

Part 1

INFORMATION PROVIDED BY THE OWNER

Part 1

INFORMATION PROVIDED BY THE OWNER

1. INVITATION LETTER

In an open competitive bidding process, without preselection of suppliers, an invitation letter, which is part of the BIS documents, should be sent to the interested suppliers. In a limited competitive bidding process, with preselection of several suppliers, the invitation letter is usually a separate document which is sent to each individual potential supplier. In a direct negotiation approach, no invitation letter is needed since no competitive bidding takes place. In this case, the information exchange is between the prospective owner and the selected supplier through direct contract negotiations.

The invitation letter should state the intention of the owner to proceed with the project and it should indicate the main characteristics of the project (power ranges, reactor type(s), scope of supply), the site of the plant and the proposed plant schedule as well as the general approach adopted for the bidding and contracting process. The invitation letter should also contain a summary of the main points of the BIS, with special emphasis on those parts which are of particular importance for the project (for instance the owner's policy regarding domestic participation and technology transfer, and his financing requirements).

In a split package approach, the invitation letter should also include a brief description of the management of the project as contemplated by the owner.

In the invitation letter the owner should request the bidders to send a written reply within an appropriate time (several weeks) regarding the formal notification of their intent to bid.

The invitation letter should be kept as short as possible and should contain no details of the subjects since these are given in the other BIS documents.

2. ADMINISTRATIVE INSTRUCTIONS

The administrative instructions should contain all organizational and administrative rules and procedures for the bidding process and for the submission of the bid documents. Information on the following points should be included:

(a) Owner's legal address and representatives
(b) List of BIS documents
(c) Request for notification of the intent to bid
(d) Modifications to the BIS
(e) Requests for clarifications

(f) Bid submission date and place
(g) Right of property of bid documents
(h) Presentation of bid documents
(i) Confidentiality.

(a) Owner's legal address and representatives

The full address of the owner should be given as well as the name(s) of the person(s) empowered to represent the owner regarding all purposes and aspects of the bidding process and to whom all communications of the bidders are to be directed.

(b) List of BIS documents

To provide a quick overview of the contents of the BIS, it is convenient to include in this section a complete list of all documents constituting the BIS (including numbers of pages) and a short explanation of their purpose.

(c) Request for notification of the intent to bid

The request for a formal notification of the intent to bid is made in the invitation letter. In this section of the administrative instructions the time allowed for the delivery of the notification should be given. The bidder should also be requested to include in the notification a statement that he has carefully examined the BIS and has taken note of the conditions under which the work has to be carried out.

(d) Modifications to the BIS

To ensure a smooth bidding process, modifications to the BIS should not be made after they have been sent to the bidders. However, if omissions or discrepancies are discovered at a later date, modifications to the BIS may have to be made by the owner. In the administrative instructions, the procedure of dealing with such modifications should be indicated. Usually, a written communication is sent simultaneously to all bidders, notifying them of the changes made. This notification by the owner then becomes part of the BIS. The bidders are requested to send an acknowledgement of receipt to the owner. An identification or numbering system should be used in order to keep track of all modifications.

(e) Requests for clarifications

The bidders have the right to request clarifications from the owner if they find discrepancies or are in doubt about the meaning of any part of the BIS. It is general

practice to consider only written requests for clarification and to answer these requests also in writing, with copies being sent to all bidders. Such clarifications may lead to modifications to the BIS. Regular or ad hoc open meetings with all bidders may be useful for complementing the written communications.

(f) Bid submission date and place

The closing date for submission of the bids and the address to which they have to be sent should be given. It should be stated that bids submitted at a later date will not be accepted. Normally, a period of 6–9 months should be allowed for bid preparation. The technical bid and the commercial bid may be presented separately, but in principle they should be submitted at the same date.

(g) Right of property of bid documents

The owner should state in the BIS that the bid documents are his property and that he is under no obligation to return them to the bidders.

(h) Presentation of bid documents

Clear instructions regarding the presentation of bids should be given. These instructions should include the following points: number of copies, format, organization, structuring and marking, language(s), engineering system of units to be used, validity period, and presentation of supplementary information (information which was not specifically requested in the BIS but which the bidder may find useful to add separately for evaluation).

It is of particular importance to instruct the bidders that they have to keep the commercial conditions of their bids (Part 2, Section 12) separate from the rest of the bid documents (the commercial bid may be submitted in a closed and sealed envelope marked Price Proposal).

All bids should be structured in the same way since this will facilitate the bid evaluation process. The owner should provide a general outline of the structure of the bids. The information given in the bids should be arranged and presented in volumes. These should be numbered and the same kind of information should be provided in the same volumes in all bids. The volumes should be kept separate and should be submitted in a certain sequence, as indicated below.

Vol.1: General information
- — Legal and commercial documentation
- — Relevant experience of the bidders
- — Reference plant

— List of main subcontractors
— Summary of the bid presentation
— Overall schedule of the project and scope of supply
— Summary of technical description
— Organization of the project
— Deviations and exceptions

Vol.2: General technical aspects
— Design
— Construction and commissioning
— Operation and maintenance
— Safety and licensing
— Documentation.

Vol.3: Technical description of nuclear island

Vol.4: Technical description of nuclear fuel and fuel cycle

Vol.5: Technical description of turbine-generator plant systems

Vol.6: Technical description of balance of plant

Vol.7: Technical description of electrical systems

Vol.8: Technical description of instrumentation and control

Vol.9: Technical description of civil works

Vol.10: Spare and wear parts, consumables and special tools

Vol.11: Scope of supply and services

Vol.12: Alternatives and options

Vol.13: Project schedule

Vol.14: Quality assurance programme

Vol.15: Training

Vol.16: National participation and technology transfer

Vol.17: Guarantees and warranties

Vol.18: Commercial conditions
— Price, price breakdown and currency
— Price adjustment
— Terms and schedule of payments
— Financing.

This organization of the volumes is applicable for a turnkey project. The account numbers of Appendix A for the same subjects are to be found at different places in the volumes because, for example, miscellaneous plant equipment (account 26) or water intake and heat rejection (account 25) or special materials

(account 27) are included in the nuclear island as well as in the turbine-generator plant systems. Especially in a split package approach, the different account numbers should be organized in accordance with the desired scope of supply and services (see Part 2, Section 4).

(i) Confidentiality

Regarding the confidentiality of the documents, the owner should request the bidders not to disclose the contents of the BIS to any third party, except if it is necessary for bid preparation. At the same time the owner should assure the bidders of a confidential treatment of the bids.

3. GENERAL INFORMATION

The prospective suppliers cannot be expected to prepare complete and firm bids if they have not received sufficient and adequate information on the project, the site, the electrical system and the available local (site related) and national infrastructures. It should be kept in mind that the quality of the bids will strongly depend on the completeness of the information provided to the bidders. A bid which has been prepared without this information can only be regarded as preliminary.

Most if not all of the general information to be provided should be available to the owner before he begins to prepare the BIS. However, the information may be contained in different reports, studies or documents from various sources. All information relevant to the BIS should be updated, if necessary, and checked for completeness, correctness and compatibility.

It is understood that the bids will be prepared according to the requirements defined by the owner and according to the information provided in the BIS. If after bid submission it turns out that some of the information provided by the owner is misleading or even wrong, the suppliers cannot be held responsible for the additional costs which may result from the necessary modifications and changes or from a delay of the project.

3.1. Project description

The owner should provide a comprehensive description of the project he wishes to implement. He should also indicate how this project fits into the overall framework of the country's nuclear power programme.

The project description should provide information about the nuclear power programme and the plant, the reactor type(s), the unit rating, the number of units on the site, the implementation date, the time schedule for the implementation of successive units at the site, the plant design and the economic lifetime, the

load factors, the operating mode, etc. It is useful to add the relevant parts of the feasibility study for the project as complementary information.

A tentative plot/plan for the plant may be enclosed in order to give the bidders an idea of the possible positioning and/or layout at the given site. If future extensions of the project are desired, with the installation of additional units, this should be indicated.

In the case of a split package approach, the owner should provide information on how he intends to manage the project (either alone or with the help of an architect/engineer) and what parts of the overall scope of supply and services he intends to take upon himself. The owner should also describe the scopes of supply and services for each package within the contractual approach.

3.2. Site information and data

The provision of complete and comprehensive site information is especially important for the preparation of the bids since the site conditions have a great influence on the layout, design and construction as well as the costs of the nuclear power plant. Therefore, all site conditions, factors, characteristics and data, even those which may seem not to be directly related to the project, should be given in the BIS in as much detail as possible. The provision of comprehensive site data will protect the owner from incurring unforeseen expenses in the course of project implementation.

Before the preparation of the BIS, the owner must have selected a qualified site for the plant and performed an in-depth study. Also at this early stage he should have prepared a site report in order to obtain the site review and approval from the relevant authorities. The owner should include in the BIS all site information relevant to the bids. Furthermore, the owner should offer the bidders free access to all detailed site studies and collected site data.

The subject areas for which site information and data are needed are discussed below. (More specific comments are given in the relevant NUSS publications — see the listing in the Bibliography — and in TRS No. 217, Section 9.)

(a) Geography and topography

The geographical and topographical data for the site and the boundaries of the area must be sufficiently accurate. The corresponding co-ordinates and elevations of the site area should be given.

(b) Geology, soil mechanics and seismology

The geological, soil mechanics and seismological conditions of the site have to be described in detail so that the bidder can propose a design which is suitable

for the site. Particularly important are the subsoil conditions, namely the strength, stability and homogeneity of the subsoil, the liquefaction potential, the seismic history, the seismotectonics and the location of faults at the site, and the definition of seismic design values.

(c) Hydrology

The following information has to be given: water sources, historical data on flow rates and temperatures, ocean wave sizes and frequency, water quality (chemical composition, silt content), groundwater conditions and characteristics, mean values, variations. The water conditions are of particular importance for the design of the main and auxiliary cooling water systems, the water make-up systems and the drinking water systems.

(d) Meteorology

Information on climatic conditions as well as historical data on temperatures, winds, humidity, precipitation and extreme meteorological events should be provided. The meteorological data are mainly required for the design of the heating and ventilation systems as well as for calculating the dispersion of radioactivity in the air. These data are also important for assessing the possible effects of extreme meteorological events.

(e) Demography, traffic routes, agricultural and industrial use of land, access to the site

Demographical data, information on traffic routes and environmental data are mainly required for the assessment of the plant safety and of environmental effects. Information on all available or potential access routes to the site is important for considerations of the transport possibilities.

(f) Other site information

Information on other site characteristics or factors which might have an influence on the design, such as background radiation, ultimate heat sink and location of other power plants or industrial installations near the site, should be given in as much detail as possible.

The national or international codes, standards and requirements (for example the relevant safety guides and standards of the NUSS programme) which the owner wishes to be complied with should be listed in this section.

It is good practice to offer the bidders free access to the site so that they can make their own studies if they consider this necessary for complementing the information given in the BIS. The owner should establish a procedure for the resolution of questions regarding the interpretation of the site data.

3.3. Electric grid system

For a nuclear power plant, special consideration has to be given to the interaction of the grid system and the proposed plant. The main aspects of the electric system to be considered are:

— Cold and spinning reserves available in the system
— Power transmission capacity of the grid during critical conditions
— Power control and load dispatching system
— Voltage and frequency fluctuation control
— Probability of supply interruptions and grid disturbances.

The technical characteristics of nuclear power plants, such as startup, load change and load following capabilities, effects of power cycling on components and fuel elements, and ability to withstand externally induced disturbances, are closely related with the integration of the plant in the electric system. Therefore, the owner should provide the bidders with detailed information on the electric system to which the plant is to be connected in order to ensure a proper preparation of the bids.

Before starting the preparation of the BIS the owner should perform a comprehensive analysis of the electric system for the particular site and for the desired size of the nuclear plant. The results of this analysis, together with any other relevant information, should be included in this section of the BIS.

3.4. National infrastructures

The general purpose of the information on national infrastructures is to give the bidders a detailed picture of the prevailing conditions of the country in which the project will be implemented. In particular, the bidders should be informed of the organization of nuclear activities and the regulations in force in the country, the owner's infrastructure and the local resources. This information will also help the bidders to make plans regarding the requested national participation and technology transfer.

Information on the organization of nuclear activities and the regulations in force in the country, and on organizations involved in the nuclear power programme should be given in as much detail as possible. The owner's resources (manpower

capabilities and qualifications, maintenance capabilities and equipment, training facilities) should be described, and the relevant national labour legislation and practices should be indicated. Details on the national nuclear regulatory system and procedures are given in Section 4.1.

The information on local resources should cover in particular the industrial and manpower infrastructures. Lists and general descriptions (with the numbers of employees and the scope of activities) of engineering firms, construction and erection companies, and electrical, mechanical and electronics industries existing in the country should be included. The relevant results of previous surveys and studies (nuclear power planning, feasibility study) should be added as complementary information to the bidders.

The availability of qualified manpower and materials are further topics to be dealt with in this section.

All this information is also relevant for the planning of national participation in the project. A clear outline of the policy and strategy for the promotion of national participation should be given, and information regarding the legislation on the protection of local industries, if any, should be included.

A description of the scientific and technological infrastructure, with a listing of national and private research and development institutes, educational institutions, training centres and professional associations, may also be useful. The above-mentioned information, in whole or in part, can probably be obtained from the feasibility study for the project.

4. TECHNICAL REQUIREMENTS AND CRITERIA

In this section of the BIS the owner should complement the previous information (Section 3) by a statement of his specific technical requirements for project execution and the criteria for the design and construction of the plant. He should also explain his intentions regarding the operation and maintenance of the plant. The points to be dealt with in this section are:

— Codes and standards
— Design
— Construction and commissioning
— Operation and maintenance
— Safety and licensing
— Quality assurance
— Training
— Project schedule
— Documentation management.

4.1. Codes and standards

Safety-related and non-safety-related codes, standards, regulations and guides play key roles in ensuring the safety and good performance of nuclear power plants, since they

- serve as a basis for safety and environmental protection
- define performance requirements
- codify good practice proven by experience
- provide the basis for equipment standardization
- provide the basis for inspection and enforcement
- encourage public acceptance.

This is why, in this section of the BIS, the owner should give clear indications as to which codes and standards he requires or is willing to accept for the design and construction of the plant.

The approach regarding safety-related codes and standards is covered in Section 4.5. Thus, only a listing of additional codes and standards which are not necessarily related with safety should be included here, indicating priorities or preferences, if any.

The owner should provide a list of the relevant national codes and standards applicable to the nuclear plant. If the owner's national codes and standards are more stringent than the codes and standards of international institutions or the national codes and standards of the supplier's country, they should prevail. Furthermore, the owner should provide a list of all international codes and standards and of the national codes and standards of the suppliers which he is willing to accept if domestic codes are not applicable or available. In principle, there should be consistency in the codes and standards to be used.

The following list may be of help to the owner in the preparation of this information:

International codes and standards have been formulated by the following organizations:

International Atomic Energy Agency (IAEA)

International Electrotechnical Commission (IEC)

International Organization for Standardization (ISO)

International Commission on Radiological Protection (ICRP)

International Commission on Radiation Units and Measurements (ICRUM)

International Air Transport Association (IATA)

International Maritime Consultative Organization (IMCO).

The following list gives code abbreviations from other institutes and organizations whose regulations and standards may be considered.

AD	Arbeitsgemeinschaft Druckbehälter
ADR/RID/RSD	Transport des marchandises dangereuses
AFNOR	Association Française de normalization
AIS	American Institute of Steel
ANS	American Nuclear Society
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BS	British Standards
CEA	Comité Européen des assurances
CFR	Code of Federal Regulations (USA)
CSA	Canadian Standards Association
DIN	Deutsche Industrie-Normen
EURO	Normes 25-67 "Constructions métalliques"
FEM	Fédération Européenne de la manutention
HIS	Hydraulic Institute Standards
IEEE	Institute of Electrical and Electronics Engineers
ISA	Instrument Society of American Standards
KTA	Kerntechnischer Ausschuss
MSS	Manufacturing Standardization Society
NBS	National Bureau of Standards
NEMA	National Electrical Manufacturer's Association
RCC	Règles de conception et de construction des centrales nucléaires
SE	Stahl-Eisen Blätter
TEMA	Tubular Exchangers Manufacturers Association
TRD	Technische Regeln für Dampfkessel
TÜV	Technischer Überwachungsverein
USNRC	United States Nuclear Regulatory Commission

VDE	Verband Deutscher Elektrotechniker
VDEW	Vereinigung Deutscher Elektrizitätswerke
VDI	Verein Deutscher Ingenieure
VGB	Vereinigung der Grosskraftwerks-Betreiber e.V.

4.2. Design

In this section of the BIS the owner should complete the information provided in Section 3.1 by details of the plant's main characteristics for design purposes, such as:

- Main plant characteristics
- Requirements based on the site characteristics
- Type of cooling
- Other specific requirements and criteria.

In particular, the following data should be given:

- Number of units requested and/or planned
- Net electrical output of the plant
- Acceptable tolerance (range) in power output
- Reactor type(s)
- Length of fuel cycle (12–18–24 months)
  (for off-load refuelled reactors)
- Spent fuel storage capacity at the plant (number of cores or years)
- Waste storage capacity at the site (number of drums or years)
- Preferred turbine-generator rotational speed (if any)
- Quantity and quality of steam for heating or cogeneration purposes (if any).

As a complement to Section 3.2, the owner should provide additional information on the requirements and criteria related to the site which influence the design of the plant and which he wishes to be considered:

- Engineering requirements for the integration of the plant into the electric system, cooling water supplies, communication links, access to the site and possible future extension of the plant.
- Radiological protection criteria with regard to the radiation exposure of the public, considering the population distribution and the control of the release of radioactive material to the environment.
- Meteorological, hydrological, geological and seismological site characteristics. It is of particular importance to indicate precisely the seismic criteria to be applied for the design as established by the owner.

— Protection against natural phenomena, such as tornadoes, hurricanes, floods, tsunamis and seiches.
— Protection against man-induced events, such as dam ruptures, mining operations, aircraft crashes, transport accidents and chemical works accidents, third-party interventions.

The owner may wish that, in addition to the requirements imposed by the applicable codes and standards, topics such as those listed in Section 2.1 of Part 2 or other topics be specially considered for plant design. This should be clearly stated in the BIS, indicating all details.

In a split package approach, these specific requirements should refer to each package and the owner should in all cases provide complete information related to the technical requirements for the interfaces between the packages.

4.3. Construction and commissioning

Since in a turnkey approach the supplier is fully in charge of plant construction, the owner has to provide no other information than that related to the legislation in force (see Section 3.4) and the scope of supply and services (dealt with in detail in Section 5). The owner may, however, wish to express his specific requirements or wishes regarding the use of materials, construction techniques and procedures.

For a turnkey approach, it is not necessary to define the interfaces between plant construction and plant commissioning.

In a split package approach the owner has overall responsibility for the co-ordination of the work. Therefore, he should clearly indicate how he intends to organize and manage the site activities and the interfaces between plant construction and plant commissioning. The owner should also give complete information on the facilities (site offices, storage building and space, medical services, security services) that will be provided for each contractor and when they will be available.

For both the turnkey approach and the split package approach the owner has to provide detailed information on his provisions and involvements during commissioning, including the preparation of procedures and manuals for the commissioning, operation and maintenance phases.

4.4. Operation and maintenance

As a complement to the information included in Section 3.3, the owner should provide in this section of the BIS as many details as possible regarding the operational modes of the plant (base load or load following), including the expected startups, load variations and external disturbances during the plant life. If a load following plant is taken into consideration, the expected load change capabilities should also be indicated.

If the owner requires the achievement of certain specific operational characteristics for the plant, these should be clearly stated, giving also the related technical requirements. Such specific operational characteristics may refer to the following items:

— Startup capabilities from hot and cold conditions
— Shutdown capability
— Load pickup in the power range
— Reactor power set-back capabilities and part load operation
— Step and ramp load changes at different power levels
— Load rejection capability
— Limits for frequency and voltage changes
— Minimum accepted power load for continuous operation
— Capability of the plant to operate in isolation from the grid
— Operational cycles and transients
— Blackout operational capability
— Emergency power supply.

Further information on these subjects may be found in the Guidebook on Interaction of Grid Characteristics with Design and Performance of Nuclear Power Plants (TRS No. 224).

Regarding the subject of plant maintenance, the owner should provide in this section a description of his general approach, procedures and practices for maintaining the existing electric power plants (centralized services, organization, personnel, spare parts, scheduling, on-site and off-site facilities). It is of particular importance to indicate the preferences, if any, for maintenance schedules as well as the limiting conditions and the constraints for maintenance periods.

4.5. Safety and licensing

The purpose of this section of the BIS is to provide information to the bidders with regard to the nuclear safety and licensing requirements for the project. These requirements are the result of the legislation in force in the owner's country as well as of the regulations, rules, guides and procedures established by the regulatory authority.

Thus, the owner should provide in this section information on all national laws, decrees, rules, codes and standards related to nuclear safety which are applicable to the nuclear plant. Furthermore, he should give a detailed description of the licensing procedure (including the schedule) to be followed, indicating the different steps and the kind and number of documents to be submitted.

The owner should point out clearly the expected participation of the suppliers in the preparation of the relevant documents and the required assistance of the

suppliers during the licensing process. As the licensee, he alone is responsible to the authority and he has to obtain the necessary licences for construction and operation of the plant.

The regulatory authority of the owner's country may not yet have developed a complete set of codes and standards for the national licensing procedure. In this case, the owner should indicate in this section the policy to be applied for the licensing of the plant. To ensure the safety of the project, the local authority usually requests that the plant should be designed and constructed in accordance with the codes, standards and regulations applicable in the country of origin and that it should be licensable there. In this case, the regulatory authority of the owner's country may have additional requirements or may impose some different obligations.

It is of great importance for the owner to fix the date of validity for the applicable safety regulations (reference date), since additional costs related to an increase or a modification of the safety conditions for the project after this date have to be borne by the owner. Normally, the date of bid presentation is taken as the validity (reference) date.

Further information on these subjects may be found in the IAEA Guidebook on the Introduction of Nuclear Power (TRS No. 217, Chapters 5 and 6) and in the IAEA Safety Series No. 50-C-G (NUSS).

4.6. Quality assurance

For a nuclear power project, more stringent requirements regarding the quality of equipment and services are applied than for a conventional project. The plant owner has the overall responsibility for ensuring the fulfilment of the quality objectives. The regulatory authority in turn has to ensure that the owner complies with his duties and responsibilities. It is therefore customary that the regulatory requirements include the establishment and implementation of a quality assurance (QA) programme for all project activities important to safety.

The purpose of the QA programme is to ensure that the plant will be designed, constructed, installed, tested and operated in a satisfactory way. This is only possible if all participants in the nuclear power project (plant designers, suppliers, A/E, plant constructors, plant operators) are obliged to plan, perform, control and document their work in a systematic and consistent manner. The QA programme is the management tool used to ensure that all activities affecting the safety and quality of the plant are performed in a planned, systematic and controlled manner. The responsibility for the establishment and implementation of the overall QA programme is with the plant owner.

The owner may delegate the tasks of establishing and implementing all or parts of the overall QA programme to other organizations, but he has to retain the overall responsibility for the effectiveness of the programme. Through contractual arrangements with all participants in the project the plant owner will ensure for certain

activities the establishment and implementation of a QA programme by them. These constituent QA programmes should be based on the QA principles specified in the regulatory requirements and codes or in industrial standards.

In this section of the BIS the owner should provide all information referring to the QA programmme he intends to apply for the project. The QA programme requirements can be specified either by reference to the applicable codes, standards and regulatory requirements (overall specification method) or by listing all those QA programme activities which the supplier has to implement in his execution of the contract (unique order method).

Typical provisions included in the programme specification statement are the following:

- Applicable QA code, standard or specifications. This may be the IAEA Code of Practice on Quality Assurance for Safety in Nuclear Power Plants (Safety Series No. 50-C-QA, published 1978) which represents a minimum requirement for a QA programme and would be acceptable for suppliers from various countries. The requirements of the IAEA Code of Practice can be met by referring to the series of IAEA Safety Guides.
- Requirements for the submission of documents defining the QA programme. Specifications for the required documentation are given in the section of the BIS containing the requirements for information to be submitted with the bid.
- Requirements for owner–supplier co-ordination, including the right of access of the owner to the supplier's premises as well as documentation for the purpose of QA programme review and evaluation. These requirements may also include the right for independent verification by an independent inspection organization or by regulatory inspectors.
- Requirements for passing down the QA programme requirements to lower tiers.

