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UTILITY/USER REQUIREMENTS for the MODULAR HIGH TEMPERATURE GAS-COOLED REACTOR PLANT

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DEFINITIONS

- PLANT - All buildings, structures, systems and components that together accomplish the process of energy production and conversion and support the human activities of administration, operation and maintenance.
- NUCLEAR ISLAND - That portion of the plant that has within its boundary the following:
- 1) The standard reactor modules and safety-related buildings, structures, systems, portions of systems and components dedicated to assuring reactor shutdown, decay heat removal, fission product retention, and security of vital areas including new (unirradiated) fuel.
 - 2) At the designer's discretion, non-safety-related buildings, structures, systems, portions of systems and components that support reactor operation or investment protection.
- STANDARD REACTOR MODULE - That portion of the Nuclear Island which is duplicated with the addition of each reactor. This would include, in part, the reactor, steam generator, helium circulator, reactor building, reactor cavity cooling system, etc.
- ENERGY CONVERSION AREA - That portion of the plant not included within the Nuclear Island.
- EQUILIBRIUM PLANT - A commercial plant that incorporates a design that has matured through construction of replicate facilities and has accrued the benefits of standardization, learning and optimal use of associated manufacturing facilities.

SECTION 1 INTRODUCTION

The purpose of this document is to set forth the top level Utility/User requirements for a Modular High Temperature Gas-Cooled Reactor electric generating plant that incorporates 4 reactors and 2 turbine-generators to produce a nominal electrical output of 550 MW net.

The requirements provided in Sections 2 through 7 call for fundamental changes in the approach to attainment of economic and safety goals. The essence of these changes may be found in the balance between the safety and investment protection goals of Section 2 and the economic goals of Section 7. Section 2 requires that NRC and EPA criteria for protection of the public be met at the plant Exclusion Area Boundary without consideration of sheltering or evacuation. It further sets very stringent limits for plant equivalent availability and for investment protection. At the same time, Section 7 requires that such plants be competitive with comparably sized advanced coal plant alternatives.

Rather than being contradictory, these requirements imply a new design approach whereby the inherent characteristics of the HTGR are exploited to their fullest extent. In such a design, both the safety and economic viability of the plant concept must derive from simplicity of design and operation. Reliance upon complex and expensive active systems (e.g. active decay heat removal systems) for the attainment of safety goals must be avoided.

Recognizing the high cost of development and licensing, the requirements provide for certification of the Nuclear Island as a standard design by the NRC. Accordingly, Section 6 provides, for key design parameters, a siting envelope that is intended to encompass approximately 85% of domestic U.S. sites. As a further inducement to standardization and the economics of serial production, the concept of the Standard Reactor Module has been introduced. The Standard Reactor Module is intended to be the basic building block for use in other electric generation and cogeneration applications in addition to the reference 4 reactor, 2 turbine configuration addressed herein.

The requirements contained in this document are applicable to equilibrium commercial plants and thus incorporate assumptions associated with a supportive institutional infrastructure (e.g. stable regulatory environment, availability of a repository for spent fuel, etc.).

These requirements are intended to provide a basis for development of a design that is responsive to the needs of the Utility/User. It is the responsibility of the designers to advise of any requirement which results in an undue economic or operational penalty in the overall plant design.

SECTION 2

OVERALL DESIGN REQUIREMENTS

The overall goal of a plant design developed in response to these requirements is the safe and economical production of electricity.

2.1 DESIGN METHODOLOGY

1. Systems engineering methodology shall be employed to identify and document functions and their related requirements that drive the design of plant systems, structures and components.
2. In documenting the plant design, traceability shall be maintained in the documentation of plant requirements and in the corresponding selection of plant design features.
3. The plant design documentation provided to the utility/user shall include a hierarchical listing of design requirements down to the level of major components, shall identify the basis for design selections and, for normal, transient and postulated accident conditions, shall describe for each system the purpose, basis for configuration, principles of operation and interfaces/interactions with other systems.
4. Formal utility/user reviews of the plant design shall be made and the results of and designer response to the review documented at the completion of Conceptual, Preliminary and Final Design. Design reviews shall include consideration of plant Licensability, Operability, Maintainability, Fabricability and Constructability.