When the BIS are issued for a limited scope of work, the unique order method for specifying the QA programme requirements may be used. In this case the following statements should be made:

- Specific requirements of the applicable standards (for instance the requirements for in-process and final inspection and test of equipment, with specified inspection and test control procedures).
- Requirements for the submission of the inspection and test plan and of other appropriate documents.
- Requirements for access to plant facilities and documents for the purpose of witnessing inspection and tests.
- Requirements for passing down the QA requirements to the suppliers and other contractors.

More information on this subject can be found in the IAEA Safety Series Nos. 50-C-QA and 50-SG-QA as well as in the Manual on Quality Assurance Programme Auditing (TRS No. 237).

4.7. Training

The provision of a nuclear power plant normally includes training of the owner's operation and maintenance personnel by the supplier. Training in other areas is covered in Section 6, under technology transfer.

The owner should indicate in this section of the BIS the organizational plan and structure he intends to adopt for plant operation and maintenance as well as the different functions of the personnel.

Usually, the organizational structure consists of the following departments which are under the direction of a plant manager (or station superintendent) and an assistant plant manager (or deputy superintendent):

- *Operations department*, responsible for direct plant operation and also for fuel handling in the case of reactors with on-load refuelling.
- *Maintenance department*, responsible for all maintenance work, for mechanical and electrical equipment, instrumentation, buildings, as well as for in-service inspection and spare parts management.
- *Technical support department*, responsible for planning and scheduling, reactor physics, fuel management, fuel handling (off-load refuelling), spent fuel storage, waste and effluent management, chemistry, performance review, evaluation of abnormal occurrences, documentation, systems engineering and design modifications.
- *Safety department*, responsible for health physics, fire fighting and industrial safety, emergency preparedness, abnormal occurrences and accident analysis.
- *Quality assurance department*, responsible for QA during plant operation and maintenance.
- *Training department*, responsible for establishing, maintaining and verifying personnel competence.
- *Security department*, responsible for plant security and safeguards measures.
- *Administration department*, responsible for providing administrative support and general services.

A different distribution of departments and assignment of functions is also possible. The organizational plan should be a complete description of the organization and its functions.

The owner should indicate his policy regarding educational qualification requirements and the language to be used during training. For the plant management, supervisory and control room operations personnel, additional training will probably

be provided by the supplier, and the owner should indicate the type of specialized training which he intends to provide for this group.

The owner should give information on the number of personnel at the different organizational levels (managers, supervisors, engineers, reactor physicists, chemists, technicians, craftsmen) for whom he will provide training, as well as on their experience and educational background. Furthermore, he should indicate the desired training programme and participation in the work for this personnel.

It is considered good practice to offer to the bidders free access to the owner's training facilities so that they can better assess the owner's training capabilities. In principle, as much training as possible should be provided within the owner's country.

Additional information may be found in the IAEA Guidebooks on Qualification of Nuclear Power Plant Operations Personnel (TRS No. 242) and Manpower Development for Nuclear Power (TRS No. 200).

4.8. Project schedule

The main objective of this section of the BIS is to give information on the owner's requirements and intentions regarding the start of plant operation (delivery time), the schedule for the acquisition process, and the schedule for his own scope of supply and services.

The first point is important for the bidders since they have to plan their work and to establish their own schedules for the project accordingly. The owner should also indicate any special reasons for the start of plant operation at the given date, such as annual peak load period or complementary projects within the programme for an expansion of electricity generation.

As a second point, the owner should give details on his intended schedule for the acquisition process, starting from the date of bid submission. He should include in particular the tentative dates for finalizing the bid evaluation, the selection of the supplier, the end of contractual negotiations, the letter of intent (with or without limited authorization of work), the signing of the contract and the effective contract validation.

Furthermore, as a third point, the owner should include the intended schedule for his own scope of supply and services. Of particular importance are site related supplies and services which may often lie on the critical path and which have to be co-ordinated with the work of the supplier. Also, if the provision of uranium, heavy water or fuel cycle services are included in the owner's scope of supply and services, the delivery dates should be indicated. This information is complementary to that discussed in Section 5.

For the sake of completeness, the owner should also include in this section a bar chart schedule and the expected milestone dates for the licensing process.

In the case of a split package approach, the owner should give the same key dates as above for the acquisition process of each package as well as the general schedule of the whole project, indicating also milestone dates for co-ordination and delivery of packages or major parts thereof. For optimal and smooth project co-ordination the owner should list all dates relevant to the interfaces between the nuclear island, conventional island, BOP and the civil works as far as appropriate. This list should include software information and dates for hardware delivery, assembly and finalization.

4.9. Documentation management

Because of the great complexity of a nuclear power project, documentation is essential, not only for reasons of safety but also because it is required for licensing and for the QA programme. Documentation is also needed for ensuring good performance during operation and for the implementation of an effective maintenance programme. Millions of documents are prepared during project execution, and the owner must have easy access to all information contained in the documentation during the lifetime of the plant.

In this section of the BIS, the owner should provide information with regard to the documentation system in use or which is to be used in his own organization. He should also give information on all codes, standards, regulations and systems for administrative and technical documentation control in force in his country.

The detailed information on the procedures normally applied by the owner for documentation management may cover the following items:

— Identification codes
— Classification system
— Document processing diagrams
— Preparation of documents
— Clearance and approval
— Reproduction and distribution
— Expediting and follow-up
— Filing system
— Computer support system
— Computerized document control system.

The documentation systems of the owner and of the bidder must be co-ordinated. It should be remembered that modification of the existing complex documentation management systems can be very difficult and costly both in time and money. The detailed information on documentation should be provided in a project procedure manual, as part of the bids.

It is also convenient to provide in this section of the BIS information on the official documentation requirements of governmental organizations, and on the

administrative procedures for obtaining licences and authorizations for the implementation of the project, such as customs clearances, authorization for transport of heavy equipment and use of water at the site as well as residence permits for foreigners. This information should be as complete as possible since this is of great help to the bidders in the preparation of their bids.

5. SCOPE OF SUPPLY AND SERVICES

The purpose of this section of the BIS is to provide information to the bidders on the scope of supply and services which they should include in their bids. This information depends on the contractual approach chosen for the project.

In a turnkey approach, the owner should clearly and specifically define his scope of supply and services in the overall framework of the project. According to the concept of the 'completeness clause', the bidders should commit themselves to consider in their bids all those supplies (including spare parts) and services necessary for safe and reliable plant operation which are not included in the owner's scope of supply and services.

The scope of supply and services of the owner may include the provision of and preparatory work for the following items:

- Site data and information
- Development of the site (cleaning, levelling, draining, fencing)
- Access to the site (road, rail, harbour facilities)
- Improvement of roads for transport of heavy components
- Connection of the site to the electric grid
- Delivery of electricity during construction, commissioning and startup
- Switchyard
- Communications (telephone, telex, radio)
- Drinking water and process water
- Site offices and furniture
- Housing for the supplier's site personnel
- Housing for the owner's personnel
- Accommodation for construction workers
- Public information centre
- Training centre
- Storage facilities for construction materials
- Cranes, transport equipment (outside the buildings)
- Site workshops
- Environmental control system (radiological monitoring)
- Administration buildings and installations

— Canteen
— Sanitary services
— Firefighting installations and equipment (outside the buildings)
— Garages
— Transport services
— Site security installations and services
— Post office
— Shopping facilities
— School
— Medical services, hospital
— Recreational installations and services
— Assistance for obtaining local permits, visas
— Customs clearances and customs clearance zones on site
— Pre-service and in-service inspection.

This list has to be tailored to suit the prevailing conditions for the project and the contract strategy employed. It may be reduced or it may be extended by including other items. The owner should pay special attention to those items which depend on the technology and design offered by the bidders.

The wishes of the owner regarding auxiliary or additional supplies and services which are not directly related to the plant and hence are not included in the concept of the 'completeness clause' should be clearly stated and listed in detail.

Special reference should be made to the fuel cycle. The owner should clearly state his intentions regarding the handling of the fuel cycle activities. In particular, he should indicate which supplies and services related to the fuel cycle are included in his own scope of supply and services, and which ones should be offered by the bidders. The following supplies and services belong to the fuel cycle:

— Supply of yellow cake
— Conversion to UO_2 or UF_6
— Enrichment services (if applicable)
— Manufacture of fuel elements (first core and reloads)
— In-core fuel management programme
— Spent fuel management, including transport, storage, reprocessing and waste disposal.

The owner should request the bidders to include in their scope of supply and services the manufacture of fuel for the first core and the provision of the in-core fuel management programme. Normally, the owner also requests from the bidders an offer for the manufacture of fuel for several reloads; these may be on an optional basis. Regarding the other fuel cycle supplies and services, the owner may request the suppliers to include all or some of them in their respective scopes of supply and services.

In the case of heavy water reactors, the owner should indicate whether he intends to retain the supply of heavy water in his own scope or whether he wishes this item to be included in the supplier's scope.

The owner should also indicate in this section of the BIS any desired alternatives and options for items of the scope of supply and services.

In a split package approach, the definition of the scope of supply and services is much more complex since there are several suppliers with different scopes while the overall responsibility for completion of the plant remains with the owner. In fact, the owner's scope of supply and services corresponds to that part of the project which is not covered by the scope of supply and services of the different suppliers of packages. In addition to defining his own scope of supply and services, the owner has to define in detail the scope of supply and services of each package as well as the physical boundaries or limits of the scope of supply and services for each package, and the interfaces between the packages.

The bids for the different packages may be submitted simultaneously or in a certain sequence. When bidding is sequential, the definition of the scopes and limits is somewhat easier for the follow-up packages.

In is recommended to define the scope of supply and services for each package in a functional way, stating that the systems and components should be 'functionally complete'. This means that when the necessary supplies are installed (for air, water, steam, chemicals, gases, electric power), when piping and cabling is completed and when the various connections are made, each system or component should be completely operational and able to fulfil its functions. It is good practice to use also scope lists in which the responsibilities for the design criteria as well as those for the design, manufacture, transport, erection, testing and commissioning of the different plant systems and components are identified. Such lists could be prepared on the basis of the IAEA account system (Appendix A). (See also Part 2, Section 4.)

Particular attention should be given to precisely defining the limits of the scope of supply and services. This is not difficult for the 'functionally complete' main packages or parts of the plant. However, for some items, such as piping, cabling and instrumentation and control wiring, which are supplied by different suppliers, the definition of the areas may pose problems. The limits have to be defined exactly, by indicating the distances (one or two metres) outside the buildings for piping, the cabling terminals of the equipment included in the scope of supply of each supplier, and the terminals of the panels and desks in the control room or the local control centres for instrumentation and control wiring.

In a split package approach, the related civil works may be included in the owner's scope of supply and services or they may constitute a part of the bidder's scope. If the owner intends to retain all civil works within his own scope of supply and services, special attention should be given to the definition of the interfaces. In this case the owner should request the bidders to provide all necessary design criteria

as well as design and layout information for the interfaces between civil works and mechanical and electrical equipment. Furthermore, the owner should state who is responsible for the deliveries of such items as the embedded anchor plates and other embedments, equipment foundations, mechanical supports and hangers, scaffolds and mechanical seals.

Options with regard to the reduction or increase of the scopes of supply and services for each functionally complete package as well as the procedures to be applied for spare parts should be indicated.

In a split package approach, it is considered good practice to provide detailed information on the owner's scope of supply and services, in particular regarding the interfaces with the packages for which bids are requested. In addition to the items listed under the owner's scope of supply and services, the following points should be made clear:

— Overall project management
— Site management
— Quality assurance and quality control
— Engineering and design
— Construction and erection
— Plant commissioning
— Balance of plant.

6. NATIONAL PARTICIPATION AND TECHNOLOGY TRANSFER

The information provided to the bidders in Section 3.4 covers the national and industrial infrastructures as well as the policy and strategy for national participation in the project and the legislation for the protection of local industries.

In this section of the BIS, the owner should specifically indicate his requirements with regard to national participation and technology transfer. If the owner's country has a firm policy for the promotion of national participation, technology transfer and industrial development in the framework of the nuclear power programme, then a simple statement of interest in the maximum use of national resources is not sufficient. In this case, the owner should give estimates of the percentages of local participation for the overall plant as well as for the different items and activities of the project, i.e. engineering, materials, equipment and components, civil construction, erection and commissioning.

It is recommended to include a breakdown (national participation list) of all activities, systems, items of equipment and components which the owner believes can be performed or produced locally, as well as a list of materials which are available in the country and which the owner believes can be used in the project. The owner should indicate on the list which items must be supplied locally.

There may be an additional list, containing the supplies and services which, in the owner's opinion, are not available locally in the required technical quality and at the time when they are needed for the plant but which deserve a more careful analysis in the framework of the long-term industrial development programme. The owner should also describe in detail the procedures and methods which he intends to apply in the evaluation of changes of the origin of supplies and services included in the national participation list, and the procedure for decision making applied for the additional list. Usually, the procedures consist of quality evaluation, scheduling, financing and price comparisons, with special consideration of applicable taxes and duties.

Regarding the technology transfer, the owner should clearly state the goals of the project. He should also specify his plans for the implementation of technology transfer. The transfer of technology is usually based on joint ventures, co-operative arrangements, technical assistance, licences and know-how transfer agreements involving training of personnel (see Section 4.7), participation in the tasks, and provision of information and experts. The owner should indicate the kind of arrangements he intends to use and the scope for each case as well as the involvement of third parties, if required.

The training of personnel is closely connected with the transfer of technology (see Part 2, Section 7). If the owner intends to train groups of personnel other than O&M staff, with a view to future projects of the nuclear programme, he should clearly state this and give detailed information.

Areas of special interest in this respect are the following:

— Project management
— Systems and component engineering
— Core design (physics, mechanical, thermohydraulic)
— Fuel cycle services
— Accident and safety analysis
— Plant transients and dynamic analysis
— Stress analysis for civil and mechanical structures
— Static and dynamic analysis (including seismic analysis) for civil and mechanical structures
— Materials engineering
— Component design
— Electrical systems and equipment
— Instrumentation and control systems
— Site management
— Quality assurance and quality control
— Planning and project scheduling
— Commissioning

— Radiological protection
— Testing facilities.

The manpower development as part of the technology transfer programme may consist of: (a) classroom and laboratory or workshop training (basic and/or specialized courses), (b) on-the-job training (at plants under construction and/or in operation, at factories, at engineering offices), and (c) simulator training.

More detailed information on national participation is provided in the IAEA Guidebook on Manpower Development for Nuclear Power (TRS No. 200, Chapter 2).

7. BID EVALUATION CRITERIA

The purpose of enclosing in the BIS the bid evaluation criteria to be applied by the owner is to point out to the bidders the items on which particular emphasis will be placed.

According to the conditions prevailing in the owner's country and the general approach established for the project, the evaluation criteria may include the following items:

— Compliance of the bid with the contents and requirements of the BIS. Compliance with the terms and conditions of the draft contract, completeness of supply.
— Experience, reputation, organization, facilities, services and financial resources of the bidder.
— Project organization and implementation plan of the bidder.
— Technical characteristics of the bid, provenness of design, standardization, constructability, operability and maintainability of the plant.
— Project schedule.
— QA/QC practices, procedures and measures.
— Asurance of supply of the plant and spare parts, including heavy water, if applicable.
— Guarantees and warranties.
— Assurance of fuel supply and fuel cycle services.
— Assurance of nuclear safety, demonstrated licensability of the plant, environmental effects, waste management.
— National participation and technology transfer, training programme.
— Quality and extent of follow-up operational and maintenance services of the bidder.
— Prices, price adjustments, foreign and local currency requirements.
— Terms of payment and financing conditions.
— Electricity generation costs (levelized discounted electricity generation costs).

These items provide the general framework for bid evaluation; the order in which the criteria are listed above should not be interpreted as an order of priorities.

The owner may select and emphasize some of the above items and evaluation factors or he may define and choose others. He will probably not wish to restrict himself regarding the bid evaluation procedure nor will he disclose it to the bidders, but it is in his best interest to inform the bidders about what he considers to be essential or of importance.

In this section of the BIS it should also be stated that, whatever the decision of the owner regarding the selection of suppliers, the bidders will have no right to make claims.

Further detailed information on the subject area is provided in the IAEA Guidebooks on Technical Evaluation of Bids for Nuclear Power Plants (TRS No. 204) and Economic Evaluation of Bids for Nuclear Power Plants, 1986 Edition (TRS No. 269).

8. DRAFT CONTRACT: TERMS AND CONDITIONS

This section deals with the preparation of a draft of the main contract for the supply of the plant under a turnkey approach. However, most points are also valid for individual packages in a split package approach.

There will usually be several contracts for a nuclear power project. Even with a turnkey approach, in addition to the main contract for the supply of the plant, there will be contracts for the owner's scope of supply and probably for at least some parts of the fuel cycle, and for financing. With a split package approach, a separate contract is needed for each package.

The draft contract contains the contractual terms and conditions of the owner for the final contract. The draft contract must be clear and precise; it should protect the owner's interests, but it should also be equitable and acceptable for the bidder. If the bidder does not agree with some of the owner's proposed terms and conditions, he must state this and give a list of deviating points (see Part 2, Section 11). The comments of the bidder to the draft contract qualify the bidder with regard to his position in accepting the terms and conditions as proposed by the owner. If a bidder does not submit any comments, it must be clearly stated that he accepts all terms and conditions of the draft contract. The draft contract as well as the comments of the bidder form the basis for the contract negotiations with the selected bidder. The result of these negotiations is the final contract which governs the relationship between owner and contractor over the whole period of project execution.

The draft contract should deal with all administrative, organizational, legal, technical, economic and financial matters which are of overall importance to the project and which need to be settled for the final contract. The main items usually covered in the draft contract are discussed in detail in the following sections.

It is emphasized that the draft contract must be prepared with extreme care by specialists in the field, including industrial lawyers from the owner's country who are experienced in international contracting.

8.1. Introduction

All contracts must have an introduction in which the parties to the contract are defined and their legal capabilities to contract and to commit their corresponding organizations are stated. In this introduction the need for governmental approval, if required, should also be stated. Governmental approval is in general related to international agreements or commitments and to financial aspects of the project.

8.2. Elements of the draft contract

A series of documents constitute the elements of the contract. These documents should be listed and defined. Usually, there will be a main contract and several annexes. The main contract includes the terms and conditions for substantial matters of the project. The annexes comprise all specifications and details, which are mostly of a technical nature.

In principle, the main contract with the annexes can be prepared in two different ways. One method is to enclose all previous documents in their original form, namely the BIS and the bid, with all agreed amendments and modifications presented in a separate document. All these documents are integral parts of the contract. The other method is to produce a revised version of the draft contract by modifying the original text with the agreed changes. In this case the original documents are not included in the contract, but they may be used for reference purposes in a given order of priority. It is strongly recommended to follow the latter approach. In both cases, the following documents form the basis for the contents of the annexes:

- The BIS;
- The bid;
- Complementary letters and amendments to the BIS and the bid;
- Complementary (to the BIS) site data and information;
- Relevant specific descriptions, procedures, schedules, etc., developed during contract negotiations;
- Other documents, as expressly referred to.

If the elements of the contract do not correspond with one another or if there are different interpretations, the stipulations of the main contract should prevail. It is important to include in the contract a list of precedence of the contract documents. Further, to avoid non-conformity or divergence of interpretation, the documents listed above may be used in a certain order of precedence, although they do not constitute part of the contract.

A point of importance is a statement by the supplier confirming that he has received from the owner all data and details which he requires for the satisfactory execution of the contract and for fulfilling his obligations.

8.3. Definitions

For a proper understanding and for clarity of interpretation of the documents, it is essential that the terms used have the same meaning for both parties to a contract and that, as necessary, such terms be properly defined. The terms thus defined in the draft contract are to be used in all related documents. A possible selection of such terms is as follows:

Acceptance
Applicable Rules
Architect/Engineer (A/E)
Authorities
Auxiliary Power
Balance of Plant (BOP)
Bid
Bidder
Bid Invitation Specifications (BIS)
Commissioning
Construction
Construction Time
Consultant
Contract Documents
Contractor
Contract Price
Duration Test
Engineer
Final Price
Final Take-over
Firm Price
First Core Loading
Fixed Price
General Schedule
Guarantee Period
Guarantee Test
Heat Rate
Licence
Limit of Supply
Materials
Net Output
Nuclear Damage
Nuclear Fuel
Nuclear Steam Supply System (NSSS)
Owner
Plant
Plot/Plan
Preoperational Test
Provisional Take-over
Quality Assurance
Quality Control
Rated Output
Schedule of Services
Schedule of Supplies
Scope of Services
Scope of Supply
Site
Subcontract
Subcontractor
Supply
Trial Test Run
Turbine-Generator (TG)
Works

It is desirable that the bidder uses the same terms for the same meaning in all his bid documents.

The IAEA has defined a series of terms used throughout the NUSS documents. These definitions may be referred to. (See List of Definitions as Used in NUSS Documents, Internal document, Division of Nuclear Safety, IAEA, March 1986.)

8.4. General clauses

The general clauses of the contract set forth requirements regarding: the legal framework of the owner's country, the applicable standards and regulations, the system of measures and the language to be used.

The draft contract should stipulate that, for the design and construction of the plant or any part thereof, the supplier will fulfil the requirements of the laws and regulations applicable in the country where the plant will be built and operated. With respect to any such requirements becoming effective after the defined reference date, the provisions laid down in the draft contract concerning changes and additional work should apply.

The supplier should also be prepared to apply the codes and standards requested by the owner before the reference date (Section 4.1) and those mutually agreed upon after that date.

The draft contract should specify the system of units to be applied (for instance the International System of Units, SI) and the language to be used for the different documents, including the main contract and annexes as well as claims, amendments, legal documentation, reports, drawings, instructions, the project procedure manual and other manuals, technical documents, etc.

If the language of the buyer's country and the language of the supplier's country are different, a common basis has to be found. Discussions may be held in any language, but the same language should be used for all documents and written communications, in particular for contractual matters. This should preferably be the official or working language of the owner's country.

8.5. Object of the draft contract

The draft contract should contain a definition of the scope of the contract, indicating in general terms the responsibilities of the supplier with regard to the supplies and services, and the main characteristics of the plant to be supplied.

Besides the items included in the owner's scope of supply and services, the principal supplies and services in a turnkey approach comprise normally the provision of studies and technical documents on design, manufacture, quality assurance and quality control, fulfilment of the requirements of the owner's licensing authorities, transport, insurance, storage, construction, and testing of materials and equipment, first core loading, trial test run, preoperational testing, commissioning, until the take-over of the plant by the owner. The owner's scope of supply and services should be clearly stated in accordance with Section 5.

In a split package approach, the supplies and services refer to each specific package. The draft contract should include a more detailed listing of the scope of supply and services, giving a precise description of the boundaries and interfaces. In this case, an adequate linkage and full consistency between the various contracts to be signed should also be ensured.

In both the turnkey approach and the split package approach, the contract should contain a general clause stating that, regardless of the lists and descriptions of the scope of supply and services, it should be the responsibility of the supplier to ensure that all his supplies and services, together with the owner's supply and services, are functionally complete and meet the requirements for successful completion of the project.

According to the principle of reciprocity, the contract should also contain a statement by the owner, expressing his commitment to take over the plant or a part thereof if the contractual conditions are fulfilled.

8.6. Planning and execution of the work

This section deals with the main aspects of the planning and execution of the work by the supplier. The draft contract should include a general schedule for the main points of the critical path, schedules for supplies and services, and specific schedules for the main activities during construction; these schedules are the basic tools for the supervision of activities by the owner. A schedule of payments should also be set out.

Other topics to be dealt with in this section are the following: installation of site facilities, co-ordination with the owner's scope of supply, equipment and materials on the site, manpower during construction, commissioning, startup, trial test run, and the relationship between the owner's and supplier's respective parts of project management.

This section of the draft contract should also contain a statement that the supplier has the overall responsibility for the direction and co-ordination of the different sections of work, and that the owner will exercise his right of supervision. In a split package approach, a clear definition of the responsibilities for project co-ordination should be provided as well as a statement of the owner's plans for the management of the project.