2.2 AVAILABILITY

1. The design equivalent availability* averaged over the lifetime of the plant shall be at least 80% for electrical generation when modeled using equipment mean time to failure and mean time to repair data for like type or similar systems and/or components.
2. The equivalent unavailability averaged over the lifetime of the plant owing to scheduled outages shall not exceed 10% (Average of 876 hrs/year).

* Equivalent Availability is mathematically defined as:

$$A_e = \frac{\int_0^{T_p} P_a(t) dt}{T_p}$$

Where: $P_a(t)$ = Available net electrical power expressed as a percentage of design power as a function of time (t)

t = Time

T_p = Time period (operational lifetime)

3. Design modifications and improvements to achieve the above availability requirements shall be considered for incorporation in the design, if a one percentage increase in the total capital investment produces, at a minimum, a seven tenths percentage improvement in the equivalent availability factor. For example, if the total capital investment of a HTGR plant is \$1 billion with an evaluated equivalent availability of 80%, then an additional plant investment of \$10 million would be justified if the evaluated equivalent availability is increased from 80% to 80.56% or higher.

2.3 PLANT INVESTMENT PROTECTION

1. It shall be a design goal that the calculated equivalent unavailability averaged over the lifetime of the plant owing to forced outages shall not exceed 10% (Average of 876 hrs/year).
2. Outages of six months or greater shall not contribute more than 10% of the total equivalent unavailability from forced outages, including those not expected to occur in an individual plant's lifetime.
3. The calculated annual value for risk (i.e. the sum of event frequency times consequence over all events) to plant equipment or property when averaged over plant lifetime shall not exceed the annual property damage insurance premium used in economic assessments. Currently the assumed portion of the annual premium for property damage is \$4.5 million.
4. The mean likelihood of exceeding the design limits associated with the safety related design conditions, and which could therefore lead to the regulatory shutdown of other MHTGR plants, shall be less than 10⁻⁵ per plant year.
5. The design shall include security measures for the physical protection of the plant against acts of sabotage.

2.4 SAFETY AND LICENSING

1. Design and licensing documentation shall be developed as necessary to obtain design certification of the Standard Nuclear Island by the NRC.
2. The plant shall be designed in accordance with the top-level regulatory criteria provided in HTGR-85-002, Top Level Regulatory Criteria for the Standard HTGR.
3. The plant shall be designed to meet the top level regulatory criteria defined above without credit for sheltering or evacuation of the public beyond the plant's exclusion area boundary.

2.5 PROVISIONS FOR VISITORS - HOLD

1. Provisions shall be made (e.g.: viewing galleries) to facilitate public viewing of selected plant areas by persons and groups under controlled conditions. As a minimum, such provisions shall allow viewing of the control room and refueling floor.

SECTION 3

PLANT REQUIREMENTS

3.1 OVERALL PLANT CONFIGURATION

1. The plant shall be configured to locate the reactor modules within a Nuclear Island that is physically separated from the Energy Conversion Area.
2. The Nuclear Island shall include 4 Standard Reactor Modules.
3. The Energy Conversion Area shall incorporate two steam turbine-generators.
4. The design of the Standard Reactor Modules shall conform to the requirements contained within this document and in addition shall accommodate the performance and transient characteristics of the following additional reactor/turbine-generator combinations:
 - a) Two (2) reactor modules operating in parallel supplying steam to a single turbine-generator.
 - b) Four (4) reactor modules operating in parallel supplying steam to a single turbine-generator.
 - c) Cogeneration configuration (TBD)

Accommodation of a), b) and c) above shall be confirmed through analysis by the completion of preliminary design to verify that Standard Reactor Module system and component design limits are not exceeded under anticipated transient and accident conditions.

3.2 PLANT PERFORMANCE

3.2.1 Plant Output

The plant shall produce a nominal net electrical output of 550 MW for delivery to the utility grid.

3.2.2 Plant Duty Cycle/Transients

1. The plant shall be designed for base-load operations and additionally shall be capable of accommodating the weekly load cycle of Figure 3-1 over its design life.
2. The plant shall be designed to accommodate the number of transient events contained in Table 3-1.