8.7. Information, inspection, testing and control

In addition to a statement of the supplier's obligation to keep the owner informed of the progress of work, this section of the draft contract should contain a statement of the right of the owner to inspect at any time all manufacturing and

other activities being performed by the supplier in connection with the contract. The supplier should ensure that the owner's personnel have free access not only to his offices and workshops but also to the offices, workshops and factories of his subcontractors. The supplier is responsible for performing all tests and inspections during the implementation of the project. The supplier must inform the owner about major tests reasonably in advance. A description of the procedures which the owner wishes to apply for exercising his inspection right should also be included.

Since these points often lead to conflicts and since the contract should be equitable and acceptable for both parties, the owner should define his requirements in accordance with his needs for proper supervision. The owner should also commit himself not to interfere in the normal progress of work when exercising his right of supervision.

8.8. Assignment of the work and subcontracting

A list of the possible partners and/or the main subcontractors of the supplier should be provided in the bid. The owner should reserve the right to object to any major assignment of work and subcontracting to third parties which has not been provided for in the contract. One of the main reasons for awarding a contract to a company is the expertise and experience of this company in a particular field. Therefore, there should be a limit to the possibilities of this company to assign or subcontract any work which has been given to it on the basis of its own expertise and experience.

The owner should also reserve the right to object to subcontractors if he has reasonable grounds for this.

It is important that the owner has the assurance that full responsibility for fulfilling the contractual obligations remains with the contractor, though part of the work may be assigned to third parties.

8.9. National participation and technology transfer

This section should contain the general rules and procedures to be applied for the implementation of national participation, the expected supplies and services (engineering, materials, manufacture, construction, commissioning) from local companies, and the scope of responsibilities of the supplier for such local supplies and services. The details of this information will depend on the importance of this topic for the project. A list of the local supplies and services available may be included in the draft contract (see Section 6) for use in the contract negotiations.

The supplier should be requested to commit himself generally to making preferential use of local resources, in particular local manpower. The plans of manpower development for the purpose of technology transfer should be specified.

8.10. Training of personnel

The training to be provided by the supplier within his scope of services is mainly for the owner's operation and maintenance personnel; this training is additional to the training of local manpower covered under technology transfer. The overall aspects of the training effort should be specified, with special attention to on-the-job training in nuclear plants and simulator training. The details for such items as the training programme, co-ordination, the number of people to be trained and the disciplines for training may be agreed upon at a later stage, but the overall scope of responsibilities of the supplier regarding the provision of training and the costs should be defined in this section of the draft contract.

The owner's commitment will consist of ensuring that an adequate number of qualified personnel (trainees) is available at the appropriate time.

8.11. Changes and additional work

The complexity of nuclear power projects and any new developments in technology and safety requirements during the long construction time of a nuclear power plant often lead to changes of the original plans or to additional work. The procedures for the implementation of these changes or the performance of additional work have to be agreed upon. Since most of these changes will have effects on costs and schedules which may be far reaching, it is important to include appropriate clauses in the contract to govern the course of activities. A distinction has to be made between the following changes:

- Changes initiated by the supplier which have no impact on the performance and safety of the plant and which do not influence costs and time schedules;
- Changes initiated by the supplier which may improve the performance, safety, operation or maintenance of the plant and which may influence costs and time schedules;
- Changes required by the licensing authorities of the owner's country;
- Changes required by the owner.

The owner should have the right to request from the supplier the performance of any necessary additional work related to the plant if this work could not have been foreseen at the time of contract signature.

The contractual procedures for putting into effect the required changes or additional work have to be laid down in the draft contract. In particular, it has to be stated who (owner or supplier) will have to bear the additional costs and who will be responsible for schedule delays. Also the way of determining these cost increases and the length of delay has to be indicated.

8.12. Transport and customs clearance

The owner should describe in the draft contract the intended procedures for handling this matter, not only for the imported supplies but also for the local ones.

The transport to the site of materials, equipment and goods required for the construction of the plant is an almost independent activity which is relatively expensive. For overseas transport, there may be conflicting requirements regarding the use of national carriers in the owner's country and in the supplier's country.

In this section of the draft contract, the owner and supplier should establish the contractual obligations regarding shipping, loading and unloading, transportation insurance, auxiliary transportation means, obtaining of necessary permits, customs clearances, etc. The owner should consider the possibility and convenience of establishing a customs zone at the site.

It is recommended to include responsibility for customs clearances for imports in the owner's scope of supply in order to avoid unnecessary delays resulting from the supplier's lack of knowledge of the local rules and procedures. The supplier should provide all necessary documents in the owner's official or working language.

8.13. Risks and transfer of title

The various aspects of the risks of loss or damage and the transfer of title (or ownership) have to be covered in the draft contract.

In a turnkey project, the supplier should bear the risks of accidental loss or damage until the defined date of provisional take-over by the owner. In the case of injury suffered by persons or in the case of loss or damage sustained by or occasioned to third parties and their properties, the liability of the supplier and of the owner should be determined by the law of the country where the injury, loss or damage occurred. However, the supplier should be responsible for the observance and application of appropriate measures for physical security and safe working conditions on the site.

If the owner takes on the responsibility for transport, it is essential to pay special attention to the transfer of the risks.

The title to (or ownership of) all or some materials, goods, equipment or systems intended for inclusion in the nuclear power plant under contract may be transferred by the supplier to the owner upon delivery of these items to a specified place or upon receipt of the items at the plant site, as mutually agreed upon between them. However, in a turnkey approach, the transfer of title, if appropriate, may be deferred until the provisional take-over of the plant by the owner.

8.14. Liability

The draft contract should make provisions regarding any conventional liability on the part of the supplier and his subcontractors.

The owner should be prepared to be liable for nuclear damage since in the event of a nuclear accident, liability for such damage to third parties is channelled to him. If the owner has signed or ratified a relevant international convention, such as the Vienna Convention on Civil Liability for Nuclear Damage of 1963[1] or the Convention on the Physical Protection of Nuclear Material (IAEA document, INFCIRC/275/Rev. 1), this should be stated in the draft contract.

8.15. Insurances

In the case of a turnkey approach, it should be made clear in the draft contract that the requirements for insurance coverage do not affect the provisions regarding risks and liability.

The supplier should take out a property insurance against all non-nuclear risks which can occur during the construction of the plant and during transport, risk of fire and elementary damages. He must also take out a liability insurance for adequate coverage for himself, his subcontractors and, as necessary, all personnel working on the site until plant take-over.

To cover the nuclear risk, the owner may take out a nuclear liability insurance covering damage due to nuclear occurrences on the site. This insurance should be effective upon delivery of the first fuel assembly to the site. At this time the owner may also take out a property insurance covering damage to the plant and properties on the site arising from the nuclear process. Attention must be paid by the owner to avoiding gaps and overlaps in the insurance coverage and he may therefore request the supplier to submit the latter's insurance policies for approval.

In a split package approach, the owner normally takes out a comprehensive property and liability insurance.

8.16. Quality assurance

This section of the draft contract should include the fundamental criteria and aspects of the QA programme which the owner proposes to apply regarding the quality of equipment and services during design, procurement, construction and manufacture, as well as the procedures for workshop inspection, site inspection and tests, installation, commissioning and operation, including packing, handling, shipping, transport and storage.

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[1] See Legal Series No. 4, IAEA, Vienna (1966) 3.

The owner is ultimately responsible for the implementation of the QA programme. The supplier's QA programme has to meet all requirements specified in the BIS and should be subject to approval by the owner. The owner's QA programme should be prepared in co-ordination with the supplier(s).

8.17. Licensability and licensing

It is the owner's responsibility to obtain a licence or authorization from the national regulatory authority. The licensing requirements are defined by the national authorities; only the owner himself can apply for the necessary authorizations and licences. The overall licensability criteria, requirements and licensing procedures in the owner's country have to be stated in this section of the draft contract. Licensability is one of the major topics which can influence the costs and the time schedule, as shown by experience.

The supplier should be under the obligation to comply with all licensing requirements in the owner's country, as far as they are applicable to the specific project, and should provide, in due time, all documentation, information and assistance which the owner needs in his submissions to, and communications with, the licensing authorities. As a minimum, the completeness of the documentation and information to be provided by the supplier should be such as to conform to the requirements of the licensing authorities of the supplier's country (see Section 4.5). Proprietary information, subject to confidentiality, may have to be included if requested by the licensing authorities of the owner's country.

Contractual obligations related to the reference plant defined for licensing purposes should be clearly indicated.

8.18. Delivery times

The section on delivery times should deal with various aspects related to the schedule of work for the completion of the plant. The milestone dates of the general schedule which have to be adhered to by the supplier and the owner should be listed. The procedures for schedule control and for dealing with delays should also be described.

8.19. Documentation

A detailed schedule for the submission of documentation and information by the supplier must be established in the draft contract. This schedule should include the submission of documents for as-built design, and records of plant construction and testing; these must be complete before take-over of the plant. Also to be included is a listing of the documentation requirements and acceptance procedures, as applicable (see also Part 2, Section 1.5). This is of particular importance in a split package

approach where the owner will need extensive information for co-ordinating the work of several suppliers in the design, manufacture, construction and testing of different parts of the plant. Emphasis should be placed on those items for which delays in deliveries might have a direct effect on the overall completion date of the project.

8.20. Spare and wear parts, consumables and special tools

The owner may wish to include in the supplier's scope of supply the provision of all necessary spare and wear parts for a reasonable period of plant operation (2–5 years), or he may wish to order the required spare parts later from the supplier or directly from subcontractors of the supplier, at the time when equipment orders are placed. In this section of the draft contract the procedure which the owner proposes to use should be indicated.

Spare and wear parts which have been used for meeting warranty commitments during the guarantee period should be replaced by the supplier at his cost within a reasonable time period.

To be included in the supplier's scope of supply is the provision of adequate information which enables the owner to procure spare and wear parts as well as consumables.

The terms spare parts, wear parts and consumables must be clearly defined because there may be different interpretations of these terms and because various categories exist.

- Parts of components which have to be regularly replaced are defined as wear parts.
- Parts of components which are expected to last a long time (the whole plant life) but which are essential for reliable plant operation and must be replaced immediately in case of damage or malfunction are defined as spare parts.
- Consumables belong to the category of resins, oils, etc.

8.21. Alternatives and options

The major alternatives and options for supplies and services should be listed and described, including the period of validity of each option and the latest date for ordering as well as the procedures applied by the owner to come to a decision and to communicate it to the supplier.

In principle, the provision of alternatives and options, if accepted by the owner, should be governed by the same terms and conditions as all other supplies included in the contract. Differences, if any, should be stated on a case-by-case basis.

8.22. Guarantees or warranties

Guarantees or warranties fundamentally cover the design, materials, physical parameters and workmanship, delivery time and performance of the plant, including the fuel. The performance guarantees normally include the net power output and the heat rate of the plant as well as the burnup of the fuel (see also Part 2, Section 10).

The owner might ask for other guarantees or warranties to which the supplier may agree, for instance concerning the NSSS thermal output, steam conditions, load variations, time required to start up, heavy water losses (if applicable) and plant availability for a certain period of operation. However, the owner should also consider that a higher commercial risk for the supplier will be reflected in the price of the plant.

This section of the draft contract should include the requested guarantees or warranties as well as the relevant warranty period, the procedures for determining compliance within a certain defined tolerance, and the consequences of non-compliance.

Rectification of defects or failures, or financial compensation or indemnities, as applicable, are the usual consequences of non-compliance. For each guarantee or warranty the consequences have to be specified as well as the limits for the conditions or the range of acceptable variations, the validity period, and individual and overall limits for financial compensation.

8.23. Take-over

This section of the draft contract should contain the procedures for the owner's taking over of the nuclear power plant. Take-over is normally carried out either in one stage or in two stages. If effected in one stage, it should take place at the start of commercial operation. If carried out in two stages, it involves the following steps:

— Provisional take-over at the start of commercial operation of the plant (beginning of the warranty period), after completion of the trial test and identification of any deficiencies and pending issues;
— Final take-over upon expiration of the warranty period.

The draft contract should define how and on what basis the detailed procedures will be developed and agreed upon. These procedures will lead to the take-over of the plant, particularly with regard to commissioning and preoperational testing, as well as the trial test run and the performance test run during which the guarantee values are verified (except for fuel burnup).

Before the expiration of the warranty period, a general inspection of the equipment and systems and of their functioning is performed. Deficiencies and pending issues are thus identified. The draft contract should deal with the question of remedial actions and measures. The costs of proper remedies of deficiencies found

during this last general inspection should be entirely borne by the supplier. In the event that the defects and deficiencies are such that they cannot be remedied and that the equipment or system does not operate as specified, it may be necessary to negotiate cost reductions to compensate for the loss to the owner.

The contractual conditions for fuel performance verification should also be described.

A protocol of take-over of the plant should be made and should be signed by the owner and the supplier.

In a split package approach, take-over should be defined separately for each package.

8.24. Prices, price adjustments and terms of payment

This matter can be dealt with in basically the same way as in any other contract for a power plant or a large industrial plant with a similar contractual approach (turn-key or split package). The draft contract, which is prepared as part of the BIS, can obviously contain no price data.

In principle, payments should be made in relation to the progress of work (milestones of the general schedule). It is also recommendable to establish a relationship between the payment schedule and the calculation of escalation (refer to Part 2, Section 12).

8.25. Force majeure

In principle, neither the owner nor the supplier may be made liable for a failure to meet contractual obligations which is due to force majeure. The concept of force majeure covers all those events which cannot be reasonably foreseen or which are beyond the control of either party to the contract.

Force majeure may be defined by the applicable law. The owner may also consider listing in this section of the draft contract a number of occurrences which are considered cases of force majeure.

The draft contract should indicate how the owner intends to manage the consequences of force majeure regarding the replacement of equipment and any delays, and the procedures to be followed for claiming compensation for force majeure.

8.26. Termination and suspension of the contract

The conditions, procedures and indemnifications regarding termination or suspension of the contract should be provided for in this section of the draft contract.

The contract may be terminated before take-over of the plant if there are serious defects or omissions in the fulfilment of contractual obligations by either party involved.

The owner may, subject to reasonable advance notice, terminate the contract at any time and for any reason before take-over of the plant. However, as appropriate, he would have to pay the supplier a reasonable compensation.

The parties involved may agree to terminate the contract owing to force majeure. The right and the procedures for temporary suspension of the contract should also be covered in the draft contract.

8.27. Guarantee of title and proprietary information

The supplier has to give a guarantee that the plant is free from third-party rights or claims whatsoever. Also, the contract should contain clauses for the protection of proprietary information given by the owner or the supplier, and for the protection of trade secrets associated with the scope of supply and services of the supplier.

8.28. Execution of the contract

Usually, a contract includes a number of conditions which have to be complied with before it may be executed. Such conditions relate, inter alia, to:

— Financing arrangements
— Downpayments
— Governmental approval or authorization
— International commitments
— Safeguards requirements
— Export licence
— Pertinent regulatory and licensing requirements.

Considering that the fulfilment of some of these conditions may take a long time, the owner should state in the draft contract which conditions have to be complied with before validation of the contract and which conditions may be fulfilled thereafter.

8.29. Applicable law

In this section of the draft contract the main applicable law regarding the contractual relationships between the parties has to be specified. Usually, the applicable law is the one in force at the date of contract signature in the country where the major part of the project will be executed.

8.30. Arbitration

The draft contract should stipulate the principle that matters in dispute should be settled by amicable agreement. Failing this, such matters have to be submitted to international arbitration as mutually agreed upon to ensure impartiality.

9. COMMERCIAL CONDITIONS

The owner should inform the bidders about his wishes regarding the level of price breakdown for some systems, in particular those which he would like to be supplied locally. The IAEA system of accounts (Appendix A) can be used for this purpose. The owner should also state his wishes or preferences regarding the price adjustment formulae and the terms of payment as well as the currencies for the quotation of particular items.

In addition, the owner should inform the bidders of his policy regarding the financing of the plant (proportions of foreign loans, countertrade, joint ventures). (See also Part 2, Section 12.)

Part 2

INFORMATION REQUESTED FROM THE BIDDERS

Part 2

INFORMATION REQUESTED FROM THE BIDDERS

1. GENERAL INFORMATION

The purpose of this section of the BIS is to request from the bidders the formal presentation of their companies and a summary of the contents of their bids giving the owner a general overview of the offers. Matters to be dealt with in this section are:

- Legal and commercial documentation
- Relevant experience of the bidders
- Reference plant
- List of main subcontractors
- Summary of the bid presentation
- Overall schedule of the project
- Summary of technical description and scope of supply
- Organization of the project.

1.1. Legal and commercial documentation

The bidders should be requested to provide complete documentation which proves their legal capability to contract and execute the work in the owner's country according to the laws in force. The bidders should also provide certified copies and translations, if applicable, of the statute of their companies, association of companies or consortium, as well as of the authorization of the corresponding board(s) of directors for the submission of the bid.

If the bidder is an association of companies or a consortium, he should also state whether the association is a permanent one or whether it has been established for the purpose of the project, giving clear indications of the responsibilities of each company.

The owner should request from the bidders the designation of authorized representatives, including a local representative, and the establishment of an address in the owner's country.

All signatures should be duly certified by the competent legal authorities.

The bidders should be requested to submit documentation demonstrating their commercial viability.

1.2. Relevant experience of the bidders

In order to obtain a proof of the expertise of the bidders in the techniques they offer, the owner should request them to include in their bids a complete listing and

an adequate description of the plants, works and projects constructed or managed by them or in which they took part and which can serve as examples of their relevant experience. The bidders should also be requested to clearly indicate the role and responsibilities they had in each project. In the case of an association of companies or a consortium, the expertise has to be demonstrated for each group.

The owner should also request the bidders to provide detailed information on their relevant experience in the owner's country.

The bidders should be allowed to include in this section of the bid any other information which they believe contributes to the evaluation of their relevant experience.

1.3. Reference plant

It is of particular importance that the owner requests the bidder to identify a reference plant(s) for his proposal.

Concerning the design, the safety features, the quality and the scope of supply, the owner should request the bidder to mention one or several reference plants or reference techniques. For each reference plant the bidder should provide the respective technical documentation (general description, technical data, drawings, component lists) as well as detailed information on its construction and performance history (as far as applicable).

If, before the date of bid presentation, modifications have been made to the reference plant(s) after beginning of operation for reasons of operational convenience and improvement of plant availability, licensing requirements or for other reasons, information on these modifications should be included in the bid.

The bidders should also be requested to provide a copy of the standard safety analysis report of their plants or, if possible, the safety analysis report of the reference plant(s) on which the bid is based. Such documents are, however, not considered part of the bid.

The bidders should be requested to clearly state all significant deviations of their proposals from the reference plant(s) or any technical adaptations to site conditions, giving the reasons for these in each case.

1.4. List of main subcontractors

The owner should request the bidders to provide a list of the names, activities and experience of the main subsuppliers proposed by them. It is important for the owner to have this information, since these groups will have a great influence on the implementation of the project.

This list should include in particular the local subcontractors with whom the bidder intends to fulfil the requirements for national participation specified by the

owner, unless this information is contained in the material requested from the bidder in Section 9 of Part 2.

1.5. Summary of the bid presentation

For the convenience of the owner, the bidders should be requested to provide an outline of the bid which shows the bid presentation. Such an introductory outline can help the owner in his understanding of the bids and can facilitate their handling for evaluation purposes.

This outline or summary should include the organization of the proposal, the division into parts or volumes, and a brief overview of the content of each part. This should be in agreement with the owner's requirements (Part 1, Section 3).

An explanation of the plant identification system used in the bid, including coding, classification, symbols and abbreviations, should also be requested in this section of the BIS.

1.6. Overall schedule of the project

The owner should request the bidders to present an overall schedule of the activities and events in connection with project development. This schedule should include all activities of the contractor which he has to perform to meet his responsibilities regarding the scope of supply and services as defined in Section 4 of Part 2 as well as all requirements of the BIS.

1.7. Summary of technical description and scope of supply

The owner should request the bidders to include in this section of their bids a summary technical description of the offered plant since this will facilitate a first comparison of the bids.

The information provided by the bidders in this summary should refer only to the main items of their proposal for the project, since detailed and comprehensive information on these points will be requested from the bidders (Section 3 of Part 2). This summary should consist of two parts: (1) a technical description of the plant, including the basic concept, the main data and the site plan; and (2) the scope of supply and services. As far as applicable, the technical description should refer to the following items:

- Overall plant (plot/plan and general arrangement)
- Reactor core
- Fuel assemblies
- Control elements and control element drives
- Moderator system

— Reactor main cooling system
— Reactor pressure vessel
— Calandria and pressure tubes
— Pressurizer system
— Steam generators
— Reactor coolant pumps
— Reactor auxiliary systems
— Fuel handling and storage systems
— Safety systems
— Reactor ancillary systems including radwaste treatment system
— Containment system
— Heating, ventilation and air-conditioning systems
— Fire protection system
— Turbine-generator plant
— Turbine and auxiliaries
— Condensate system
— Feedwater system
— Cooling water systems
— Generator and auxiliaries
— Main transformer
— Electrical systems
— Instrumentation and control
— Civil works
— Physical security system(s).

To facilitate comparison of the bids, the owner should request the bidders to present the summary technical description in a certain way and he should include in this section of the BIS a sample of the format to be used for the presentation of this information. Table I gives an example of such a format for the main plant data.

In a split package approach, the technical description should refer to the scope of supply for each package.

1.8. Organization of the project

The bidders should be requested to provide a comprehensive description of the organization for the management of the project. This description should include the following items:

— Information regarding the distribution of responsibilities within the bidder's organization;
— Background and experience of the prospective top management staff for the project;

TABLE I. PRESENTATION OF MAIN DATA

Item	Unit	Data
Overall plant		
Reactor type		
Number of coolant loops		
Generator output at terminals	MW(e)	
Net power station output	MW(e)	
Reactor thermal output	MW(th)	
Reactor core		
Type of fuel		
Number of fuel assemblies		
Shape of fuel assemblies		
Fuel rod arrangement		
Active length of fuelled rods	mm	
Total uranium inventory	Mg	
Clad tube outer diameter	mm	
Clad tube wall thickness	mm	
Clad tube material		
Fuel burnup at equilibrium	MW·d/Mg	
Moderator/fuel volume ratio		
Mean heat flux density	W/cm^2	
Average specific power of fuel rod	W/cm	
Refuelling		
Overall weight per assembly	kg	
Overall uranium weight	Mg	
Reactor pressure vessel		
Internal diameter	mm	
Cylindrical shell thickness	mm	

TABLE I (cont.)

Item	Unit	Data
External overall height	mm	
Base material		
Cladding material		
Cladding thickness	mm	
Weight of bottom portion	Mg	
Steam generator		
Type		
Height	mm	
Diameter	mm	
Shell material		
Sheet thickness	mm	
Tube sheet and cladding material		
Tube sheet thickness and cladding thickness	mm	
Tube material		
Tube dimensions	mm	
Heat transfer surface	m^2	
Steam quantity per unit	kg/s	
Main steam pressure at steam generator outlet	bar	
Moisture content at steam generator outlet	%	
Feedwater inlet temperature	°C	
Weight of largest component	Mg	
Turbine-generator plant		
Turbine type		
Main steam flow	kg/s	
Main steam pressure at turbine stop valves	bar	
Main steam moisture	%	

TABLE I (cont.)

Item	Unit	Data
Type of condenser		
Condenser pressure	bar	
Condenser cooling surface	m^2	
Main cooling water temperature	°C	
Main cooling water flow on average water level	kg/s	
Generator speed	rev/min	
Weight of largest component	Mg	
Generator		
Active power	MW	
Apparent power	MV·A	
Power factor		
Voltage	kV	
Voltage regulating range	%	
Frequency	Hz	
Cooling		
Weight	Mg	

— Organizational charts of the project, including the main linkages between headquarters and the local office, the number of people and the duties of the responsible persons;
— Organizational charts for site management;
— Rules and procedures governing the organization of the project.

The owner should also request the bidders to designate a corporate manager who would deal with problems arising during project execution which are beyond the authority and responsibilities of the project management.

It should be noted that in a split package approach the project and site management of the different suppliers should be co-ordinated by the owner's management team. Therefore, the organizations and procedures proposed by the bidders should be compatible with the requirements of the owner (Part 1, Section 4.2).

2. GENERAL TECHNICAL ASPECTS

The information requested from the bidders in this section of the BIS should enable the owner to obtain a clear picture of the bidders' intentions regarding project execution.

2.1. Design

The fulfilment of the owner's requirements as laid down in the BIS should be taken into consideration by the bidders when presenting the information on the technical conditions for plant design. The bidders should be requested to provide information on all design criteria and engineering features for the design of the proposed plant. The following items are of interest here:

- Reference plant(s)
- Provenness of plant and systems design
- Provenness of equipment and components
- Use of standardized and interchangeable materials, equipment and components
- Design life
- Redundancy and diversification
- Physical separation and segregation of safety related equipment, components and systems
- Inspectability and maintainability
- Testability of important operational and safety systems during plant operation
- Pre-service and in-service inspection requirements
- Radiation zoning criteria
- Accessibility to controlled areas
- Accessibility to equipment and components within controlled areas
- Adequacy of capacities for storage of wastes and consumables
- Appropriate space for temporary storage during maintenance, repairs and in-service inspection
- Effective inspection routes, escape routes
- Control systems and supplementary control points
- Emergency power supply
- Automatic emergency control
- Waste management
- Fire protection
- Physical protection
- Component related criteria.

A general criterion to be applied is the up-to-date proven design, which should incorporate improvements on the basis of operational feedback that is not necessarily covered by licensing and safety requirements.

In all cases, the bidders should indicate in their bids the applicable codes and standards.

2.2. Construction and commissioning

The owner should request the bidders to include in their bids a description of their plans for construction and erection of the plant. This description should refer to equipment and installations at the site, operations at the site, personnel required for these operations, and the site infrastructure during construction and erection. The bidders should also describe the procedures to be applied for storing and conservation of equipment.

It is of particular importance to request also information on the technical conditions and procedures proposed for preoperational tests, commissioning, demonstration tests and acceptance tests, including the programmes for each of these steps and the relevant documentation. It should be remembered that the purpose of these tests is to demonstrate the capability of the plant to meet the specified operational and safety related performance characteristics. This information should cover the following points:

— system and component testing
— core loading
— cold and hot tests
— initial criticality
— low power tests
— startup and power tests
— trial operation and acceptance of the plant.

The bidders should commit themselves to provide monthly reports covering the progress of the project (procurement, manufacture, transport, testing, etc.).

2.3. Operation and maintenance

In this section of the BIS the owner should request the bidders to provide information on the technical conditions for the operation and maintenance of the plant. This information should cover the basic requirements for operation and maintenance as well as the operational characteristics of the offered plant, including the annual radiation exposure of O&M personnel; manpower requirements during maintenance, refuelling and/or in-service inspection; consumables, etc.

Some requirements regarding the operational characteristics of the plant are given by the owner in the BIS (Part 1, Section 4.4). The bidders should be requested to confirm compliance with these requirements in their proposals and to provide information on all other operational capabilities of their plant which are not specifically indicated by the owner.

The bidders should also be requested to include in this section of the bid information on the general operating procedures applicable to the proposed plant, in particular for

— steady-state power operation
— load changes and load rejection
— startup operation
— shutdown operation
— reactor and turbine trips
— emergency conditions.

The owner should also request in this section of the BIS information on fuel management, at least for the following points:

— handling of new fuel assemblies
— plans and procedures for refuelling
— handling of spent fuel.

The bidders should be requested to provide a description of the technical specifications for plant operation, including the operational limits and restrictions as well as the surveillance programme.

The bidders should be requested to inform the owner of already established information exchange systems of owners of similar plants, describing the scope of activities of each group and the possible advantages in joining such groups.

2.4. Safety and licensing

The owner should request the bidders to provide information regarding compliance of their proposals with the safety requirements indicated in Part 1, Section 4.5.

Furthermore, the bidders should be requested to provide detailed information on the engineered safeguards to be applied in their offered plants. This information should refer to the following points:

— Safety related codes, standards, regulations and guidelines;
— Protection against faults, accidents and external incidents, indicating emergency systems;
— Radioactivity and radiation protection.

All licensing requirements valid in the bidder's country as well as ongoing modifications of codes and standards and licensing requirements which are known at the reference date should be included in the bids as far as applicable to the specific project.

The owner should also request the bidders to commit themselves to provide information on any ongoing modifications of the licensing requirements in their country during project execution at regular intervals.

2.5. Documentation

The bidders should be requested to provide a comprehensive list of all technical documentation which they will submit during project execution, particularly of the documents (drawings, analysis, calculation, etc.) which have to be reviewed or approved by the owner, as far as applicable. The main types of documents should be briefly defined in order to avoid differences in interpretation. This is particularly important for computer and software packages the contents of which should be briefly described.

3. TECHNICAL DESCRIPTIONS

In this section of the BIS the owner should request the bidders to provide a complete and detailed technical description of their scope of supplies. This description should express exactly what the bidders actually offer and should not be limited to the technical data of a standard plant.

In this Guidebook, the IAEA Account System for Nuclear Power Plants (Appendix A) has been used to identify the plant systems, components and equipment.

3.1. Nuclear island (NI)

The bidders should be requested to include in this section of the bid all information on the functional and physical characteristics of systems, components and equipment, the design basis, safety considerations, operational functions, incidental behaviour, as well as all technical information about the materials and/or the quality class and seismic design used. For example, the information should include the following items:

- Functional description of systems and components
- Description of design features
- Flow diagrams
- Performance data sheets
- Arrangement drawings
- Component outline drawings
- Containment penetrations drawings (electrical and mechanical)
- Equipment lists
- Equipment catalogues
- Valve lists
- Thermodynamic and thermohydraulic data
- System and component design data
  (for more details refer to Appendix B)

— Operational and test procedures
— Part load diagrams
— Startup and shutdown diagrams
— Transient diagrams.

The main systems to be considered are listed in Appendix A.

3.2. Nuclear fuel and nuclear fuel cycle

Technical descriptions for the nuclear fuel and the nuclear fuel cycle should be considered with particular care. The bidders should be requested to include in their bids detailed technical descriptions of the nuclear fuel assemblies offered, including physical, thermohydraulic, thermodynamic and mechanical data as well as calculations for batch planning (short term and long term). This technical description should refer to the following items:

— General NSSS
— Core
— Fuel pellets
— Fuel cladding
— Fuel rods
— Fuel assembly
— Fuel performance
— In-core inventories
— Stretchout capability
— Reactivity budget and control characteristics, % $\Delta k/k$
— Different cycle lengths
— Available control % $\Delta k/k$
— Use of burnable poison
— Reactivity coefficients
— Neutron fluxes
— Core thermohydraulic characteristics
— Manufacturing methods
— References for the offered fuel assemblies
— Evolution of burnup
— Safety design aspects
— QA programme
— Licensability
— Information and data for third-party fuel assembly delivery
— Handling and inspection methods for new and spent fuel
— Tools for fuel and control rod manipulation
— List of technical data (see Appendix B)
— Scope of supply and services (not included in Section 4).

It is essential that the first core be included in the scope of supply for the plant. It is recommended to include also the supply of the first reload. The owner should request the bidders to include the supply of further reloads as an option.

The owner may wish to obtain offers for additional reloads through competitive bids from qualified fuel manufacturers. Therefore the bidders should be requested to express in their bids their commitment to deliver within their scope of supply all relevant data and information.

The owner should also request the bidders to include in their bids the technical specifications for the yellowcake and the enriched uranium; these are required for ordering and manufacturing the fuel (see Part 1, Section 5).

Regarding the nuclear fuel cycle, the owner should request the bidders to provide a complete technical description of each part of the supplies they will include in their bids, in accordance with the requirements made by the owner (Part 1, Section 5).

3.3. Turbine-generator plant

The considerations regarding the nuclear island are also valid for the turbine-generator (TG) plant and the owner should request such information from the bidders. Additionally, specific information for the turbine and generator as listed below should be requested:

- Heat balance diagrams for different power outputs;
- Startup and shutdown diagrams and procedures for turbine and generator;
- Transient diagrams and limit curves;
- Turbine heat rate curve versus generator output;
- Corection curves for turbine heat rate and generator power output;
- Diagrams for the turbine-generator set: reactive capability curve, saturation curves, short-circuit decrement curve, load time curve;
- Drawings for turbine and generator (layout, cross-sections, laydown areas for maintenance);
- System and component design data (for more details see Appendix B).

3.4. Balance of plant

The bidders should be requested to provide in this section of the bid the technical description of the balance of plant. Some items of the BOP (outside the islands) are listed below:

- Protection and fire fighting systems
- Water supply system
- Ventilation and air-conditioning systems
- Air and gas system

— Auxiliary steam systems
— Laboratories, workshops and laundries
— Drainage system.

In a split package approach, the bidders should be requested to provide all interface data and requirements for the different packages and the BOP.

3.5. Electrical systems

Regarding the electrical systems of the plant, the owner should request the bidders to provide information on the following items:

— Cabling principles
— Plant system one-line diagram
— Diagrams of main circuit
— Diagrams of internal circuit
— Diagrams of measuring points
— Drawings of cables and wiring
— List of motors and condensers for normal and emergency power supply
— Equipment lists
— Equipment catalogues
— Specifications for transformers and switchyard
— Layout drawing for electrical components
— Functional specifications
— Test procedures.

3.6. Instrumentation and control

Regarding the instrumentation and control of the plant, the owner should request the bidders to provide information on the following items:

— Drawings of control room(s) layout
— Drawings of typical panels and instrument racks
— Diagrams of measuring points
— Drawings of cables and wiring
— Equipment lists
— Equipment catalogues
— Diagrams of protection and control devices
— Functional diagrams for I&C
— Design sheets for I&C
— Diagrams for reactor protection systems
— List of alarm limit values
— List of trip signals
— Logic and analog diagrams

— Flow diagrams for I&C
— Functional specifications
— Test procedures.

3.7. Civil works

The owner should request the bidders to provide technical information regarding all civil works to be performed for the plant. This information should include the following items:

— Excavation
— Drawings of civil and structural layout
— Formwork
— Prestressing and/or reinforcements
— Anchors and foundations
— Steel structures
— Embedded parts
— Construction methods
— Sequence plans for construction
— Landscaping and architectural schemes
— Drawings of site facilities during construction.

More detailed information on buildings and structures is contained in Appendix A.

3.8. Spare and wear parts and consumables

In Sections 5 and 8 of the BIS (Part 1) the owner gives information on the spare and wear parts as well as the consumables to be included in the scope of supply of the bidders.

In this section of the BIS the owner should request the bidders to provide in their bids a list of the spare and wear parts and consumables to be stored in the plant which constitute the appropriate minimum stock for a number of years (2–5 years) and which should be available at the start of commissioning.

The owner may also request the bidders to submit a list of additional spare parts which they believe should be available during plant operation.

4. SCOPE OF SUPPLY AND SERVICES

In Section 5 of the BIS (Part 1) the owner provides information to the bidders regarding the scope of supply and services to be offered. In this section of the BIS

the owner should request the bidders to provide a detailed and complete list of the scope of supply and services included in their bids.

Depending on the contractual approach and the items included in the owner's own scope of supply and services (listed in Part 1, Section 5) the scope of supply and services of the bidders may vary widely.

In the case of a turnkey approach with a completeness clause the list to be provided by the bidder should be as detailed and complete as possible and should include the quantities to be supplied. However, this list should be superseded by the completeness clause so that all those items are covered which might have been omitted or are not expressly included but which are necessary for safe and reliable operation of the plant.

In the case of a turnkey approach without a completeness clause the bidder's list of his scope of supply and services constitutes the exact definition of what has to be delivered. In this case, the required items which are not included in the list will be part of the owner's scope of supply and services or will be considered in the bidder's additional supplies.

For functionally complete packages in a split package approach the above criteria can be applied in a similar way as in the turnkey approach. However, since in this case the precise definition of the interfaces and limits of the bidder's scope of supply and services is essential, the scope list should include the relevant information in all detail.

The owner may ask the bidders to arrange the information contained in the scope list in the sequence indicated in Part 1, Section 2, where all items are grouped in 18 volumes. The respective accounts of the IAEA Accounts System (Appendix A) are given below for convenience. Attention is drawn to the fact that the sequence of volumes as suggested in Part 1 is different from the sequence of subjects as covered by the account numbers in the IAEA system.

22 REACTOR PLANT EQUIPMENT

- 221 Reactor equipment
- 222 Main heat transfer and transport system
- 223 Reactor auxiliary systems
- 224 Reactor ancillary systems
- 225 Nuclear fuel handling and storage systems
- 226 Other reactor plant systems and components

100 FUEL ASSEMBLY SUPPLY, *FIRST CORE*

110 SERVICES, *FIRST CORE*

120 FUEL ASSEMBLY SUPPLY, *RELOADS*

130 SERVICES, *RELOADS*

140 REPROCESSING OF IRRADIATED FUEL ASSEMBLIES

150 HEAVY WATER SUPPLY, *FIRST CHARGE*
(if not under Nuclear Island)

160 HEAVY WATER SUPPLY, *REPLACEMENT QUANTITIES*
(if not under Nuclear Island)

23 TURBINE-GENERATOR PLANT EQUIPMENT

- 231 Turbine plant
- 232 Generator plant
- 233 Condensate systems
- 234 Feedwater and main steam systems
- 235 Drain systems
- 236 Other secondary side systems

25 WATER INTAKE AND HEAT REJECTION

- 251 Circulating water intake structures
- 252 Structures for circulating water pumping and outfall
- 253 Structures for recirculating water cooling
- 254 Main circulating water piping
- 255 Secured service water piping
- 256 Service water piping for conventional plant
- 257 Equipment

26 MISCELLANEOUS PLANT EQUIPMENT

- 261 Heating, ventilation and air-conditioning systems (HVAC)
- 262 Fire protection and fire fighting systems
- 263 Secondary side auxiliary systems
- 264 Water supply systems
- 265 Cranes, hoists, elevators, gantry
- 266 Laboratory equipment

27 SPECIAL MATERIALS

- 271 Reactor coolant (if not under fuel cycle, account 150)
- 272 Moderator (if not under fuel cycle, account 150)
- 273 Reflector material
- 274 Intermediate coolant
- 275 Turbine cycle working fluids
- 276 Initial materials

24 ELECTRICAL EQUIPMENT AND INSTRUMENTATION AND CONTROL PLANT EQUIPMENT

- 241 Generator and houseload equipment
- 242 Diesel and diesel control equipment
- 243 Auxiliary electrical equipment
- 244 Ancillary and communication systems
- 245 Instrumentation and control equipment (conventional and nuclear)

21 BUILDINGS AND STRUCTURES AT THE PLANT SITE

- 211 Site preparation, facilities, infrastructure
- 212 Reactor building (materials)
- 213 Reactor auxiliary building
- 214 Turbine building
- 215 Electrical building
- 216 Other buildings
- 217 Structures for transformers
- 218 Stacks (when separate from buildings)

30 ENGINEERING, DESIGN AND LAYOUT SERVICES BY SUPPLIER(S) AND/OR A/E AT THE HOME OFFICE(S)

31 PROJECT MANAGEMENT SERVICES BY SUPPLIER(S) AND/OR A/E AT THE HOME OFFICE(S)

32 ENGINEERING, DESIGN AND LAYOUT SERVICES BY SUPPLIER(S) AND/OR A/E AT THE PLANT SITE

33 PROJECT MANAGEMENT SERVICES BY SUPPLIER(S) AND/OR A/E AT THE PLANT SITE

34 CONSTRUCTION SITE SUPERVISION BY SUPPLIER(S) AND/OR A/E

35 CONSTRUCTION LABOUR BY SUPPLIER(S) AND/OR A/E OR CONSTRUCTION COMPANIES AT THE PLANT SITE

36 COMMISSIONING SERVICES BY SUPPLIER(S) AND/OR A/E AT THE PLANT SITE

37 TRIAL TEST RUN SERVICES BY SUPPLIER(S) AND/OR A/E

38 CONSTRUCTION FACILITIES, TOOLS AND MATERIALS AT THE PLANT SITE

39 COMMISSIONING MATERIALS, CONSUMABLES, TOOLS AND EQUIPMENT AT THE PLANT SITE

40 STAFF TRAINING, TECHNOLOGY TRANSFER AND OTHER SERVICES

41 HOUSING FACILITIES AND RELATED INFRASTRUCTURE

51 SPARE PARTS

In accordance with Section 3.8. of Part 2, the spare parts should be listed in the format of the 'component' list and identified by the respective account number.

The owner can choose to have all lists of the scope of supply and services presented in a separate volume of the bid, as suggested in Part 1, Section 2, or he may request the bidders to add the corresponding scope lists to each volume of the technical descriptions.

The bidders should be requested to present their scope of supply and services in a uniform, structured manner, indicating all stages and aspects of the supply process. The list of items given below represents a guideline for the bidders; they can also augment it, if necessary, according to their experience.

- Code identification
- Quantity
- Design criteria
- Basic design
- Detailed design
- Engineering review
- Manufacture or supply
- Transport
- Erection
- Commissioning
- Interfaces
- National origin or imported
- Seismic class
- Safety classification
- Licensing support
- Safety analysis report provided by the supplier for licensing, and other reports.

5. ALTERNATIVES AND OPTIONS

The owner should request the bidders to include in their bids detailed information on all alternatives and options as referred to in Part 1, Section 5. This information should enable the owner to evaluate each alternative and option according to its own merits.

The bidders should be allowed to propose also technical alternatives and options not specifically requested by the owner. In this case the bidders should provide justifications for their proposals and detailed information on the implications of each alternative and option offered.

6. QUALITY ASSURANCE PROGRAMME

The bidders should be requested to submit to the owner the QA programme documentation necessary for review and evaluation of their capabilities to meet the QA requirements. These documents may be submitted in parts and this section of the BIS should specify the kind of information to be submitted and the stage at which it has to be submitted, namely: (1) together with the bid, (2) after award of the contract, (3) before start of project activities, for instance during design or manufacture of equipment, and (4) when the work is completed, as the 'data package'.

The owner should also express his right to request additional information, if necessary, during bid evaluation or project implementation.

(1) The documents requested together with the bid should normally include the following parts:

(a) Description of the QA programme to be applied to the activities of the supplier and his subsuppliers. This description should show that the QA programme meets all requirements indicated in the BIS and that it will enable the owner to fulfil his duties towards the authorities, in agreement with the delegation of tasks and responsibilities as indicated by the owner in Section 4.5 of Part 1. The QA programme description should include the following parts:

- Description of the organization of QA activities which the bidder intends to apply and follow in order to establish and maintain an effective QA programme. This description should clearly define the responsibility, authority and freedom of action of the personnel performing QA activities.
- Description of the procedures for the preparation, review, approval and issue of documents important for the performance and verification of the work. This includes the identification of individuals and groups responsible for preparing, reviewing, approving and issuing documents related to QA activities.
- Description of the QA activities ensuring that the applicable and specified design requirements (design basis, regulatory requirements, codes and standards, safety levels and seismic classes) are identified and correctly translated into procedures, instructions, drawings and specifications.
- Description of the QA activities ensuring that the procurement documents conform to all applicable regulatory requirements, design basis documents,

standards, specifications, contractual and other requirements. The bidder should demonstrate his evaluation of the subsuppliers, ensuring their capability to provide the items and services in accordance with the procurement requirements.

- Description of the measures for the control and identification of materials, parts and components, including partially manufactured assemblies. Handling, storage and shipping as well as cleaning and protection of materials and equipment should be included.
- Description of the control measures for processes affecting quality, to be applied during design, fabrication, construction and testing. This should include a commitment that a complete inspection programme for the items and services will be prepared and implemented in order to verify their conformance with instructions, procedures, drawings and specifications. (The complete inspection programme may be submitted at later phases of the procurement process.)
- Description of the auditing programme and schedule for an evaluation of the QA programme effectiveness.
- Description of measures for non-conformance control and corrective action, ensuring that conditions adverse to quality are identified and corrected.
- Description of the QA records system that gives objective evidence of quality by presenting the results of reviews, inspections, tests, audits, work performance, monitoring, material analyses, etc.

(b) References regarding previous activities, and description of experience in QA programme establishment and implementation.

(c) List of standards, procedures and specifications which will be used for the design, manufacture, installation, inspection and testing of equipment to be supplied.

(d) Copy of valid certificate of authorization for ASME-Code. Section III, or equivalent national standard, if available.

(2) After the award of the contract, additional information related to the QA programme should be requested. This may include the following documents:

- QA manual for contracted project activities, including all necessary QA procedures.
- Inspection and test plans (quality plans) for equipment to be manufactured and installed within the scope of supply. This should include all notification, hold and witness points in the manufacturing or installation process.
- Documents for procedures and instructions specified in the quality plan.
- List of materials, components and parts to be supplied by the subsuppliers.
- Evidence that the QA requirements will be implemented by the subsuppliers.

(3) The owner should express his right to specify the documents to be submitted upon completion of the contract together with the equipment, as the 'data package'.

7. TRAINING

Generally, in a nuclear power project at least part of the training of operation and maintenance personnel is provided by the supplier. In Section 4.7 of the BIS (Part 1) the owner informs the bidder of the intended organizational structure and the training of O&M personnel to be provided by him.

The information to be submitted together with the bid should cover the training of the owner's personnel which will be provided by the supplier in the owner's country and abroad. The bidder should be requested to submit complete information on his training programme, his training experience and the training facilities.

The bidder's proposal for training should include information on the following points:

- Organizational structure, number, qualifications and functions (job position) of personnel; if the bidder's ideas regarding the staffing of the plant are different from those of the owner (as indicated in Part 1, Section 4.7) he should propose an alternative solution;
- Training courses and on-the-job training for the owner's personnel, including details of the contents and grade of the training courses and on-the-job training; training time schedules and training locations;
- Training material, such as manuals, video facilities, course outline;
- Recommended personnel qualification requirements and examination procedures;
- Simulator services and, optionally, training facilities and training programmes.

The bidder should also provide a plan for the organizational setup required to meet the objectives of the training programme, and a recruitment plan giving the number of persons to be employed, their qualifications and the dates when they will be needed.

The bidder may also be requested to provide language courses for the trainees.

8. PROJECT SCHEDULE

In this section of the BIS the owner should request the bidders to provide information on the general project schedule, bar charts and critical path diagrams for the construction of the plant, based on units of one month or less.

The owner should also request a list of milestones in the form of a milestone project schedule, as well as a schedule of the services offered, and a schedule for the submission of equipment and component documentation.

Furthermore, the bidders should be requested to provide an overall programme and a description of the methods they will apply for the control and updating of these schedules during construction, including the computer techniques to be used and a proposal for regular reporting to the owner.

The schedule presented by the bidder should include the delivery dates of items in the owner's scope of supply and services which have to be met for the completion of the project.

In a split package approach, the bidders should be requested to provide the interface schedule as well.

9. NATIONAL PARTICIPATION AND TECHNOLOGY TRANSFER

In Sections 3.4 and 6 of the BIS (Part 1) the owner provides information on the national industrial infrastructure and on his requirements for national participation and technology transfer. In this section of the BIS the bidder should be requested to provide information on the ways and means of ensuring compliance with the owner's requirements regarding his objectives for national participation and technology transfer. In this connection, the bidder should be requested to provide information on the applicable laws and regulations as well as the governmental procedures in his country which may affect the conditions of the contract or the export of components and equipment, documents, fuel supply and fuel cycle activities and services and, in particular, technology transfer.

The bidder should be requested to indicate the materials, components, equipment and services which he expects to be provided in the owner's country, and to submit a list of possible local subsuppliers. The bidder should describe the assistance he is willing to give in order to achieve the goal of using suppliers from the owner's country as well as the conditions for the proposed assistance.

The bidder should be requested to provide a list of supplies, equipment and services which are not available in the country for the first project but which may become available in the future as a result of technology transfer.

Regarding the training of additional personnel for technology transfer, the bidders should be requested to include in their bids all relevant details and conditions for fulfilling the owner's requirements as stated in Section 4.7 of the BIS (Part 1). The bidders' offer for technology transfer, which may be for a long-term nuclear power programme, should be as concise as possible.