FIGURE 3-1 WEEKLY LOAD CYCLE

TABLE 3-1

*DESIGN DUTY CYCLES

	<u>Design Number of Occurrences for Plant Lifetime</u>
1. Reactor/plant startup from cold conditions	160
2. Reactor/plant shutdown to cold conditions	160
3. Rapid load ramp (5%/min) (25-100%)/(100-25%)	1000/1000
4. Normal load ramp (0.5%/min) (100-25%)/(25-100%)	17,500/20,800
5. Step load changes ($\pm 10\%$)	2000

* Additional Duty Cycle events and their frequency of occurrence are to be determined by the responsible designers for concurrence by the Utility/User.

3. Features shall be included to facilitate continual plant operation through the transients of Table 3-1 (except for shutdown) and at reduced electrical output upon loss of function of major plant components where more than one is employed.

3.2.3 Plant Service Life

1. The plant shall be designed for an operating life of 40 calendar years from start of operation while accommodating either base load operation or the weekly load cycle of Figure 3-1.

3.3 OPERATIONAL REQUIREMENTS

3.3.1 Plant Control/Response

1. The plant shall be normally operated from a single control room except during postulated events that would render the control room uninhabitable or the controls inoperable.
2. The control room shall incorporate features necessary to facilitate startup, shutdown, monitoring and control and shall provide for the shutdown of major systems and components by the operator in order to limit investment risk and provide personnel protection.
3. Controls and instrumentation for supporting systems, subsystems or components whose failure would not have an immediate impact on plant output shall be preferably located outside the control room in the proximity of the system, subsystem, component or process.
4. Human engineering techniques shall be employed in the design of the controls and instrumentation/operator interface to enhance operator response and reduce the probability of human error.
5. Internal diagnostic monitoring shall be incorporated within major plant control systems to detect malfunctions.
6. Fixed audible alarm annunciator points shall be restricted to those critical parameters which can lead to initiation of protective action for major plant components or the loss of electrical production.
7. Provisions shall be made to automatically detect and document the sequence of significant events (e.g. control inputs, changes in the operation of major systems and components, protective trips, etc.) that occur during plant operation.
8. The plant process control systems shall be functionally independent from major component and equipment monitoring and protective features.

9. The design of protective features shall provide for periodic functional testing that will not interfere with normal plant operation.
10. Each individual reactor module shall be capable of continuous operation under automatic control between 25% and 100% of nominal module feedwater flow.
11. The plant shall be capable of changing reactor and plant output under automatic control at a rate up to and including 5% of rated output per minute of those reactors on line.
12. Control system features shall be included to facilitate operation of reactor modules and turbine-generators independently and at different power levels.
13. The plant shall be designed to sustain continuous operation through and following transients associated with the loss or failure of a major component, system, or train, including an individual reactor or turbine-generator.
14. Features shall be included as required to limit recovery time to resumption of reactor power operation when a protection trip occurs consistent with meeting the plant availability goal.
15. The plant design shall provide sustained and controlled operation for the conditions listed below:
 - a) Load rejection from full generator electric output to house electrical load without receiving a reactor trip signal. Plant operating capability for up to 12 hours under house electric load conditions shall be provided.
 - b) Turbine trip (except on low condenser vacuum) from any load level without receiving a reactor trip signal. Continuous reactor operation at reduced output shall be provided.
 - c) Step changes of $\pm 10\%$ in plant output caused by utility electrical transmission grid frequency upsets.
16. The design shall permit for reloading the plant at 5% of rated load per minute from either of the conditions listed in 15 a) or b) above without the necessity for a mandatory hold except for those associated with the turbine-generator.

3.3.2 Environment

1. The design shall include features to assure that specified area and compartment environmental conditions are maintained during normal and transient operation and in

specified areas under accident conditions to assure habitability requirements are met for operator occupancy and for equipment, component and instrumentation operability and maintainability. Special consideration shall be given to the necessity for removing and/or controlling chemical fumes, dust, smoke, radioactive gases and particulates.

2. Requirements for environmental qualification of equipment under normal and abnormal plant operating conditions and postulated accidents shall be defined and documented by the end of preliminary design.