If it is planned to found new companies or joint ventures to promote national participation, the bidder should provide detailed information, keeping in mind the

local situation regarding raw materials and their supply as well as future demands for these materials within the nuclear power programme as indicated in the BIS (see also Section 4.8 and Chapter 8 in the IAEA Guidebook: Economic Evaluation of Bids for Nuclear Power Plants, 1986 Edition (TRS No. 269).

10. GUARANTEES AND WARRANTIES

In Section 8 of the BIS (Part 1), which deals with the draft contract, the owner presents information to the bidders regarding his approach and requirements for guarantees and warranties. In this section of the BIS, the owner should request the bidders to submit a list of guarantees and warranties which they are prepared to offer. For each of the guarantees and warranties the following points should be specified:

- Subject of the guarantee or warranty, including the numerical value if applicable, the range of acceptance and the duration;
- Procedures for determining compliance;
- Consequences of non-compliance (repair, replacement or monetary penalties);
- Criteria for the application, amounts and limits of monetary penalties;
- Overall limits for monetary penalties;
- Bonus arrangements, if applicable.

According to the owner's requirements, the usual guarantees and warranties would cover the following items:

- Design, materials and workmanship;
- Performance and physical parameters (rated output, net output, heat rate, steam conditions, operating characteristics, fuel integrity and burnup);
- Delivery time for the plant or for packages of software and hardware, as applicable;
- Heavy water losses (if applicable).

The owner may request, or the bidders may offer, additional guarantees or warranties for a wide range of subjects or plant characteristics, such as extended period warranties for special components or equipment, or plant availability. The bidders should provide details for each additional guarantee or warranty, including in particular provisions for remedial measures or monetary penalties in case of non-compliance without which a guarantee or warranty would be meaningless.

11. DEVIATIONS AND EXCEPTIONS

The owner should request the bidders to provide complete information on all deviations and/or exceptions from the BIS. The bidders should be requested to

submit in their bids a specific statement regarding their acceptance of all conditions of the BIS not specifically referred to in the list of deviations and exceptions.

The bidders should be requested to refer in their list of deviations and/or exceptions to the appropriate section and statement in the BIS and/or the account number.

The owner should request the bidders to provide the following detailed information regarding each proposed deviation and/or exception, as far as applicable:

— Definition of the departure from the BIS
— Reasons and justification for the departure
— Extent to which the overall guarantees and warranties are affected
— Extent to which the safety and licensability requirements are affected
— Cost implications
— Project schedule implications
— Practicability of rejecting the proposed departure from the BIS.

12. COMMERCIAL CONDITIONS

The owner should request the bidders to provide information on prices, terms of payment and financing conditions in sufficient detail so that he can perform the economic and financial bid evaluations and then make the commercial contractual arrangements with the selected supplier.

To facilitate the economic bid evaluation, the bidders should refer to the IAEA Guidebook on Economic Evaluation of Bids for Nuclear Power Plants, 1986 Edition (TRS No. 269) and the IAEA Accounts System (Appendix A). For consistency of information, the offered bid prices should be linked with the IAEA Accounts System.

12.1. Prices, price breakdown and currency

The prices quoted by the bidder for the scope of supply and services offered, referred to as base bid prices, should be firm or fixed prices at the date of bid submission and should be applicable during the validity period. The bidder should clearly indicate in his offer whether the prices are firm or fixed.

A firm price is binding on the bidder if it is accepted during the validity period; it is subject to adjustment as a result of escalation. The price adjustment formulae and the corresponding coefficients must be provided by the bidder in the formats suggested in Section 12.2.

A fixed price is binding on the bidder if it is accepted during the validity period and is based on delivery at the commercial operation date; it is not subject to adjustment as a result of escalation.

If the owner wishes to consider within his own scope of supply and services the arrangements for transportation and transportation insurance, in accordance with Incoterms, he can choose among the following possibilities:

— Ex-works
— FOB (free on board)
— FAS (free alonside ship)
— CIF (costs, insurance, freight) with or without unloading
— C and F (costs and freight).

For each of these alternatives the possibility of using foreign and domestic shipping agencies for transportation may be considered. Details must be given for the scope of responsibilities for the transfer of equipment from the point of arrival to the duty place, and for the provision of cranes, special transport and hoisting equipment, and trailers. The owner must request from the bidder a preliminary transportation study and cost information for heavy equipment. Export fees and taxes should be included in the cost of the equipment. The import taxes and fees should be borne by the owner.

The owner may wish to request from the bidders information regarding the following costs:

— Base costs for the scope of supply (accounts 21–27)
— Base costs for options in the scope of supply (accounts 21–27)
— Base costs for the scope of services (accounts 30–37)
— Base costs for options in the scope of services (accounts 30–37)
— Base costs for construction and commissioning materials (accounts 38–39)
— Costs for personnel training (account 40)
— Costs for technology transfer (account 40)
— Costs for housing facilities and related infrastructure (account 41)
— Costs for transportation and transportation insurance (account 50)
— Costs for spare parts (account 51)
— Costs for options on spare parts (account 51)
— Costs for insurances (account 53)
— Financing terms and conditions including escalation, interest and fees (accounts 60–62).

Man-hour or man-month rates for different qualifications and different services should be requested, if applicable.

Regarding training, the prices may be given on the basis of a 'price per person per month' or a price per course for each type of special training course and on-the-job training offered by the bidders.

The degree of price breakdown requested from the bidders should be such that the prices can be used for bid comparison, that the price adjustment formulae can be applied and that national participation can be determined. The price breakdown

TABLE II. ITEMIZED BID PRICES

Specifications _____ Bidder _____

Sheet revision No._____ Sheet_____ of_____

Account number and description	Offered bid prices		Comments
	Local	Foreign	
22 Reactor plant equipment			
221 Reactor equipment .1 Reactor vessel .2 Reactor vessel internals (excl. fuel assemblies, reflector material, moderators and reactivity control components) Subtotal for 221			
222 Main heat transfer and transport system			
Total for Account 22			

of the scope of supply offered should be presented in table form, indicating the currencies (domestic and foreign). The owner should clearly state the price itemization level (system level or component level) to be applied by the bidder. The owner should bear in mind that the individual elements of the price breakdown given by the bidder may not represent the 'stand-alone' price. He should require the bidder to explicitly indicate 'stand-alone' prices.

Tables II and III are examples of the format for the price breakdown, following the IAEA Accounts System (Appendix A). The presentation of the required information in this format will facilitate the subsequent bid evaluation. The offered prices are referred to as the base bid prices at the reference date.

If the owner requires a higher or lower level of disaggregation for some systems, this must be clearly indicated in the formats. In addition, if the owner

TABLE III. ITEMIZED BID PRICES FOR OPTIONS

Specifications _____ Bidder _____

Sheet revision No._____ Sheet_____ of_____

Account number and description	Offered bid prices		Comments
	Local	Foreign	
226.1 In-service inspection equipment for primary components			
226.2 Special transport equipment			
226.3 Intermediate storage facilities for burnt fuel			
120 Reload fuel			
144 Irradiated fuel transport cask			

requires some systems and components to be expressly identified for national participation, these items should be listed in the tables or in a separate table, in correspondence with the scope of supply and services (Section 4, Part 2). For these domestically supplied components the foreign prices should also be given. The price breakdown as presented in Appendix A may not fit the owner's requirements for national participation. In this case the owner should tailor the accounts appropriately.

Regarding the nuclear fuel cycle, the owner should request the bidders to quote in detail the prices for the offered scope of supply and services. The IAEA Accounts System for the nuclear fuel cycle (Appendix A) may be used as guidance.

The owner should request the bidders to provide a complete price information, also on all options and/or alternatives.

The foreign portion of the base prices should be quoted in the currency (currencies) in which the bidder expects to be paid. The owner should also request the bidder to quote the prices for domestically furnished components and services in the local currency. The expenses for foreign experts on the site should be quoted in the local currency as well as in the currency of the bidder's country.

12.2. Price adjustment

The owner should request the bidders to present the prices in two groups: (1) fixed or unescalated prices and (2) prices subject to price adjustments (firm prices). The firm prices offered in the bids are subject to escalation. This may be taken into account by using a Price Adjustment Formula (PAF) which should be part of the bidding document:

$$P(t) = P(t_1) \times [A + B\,(L_t/L_1) + C\,(M_t/M_1)]$$

where

$P(t)$ is the adjusted price or payment to be made on date 't', taking into account the price escalation;

$P(t_1)$ is the offered price or payment corresponding to the reference date 't_1';

L_t is the labour (wages) index as determined or reported by the official source on the date of payment;

L_1 is the specific labour index on the reference date 't_1' which defines the base price;

M_t is the materials index on the date of payment;

M_1 is the specific materials index (e.g. for steel) on the reference date 't_1' which defines the base price.

A,B,C are coefficients whose sum is equal to 1. Coefficient A is the fixed portion corresponding to general costs (not subject to escalation); coefficients B and C are the escalated portions. Thus, if the particular payment is not subject to escalation, coefficient A is 1.0 and coefficients B and C are both zero.

The coefficients in brackets refer to the fixed portion, the labour portion and the materials portion, respectively. These coefficients are subject to contract negotiations and mutual agreement. The time and frequency of price adjustments are offered by the bidder and may differ.

The price adjustment formula may be extended if other cost indices (for transportation or different materials) are included.

Additional information can be found in the IAEA Guidebook on Economic Evaluation of Bids for Nuclear Power Plants, 1986 Edition (TRS No. 269).

Table IV gives an example of a format for the presentation and description of the price adjustment formulae which the bidder proposes to apply. The level of

TABLE IV. ESCALATION FORMULAE

Specifications _____ Bidder _____

Sheet revision No._____ Sheet_____ of_____

Account number	Escalation formulae to be applied
221 Reactor equipment	$P(t) = P(t_1) \times [A_1 + B_1(L_t/L_1) + C_1(M_t/M_1)]$
30 Engineering design and layout services by the supplier(s) and/or A/E at the home office(s)	$P(t) = P(t_1 \times [A_2 + B_2(L_t/L_1)]$

disaggregation must correspond to the level of price breakdown defined in Section 12.1. The price adjustment formulae should be separately defined for the local and foreign parts of the scope of supply.

For the foreign component, the bidder should provide historical values for the indices in the price adjustment formulae over a period of 10 years before the reference date. These data can be obtained from official sources and the bidder should indicate the source of the indices and and their definitions.

12.3. Terms and schedule of payments

In the BIS the owner should state his wishes regarding the conditions of payment of the price given in the accepted bid and agreed upon in the draft contract (see Part 1, Section 8). The percentage amounts of the contracted price to be paid by the owner upon provisional acceptance should also be stated.

TABLE V. PAYMENT SCHEDULE

Specifications _____ Bidder _____

Sheet revision No._____ Sheet_____ of_____

Account number: _____

Prices: firm/fixed

Event or milestone	Months from contract validation	Payments to be made on fulfilment of task (base date values)		
		Payment		Comments
		Foreign	Local	
Provisional acceptance				

Table V gives an example of a format which the bidder can use for his presentation of the schedule of payments for the base bid and for options. The schedule of payments is usually linked with the fulfilment of certain tasks (events or milestones) in connection with plant construction and the delivery of equipment; this must be referred to in the schedule. The account numbers should agree with those specified in the itemization of prices (Tables II–IV). The drawdown periods for the loans from credit agencies and commercial banks should correspond to the events as detailed in the schedule.

12.4. Financing

The owner may wish to request from the bidders proposals for financial arrangements, at least for the foreign component of their scope of supply and services as well as for the nuclear fuel and the nuclear fuel cycle. The financial package proposed should clearly indicate the extent of coverage of the base bid price, plus price escalation and interest during construction, plus contingencies.

The bidders should be requested to specify the financing instruments or approaches which they propose, indicating also the institute or the group (consortium) of banks and other financial institutions participating in financing. Export credit financing, multicountry financing, project financing, co-financing, joint ventures, countertrade and suppliers' credits are approaches which the bidder may propose for his bid.

The information about the financing terms and conditions to be provided should include the following points:

- Source of financing
- Amount and currency
- Interest rate
- Repayment period
- Grace period
- Fees and commissions
- Downpayment
- Schedule of payments
- Reference date for the data and information
- Guarantees
- Multilateral countertrade
  (products, goods, resources, etc.).

APPENDICES

Appendix A. IAEA Account System
for Nuclear Power Plants
Appendix B. Technical Questionnaires
Appendix C. Abbreviations

Appendix A

IAEA ACCOUNT SYSTEM FOR NUCLEAR POWER PLANTS

This account system was prepared for assistance in checking the completeness of bids and in evaluating the total plant costs. The system is presented in the form of an illustrative example. Other systems of cost accounts exist which could also be used. The account system as described is sufficiently flexible to allow different reactor types to be considered. It is also adaptable so that it suits the particular requirements of the owner as well as the supplier.

The base costs to be listed under accounts 21–27 include the costs of equipment, construction materials and installation labour of the components and systems, as well as the engineering and documentation directly associated with the manufacture of these components and systems at the factory. These accounts may also include, if appropriate, the assembly of some components (calandria, condenser, turbine, generator, etc.) by the supplier at the plant site. The labour costs for construction and erection, including site supervision of all equipment, structures, components and systems at the site, are listed under accounts 34 and 35.

TOTAL CAPITAL INVESTMENT COSTS

BASE COSTS

21 BUILDINGS AND STRUCTURES AT THE PLANT SITE

211 Site preparation, facilities, infrastructure
- .1 Land reclamation, clearing and grading
- .2 Access roads, sidewalks, access roads connected with public roads
- .3 Railway access
- .4 Sanitary installations, yard drainage
- .5 Storm sewer systems, waterfront structures
- .6 Harbour and cranes, waterway improvements
- .7 Air access facilities
- .8 Fences, gateways, security installations
- .9 Other infrastructures

212 Reactor building (materials)

All materials related to the structure in which the nuclear reactor is placed

.1 Excavation, backfilling and all related work
.2 Foundation, such as plates, piles, caissons, substructure concrete and other materials
.3 Superstructure, including inner and outer concrete structures, other inner structures, structural steel and other materials
.4 Special shielding inside reactor buildings isolated from normal concrete walls and not an integral part of components
.5 Building service systems as far as they are an integral part of civil works (see account 26)
.6 Cable and pipe ducts connecting the reactor building with other buildings
.7 Containment, i.e. free-standing steel containment, liner, caissons, ice-condenser; airlocks for personnel, materials or emergency pipe and cable penetrations are included.

213 Reactor auxiliary building

.1 Excavation, backfilling and all related works
.2 Foundation, such as plates, piles, caissons, and substructure concrete and other materials
.3 Superstructure, including inner and outer concrete structures, other inner structures, structural steel and other materials
.4 Special shielding, such as movable walls which are not integral parts of components
.5 Building service systems as far as they are integral parts of civil works (see account 26)
.6 Cable and pipe ducts connecting the reactor auxiliary building with other buildings

214 Turbine building

The structures to be accounted are similar to those mentioned under 213, as applicable

215 Electrical building

The structures to be accounted are similar to those mentioned under 213, as applicable

216 Other buildings

Buildings that may be included are:
— Fuel storage building
— Radioactive waste treatment and storage buildings (radwaste building)

— Emergency diesel generator building
— Water treatment building
— Administration building
— Control building
— Information centre
— Service building
— Switchgear building
— Security building

217 Structures for transformers

218 Stacks (when separate from buildings)

22 REACTOR PLANT EQUIPMENT

221 Reactor equipment

.1 Reactor vessel
- .11 Reactor vessel and accessories
- .12 Closure head and attachments
- .13 Studs, fasteners, seals and gaskets
- .14 Calandria tubes and fittings
- .15 Pressure tubes and fittings
- .16 Insulation
- .17 Tools (stud tensioning device), accessories and handling equipment

.2 Reactor vessel internals (excluding fuel assemblies, reflector materials, moderators and reactivity control components)
- .21 Core tank or barrel container or moderator tank
- .22 Core baffles, core shrouds, distributors, orifices, throttles and strainers
- .23 Upper core structure
- .24 Control rod guide assemblies
- .25 Feedwater distributor
- .26 Steam separators and driers
- .27 Guides, channels, holders, etc. for irradiation specimen
- .28 Tools, accessories, handling and storage equipment

.3 Reactor vessel support structures
- .31 Reactor pressure vessel supports, brackets, sealings, pipe supports or others, including shielding materials if they are integral parts of the support structure

.4 Reactor control devices and other core installations
- .41 Control rod drive mechanism (magnetic, hydraulic, motor driven, others)
- .42 Control assemblies, drive shafts, etc.
- .43 In-core instrumentation (mechanical equipment)
- .44 Primary and secondary neutron sources
- .45 Burnable poison (if not integral part of the fuel)
- .46 Boron fast shutdown system (for boric acid see account 27)

.5 Moderator system, excluding moderator/reflector materials
- .51 Piping
- .52 Valves and fittings
- .53 Supports (piping related)
- .54 Insulation
- .55 Circulating pumps, including motors, supports, fixtures
- .56 Tanks, including supports, fixtures
- .57 Heat exchangers

222 Main heat transfer and transport system

.1 Reactor coolant system
- .11 Main coolant piping for guiding the main coolant between reactor pressure vessel, calandria, main coolant circulating pumps and steam generators
- .12 Valves and fittings, including loop isolation valves (if present)
- .13 Supports (piping related)
- .14 Insulation
- .15 Main coolant circulating pumps with motors and all necessary cooling, lubrication, other auxiliary systems, support structures, special tools, service equipment, etc.
- .16 Steam generators, completely assembled (U-tube, once-through vessel type) with support structures, brackets, sealings, fixtures
- .17 Special service equipment, tools, cranes, in-service inspection installations, etc.

.2 Main feedwater line and main steam line up to the fixpoint at containment
- .21 Piping
- .22 Valves and fittings, including isolation, safety and relief valves in main steam line and feedwater line
- .23 Supports (piping related)
- .24 Insulation

.3 Pressurizing system
- .31 Piping
- .32 Valves and fittings

.33 Supports (piping related)
.34 Insulation
.35 Pressurizer
.36 Pressurizer relief tank
.37 Cooling equipment
.38 Pump for pressurizer relief tank

223 Reactor auxiliary systems

.1 Volume control system, seal water supply system for main coolant pumps
.11 Piping
.12 Valves and fittings, control valves with annunciator, magnetic valves, check valves, isolation valves and other special valves
.13 Supports (piping related)
.14 Insulation
.15 Charging pumps, including motors, supports, fixtures
.16 Tanks, including supports, fixtures

.2 Boric acid and demineralized water supply system and chemical control system
.21 Piping
.22 Valves and fittings
.23 Supports (piping related)
.24 Insulation
.25 Pumps, including motors, supports, fixtures
.26 Tanks, including supports, fixtures

.3 Coolant purification system
.31 Piping
.32 Valves and fittings
.33 Supports (piping related)
.34 Insulation
.35 Pumps, including motors, supports, fixtures
.36 Tanks, including supports, fixtures
.37 Ion exchanger

.4 Coolant degassing system
.41 Piping
.42 Valves and fittings
.43 Supports (piping related)
.44 Insulation
.45 Pumps, including motors, supports, fixtures
.46 Heat exchangers, cooler, including supports, fixtures
.47 Degassification column, heater, including supports, fixtures

.5 Coolant storage and treatment system
- .51 Piping
- .52 Valves and fittings
- .53 Supports (piping related)
- .54 Insulation
- .55 Pumps, including motors, supports, fixtures
- .56 Tanks, including supports, fixtures
- .57 Ion exchanger
- .58 Heat exchangers, coolers, heater, condenser, including supports, fixtures
- .59 Evaporator columns, including supports, fixtures

.6 Nuclear component cooling system
- .61 Piping
- .62 Valves and fittings
- .63 Supports (piping related)
- .64 Insulation
- .65 Pumps, including motors, supports, fixtures
- .66 Tanks, including supports, fixtures
- .67 Heat exchangers, including supports, fixtures

.7 Fuel pool cooling and cleaning system
- .71 Piping
- .72 Valves and fittings
- .73 Supports (piping related)
- .74 Insulation
- .75 Pumps, including motors, supports, fixtures
- .76 Tanks, including supports, fixtures
- .77 Ion exchanger
- .78 Heat exchangers, including supports, fixtures

.8 Residual heat removal and emergency core cooling system
- .81 Piping
- .82 Valves and fittings
- .83 Supports (piping related)
- .84 Insulation
- .85 Pumps, including motors, supports, fixtures
- .86 Accumulator, including supports, fixtures
- .87 Heat exchanger, including supports, fixtures

.9 Other safety systems

For other reactor types (BWR, PHWR, etc.) the respective auxiliary systems may be introduced in this account instead of the systems listed above as an example.

224 Reactor ancillary systems

.1 Liquid waste storage and processing system
- .11 Piping
- .12 Valves and fittings
- .13 Supports (piping related)
- .14 Insulation
- .15 Pumps, including motors, supports, fixtures
- .16 Tanks, including supports, fixtures
- .17 Ion exchanger
- .18 Heat exchanger, including supports, fixtures
- .19 Evaporation columns, filter traps, separators, including supports, fixtures

.2 Gaseous waste processing system

Besides waste gas processing this system includes also the normal circulation of inert gas inside the Nuclear Island water systems
- .21 Piping
- .22 Valves and fittings, control valves with annunciator, magnetic valves, check valves, isolation valves and other special valves
- .23 Supports (piping related)
- .24 Insulation
- .25 Pumps, compressors, blowers, including motors, supports, fixtures
- .26 Tanks for storage, buffering, including supports, fixtures
- .27 Heat exchangers, coolers, heaters, including supports, fixtures
- .28 Recombiners, dryer columns, activated charcoal beds, cold traps, silicagel beds, including supports, fixtures

.3 Radioactive waste processing system
(Solidification of low and medium level radioactive wastes inside the plant)
- .31 Piping
- .32 Valves and fittings
- .33 Supports (piping related)
- .34 Insulation
- .35 Filling and drumming station
- .36 Cement mixing and handling equipment, including supports, fixtures
- .37 Bitumen mixing and handling equipment, including supports, fixtures
- .38 Tools, rails and other necessary equipment, including supports, fixtures

.4 Nuclear component drain and vent systems
- .41 Piping
- .42 Valves and fittings
- .43 Supports (piping related)
- .44 Insulation
- .45 Pumps, including motors, supports, fixtures
- .46 Filters, sieves, traps, including supports, fixtures

.5 Nuclear building drain system
- .51 Piping
- .52 Valves and fittings
- .53 Supports (piping related)
- .54 Insulation
- .55 Pumps, including motors, supports, fixtures
- .56 Filters, sieves, traps, buffer tanks, including supports, fixtures

.6 Nuclear sampling system
- .61 Piping
- .62 Valves and fittings
- .63 Supports (piping related)
- .64 Insulation
- .65 Tanks, including supports, fixtures
- .66 Other special installations

.7 Hydrogen monitoring system
- .71 Piping
- .72 Valves and fittings
- .73 Supports (piping related)
- .74 Insulation

Special measuring equipment should be calculated under account 24.

For other reactor types (BWR, PHWR, etc.) the respective ancillary systems may be introduced in the account system instead of the systems listed above as an example.

225 Nuclear fuel handling and storage systems

.1 New fuel storage and inspection facilities
- .11 Storage racks, supports, hangers, fixtures
- .12 Manipulation and inspection tools and installations
- .13 Fuel casks (if any)

.2 Fuel assembly loading machine inside and/or outside the reactor building
- .21 Loading machine bridge(s)

.22 Manipulating mast for fuel assemblies and control rods from loading machine
.23 Other tools for handling or manipulation of fuel assemblies, control rods, core inserts, neutron sources, etc.

.3 Spent fuel storage pool inside and/or outside the reactor building
.31 Storage racks, compact racks
.32 Pool lining material, sluice gates, inserts, supports, leak control system
.33 Transfer locks and respective installations
.34 Tilter with fuel assembly drying system
.35 Supports, hangers, consoles for core components
.36 Sipping equipment
.37 Fuel assembly repair equipment
.38 Other handling installations, casks for damaged fuel assemblies, etc.

.4 Cask pool inside or outside the reactor building
.41 Cask supporting and protection equipment
.42 Pool lining material, sluice gates, dumper, shock absorber, set-down equipment
.43 Decontamination equipment for fuel cask

.5 Spent fuel pool cleaning and cooling system (if not accounted under 223.7)

226 Other reactor plant systems and components

Under this account, all systems and components not mentioned in other accounts may be listed.

23 TURBINE-GENERATOR PLANT EQUIPMENT

231 Turbine plant

.1 High pressure and low pressure turbines
.2 Turbine drain system
.3 Seal steam/leak-off system
.4 Moisture separator/reheater system
.5 Turbine bypass system
.6 Lubrication and control fluid system
.7 Ancillary equipment, such as speed controller, main stops, throttles, valves, gland seals, turning gear, piping, insulation, panel boards,

instrumentation as an integral part of TG, protective devices, special tools, rotor lifting slings, shielding, etc.

.8 Support structures, turbine foundation (no concrete), mechanical parts (spring foundation, plates, fixtures, etc.)

232 Generator plant

.1 Generator
.2 Water system
.3 H_2 system
.4 CO_2 system
.5 N_2 system
.6 Lubrication system
.7 Seal oil system
.8 Excitation system
.9 Other auxiliary installations (support structures, valves, cable connections, etc.)

233 Condensate systems

.1 Main condensate system
- .11 Piping
- .12 Valves and fittings
- .13 Supports (piping related)
- .14 Insulation
- .15 Main condensate pumps, including motors, supports, fixtures
- .16 Condensate storage tank, including supports, fixtures
- .17 Condensate heaters, including supports, fixtures
- .18 Condenser, including special ducts to turbine exhaust valves
- .19 Supports, hangers, inserts, bases and screens

.2 Condensate cleaning system

.3 Condenser tubes cleaning system

234 Feedwater and main steam systems

.1 Main feedwater system
- .11 Piping (not included in 222.21)
- .12 Valves and fittings
- .13 Supports (piping related)
- .14 Insulation
- .15 Feedwater pumps, booster pumps, startup and shutdown pumps, including motors, supports, fixtures

.16 Feedwater tank, including supports, fixtures
.17 LP heaters, including supports, fixtures
.18 HP heaters, including supports, fixtures

.2 Emergency feedwater system

.3 Main steam system
.31 Main steam piping (not included in 222.21)
.32 Valves and fittings
.33 Supports (piping related)
.34 Insulation

235 Drain systems

.1 Plant drain system
.2 Building drain systems

236 Other secondary side systems

.1 Conventional sampling system
.2 Steam generator blowdown system

These accounts should include all necessary components, equipment, piping systems, valves and fittings, supports, hangers, etc. The related instrumentation and control equipment and other electrical equipment should be listed under account 24.

24 ELECTRICAL EQUIPMENT AND INSTRUMENTATION AND CONTROL PLANT EQUIPMENT

241 Generator and houseload equipment

.1 Generator bus ducts, including erection materials
.2 Generator breaker system, including supports, hangers, fixtures and other related equipment
.3 Medium voltage switchgear
.4 Low voltage a.c. switchgear
.5 d.c. distribution and subdistribution equipment
.6 Batteries and chargers
.7 Converters and inverters, including control and monitoring equipment
.8 Earthing and lightning protection equipment
.9 Generator and station services protection, operation (synchronizing and changeover) and monitoring equipment

242 Diesel and diesel control equipment

.1 Diesel motor and diesel generator, including accessories, control and monitoring equipment

243 Auxiliary electrical equipment

.1 Transformers

.11 Generator transformers

.12 Station service transformers

.13 Station startup transformers

.14 Low voltage and lighting transformers

.2 Motors

.21 High voltage motors (not included in driven component)

.22 Low voltage motors (not included in driven component)

.3 Cables and penetrations

.31 High voltage cables (1 kV and above)

.32 Low voltage cables (below 1 kV)

.33 High voltage special cables (above 1 kV, fire and radiation resistant)

.34 Low voltage special cables (below 1 kV, fire and radiation resistant)

.35 Buswork marshalling equipment

.36 Subdistribution and junction boxes

.37 Materials for cabling, sealing and installation

.38 Containment penetrations (not included in 212.7)

.4 Electrical supporting structures

.41 Cable trays and supports

.42 Cable conduits and supports

244 Ancillary and communication systems

.1 Lighting and installation systems

.2 Communication systems

.3 Fire alarm systems

.4 Clock systems

.5 Closed-circuit television

245 Instrumentation and control equipment (conventional and nuclear)

.1 Process I&C equipment
(the respective mechanical system accounts should be referenced)

.11 Sensors and transmitters

.12 Signal processing equipment

.13 Open loop control system, including protective interlocking and disturbances annunciators
.14 Pumps and aggregate protection
.15 Control valve actuators and drives
.16 Closed loop control system
.17 Control boards in control rooms and local control boards (including instrument recorders, indicators, alarms and controls)

.2 Process computer
.21 Supervisory computer
.22 Other computers

.3 Turbine I&C equipment
.31 Sensors, transmitters on turbine
.32 Turbine control equipment
.33 Turbine monitoring equipment
.34 Testing equipment

.4 Nuclear instrumentation
.41 Primary coolant measuring equipment
.42 Sensors and transmitters for reactor protection system and auxiliary nuclear systems
.43 Loose part monitoring system
.44 Seismic instrumentation
.45 Vibration monitoring system
.46 Ex-core instrumentation (electrical equipment)
.47 In-core instrumentation

.5 Nuclear control
.51 Reactor control
.52 Auxiliary nuclear equipment control

.6 Reactor protection system
.61 Equipment

.7 Radiation monitoring system inside plant
.71 Equipment
.72 Radiochemistry laboratory

.8 Instrumentation tubing

25 WATER INTAKE AND HEAT REJECTION

251 Circulating water intake structures

.1 Circulating water intake canals
.2 Service water intake canals

.3 Circulating water intake works
.4 Service water intake works
.5 Circulating water cleaning structures
.6 Service water cleaning structures
.7 Circulating water supply culverts
.8 Service water supply culverts
.9 Other structures, such as
- boicide treatment building
- screen wash water canals
- screen wash cleaning structures and bridge, and special site-related structures
- ducting structures

252 Structures for circulating water pumping and outfall

.1 Circulating water pump structures
.2 Service water pump structures
.3 Process cooling water pump structures
.4 Circulating water overflow structures, surge tank
.5 Screen wash water discharge canals
.6 Circulating water seal pit, circulating water aeration structure 1
.7 Circulating water deaeration structures
.8 Service water surge pond
.9 Other structures, such as
- circulating water return culverts
- service water return culverts
- circulating water outfall structures
- service water outfall structures
- circulating water outfall culverts
- service water outfall culverts
- circulating water spillway structures
- circulating water aeration structure 2
- structures for artificial circulating water aeration
- routing structures for circulating water outfall
- special structures (plant specific)
- bridge structures
- ducting structures

253 Structures for recirculating water cooling

.1 Cooling water structures (circulating water)
.2 Cooling water structures (service water)
.3 Cooling tower structures (process cooling water)

.4 Cooling tower pump structure (circulating water)
.5 Cooling tower pump structure (service water)
.6 Cooling tower pump structure (process cooling water)
.7 Cooling tower connection structures.
.8 Cooling tower discharge structures
.9 Other structures, such as
- cooling tower recirculation structures
- cooling tower recirculation culverts
- cooling tower distribution structure
- cooling tower bypass structures
- cooling tower blowdown structures
- cooling tower blowdown culverts
- special structures (plant specific)
- bridge structures
- ducting structures

254 Main circulating water piping

255 Secured service water piping

256 Service water piping for conventional plant

257 Equipment

26 MISCELLANEOUS PLANT EQUIPMENT

261 Heating, ventilation and air-conditioning systems (HVAC)

.1 Ventilation and air-conditioning systems for reactor building, reactor auxiliary building, fuel building or other buildings belonging to the controlled area(s)

.2 Ventilation and air-conditioning system, heating systems for all buildings not mentioned under 261.1

The following items belong to 261.1 and 261.2, respectively:
— Air supply systems, consisting of:
filters, heaters, coolers, fans, blowers, humidifier systems, ducts, piping, armatures, valves and other special equipment (motors and actuators are included), supports, hangers, dampers, etc.
Instrumentation and control equipment as listed under account 24, if they are not integral parts of the HVAC equipment

— Off-air systems, consisting of:
fine filters, charcoal filters and others, blowers, fans, ducts, piping, armatures, valves, supports, hangers, dampers
Instrumentation and control equipment as listed under account 24, if they are not integral parts of the HVAC equipment

.3 Auxiliary boiler, complete unit

262 Fire protection and fire fighting systems

All fire protection and fire fighting systems for the complete nuclear plant should be listed under this account, for each specific building or area

.1 Alarm system
.2 Sprinkler system
.3 Mobile installations
.4 Manually operated and hand fighting equipment
.5 Hose reels and cabinets
.6 Piping system, including valves, hangers, supports

263 Secondary side auxiliary systems

.1 Central gas supply system
.2 Hydrazine supply system
.3 Chilled water system for conventional plant and secured plant
.4 Central compressed air supply system
.5 Others

These accounts should include all necessary components, equipment, piping systems, valves, supports, hangers, inserts, insulation, etc. The related instrumentation and control equipment and other electrical equipment should be listed under account 24.

264 Water supply systems

.1 Demineralizing system
.2 Demineralized water supply system

265 Cranes, hoists, elevators, gantry

Because of the differences of the various reactor systems, all cranes, elevators, hoists and gantry should be listed under this account and classified with respect to their location inside the plant:

.1 Polar crane inside reactor building
.2 Gantry crane outside of reactor building

.3 Cranes in turbine building
.4 Cranes in reactor auxiliary building
.5 Elevators in reactor building
.6 Elevators in reactor auxiliary building
.7 Elevators in electrical building

266 Laboratory equipment

.1 Hot laboratory
.2 Conventional laboratory
.3 Radiological laboratory

All laboratory installation, i.e. furniture, measuring equipment and analytical equipment, should be listed under this account. Further, the scope of supply for lighting, workshops and infrastructure inside the plant may be added in the same way as mentioned above.

27 SPECIAL MATERIALS

Initial supply of special (non-fuel and non-structural) moderator and/or reflector materials and special heat transfer fluids (other than natural water); gases or liquids (including reactor coolant, intermediate loop heat transport fluid and turbine cycle working fluids); initial supply of oil, lubricants, ion exchange resins, boric acid, N_2, O_2, He and CO_2 gases.

271 Reactor coolant (if not under fuel cycle, account 150)

272 Moderator (if not under fuel cycle, account 150)

273 Reflector material

274 Intermediate coolant

275 Turbine cycle working fluids

276 Initial materials

.1 Oil
.2 Lubricants
.3 Resins for ion exchanger
.4 Boric acid
.5 Gases, N_2, O_2, He, CO_2, Ar
.6 Others

30 ENGINEERING, DESIGN AND LAYOUT SERVICES BY SUPPLIER(S) AND/OR A/E AT THE HOME OFFICE(S)

All engineering activities performed at the home office(s) for layout, design, calculation, elaboration of technical reports as well as the PSAR and the FSAR, specifications, licensing and QA documents, etc.

301 Civil engineering, general plant layout and design

302 Mechanical engineering for systems, components and piping

.1 Reactor plant: NSSS, NI, BONI
.2 Turbine-generator plant: TG, conventional island, BOCI

303 Electrical engineering for systems and components

.1 Reactor plant: NSSS, NI, BONI
.2 Turbine-generator plant: TG, conventional island, BOCI

304 Instrumentation and control, reactor protection engineering

305 Reactor physics, thermodynamics, thermohydraulics, plant dynamics, analogue computer analysis, earthquake analysis, chemistry and other engineering activities not directly component or system related

306 Construction and/or erection manuals and instruction preparation, commissioning instructions, operation procedures

307 QA measures and documentation at home office

308 Elaboration of licensing documents (PSAR, FSAR, topical reports, etc.)

31 PROJECT MANAGEMENT SERVICES BY SUPPLIER(S) AND/OR A/E AT THE HOME OFFICE(S)

All project management services in the respective home office(s) should be listed under this account:

311 Project co-ordination inside the respective organization

312 Project co-ordination between supplier(s) or A/E and owner

313 Project co-ordination between supplier(s) or A/E and licensing authorities

314 Project co-ordination between supplier(s) and A/E(s) at the home offices

315 Project co-ordination between supplier(s) and A/E at the plant site

316 Project co-ordination between supplier or A/E and other parties involved in the project

317 Time scheduling

318 Cost control

319 Other management services, such as interface management, co-ordination of construction services, commissioning activities, QA and final documentation, training programme activities

32 ENGINEERING, DESIGN AND LAYOUT SERVICES BY SUPPLIER(S) AND/OR A/E AT THE PLANT SITE

Engineering activities at the site for design or redesign, updating, introduction of change orders or licensing requirements, replanning of systems, etc., should be calculated or estimated under this account:

321 Civil engineering

322 Mechanical engineering for systems, components and piping

.1 Reactor plant: NSSS, NI, BONI
.2 Turbine-generator plant: TG, conventional island, BOCI

323 Electrical engineering for systems and components

.1 Reactor plant: NSSS, NI, BONI
.2 Turbine-generator plant: TG, conventional island, BOCI

324 Instrumentation and control, reactor protection engineering

325 Others

33 PROJECT MANAGEMENT SERVICES BY SUPPLIER(S) AND/OR A/E AT THE PLANT SITE

Services at the site performed by the site management group of the supplier(s) and/or the A/E, for site co-ordination, supervision and management should be listed under this account:

331 Civil works

332 Mechanical systems, components and piping

.1 Reactor plant (refer to account 22): NSSS, NI, BONI
.2 Turbine-generator plant (refer to account 23): TG, conventional island, BOCI

333 Electrical systems and components

.1 Reactor plant (refer to account 24): NSSS, NI, BONI
.2 Turbine-generator plant (refer to account 24): TG, conventional island, BOCI

334 Instrumentation and control, reactor protection, etc.

335 Administration, cost control, contracting, scheduling

336 Quality assurance

34 CONSTRUCTION SITE SUPERVISION BY SUPPLIER(S) AND/OR A/E

Construction supervisory services for the scope of supply of the supplier(s) and/or A/E should be calculated separately from the construction labour (account 35) if these activities are performed under separate contract with the owner:

341 Civil works

342 Mechanical systems, components and piping

.1 Reactor plant: NSSS, NI, BONI
.2 Turbine-generator plant: TG, conventional island, BOCI

343 Electrical systems and components

.1 Reactor plant: NSSS, NI, BONI
.2 Turbine-generator plant: TG, conventional island, BOCI

344 Instrumentation and control, reactor protection, etc.

345 Others

35 CONSTRUCTION LABOUR BY SUPPLIER(S) AND/OR A/E OR CONSTRUCTION COMPANIES AT THE PLANT SITE

All plant construction labour executed at the site should be listed under this account. Site fabrication of components has to be calculated under account 22 for the respective component.

351 Civil works

.1 Civil structures (reactor building, turbine building, reactor auxiliary building, switchgear building, etc.)
.2 Mechanical structures (buildings as under 351.1)

352 Mechanical systems, components and piping

.1 Reactor plant (refer to account 22): NSSS, NI, BONI
.2 Turbine-generator plant (refer to account 23): TG, conventional island, BOCI

353 Electrical systems and components (refer to account 24)

.1 Reactor plant: NSSS, NI, BONI
.2 Turbine-generator plant: TG, conventional island, BOCI

354 Instrumentation and control, reactor protection (refer to account 24)

355 Others (refer to accounts 25 and 26)

36 COMMISSIONING SERVICES BY SUPPLIER(S) AND/OR A/E AT THE PLANT SITE

All commissioning services, including startup, performed after completion of the erection work, up to the commercial operation of the plant, should be listed under this account. Deviations from this definition have to be clearly stated.

361 Reactor plant equipment

.1 Reactor equipment as under 221
.2 Main heat transfer and transport system as under 222
.3 Reactor auxiliary systems as under 223
.4 Reactor ancillary systems as under 224
.5 Nuclear fuel handling and storage systems as under 225.

362 Turbine-generator plant equipment

.1 Turbine plant as under 231
.2 Generator plant as under 232
.3 Condensate systems as under 233
.4 Feedwater and main steam systems as under 234
.5 Drain systems as under 235
.6 Other secondary side systems as under 236

363 Electrical equipment and instrumentation and control plant equipment

.1 Generator and houseload equipment as under 241
.2 Diesel and diesel control equipment as under 242
.3 Auxiliary electrical equipment as under 243
.4 Ancillary and communication systems as under 244
.5 I&C equipment as under 245

364 Water intake and heat rejection systems as under 25

.1 Circulating water intake structures
.2 Structures for circulating water pumping and outfall
.3 Structures for recirculating water cooling
.4 Main circulating water piping
.5 Secured service water piping
.6 Service water piping for conventional plant

365 Miscellaneous plant equipment

.1 Heating, ventilation and air-conditioning systems as under 261
.2 Fire protection and fire fighting systems as under 262
.3 Secondary side auxiliary systems as under 263
.4 Water supply systems as under 264
.5 Cranes, hoists, elevators, gantry as under 265
.6 Laboratory equipment as under 266, as applicable

37 TRIAL TEST RUN SERVICES BY SUPPLIER(S) AND/OR A/E

All services necessary to perform the trial test run of the parts of plant included in the scope of supply (NSSS, NI, BOP, TG, conventional island, etc.), delivered, erected and commissioned, within the frame of the test run for the complete plant, should be calculated under this account in order to obtain the guarantee values in the period of time agreed upon in the BIS.

371 NSSS or NI

372 BONI

373 TG island

374 BOCI

38 CONSTRUCTION FACILITIES, TOOLS AND MATERIALS AT THE PLANT SITE

All costs for items, materials, structures and tools used for plant construction, and tools removed or dismantled after plant completion, should be listed under this account. Items, materials or structures which are permanent parts of the plant have to be included in accounts 21–27.

381 Site access and infrastructure improvements (specify in detail)

382 Buildings and structures
(details should be specified as under account 21)

- .1 Field offices with installations
- .2 Social buildings: canteen, hospital or medical service, shops, changing rooms, laboratories, rest rooms, apartment houses
- .3 Warehouses, storage sheds, garages
- .4 Workshops
- .5 Guard houses, fences
- .6 Fire fighting installations or measures during construction

383 Provisional installations during construction

- .1 Water supply
- .2 Gas supply (N_2, O_2, Ar, CO_2, etc.)
- .3 Electrical supply for welding machines, temporary erection tools, lighting, ventilation
- .4 Steam supply (steam boiler) with distribution system
- .5 Compressed air station with distribution system
- .6 Fuel for engines, turbines, boilers
- .7 Waste storage and treatment
- .8 Communication equipment (telephone, telex, telefax, TV and others)

384 Transportation installations not included in accounts 21–27

.1 Harbour crane
.2 Gantry
.3 Unloading equipment
.4 Lorries
.5 Scaffolds, ladders, stairways

385 Miscellaneous installations, materials, tools

39 COMMISSIONING MATERIALS, CONSUMABLES, TOOLS AND EQUIPMENT AT THE PLANT SITE

391 Materials used during the commissioning period (filters, ion exchanger, chemicals, oil, lubricants, D_2O, Na, He, CO_2) and needed before commercial operation

392 Special tools (measuring equipment, reactimeter, etc.)

393 Others

40 STAFF TRAINING, TECHNOLOGY TRANSFER AND OTHER SERVICES

401 Staff training

The scope of supply offered for training of operation and maintenance personnel should be listed under this account and the person-months evaluated; the qualification of the trainees and the respective levels of the training courses or programmes should be taken into account.

.1 Reactor plant operation personnel
.2 Reactor plant maintenance personnel
.3 I&C personnel
.4 Electrical personnel, computer personnel
.5 Physicists, chemists, radiologists, etc.
.6 Operation personnel for conventional plant
.7 Maintenance personnel for conventional plant
.8 Other plant personnel
.9 Pre-graduate and post-graduate education or other services

402 Technology transfer

.1 Transfer of written documents for
- .11 Civil engineering
- .12 Mechanical, electrical and I&C engineering
- .13 Plant layout
- .14 Systems engineering for nuclear systems and components, conventional systems and components, and electrical systems and components
- .15 Instrumentation and control, reactor protection
- .16 Manufacturing
- .17 Construction, erection
- .18 Commissioning
- .19 Maintenance, in-service inspection and nuclear fuel cycle

.2 Transfer of computer programs and data pools

.3 Assignment and delegation of personnel

.4 R&D activities

.5 Formation of new companies and organizations in the owner's country
- .51 Engineering company
- .52 Manufacturers of reactor plant equipment and conventional equipment
- .53 Manufacturers of fuel assemblies
- .54 Erection companies
- .55 Enrichment facilities
- .56 Intermediate storage for burnup fuel
- .57 Licensing body
- .58 QA organization
- .59 Others

.6 Owner's scope

Technology transfer activities dealing with the owner's scope should be included in this account.

403 Other services

Services not included in the above accounts.

41 HOUSING FACILITIES AND RELATED INFRASTRUCTURE

If it is necessary to have living quarters at the permanent site, all buildings, structures, harbour, airport, TV station, radio station, hospital, fire fighting facilities, schools, sport facilities, shopping centre, etc. should be calculated under this account, in correspondence with the requirements of the BIS.

APPENDIX A

SUPPLEMENTARY COSTS

50 TRANSPORTATION AND TRANSPORTATION INSURANCE

51 SPARE PARTS

52 CONTINGENCIES

53 INSURANCES

FINANCIAL COSTS
(including accounts 21–53)

60 ESCALATION COSTS

61 INTEREST COSTS

62 FEES

OWNER'S COSTS
(excluding accounts 21–62)

70 OWNER'S CAPITAL INVESTMENT AND SERVICES COSTS

71 ESCALATION OF OWNER'S COSTS

72 FINANCING OF OWNER'S COSTS

NUCLEAR FUEL CYCLE COSTS

100 Fuel assembly supply, *first core*

101 Uranium supply

102 Conversion

103 Enrichment

104 Fuel assembly fabrication

105 Supply of other fissionable materials

110 Services, *first core*

111 Fuel management (U, Pu, Th)

112 Fuel management schedule

113 Licensing assistance

114 Preparation of computer programs

115 Quality assurance

116 Fuel assembly inspection

117 Fuel assembly intermediate storage

118 Information for the use of third-party fuel

120 Fuel assembly supply, *reloads*

121 Uranium supply

122 Conversion

123 Enrichment

124 Fuel assembly fabrication

125 Supply of other fissionable materials

130 Services, *reloads*

131 Fuel management

132 Fuel management schedule

133 Licensing assistance

134 Preparation of computer programs

135 Quality assurance

136 Fuel assembly inspection

137 Fuel assembly intermediate storage

138 Information for the use of third-party fuel

140 Reprocessing of irradiated fuel assemblies

141 Credits for uranium, plutonium and other materials

142 Final disposal of fuel assemblies
(in case of no reprocessing)

143 Final waste disposal

150 Heavy water supply, *first charge*
(if not included in capital investment costs)

151 Heavy water services, *first charge*

160 Heavy water supply, *replacement quantities*
(if not included in O&M costs)

161 Heavy water services, *replacement quantities*

170 Financial costs for the nuclear fuel cycle and for heavy water

OPERATION AND MAINTENANCE COSTS

800 Wages and salaries for engineering and technical support staff, and operation, maintenance and administration staff

810 Consumable operating materials and equipment

820 Repair costs, including interim replacements

830 Charges on working capital

840 Purchased services

850 Insurances and taxes

860 Fees, inspections and review expenses

870 Decommissioning allowances

880 Miscellaneous costs

Appendix B
TECHNICAL QUESTIONNAIRES

Technical questionnaires are an integral part of the BIS. They are used for additional information to be presented in the bids, as requested by the owner. To facilitate the technical bid evaluation process, these formats should be prepared for all components, systems, structures, buildings, electrical equipment, and instrumentation and control equipment, as specified for delivery.

This Appendix shows how these questionnaires can be prepared. The examples presented do not completely cover a particular reactor technology; however, they are applicable mainly to PWRs. Specific questionnaires should be developed for other reactor technologies. A list of all questionnaires that should be included in the BIS is beyond the scope of this Guidebook. No uniform format for these questionnaires is in use on the international market. The formats presented here may help the owner in preparing his own questionnaires for the BIS. For components installed in different systems, standardized formats can be used in principle; a few examples are given in this Appendix.