3.3.3 Plant Staffing

1. The plant shall be designed to be administered, operated and maintained by a minimum plant staff consistent with the plant availability and safety goals.
2. The plant design goal for the permanent operating staff is a maximum of 50 full-time personnel. This staff would include first line supervisors, operating and operations maintenance support personnel.
3. As a design goal the plant shall be designed to be operated by a maximum shift staff of:
 - a) 1 - senior licensed supervisor
 - b) 2 - licensed reactor operators in the control room
 - c) 4 - roving operators
4. An evaluation of required operator response for normal, off-normal and emergency plant conditions shall be completed for each anticipated operating staff position. This evaluation shall be used to confirm that operator staffing is consistent with anticipated work loads and response times.
5. The plant design goal for the permanent technical and security staff (excluding administrative and clerical staff) is a maximum of 70 full time personnel. This staff would include first line supervisors and other personnel assigned in the categories of engineering, health physics, water and helium chemistry, laboratory staff, security and other technical disciplines.
6. The plant design goal for the permanent maintenance staff is a maximum of 75 full time personnel. This staff would include first line supervisors and personnel assigned in the categories of mechanical, electrical, electronic and instrument maintenance, quality control and stores and warehouse activities.

3.4 MAINTENANCE REQUIREMENTS

1. Provisions shall be made for monitoring plant status, configuration and performance as a basis for maintenance diagnostics and decision making.

2. Building design and equipment layout shall result in as few "vital" security areas as possible consistent with plant availability and safety requirements.
3. Building design, equipment layout and design features including cranes, hoists and monorails shall be provided to facilitate removal and replacement of major equipment items.
4. Headroom, pull space, laydown and work space for component and equipment maintenance shall be provided. As required, beams, rails, etc. shall be provided for temporary attachment of lifting devices. Where required, permanently installed lifting devices shall be included in the design. As required, building structural members shall be removable without cutting to facilitate access for in-place maintenance or replacement. Consideration shall be given to space requirements for moving equipment and components, from their permanent location to shop facilities, in the layout of aisles, sizing of doorways, elevator(s), etc.
5. Equipment and components shall be accessible from normally provided floors and platforms to the greatest degree practicable. Where components are not accessible from floors or platforms, special access, such as permanently installed ladders and local platforms, shall be provided.
6. Accessibility to individual components and equipment during normal plant operation and under accident conditions shall be considered when locating components and equipment. The use of design models should be considered to facilitate assessments of maintainability.
7. Systems and components shall be designed to facilitate hands-on maintenance.
8. Special maintenance tools shall be provided by the equipment vendor.
9. Systems shall be designed and arranged and equipment and components located in the plant to facilitate on-line maintenance.
10. Remote maintenance techniques shall be considered in the design where reduced radiation exposure or improved availability may be economically achieved.
11. Components shall be classified to reduce the number of different types, sizes and temperature and pressure ratings in order to reduce the cost of spare parts inventory.
12. The design shall incorporate standard "off the shelf" components and materials of proven performance from proven supplies.

13. A Preventive Maintenance Plan shall be developed and documented based upon the plant final design. A first draft shall be issued at completion of preliminary design. This plan shall address the preventive maintenance requirements, tasks, methods, personnel skills and anticipated man-hour requirements on a system basis for mechanical, electrical and control and instrumentation maintenance. Anticipated health physics manhours shall also be documented.
14. A spare parts listing and recommended spare parts inventory shall be developed consistent with the Preventative Maintenance Plan, anticipated unscheduled maintenance and plant availability requirements.
15. A planned outage schedule shall be developed and maintained throughout the design process. The major maintenance and ISI activities are to be identified, durations determined and a critical path established. Anticipated tasks, methods, personnel skills and man-hours required to achieve the scheduled durations shall be determined and documented.
16. Anticipated tasks, methods, personnel skills and man-hour requirements to accomplish unscheduled maintenance shall be documented on a system basis. Analysis shall be based upon industrial experience (mean time between failure and mean time to repair data) for like type systems and components. Estimated man-hours shall include equipment/system isolation, preparation for maintenance and return to service. Anticipated health physics man-hours shall also be documented.
17. Overhead cranes shall be sized to lift the heaviest piece of equipment or heaviest component part that would have to be handled to facilitate planned operations, maintenance and inspection activities.
18. Separate mechanical/machine, welding, electrical, instrument and electronic maintenance shop facilities shall be provided.
19. An evaluation shall be made to determine the need for mechanical maintenance/machine shop facilities suitable for handling radiologically contaminated or activated components. Space requirements or special processes shall be considered, including decontamination areas with appropriate water supply, drain and storage/purification facilities.
20. Lighting levels and HVAC provisions shall be provided commensurate with the intended activities in compliance with applicable regulations, codes and general industrial practice.

3.5 FABRICATION/CONSTRUCTION REQUIREMENTS

1. The plant design shall be based upon parallel construction of the complete plant as described in 3.1; however, features shall be included that facilitate construction and startup in increments of 2 Standard Reactor Modules and 1 turbine.
2. Shop, factory or field fabricated, assembled and erected components and subsystems shall be utilized as appropriate to reduce erection costs and to enhance quality control.
3. Equipment arrangement and features shall facilitate its installation, removal and reinstallation.
4. Special installation equipment not commercially available shall be provided by the equipment vendor.
5. Materials, processes and parts for civil, structural, mechanical, electrical and instrumentation systems and their components shall be incorporated as required to meet all transportation, handling, storage, construction and operational functions. Appropriate specifications, codes and code class specifications and design categories shall be identified to meet safety and economic goals identified for the plant design. Maximum use shall be made of commercial practice typified by fossil-fired facilities.
6. A Construction Plan and Schedule shall be developed by the end of Preliminary Design. The use of models should be considered to facilitate assessments of constructability, particularly in congested areas.

3.6 DECOMMISSIONING

1. Features that facilitate decommissioning or refurbishment of one reactor while maintaining others in operation shall be included.
2. Materials, configurations and features that minimize the volume of activated and contaminated materials, that minimize radiation levels and radiation exposure and that minimize the time and cost of decommissioning shall be included in the design.
3. Until more specific criteria and/or rules are published, NUREG-0586, "Draft Generic Environmental Statement on Decommissioning of Nuclear Facilities", January 1981, shall be used as guidance for anticipating NRC criteria concerning plant decommissioning.
4. It shall be assumed that upon completion of its useful life, the facility shall be put into a condition of safe storage for a period of ten (10) years and then decontaminated and dismantled as required to allow unrestricted use or continued use as a power plant site.

5. A Decommissioning Plan shall be developed as part of preliminary design. The Decommissioning Plan shall address at a minimum, on a system basis, the following:
- a. Activated/contaminated material volume to be disposed of
 - b. Total activity to be disposed of
 - c. Anticipated radiation levels
 - d. Accumulated man-rem exposure
 - e. Methods and diagnostic tools to determine a-d above
 - f. Cost and schedule
 - g. Materials, configurations and features included in the design to facilitate decommissioning
 - h. Methods and procedures for decommissioning and disposal of material
 - i. Potential redevelopment applications for the site and its power generating and transmission facilities.

SECTION 4

NUCLEAR ISLAND REQUIREMENTS

4.1 PERFORMANCE REQUIREMENTS

1. The reactors shall be designed for continuous operation producing steam at conditions compatible with the design conditions of the main turbine-generator(s).
2. Provisions shall be made to remove a reactor from service, perform maintenance or refueling and return it to service with the remaining reactors and the turbine plant in operation.

4.2 RADIATION EXPOSURE CONTROL

1. The number of inaccessible areas due to high radiation levels during reactor operation shall be minimized to facilitate routine operational and maintenance activities.
2. Materials shall be selected to minimize the production of radioactive materials due to activation and the generation of products of corrosion.
3. The design shall provide for individual personnel access to normally accessible areas of the facility for 40 hours per week in the performance of their operational, maintenance, testing and inspection duties while limiting the average, long-term whole body radiation exposure from all sources to no more than 10% of 10CFR20 requirements for radiation workers based upon the number of personnel assigned to the permanent plant staff.
4. Building configuration, access route designation and shielding design shall be responsive to the requirement to control personnel radiation exposure.

4.3 MAINTENANCE

1. Provision for removal of components within the reactor coolant pressure boundary shall be included for inspection, repair and replacement. This shall include those components generally classified as reactor internals. The method, degree of difficulty, time required to effect such removal and projected probability of occurrence shall be identified and documented by completion of preliminary design.