TECHNICAL QUESTIONNAIRE FOR NUCLEAR SYSTEMS AND COMPONENTS AND FOR TURBINE-GENERATOR PLANT

Plant:	Bidder:
System:	System identification code:

Computer code	Item	Unit	Data
	Reactor core		
	Core height (total active)	mm	
	Core equivalent diameter	mm	
	Fuel	—	
	Number of fuel assemblies in the core	—	
	Fuel weight, total	kg U	
	Fraction of heat produced in fuel	%	
	Core power density, average	kW/m^3	
	Core flow, total	m^3/s	
	Entrance subcooling temperature	°C	
	Core coolant pressure drop	kPa	
	Core coolant temperatures		
	— inlet	°C	
	— outlet	°C	
	Number of fuel rods per assembly	—	
	Cladding material	—	
	Weight of fuel assembly (for handling)	kg	
	Maximum core reactivity, k_{eff}		
	— all rods in	—	
	— strongest rod out	—	
	Reactivity of movable control rods (cold), k	—	
	Range of reactivity coefficients		
	— moderator temperature	—	
	— fuel temperature	—	
	— moderator pressure	—	
	— moderator void	—	
	— boron	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Average number of fuel elements to be replaced each year during refuelling	—	
	Neutron sources		
	— number	—	
	— materials	—	
	— strength	Bq (Ci)[a]	
	— lifetime	years	
	— maximum shutdown time without replacement	years	
	Control rods and control rod drives		
	Control rods		
	Number of control rods	—	
	Absorber material	—	
	Active length	mm	
	Overall length	mm	
	Weight of one control rod, total	kg	
	Lifetime of control rods, average	year	
	Lifetime of control rods, min./max.	year	
	Total reactivity worth of all control rods, excluding one rod with maximum reactivity worth	—	
	Control rod drives		
	Number	—	
	Lifting and lowering speed	mm/s	
	Scram time	s	
	Design pressure	kPa	
	Design temperature	°C	
	Normal operation temperature	°C	

[a] 1 Ci = 3.7×10^{10} Bq *or* 37 GBq.

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Reactor pressure vessel		
	Design pressure	kPa	
	Design temperature	°C	
	Operating pressure	kPa	
	Operating temperature (inlet/outlet)	°C	
	Overall vessel height	mm	
	Diameter over nozzles (largest diameter for transportation)	mm	
	Inner diameter of cylindrical vessel part	mm	
	Wall thickness of the cylindrical part	mm	
	Thickness of cladding	mm	
	Weight of lower vessel part	t	
	Weight of vessel head	t	
	Vessel material	—	
	Cladding material	—	
	Maximum fast neutron flux (energy greater than 0.18 MeV) at vessel wall	$n/(cm^2 \cdot s)$	
	Fast neutron flux (energy greater than 0.18 MeV)	$n/(cm^2 \cdot s)$	
	Minimum nil ductility transition temperature after 40 years of operation at 90% load factor	°C	
	Steam generators		
	Number of steam generators	—	
	Type	—	
	Heat transfer capacity per generator	MW	
	Active heat transfer surface per generator	m^2	
	Spare surface	%	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Mass of water (full load)	t	
	Mass of water (hot stand-by)	t	
	Outer diameter, max. (for transport)	mm	
	Overall height (for transport)	mm	
	Total weight (empty, for transport)	t	
	Diameter/thickness of tube sheet	mm	
	Outer diameter of tube and wall thickness	mm	
	Number of tubes per generator	—	
	Minimum tube bend radius	mm	
	Tube-to-tube sheet crevice width	mm	
	Materials		
	— tubes	—	
	— vessel body	—	
	— cladding of primary coolant chambers	—	
	— tube sheet plate	—	
	— tube support sheet	—	
	— steam dryer equipment	—	
	Primary coolant side		
	Design pressure	kPa	
	Design temperature	°C	
	Primary coolant flow	m^3/s	
	Operating inlet temperature	°C	
	Operating outlet temperature	°C	
	Operating pressure	kPa	
	Pressure drop at full load	kPa	
	Steam side		
	Design pressure	kPa	
	Design temperature	°C	
	Steam flow (full load)	kg/s	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Steam pressure at outlet nozzle	kPa	
	Steam temperature at outlet nozzle	°C	
	Steam moisture at full load	wt%	
	Feedwater temperature at inlet nozzle	°C	
	Reactor coolant pumps		
	Number	—	
	Type	—	
	Design temperature	°C	
	Design pressure	kPa	
	Operating pressure	kPa	
	Delivery head	m	
	Flow rate in normal operation	m^3/s	
	Required power at the coupling (hot/cold)	kW	
	Speed	rev/min	
	Type of seal	—	
	Seal water flow rate (if any)	m^3/s	
	Seal water requirements	—	
	Weight of pump (empty)	kg	
	Total inertia of rotating parts	$kg \cdot m^2$	
	Materials		
	— casing	—	
	— shaft	—	
	— impeller	—	
	— seal	—	
	Electric motor (refer to standard electric motor format)		
	Pressurizer		
	Pressure, design/operating	kPa	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Temperature, design/operating	°C	
	Total volume	m^3	
	Water volume at full power	m^3	
	Water volume, max./min.	m^3	
	Steam volume at full power	m^3	
	Installed heater power, total	kW	
	Number of heaters	—	
	Outer diameter	mm	
	Wall thickness	mm	
	Total height	mm	
	Dry weight	t	
	Base material	—	
	Cladding material	—	
	Pressurizer safety and relief valves		
	Type	—	
	Number	—	
	Design pressure	kPa	
	Design temperature	°C	
	Blowdown flow	m^3/s	
	Lift-up set points	kPa	
	Pressurizer spray valves		
	Type	—	
	Number	—	
	Spray rate, max.	m^3/s	
	Spray set points	kPa	
	Pressurizer relief tank		
	Number	—	
	Pressure, design/operating	kPa	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Temperature, design/operating	°C	
	Total volume	m^3	
	Water volume, normal	m^3	
	Water volume, max./min.	m^3	
	Maximum blowdown quantity	kg	
	Maximum temperature after blowdown	°C	
	Base material	—	
	Cladding material	—	
	Pump for pressurizer relief tank (refer to standard pump format)	—	
	Cooler for pressurizer relief tank (refer to standard heat exchanger format)	—	
	Reactor coolant circulation piping		
	Diameter (D_i/D_{out})	mm	
	Wall thickness	mm	
	Design pressure	kPa	
	Design temperature	°C	
	Operating pressure	kPa	
	Operating temperature	°C	
	Base material	—	
	Cladding thickness (if applicable)	mm	
	Cladding material	—	
	Emergency core cooling system and residual heat removal system		
	Heat removal rates at different modes of operation	kJ/h	
	Cooling water requirements for design	m^3/s	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Number of trains or components needed	—	
	Number of hours needed for cooldown at the different modes of operation	h	
	High pressure flow rate	m^3/s	
	Low pressure flow rate	m^3/s	
	Minimum boron concentration	ppm	
	Note: The questionnaires for specific system components have to be prepared as shown on previous pages, using also standard format data.		
	Gaseous waste treatment system		
	Type of system	—	
	Design maximum/normal off-gas rate	kg/h	
	Design maximum/normal off-gas rate	Bq/a (Ci/a)	
	Delay before release to the stack	days	
	Maximum hydrogen concentration in the system	%	
	Hydrogen supply conditions		
	— flow rate and pressure	m^3/s and kPa	
	— quality	—	
	Nitrogen supply conditions		
	— flow rate and pressure	m^3/s and kPa	
	— quality	—	
	Oxygen supply conditions		
	— flow rate and pressure	m^3/s and kPa	
	— quality	—	
	Note: The questionnaires for specific system components have to be prepared as shown on previous pages, using also standard format data.		

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Solid waste treatment system		
	Expected amount of wastes to be treated		
	— spent resins	m^3/a	
	— concentrates	m^3/a	
	— chemical wastes	m^3/a	
	— compressible wastes (compacted)	m^3/a	
	— number of radioactive filters	number per year	
	— other wastes to be solidified	m^3/a	
	Type of encapsulation	—	
	Fraction of drum volume available for wastes	—	
	Number of drums expected (200 L or 400 L)	number per year	
	Drumming capacity per shift	—	
	Number of drums which can be stored		
	— within the nuclear building complex	—	
	— in separate storage buildings	—	
	— totally within the plant boundary	—	
	Radiation at drum surfaces for long-term storage (max., min., number of drums)	mrem/h	
	Note: The questionnaires for specific system components have to be prepared as shown on previous pages, using also standard format data.		
	Standard pump data		
	Type	—	
	Number of units	—	
	Number of stages	—	
	Number of units required to operate		
	— normal operation	—	
	— maximum design conditions	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Operation characteristics		
	— capacity	kg/s	
	— total dynamic head	m	
	— efficiency	%	
	— power of electric motor	kW	
	— pump speed	rev/min	
	— net positive suction head (NPSH)	m	
	— type of bearings	—	
	— type of seals	—	
	Materials		
	— casing	—	
	— shaft	—	
	— impeller	—	
	Weight (for transport)	kg	
	Standard heat exchanger data		
	Type	—	
	Number of units	—	
	Number of tube passes	—	
	Number of units required to operate		
	— normal operation	—	
	— maximum design conditions	—	
	— thermal capacity	kW	
	— heat transfer surface	m^2	
	— spare heat transfer surface	m^2	
	— approach temperature difference	°C	
	— cleanliness factor (if applicable)	%	
	— dimensions (overall)	mm	
	Tube side		
	— design flow rate	kg/s	
	— operating flow rate	kg/s	
	— design temperature	°C	
	— inlet/outlet temperature	°C	
	— design pressure	kPa	
	— operating pressure	kPa	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Shell side		
	— design flow rate	kg/s	
	— operating flow rate	kg/s	
	— design temperature	°C	
	— inlet/outlet temperature	°C	
	— design pressure	kPa	
	— operating pressure	kPa	
	Materials		
	— tubes	—	
	— tube sheets	—	
	— tube support sheets	—	
	— shell	—	
	Weight (for transport)	kg	
	Standard tank data		
	Type	—	
	Number of units	—	
	Volume per unit	m^3	
	Design/operating pressure	kPa	
	Design/operating temperature	°C	
	Materials		
	— shell and heads	—	
	— lining or cladding	—	
	— internals	—	
	Weight (for transport)	kg	
	Dimensions		
	— diameter	mm	
	— wall thickness	mm	
	— height	mm	
	Standard evaporator data		
	Type	—	
	Number of units	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Number of units required to operate		
	— normal operation	—	
	— maximum design conditions	—	
	Capacity	kg/h	
	Heater capacity	kW	
	Heat source	—	
	Design/operating temperature	°C	
	Design/operating pressure	kPa	
	Dimensions		
	— height	mm	
	— diameter	mm	
	Materials		
	— shell	—	
	— internals	—	
	— heater, tubes	—	
	Weight (for transport)	kg	
	Standard electric motor data		
	Type	—	
	Rated power	kW	
	Rated voltage	V	
	Rated frequency	Hz	
	Full load speed	rev/min	
	Full load current	A	
	Full load torque	N·m	
	Efficiency at full load	%	
	Power factor at full load	%	
	Insulation class	—	
	Type of cooling	—	
	Starting method	—	
	Motor starting time	s	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Intermittent duty cycle	h^{-1}	
	Weight	kg	
	General data of turbine-generator plant		
	Rated output at generator terminals	MW	
	Mean heat rate	kJ/kW·h	
	Steam pressure at turbine stop valves	kPa	
	Steam temperature at turbine stop valves	°C	
	Moisture content of steam at turbine stop valves	%	
	Main steam flow at rated output	kg/s	
	Final feedwater temperature	°C	
	Condenser pressure at rated output	kPa	
	Nominal cooling water inlet temperature	°C	
	Cooling water flow to main condenser	m^3/s	
	Overall length of turbine generator set	m	
	Additional length for generator rotor withdrawal	m	
	Minimum crane hook height from operating floor	m	
	Operation		
	Cold shutdown time	h	
	Hot shutdown time	h	
	Startup time to full load after cold shutdown	min	
	Startup time to full load after hot shutdown	min	
	Permissible ramp load change	%/min	
	Permissible step load change	%	
	Minimum continuous load	%	
	Continuous permissible frequency range	Hz	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Transient frequency limitations as a function of time	Hz	
	Maximum output with one section of condenser isolated	MW	
	Maximum output with one-half of condenser out of service	MW	
	Maximum output with one train of LP feed heaters out of service	MW	
	Maximum output with one train of HP feed heaters out of service	MW	
	Maximum output with all HP heaters out of service	MW	
	Maximum permissible temperature in condenser	°C	
	Condenser pressure at which turbine is tripped	kPa	
	Condenser pressure at which bypass is tripped	kPa	
	Main steam line		
	Number	—	
	Design pressure	kPa	
	Design temperature	°C	
	Operating pressure at first isolation valve	kPa	
	Operating temperature at first isolation valve	°C	
	Main steam flow rate	kg/s	
	Moisture in steam		
	— at steam generator outlet	wt%	
	— at turbine inlet valve	wt%	
	Dimensions		
	— outer diameter	mm	
	— wall thickness	mm	
	Materials	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Safety valves		
	Type	—	
	Number	—	
	Design pressure	kPa	
	Design temperature	°C	
	Maximum blowdown flow at design pressure (... kPa)	kg/s	
	Actuation point	kPa	
	Feedwater lines		
	Number	—	
	Design pressure	kPa	
	Design temperature	°C	
	Maximum operating pressure	kPa	
	Maximum operating temperature	°C	
	Flow rate, total	kg/s	
	Dimensions		
	— outer diameter	mm	
	— wall thickness	mm	
	Materials	—	
	Turbine bypass		
	System	—	
	Capacity	kg/s	
	Bypass valves		
	— number, type	—	
	— capacity	kg/s	
	— dimensions	mm	
	— materials	—	
	Number of inlets to condenser	—	
	Condensate injection capacity	kg/s	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Turbine		
	Speed	rev/min	
	Number of LP cylinders	—	
	Length of last-stage LP blades	mm	
	Type of erosion protection of LP blades	—	
	Total LP exhaust area	m^2	
	Exhaust loss at rated output	kJ/kg	
	Critical speeds in, or close to, operating range		
	— HP rotor	rev/min	
	— LP 1 rotor	rev/min	
	— LP 2 rotor	rev/min	
	— LP 3 rotor	rev/min	
	— generator	rev/min	
	Combined critical speed of the TG unit	rev/min	
	Inertia constant of combined turbine-generator rotor	kW·s/kV·A	
	Rotor overspeed test		
	— speed	rev/min	
	— duration	s	
	Bearing diameters		
	— HP	mm	
	— LP 1	mm	
	— LP 2	mm	
	— LP 3	mm	
	— generator	mm	
	Bearing spans		
	— HP	m	
	— LP 1	m	
	— LP 2	m	
	— LP 3	m	
	— generator	m	
	LP condenser overpressure protection		
	— type	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	— capacity	kg/s	
	— operating pressure	kPa	
	Turbine materials		
	— turbine casings HP	—	
	LP	—	
	— rotors HP	—	
	LP	—	
	— fixed blades HP	—	
	LP	—	
	— moving blades HP	—	
	LP	—	
	Turbine dimensions		
	— overall length of turbine	m	
	Rotor length/max. diameter		
	— HP	m	
	— LP	m	
	Casing length/width/height		
	— HP	m	
	— LP	m	
	Turbine weights		
	— HP rotor	kg	
	— LP rotor	kg	
	Casings		
	— HP top half	kg	
	— HP bottom half	kg	
	— LP top half	kg	
	— LP bottom half	kg	
	— heaviest erection lift	kg	
	— heaviest maintenance lift	kg	
	— heaviest shipping weight	kg	
	— total turbine weight	kg	
	Moisture separator reheaters (MS/RH)		
	Number of units	—	
	Type of units	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Type of moisture separating elements	—	
	Degree of moisture separation	—	
	Number of reheating stages	—	
	Number of reheater bundles per stage	—	
	Type of tubes (finned or smooth)	—	
	Type of tube-to-tube sheet joint	—	
	Total tube surface area	m^2	
	Type of overpressure protection	—	
	Drain pumps		
	— number and duty	%	
	— capacity	L/s	
	— motor rating	kW	
	Materials		
	— shell	—	
	— moisture separating elements	—	
	— reheater tubes	—	
	— tube sheets	—	
	— drain pump casing	—	
	— drain pump impeller	—	
	Maximum length/diameter (shipping)	m	
	Total weight (empty)	kg	
	Lubrication oil system		
	Type of oil used	—	
	Capacity of main oil tank	m^3	
	Total quantity of oil	kg	
	Number of changes per hour	—	
	Main oil pump		
	— type	—	
	— drive	—	
	— speed	rev/min	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	— capacity	L/s	
	— discharge pressure	kPa	
	DC motor driven emergency oil pump		
	— type	—	
	— capacity	L/s	
	— discharge pressure	kPa	
	— motor rating	kW	
	AC motor driven auxiliary oil pump		
	— type	—	
	— capacity	L/s	
	— discharge pressure	kPa	
	— motor rating	kW	
	Jacking oil pumps		
	— number	—	
	— type	—	
	— discharge pressure	kPa	
	Coolers		
	— type	—	
	— number and duty	%	
	— surface area (per cooler)	m^2	
	— cooling water flow	L/s	
	— heat quantity exchanged	kW	
	— cooling water temperature rise	°C	
	— cooling water velocity in tubes	m/s	
	— materials: shell	—	
	tubes	—	
	tube sheets	—	
	Oil purifier		
	— type	—	
	— capacity	L/s	
	— motor rating	kW	
	Gland sealing system		
	Sealing steam pressure	kPa	
	Gland steam condensers		
	— number and duty	%	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	— type	—	
	— tube surface area	m^2	
	— condensate flow	kg/s	
	— condensate velocity in tubes	m/s	
	— temperature rise of condensate	°C	
	— materials: shell	—	
	tubes	—	
	tube sheet	—	
	Gland steam exhauster		
	— number and duty	%	
	— type	—	
	— capacity of each	m^3/s	
	— motor rating	kW	
	Turbine control and protection system		
	Type	—	
	Control fluid pumps		
	— number and duty	%	
	— capacity of each	L/s	
	— discharge pressure	kPa	
	— motor rating	kW	
	Control fluid coolers		
	— number and duty	%	
	— tube surface area	m^2	
	— cooling water flow	L/s	
	— cooling water temperature rise	°C	
	— cooling water velocity in tubes	m/s	
	— materials: shell	—	
	tubes	—	
	tube sheets	—	
	— capacity of control fluid tank	L	
	Mechanical governor		
	— type	—	
	— deadband	±%	
	— droop	%	
	— droop adjustment range	±%	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Overspeed protection		
	— method	—	
	— tripping speed	rev/min	
	Turning gear		
	Type	—	
	Driving speed of turbine shaft	rev/min	
	Motor rating	kW	
	Generator		
	Manufacturer	—	
	Rated apparent output	MV·A	
	Rated active output	MW	
	Rated voltage and variation	kV and ± %	
	Rated frequency and variation	Hz and ± %	
	Rated power factor	—	
	Rated hydrogen pressure	kPa	
	Rated speed	rev/min	
	Short-circuit ratio	—	
	Reactance, referred to rated output and rated voltage		
	— direct-axis synchronous reactance (unsaturated value), X_d per unit	—	
	— tolerance	—	
	— quadrature-axis synthronous reactance (saturated value), X_q per unit	—	
	— direct-axis transient reactance (saturated value), X'_d per unit	—	
	— direct-axis subtransient reactance (saturated value), X''_d per unit	—	
	— tolerance	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	— negative-sequence reactance (saturated value), X_2 per unit	—	
	— zero-sequence reactance (saturated value), X_0 per unit	—	
	Time constants		
	— direct-axis transient open-circuit time constant, T_{do}	s	
	— direct-axis transient short-circuit time constant, T'_d	s	
	— direct-axis subtransient short-circuit time constant, T''_d	s	
	— armature time constant, T_a	s	
	— generator inertia constant, H	kW·s/kV·A	
	Generator efficiency, including losses of generator auxiliary system, excitation system, etc. at rated power factor	—	
	Tolerance		
	— output 1/4	%	
	— output 2/4	%	
	— output 3/4	%	
	— output 4/4	%	
	Temperatures referred to rated output of the generator (measured with temperature detectors if nothing else is mentioned)		
	— hydrogen, cold (cooler outlet)	°C	
	— hydrogen, hot (cooler inlet)	°C	
	— stator conductor cooling water, cold (winding inlet)	°C	
	— stator conductor cooling water, hot (winding outlet)	°C	
	— stator winding	°C	
	— rotor winding, measured with resistance method	°C	
	— stator iron	°C	
	— slip rings, measured with thermometer	°C	
	— oil temperature, cold	°C	
	— bearing inlet	°C	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	— bearing outlet	°C	
	— bearing metal	°C	
	Maximum output for temperature limits according to the offered insulation class		
	— apparent output	MV·A	
	— power factor, lagging	MV·A	
	Maximum output at rated power factor, with one hydrogen cooler (or one cooler element) out of service at rated hydrogen pressure	MV·A	
	Maximum permissible output at rated power factor, with reduced hydrogen pressure but with rated temperature rise		
	— 70% rated hydrogen pressure	MV·A	
	— 80% rated hydrogen pressure	MV·A	
	— 90% rated hydrogen pressure	MV·A	
	Maximum permissible continuous output		
	— at rated power factor	MW	
	— at 1.0 power factor	MW	
	— at 0.95 leading power factor	MW	
	Excitation requirements of generator, at 105% rated voltage, rated apparent output and continuous operation		
	— excitation current	A	
	— excitation voltage	V	
	Short-circuit currents of the generator		
	— maximum asymmetrical short-circuit current	kA	
	— tolerance	—	
	— sustained short-circuit current	kA	
	Maximum continuous negative sequence current	%	
	Short-time thermal capability	—	
	Test voltages (at rated frequency for 1 min)		
	— stator winding conductors, before assembly	kV	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	— stator winding	kV	
	— rotor winding	kV	
	— primary bushings	kV	
	Maximum bearing pedestal vibrations		
	— rated speed	μm	
	— 120% rated speed	μm	
	Maximum vibrations at rated speed		
	— stator core	μm	
	— stator housing	μm	
	Weights		
	— generator complete	t	
	— stator complete	t	
	— rotor complete	t	
	— heaviest transportation weight	t	
	— heaviest maintenance weight	t	
	Dimensions of large items for transportation		
	— length	mm	
	— width	mm	
	— height	mm	
	— generator stator bore	mm	
	— generator active stator bore	mm	
	— generator air gap	mm	
	Dielectric and magnetic parameters		
	— maximum air gap induction at rated voltage and no load	T	
	— current density of stator windings	A/cm^2	
	Inertia torque	N·m	
	Voltage variation: voltage increase, passing from full-load to no-load operation at constant excitation, rated speed and rated power factor	—	
	Resistance (at 75°C)		
	— stator	ohm	
	— rotor	ohm	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Stator cooling water system		
	Water quantity		
	— in system	m^3	
	— circulated	kg/s	
	Water dielectric strength		
	— during operation	kV/cm	
	— minimum permissible conductivity	kV/cm	
	— maximum permissible conductivity	S	
	Maximum cooling water pressure during operation	kPa	
	Water pressure drop across the winding	kPa	
	Water temperature rise (inlet–outlet)	°C	
	Maximum cooling water quantity for the water to water coolers	kg/s	
	Water to water coolers (refer to heat exchanger standard format)	—	
	Seal oil system		
	Oil quantity		
	— in system	m^3	
	— circulated	kg/s	
	Maximum oil pressure during operation	kPa	
	Oil coolers (refer to heat exchanger standard format)	—	
	Maximum cooling water quantity	kg/s	
	Seal oil pumps (refer to pump standard format)	—	
	Hydrogen cooling system		
	Hydrogen leakage at rated pressure, during 24 h	kg/s	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Heat exchanged in hydrogen coolers	kW	
	Maximum cooling water quantity for H_2 coolers	kg/s	
	H_2 pressure at rated output	kPa	
	Maximum permissible operating pressure		
	— H_2 in the generator	kPa	
	— water in the coolers	kPa	
	Quantity of H_2 at normal pressure	kg/s	
	H_2 purity		
	— during operation	%	
	— minimum possible for operation	%	
	CO_2 consumption		
	— H_2 discharge	kg/s	
	— air discharge	kg/s	
	H_2 coolers (refer to heat exchanger standard format)	—	
	Excitation and voltage control system		
	Type of excitation system	—	
	Ceiling excitation voltage related to the rated excitation voltage	V	
	Excitation response ratio	s^{-1}	
	Voltage recovery characteristic after a short circuit near the power plant	V/s	
	Voltage transient load response at abrupt reactive loads of		
	— 200 MV·A (reactive)	s^{-1}	
	— 400 MV·A (reactive)	s^{-1}	
	Voltage control system sensitivity	%	
	Condensate system		
	General		
	Steam condensed at rated output	kg/s	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Heat removed at rated output	MW	
	Cooling water inlet temperature		
	— nominal	°C	
	— maximum	°C	
	— minimum	°C	
	Cooling water flow		
	— nominal	m^3/s	
	— maximum	m^3/s	
	— minimum	m^3/s	
	Condenser pressure at rated output and nominal cooling water inlet temperature	kPa	
	Condensate temperature	°C	
	Oxygen content of condensate at condenser pump discharge	ppb	
	Condenser		
	Type	—	
	Number of sections	—	
	Number of passes	—	
	Total tube surface	m^2	
	Spare surface	m^2	
	Total number of tubes	—	
	Number of tubes in air cooling section	—	
	Tube length	m	
	Tube size (o.d./wall thickness)	mm	
	Method of attachment of tubes	—	
	Total friction loss (cooling water side)	m WG*	
	Water velocity in tubes	m/s	
	Cleanliness factor (design value)	%	

* metres water gauge.

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Cleanliness factor (operationally acceptable)	%	
	Heat transfer coefficient	$kW \cdot m^{-2} \cdot °C^{-1}$	
	Method of supporting condenser	—	
	Hot-well storage capacity (if applicable)	m^3	
	Size and number of cooling water connections		
	— inlet	mm	
	— outlet	mm	
	Materials		
	— condenser shell	—	
	— tubes in condensing zone	—	
	— tubes in air cooler zone	—	
	— tube sheets	—	
	— tube support plates	—	
	— water box protection	—	
	Weight		
	— maximum weight for erection	kg	
	— maximum weight for maintenance	kg	
	— weight in service including water	kg	
	Overall dimensions		
	— length	m	
	— width	m	
	— height (excluding exhaust duct)	m	
	Evacuating equipment		
	Main air ejectors		
	— type	—	
	— number of units	—	
	— dry air capacity at rated vacuum, each	kg/h	
	— steam pressure required	kPa	
	— steam consumption	kg/s	
	— total effective tube surface, each	m^2	
	— tube material of coolers	—	
	— friction drop through coolers	m WG*	

* metres water gauge.

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Startup ejectors or vacuum pump		
	— type	—	
	— number of units	—	
	— time required to reach ...kPa	min	
	— steam pressure required	kPa	
	— steam consumption	kg/s	
	— motor rating, each	kW	
	Condensate pumps		
	Type	—	
	Number supplied	—	
	Number operating at rated output	—	
	Design conditions		
	— capacity, each	kg/s	
	— total dynamic head	m	
	— efficiency	%	
	— power required	kW	
	— motor power	kW	
	Speed	rev/min	
	Number of stages	—	
	Type of bearings	—	
	Type of shaft seals	—	
	Materials		
	— casing	—	
	— impeller	—	
	— shaft	—	
	Total weight of one pump	kg	
	Feedwater heating system		
	Feed heaters		
	Number of feed heating stages		
	— LP	—	
	— deaerating	—	
	— HP	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Number of feed heater banks		
	— LP	—	
	— deaerating	—	
	— HP	—	
	Final feedwater temperature	°C	
	LP feed heaters, heater stage 1		
	Number of heaters	—	
	Type	—	
	Terminal temperature difference	°C	
	Approach temperature difference	°C	
	Design heat transfer coefficient		
	— desuperheating zone	$kW \cdot m^{-2} \cdot °C^{-1}$	
	— condensing zone	$kW \cdot m^{-2} \cdot °C^{-1}$	
	— drain cooling zone	$kW \cdot m^{-2} \cdot °C^{-1}$	
	Total tube surface	m^2	
	Spare tube surface	m^2	
	Number of tube passes	—	
	Tube dimensions (o.d./wall thickness)	mm	
	Type of tube-to-tube sheet joint	—	
	Thickness of tube sheet	mm	
	Velocity of water in tubes at maximum continuous rating	m/s	
	Tube side pressure drop at maximum continuous rating	m WG*	
	Materials		
	— shell	—	
	— water box	—	
	— tubes	—	
	— tube sheet	—	
	— support plates		
	— baffles	—	

* metres water gauge.

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Weight		
	— complete heater, empty	kg	
	— complete heater, flooded	kg	
	Overall dimensions	mm	
	LP feed heaters, heater stage 2		
	Same specification as for stage 1		
	Deaerator heater and feedwater storage tank		
	Heater stage 1		
	Type	—	
	Terminal temperature difference	°C	
	Oxygen content of feedwater at storage tank outlet	ppb	
	Total storage volume	m^3	
	Storage volume with normal level	m^3	
	Number and capacity of safety valves	kg/s	
	Materials		
	— deaerator shell	—	
	— storage tank shell	—	
	Weight — deaerator plus tank		
	— empty	kg	
	— operating	kg	
	— flooded	kg	
	Overall dimensions	mm	
	Feedwater pumps and drives		
	Number of pumps and duty	%	
	Type of drive	—	
	Type of feedwater control (refer to standard formats)	—	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	Main pumps		
	(refer to pumps standard format)		
	Booster pumps		
	(refer to pump standard format)		
	Gear coupling		
	Type	—	
	Efficiency at design point	%	
	Maximum cooling water flow	L/s	
	Motor drives		
	(refer to electric motor standard format)		
	Turbine drives		
	Type	—	
	Characteristics at rated output		
	— pressure at stop valves	kPa	
	— temperature at stop valves	°C	
	— steam flow	kg/s	
	— vacuum	kPa	
	— speed	rev/min	
	— output at coupling	kW	
	Critical speed	rev/min	
	Type of control system	—	
	Number of control valves	—	
	Materials		
	— casing	—	
	— rotor	—	
	— rotor blades	—	
	— fixed blades	—	
	— valve chest	—	
	Condenser		
	— type	—	
	— number of passes	—	
	— total tube surface	m^2	

NSSS AND TG (cont.)

Computer code	Item	Unit	Data
	— spare tube surface	m^2	
	— temperature rise in cooling water	°C	
	— cooling water flow	m^3/s	
	— water velocity in tubes	m/s	
	Materials		
	— shell	—	
	— tubes	—	
	— tube sheets	—	
	— tube support sheets	—	

TECHNICAL QUESTIONNAIRE FOR NUCLEAR FUEL

General NSSS description

Thermal power from NSSS to T-G cycle, MW(th) _____
Core thermal power generated in fuel, MW(th) _____
Reactor pressure, kPa _____
Primary coolant flow rate (total), kg/s _____
Number of coolant loops _____
Core inlet temperature, °C _____
Core outlet temperature, °C _____
Core outlet void fraction _____
Active reactor core volume, cm^3 _____
Water/HO_2 volume ratio _____

Core description

Equivalent core diameter, m _____
Active core height, m _____
Total number of fuel assemblies _____
Number of fuel rods per assembly _____
Overall length of fuel assembly, m _____
Fuel composition _____
Cladding material _____
Fuel rod pitch, mm _____
Clad outside diameter and thickness, mm _____
Number of control rods _____
Average control rod lifetime, full-power years _____
Total mass of fuel in core, kg _____

Fuel pellet

Materials _____
Density, g/cm^3 _____
Diameter, mm _____
Length, mm _____
Maximum moisture content, ppm _____

NUCLEAR FUEL (cont.)

Fuel cladding

Materials _____
Inside diameter, mm _____
Outside diameter, mm _____
Wall thickness, mm _____

Fuel rod

Rod length (total, active), mm _____
End cap material _____
Pellet–clad diametrical gap, mm _____
Plenum or free volume space, cm^3 _____
Initial composition and pressure of internal gas _____
Weight of fuel rod, kg _____
Weight of contained uranium, kg _____

Fuel assembly

Number of fuel rods per assembly _____
Rod array _____
Rod pitch, mm _____
Minimum clearance between rods, mm _____
Overall assembly dimensions, mm _____
Type of fuel rod grids _____
Grid materials _____
Number of grids per assembly _____
Dimensional clearance between adjacent fuel assemblies _____
Total weight per fuel assembly, kg _____
Weight of contained uranium, kg _____

Physical design data

Fuel performance

Initial loading

Average discharge exposure, MW·d per Mt U _____

NUCLEAR FUEL (cont.)

Maximum discharge exposure, MW·d per Mt U _____

Maximum fuel pellet exposure at discharge, MW·d per Mt U _____

Replacement fuel at equilibrium

Average discharge exposure, MW·d per Mt U _____

Maximum discharge exposure, MW·d per Mt U _____

Maximum fuel pellet exposure at discharge, MW·d per Mt U _____

Full-power years to reach equilibrium _____

Water-to-fuel ratio, total core, rods out _____

Water-to-fuel ratio, total core, rods in _____

In-core inventories

	Core volume	
	Fraction	Weight (kg)
Uranium	_____	_____
Plutonium	_____	_____
Zircaloy	_____	_____
Stainless steel	_____	_____
Inconel	_____	_____
Other structural alloy	_____	_____
Burnable poison	_____	_____
Coolant	_____	_____
Other (specify)	_____	_____
Total:	1.0	

Initial conversion ratio (fissile atoms formed) _____

(fissile atoms destroyed) _____

Average conversion ratio _____

Conversion ratio of equilibrium core _____

NUCLEAR FUEL (cont.)

Reactivity budget and control characteristics, % Δk/k

	Initial cycle	Equilibrium
Cold to hot (moderator)		
Doppler		
Voids		
Xenon and samarium		
Depletion during cycle		
Manoeuvring just before refuelling		
Other (specify)		
Total control requirement		

Available control, % Δk/k

	Initial cycle			Equilibrium		
	Cold	Hot	Full power	Cold	Hot	Full power
Worth of control rods						
Worth of burnable poison						
Worth of boric acid						
Rod of greatest worth						
Total available						
Cold shutdown margin						

	Initial cycle			Equilibrium		
	Cold	Hot	Full power	Cold	Hot	Full power
Equilibrium xenon and samarium, ppm						

NUCLEAR FUEL (cont.)

Reactivity coefficients

	Initial cycle			Equilibrium		
	Cold	Hot	Full power	Cold	Hot	Full power
Power coefficient (without xenon or samarium), Δk/MW(th)						
Moderator temperature, Δk/°C						
Beginning of cycle						
Fuel temperature (Doppler) coefficient						
End of cycle						
Pressure coefficient, Δk/kPa						
Void coefficient, Δk/% void						
Time required for full xenon override after shutdown from rated thermal output, h						
Beginning of cycle						
End of cycle						

Neutron fluxes

Average thermal neutron flux (operating, clean) _____

Average epithermal flux (Energy greater than 0.1 eV) (operating, clean) _____

Average fast neutron flux (Energy greater than 1 MeV) (operating, clean) _____

NUCLEAR FUEL (cont.)

Core thermal and hydraulic characteristics

Gross fission power output, MW(th) _____

Maximum transient overpower allowance, % of rated thermal output _____

Specific power, kW/kg U

- Initial core (av., max.) _____
- Equilibrium core (av., max.) _____

Power density, kW/L

- Initial core _____
- Equilibrium core _____

Linear heat rating, W/cm

- Core average _____
- Maximum steady state value _____
- Maximum value in overpower transient _____
- Value at which centre melting is expected to occur _____

Heat transfer surface area, m^2 _____

Heat flux, $W \cdot cm^{-2} \cdot s^{-1}$

- Core average _____
- Maximum of steady state _____
- Maximum during overpower transient _____

Centre fuel temperature, °C

- Core average _____
- Maximum at steady state _____
- Maximum during overpower transient _____

Dryout nucleate boiling, dryout or critical heat flux ratio

- Minimum value at rated power _____
- Minimum value at overpower _____
- Estimated power level at which minimum dryout nucleate boiling ratio (DNBR) or central heat flux ratio (CHFR) is 1.0 _____
- Confidence level utilized for above determination _____
- Correlation used to determine DNBR or CHFR _____

NUCLEAR FUEL (cont.)

Coolant–clad heat transfer coefficient, $W \cdot cm^{-2} \cdot s^{-1}$	
Initial, clean	_____
Minimum	_____
Clad temperature, °C	
Average core, clean	_____
Maximum value	_____
Coolant flow, kg/s	
Total core	_____
Effective flow for heat transfer	_____
Bypass flow, %	_____
Operating pressure, kPa	_____
Core pressure drop, kPa	_____
Coolant temperature, °C	
Inlet	_____
Average outlet	_____
Outlet of hot channel	_____
Coolant quality and void fraction, %	
Core average	_____
Average exit quality	_____
Maximum at core exit of hot channel	_____
Power peaking factors (maximum design values)	
Axial	_____
Radial	_____
Local	_____
Overall	_____
Allowances for overpower transient, % of full power	
Errors in nuclear instrumentation set-point, related to power level determination	_____
Calorimetric errors	_____
Reactor trip set point	_____
Overall	_____
Axial power distribution used for design	_____

Appendix C

ABBREVIATIONS

For definitions of some of these terms, see TRS No. 269 (1986)

A/E	Architect/Engineer
BIS	Bid Invitation Specifications
BOCI	Balance of Conventional Island
BONI	Balance of Nuclear Island
BOP	Balance of Plant
CI	Conventional Island
CIF	Cost, Insurance, Freight
FAS	Free Alongside Ship
FOB	Free on Board
HVAC	Heating, Ventilation, Air Conditioning
I&C	Instrumentation and Control
NI	Nuclear Island
NSSS	Nuclear Steam Supply System
NUSS	Nuclear Safety Standards
O&M	Operation and Maintenance
QA	Quality Assurance
QC	Quality Control
SG	Safety Guide
TG	Turbine-Generator
HP	High pressure
LP	Low pressure

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(C) denotes participation in the Consultants Meeting in 1982.
(A) denotes participation in the Advisory Group Meeting in 1986.

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The following conversion table is provided for the convenience of readers

FACTORS FOR CONVERTING SOME OF THE MORE COMMON UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI) EQUIVALENTS

NOTES:

(1) SI base units are the metre (m), kilogram (kg), second (s), ampere (A), kelvin (K), candela (cd) and mole (mol).

(2) ▶ indicates SI derived units and those accepted for use with SI;
▷ indicates additional units accepted for use with SI for a limited time.
[*For further information see the current edition of The International System of Units (SI), published in English by HMSO, London, and National Bureau of Standards, Washington, DC, and International Standards ISO-1000 and the several parts of ISO-31, published by ISO, Geneva.*]

(3) The correct symbol for the unit in column 1 is given in column 2.

(4) ✻ indicates conversion factors given exactly; other factors are given rounded, mostly to 4 significant figures:
≡ indicates a definition of an SI derived unit: [ ] in columns 3+4 enclose factors given for the sake of completeness.

Column 1 *Multiply data given in:*	Column 2	Column 3 *by:*	Column 4 *to obtain data in:*	
Radiation units				
▶ becquerel	1 Bq	(has dimensions of s^{-1})		
disintegrations per second (= dis/s)	1 s^{-1}	≡ 1.00×10^{0}	Bq	✻
▷ curie	1 Ci	= 3.70×10^{10}	Bq	✻
▷ roentgen	1 R	[= 2.58×10^{-4}	C/kg]	✻
▶ gray	1 Gy	[≡ 1.00×10^{0}	J/kg]	✻
▷ rad	1 rad	= 1.00×10^{-2}	Gy	✻
▶ sievert *(radiation protection only)*	1 Sv	[≙ 1.00×10^{0}	J/kg]	✻
▷ rem *(radiation protection only)*	1 rem	= 1.00×10^{-2}	Sv	✻
Mass				
▶ unified atomic mass unit ($\frac{1}{12}$ of the mass of ^{12}C)	1 u	[= $1.660\,57 \times 10^{-27}$	kg, approx.]	
▶ tonne (= metric ton)	1 t	[= 1.00×10^{3}	kg]	✻
pound mass (avoirdupois)	1 lbm	= 4.536×10^{-1}	kg	
ounce mass (avoirdupois)	1 ozm	= 2.835×10^{1}	g	
ton (long) (= 2240 lbm)	1 ton	= 1.016×10^{3}	kg	
ton (short) (= 2000 lbm)	1 short ton	= 9.072×10^{2}	kg	
Length				
statute mile	1 mile	= 1.609×10^{0}	km	
▷ nautical mile (international)	1 n mile	= 1.852×10^{0}	km	✻
yard	1 yd	= 9.144×10^{-1}	m	✻
foot	1 ft	= 3.048×10^{-1}	m	✻
inch	1 in	= 2.54×10^{1}	mm	✻
mil (= 10^{-3} in)	1 mil	= 2.54×10^{-2}	mm	✻
Area				
▷ hectare	1 ha	[= 1.00×10^{4}	m^2]	✻
▷ barn *(effective cross-section, nuclear physics)*	1 b	[= 1.00×10^{-28}	m^2]	✻
square mile, (statute mile)^2	1 $mile^2$	= 2.590×10^{0}	km^2	
acre	1 acre	= 4.047×10^{3}	m^2	
square yard	1 yd^2	= 8.361×10^{-1}	m^2	
square foot	1 ft^2	= 9.290×10^{-2}	m^2	
square inch	1 in^2	= 6.452×10^{2}	mm^2	
Volume				
▶ litre	1 l *or* 1 L	[= 1.00×10^{-3}	m^3]	✻
cubic yard	1 yd^3	= 7.646×10^{-1}	m^3	
cubic foot	1 ft^3	= 2.832×10^{-2}	m^3	
cubic inch	1 in^3	= 1.639×10^{4}	mm^3	
gallon (imperial)	1 gal (UK)	= 4.546×10^{-3}	m^3	
gallon (US liquid)	1 gal (US)	= 3.785×10^{-3}	m^3	

Column 1 *Multiply data given in:*	Column 2	Column 3 *by:*	Column 4 *to obtain data in:*	
Velocity, acceleration				
foot per second (= fps)	1 ft/s	= 3.048×10^{-1}	m/s	*
foot per minute	1 ft/min	= 5.08×10^{-3}	m/s	*
mile per hour (= mph)	1 mile/h	= 4.470×10^{-1} = 1.609×10^{0}	m/s km/h	
▷ knot (international)	1 knot	= 1.852×10^{0}	km/h	*
free fall, standard, g		= 9.807×10^{0}	m/s^2	
foot per second squared	1 ft/s^2	= 3.048×10^{-1}	m/s^2	*
Density, volumetric rate				
pound mass per cubic inch	1 lbm/in^3	= 2.768×10^{4}	kg/m^3	
pound mass per cubic foot	1 lbm/ft^3	= 1.602×10^{1}	kg/m^3	
cubic feet per second	1 ft^3/s	= 2.832×10^{-2}	m^3/s	
cubic feet per minute	1 ft^3/min	= 4.719×10^{-4}	m^3/s	
Force				
▶ newton	1 N	[≡ 1.00×10^{0}	$m \cdot kg \cdot s^{-2}$]	*
dyne	1 dyn	= 1.00×10^{-5}	N	*
kilogram force (= kilopond (kp))	1 kgf	= 9.807×10^{0}	N	
poundal	1 pdl	= 1.383×10^{-1}	N	
pound force (avoirdupois)	1 lbf	= 4.448×10^{0}	N	
ounce force (avoirdupois)	1 ozf	= 2.780×10^{-1}	N	
Pressure, stress				
▶ pascal[a]	1 Pa	[≡ 1.00×10^{0}	N/m^2]	*
atmosphere[b], standard	1 atm	= $1.013\,25 \times 10^{5}$	Pa	*
▷ bar	1 bar	= 1.00×10^{5}	Pa	*
centimetres of mercury (0°C)	1 cmHg	= 1.333×10^{3}	Pa	
dyne per square centimetre	1 dyn/cm^2	= 1.00×10^{-1}	Pa	*
feet of water (4°C)	1 ftH_2O	= 2.989×10^{3}	Pa	
inches of mercury (0°C)	1 inHg	= 3.386×10^{3}	Pa	
inches of water (4°C)	1 inH_2O	= 2.491×10^{2}	Pa	
kilogram force per square centimetre	1 kgf/cm^2	= 9.807×10^{4}	Pa	
pound force per square foot	1 lbf/ft^2	= 4.788×10^{1}	Pa	
pound force per square inch (= psi)[c]	1 lbf/in^2	= 6.895×10^{3}	Pa	
torr (0°C) (= mmHg)	1 torr	= 1.333×10^{2}	Pa	
Energy, work, quantity of heat				
▶ joule (≡ W·s)	1 J	[≡ 1.00×10^{0}	N·m]	*
▶ electronvolt	1 eV	[= $1.602\,19 \times 10^{-19}$	J, approx.]	
British thermal unit (International Table)	1 Btu	= 1.055×10^{3}	J	
calorie (thermochemical)	1 cal	= 4.184×10^{0}	J	*
calorie (International Table)	1 cal_{IT}	= 4.187×10^{0}	J	
erg	1 erg	= 1.00×10^{-7}	J	*
foot-pound force	1 ft·lbf	= 1.356×10^{0}	J	
kilowatt-hour	1 kW·h	= 3.60×10^{6}	J	*
kiloton explosive yield (PNE) (≡ 10^{12} g-cal)	1 kt yield	≃ 4.2×10^{12}	J	

[a] Pa (g): pascals gauge
Pa abs: pascals absolute

[b] atm (g) (= atü): atmospheres gauge
atm abs (= ata): atmospheres absolute

[c] lbf/in^2 (g) (= psig): gauge pressure
lbf/in^2 abs (= psia): absolute pressure

Column 1 *Multiply data given in:*	Column 2	Column 3 *by:*	Column 4 *to obtain data in:*
Power, radiant flux			
▶ watt	1 W	[≡ 1.00×10^{0}	J/s] *
British thermal unit (International Table) per second	1 Btu/s	= 1.055×10^{3}	W
calorie (International Table) per second	1 cal_{IT}/s	= 4.187×10^{0}	W
foot-pound force/second	1 ft·lbf/s	= 1.356×10^{0}	W
horsepower (electric)	1 hp	= 7.46×10^{2}	W *
horsepower (metric) (= ps)	1 ps	= 7.355×10^{2}	W
horsepower (550 ft·lbf/s)	1 hp	= 7.457×10^{2}	W
Temperature			
▶ kelvin	K		
▶ degrees Celsius, t where T is the thermodynamic temperature in kelvin and T_0 is defined as 273.15 K	$t = T - T_0$		*
degree Fahrenheit	$t_{°F} - 32$	$\times \left(\frac{5}{9}\right)$ gives	t *(in degrees Celsius)* *
degree Rankine	$T_{°R}$		T *(in kelvin)* *
temperature difference[d]	$\Delta T_{°R}$ (= $\Delta t_{°F}$)		ΔT (= Δt) *
Thermal conductivity[d]			
1 Btu·in/(ft^2·s·°F) *(International Table Btu)*		= 5.192×10^{2}	$W \cdot m^{-1} \cdot K^{-1}$
1 Btu/(ft·s·°F) *(International Table Btu)*		= 6.231×10^{3}	$W \cdot m^{-1} \cdot K^{-1}$
1 cal_{IT}/(cm·s·°C)		= 4.187×10^{2}	$W \cdot m^{-1} \cdot K^{-1}$
Miscellaneous quantities			
litre per mole per centimetre (1 M/cm =) *(molar extinction coefficient or molar absorption coefficient)*	1 $L \cdot mol^{-1} \cdot cm^{-1}$	= 1.00×10^{-1}	m^2/mol *
G-value, traditionally quoted per 100 eV of energy absorbed *(radiation yield of a chemical substance)*	1×10^{-2} eV^{-1}	= 6.24×10^{16}	J^{-1}
mass per unit area *(absorber thickness and mean mass range)*	1 g/cm^2	[= 1.00×10^{1}	kg/m^2] *

[d] A temperature interval or a Celsius temperature difference can be expressed in degrees Celsius as well as in kelvins.

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