4.4 IN-SERVICE INSPECTION

1. Access shall be provided to the reactor coolant pressure boundary to facilitate in-service inspection as required by Section XI of the ASME Code.
2. Where cost effective the design of systems and components

shall incorporate those features required to implement In-Service Inspection functions with the unit or major component on-line. For those inspection activities that require the unit or major component be removed from service, design features shall be included to accomplish the inspection as one of those activities to be completed during the allotted plant planned downtime.

3. Plant piping design shall minimize the need for snubbers and restraints. The design shall be reviewed by an ISI specialist to ensure inspectability.
4. The design organizations shall be responsible for providing In-Service Inspection configurations, plans and procedures and for identification of inspection equipment to be used to accomplish the inspections. Special equipment not commercially available shall be furnished by the equipment vendor.
5. An In-Service Inspection Program shall be defined and documented. Anticipated man-hour requirements shall be documented to accomplish the In-Service Inspection Program. Anticipated health physics man-hours required to support the ISI Program shall be documented. The use of models should be considered to facilitate assessments of inspectability. Estimated man-hours shall include equipment/system isolation, preparation for inspection and return to service.

4.5 FUEL HANDLING, STORAGE & SHIPPING

1. Systems and features shall be provided to accomplish refueling of a reactor commensurate with the plant scheduled downtime requirement of Section 2.2 of this document.
2. The plant irradiated fuel storage capacity shall be adequate to store irradiated fuel for one year following removal from the reactors plus the additional volume required for storage of one active reactor core including replaceable reflectors consistent with the design fuel cycle.
3. The design of the irradiated fuel storage facility shall facilitate expansion without impact on plant power production.
4. The plant shall be designed to receive new fuel and to ship spent fuel both by truck and rail.
5. Provisions shall be made to receive, accumulate, inspect and store new fuel and reflector elements prior to refueling as is appropriate for the fuel design and fuel cycle.

4.6 FUEL AND FUEL CYCLE

1. The reference fuel cycle shall be based upon the use of a once-through low enriched uranium fuel cycle. Alternate fuel cycles (e.g. high enriched, recycle) which can be utilized without requiring any modification to the basic core/fuel design, to the physical plant or to refueling components shall be identified by completion of conceptual design.

4.7 LOW LEVEL RADIOLOGICAL WASTE

1. An estimate of the quantity of low-level contaminated radiological waste to be processed annually, along with its forms and in-plant origin shall be developed by the completion of conceptual design.
2. A designated storage, packaging and shipping facility/area for low-level contaminated radiological wastes shall be provided consistent with the above estimate.

SECTION 5

ENERGY CONVERSION AREA REQUIREMENTS

5.1 PERFORMANCE REQUIREMENTS

1. The turbine plant shall be designed for continuous operation at design rated plant electrical output.

5.2 TURBINE REQUIREMENTS

1. The turbines shall employ a non-reheat or steam reheat turbine cycle.

5.3 MAINTENANCE

1. The turbine plant shall include features to facilitate on-line maintenance of components consistent with plant availability and economic requirements.
2. Provisions shall be included to take a turbine-generator, its supporting auxiliaries and associated regenerative feedwater heating train out of service, perform maintenance and return them to service with the remaining portions of the turbine plant and nuclear island in operation.

SECTION 6

SITE PARAMETERS AND EXTERNAL INTERFACES

6.1 SITE PARAMETERS

1. The parameters listed in Table 6-1 shall be applied appropriately to the plant design. These parameters are based on the criterion that approximately 85% of prospective U.S. sites be enveloped. For seismic design purposes, a range of shear wave velocities is defined that is to be considered in the design.

6.2 EXTERNAL INTERFACES

1. The following external interface design conditions and requirements shall be assumed:
 - a) The plant electrical output shall be delivered to the operating utility at the low voltage bushings of the main power transformer(s).
 - b) Auxiliary power shall be delivered to the plant at the high voltage bushings of the plant start-up transformer(s).
 - c) The plant shall be interconnected to the utility grid at diverse locations by no fewer than two transmission lines.
 - d) The site shall be served by road and by rail.
 - e) Plant wastes (non-radioactive and radioactive) shall be processed, treated and monitored on site for disposal off-site.
 - f) No off-site fire protection capability exists.
 - g) Nonbrackish river water shall be used as the reference plant water source. The chemical analysis is contained in Table 6-2.
 - h) Local natural water sources are not of adequate size to support once-through condensor cooling.
 - i) No off-site municipal water supply or sewer service is available.

TABLE 6-1

SITE CHARACTERISTICS

Site Conditions

*SOIL CHARACTERISTICS

Shear Wave Velocity (fps)	1000-8000
Allowable Static Bearing Capacity (KSF)	10**

WATER TABLE

Normal groundwater elevation is approximately eight (8') feet below grade

*PRECIPITATION (SNOW)

Snow Load: 50 psf per ANSI A58.1

*WIND VELOCITY

110 mph at a height of 33 ft. (10m) above grade per ANSI A58.1

*AIR TEMPERATURE

Dry Bulb	Wet Bulb
110 degrees F(Max)	82 degrees F
-45 degrees F(Min)	N/A

*METEOROLOGICAL

Atmospheric Dispersion
X/Q Values

Annual average at EAB:
equivalent ground level
release - 2×10^{-5} sec/m³

Accident Evaluations -
Per NRC Regulatory
Guides as Appropriate

DEMOGRAPHY

Population Density

Uniform 500 people/mile²
out to 30 miles: consistent
with Reg. Guide 4.7
(tentative)

*BOUNDARIES

Exclusion Area Boundary
(EAB)

425 meters, minimum from
reactor release point

Protected Area Boundary
(PAB)

To be determined by site
layout

Low Population Zone (LPZ)

425 meters (Same as EAB)

Emergency Planning Zone
(EPZ)

425 meters (Same as EAB)

TABLE 6-1 Contd.

WATER SOURCES

Water

Nonbrackish river water (See Table 6-2 for analysis)

ELEVATION

*Nuclear Island

100-6000 ft above mean sea level

Energy Conversion Area

100 ft above mean sea level

Site Events

*SEISMIC

Maximum at Grade Ground
Acceleration:HorizontalVertical

Safe Shutdown Earthquake

0.3g

0.3g

Operating Basis
Earthquake

0.15g

0.15g

*TORNADO

Designation (RG 1.76)

Region I

Maximum Wind Speed

360 MPH

Rotational Speed

290 MPH

Translational Velocity

70 MPH

External Pressure Drop

3.0 psi @ 2.0 psi/sec.

FLOODING

No special Provisions
required. Maximum probable
flood level below plant grade.

AIRCRAFT HARDENING

No specific provisions
required. Plant considered
to be outside of commercial
flight paths.

* Site characteristics identified with an asterisk are intended to envelope 85% of prospective U.S. sites. Other characteristics are reference values.

** Value applicable to large mat foundations, not isolated footings.

TABLE 6-2

MAKE-UP WATER CHEMICAL ANALYSISConstituent

Ca	(ppm CaCO_3)	31
Mg	"	16
Na	"	71
HCO_3	"	5
SO_4	"	41
Cl	"	72
Fe	(ppm)	1-5
SiO_2	(ppm)	15
pH	(Units)	6.5-7.5
Susp. Solids	(ppm)	0-10
Diss. Solids	(ppm)	50-150
Turbidity		100-200
Total Organic Carbon	(ppm)	10-20

SECTION 7

ECONOMIC REQUIREMENTS

7.1 COMPETITIVE

1. A design goal shall be the development of a design that has an economic advantage of at least 10% in the levelized (30 year) busbar cost of electricity relative to a comparably sized, state-of-the-art coal plant alternative. Based upon current coal plant estimates, this results in a target total levelized busbar cost for the reference modular HTGR plant of approximately 45 mills/kw-hr with a total capital cost of approximately \$2,000/kwe (1986\$) which includes contingency, owner's cost and AFUDC.

7.2 ECONOMIC GROUND RULES

1. In the course of the design process, trade-off studies conducted to determine the optimum balance of capital cost and the time duration of construction and initial startup, plant staffing requirements and operating and fuel cycle costs shall utilize the latest issue of the HTGR Program Economic Ground Rules provided as a basis.