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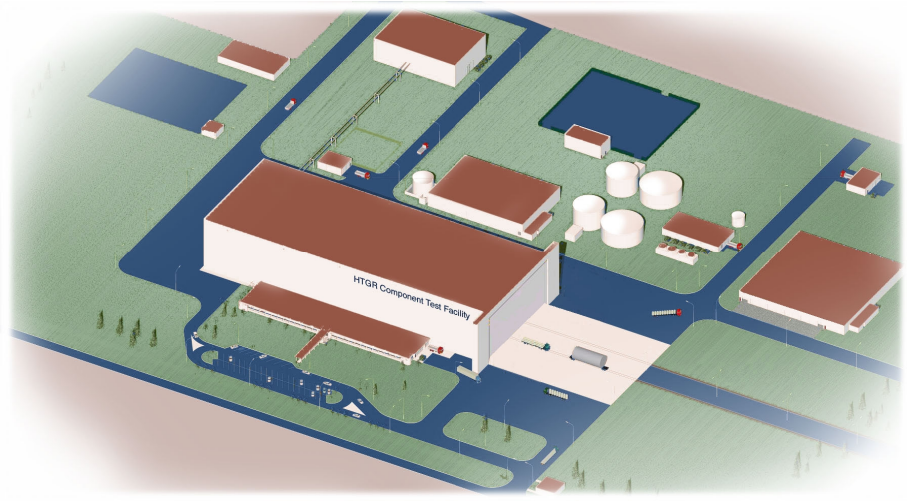
Technical and Functional Requirements

High Temperature Gas-Cooled Reactor (HTGR) Component Test Facility (CTF)



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REVISION LOG

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High Temperature Gas-Cooled Reactor (HTGR) Component Test Facility (CTF)

INL/EXT-08-14150

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CONTENTS

1. INTRODUCTION

1.1 Purpose of the Document

This document captures the assumptions and high-level functions of the High Temperature Gas-Cooled Reactor (HTGR) Component Test Facility (CTF) for the initial conceptual design phase.

1.2 Scope of the Component Test Facility

The CTF facility will provide the enclosed space, its environmental conditions, furnishings, tools, instruments and equipment necessary to meet the CTF mission; improved areas for parking, access, and egress; and an area for testing components, material, and processes related to the National Hydrogen Initiative (NHI). The CTF mission is to support the NGNP testing and licensing programs, NHI testing and licensing programs, other process applications, and, ultimately, future user-groups' programs.

This facility does not include space for the following:

- Reactor operator training
- A control room simulator
- Scaled integrated reactor component testing if the scaling exceeds the accommodations of the CTF
- Analysis, modeling, or simulation of the test operations and test data.

1.3 Definitions, Acronyms, and Abbreviations

1.3.1 Acronyms and Abbreviations

CRDM	Control Rod Drive Mechanism
CTF	Component Test Facility
^{o}C	degrees Centigrade
NDE/DE	Non-Destructive Examination/Destructive Examination
I&C	Instrumentation and Control
HELITE	Helium Loop For Innovative Technology
He	Helium
HT	Heat transfer
HTGR	High Temperature Gas-Cooled Reactor
HX	Heat Exchanger
HTR	High Temperature Reactor
IHX	Intermediate Heat Exchanger
KVK	Komponenten-Versuchskreislauf (Components Test Circuit)

Kg/sec	kilograms per second
LCC	Life Cycle Costs
l/s	liters per second
MPa	mega Pascals
MW	megawatts
NEPA	National Environmental Policy Act
NHI	National Hydrogen Initiative
NGNP	Next Generation Nuclear Plant
NRC	Nuclear Regulatory Commission
PHTC	Primary Heat Transport Capability
RCCS	Reactor Cavity Cooling System
RCRA	Resource Conservation and Recovery Act
RPV	Reactor Pressure Vessel
SG	Steam Generator
SHTC	Secondary Heat Transport Capability
TBD	To be determined
THTC	Tertiary Heat Transport Capability
V&V	Verification and Validation
WEC	Westinghouse Electric Company, LLC

1.3.2 Definitions

Adequately	Determined by the testing schedule and the maximum number of personnel, researchers, and visitors.
Bar	1 bar = 100 kPa (kilopascals) = 1,000,000 dynes per square centimeter (baryes).
Capability	The ability to perform NGNP test programs and plans to meet the testing needs of both prismatic and pebble bed vendor(s).
Component	The lowest level that a piece of equipment can do its intended function.
Enable	Render capable or able for some task.
Equip	The tools, operating environment, instruments, and furnishings necessary to enable a functional capability.

Facility	The product turned over to the HTGR CTF program from the organization contracted to perform the engineering, procurement, and construction of the HTGR CTF and its furnishing and equipping.
Life Cycle	From initial design and development through support for commercial deployment applications.
Material Handling	Could include forklifts, cranes, rabbits, dollies, etc.
Newton	The amount of force required to accelerate one kilogram of mass at a rate of one meter per second squared.
Pascal	1 Newton/square meter.
Provide	To supply or make available
Qualification	Testing of components to assess performance and ensure meeting design requirements.
Scale	Ranges for engineering-scale components to full-scale systems.
Scenarios	Anticipated conditions needed for the test, such as state, (e.g., Normal, Accident, Off-normal conditions) or type (e.g., single or multiple cycle thermal aging).
Site	For this document, the location could be in-town, at the remote testing area, or an off-site location.
Space	The length, width, and height needed to meet the area's intended task(s).
Test Types	The development of select NGNP components and the qualification of components for use in the NGNP and for subsequent HTGR user-facility component tests.

1.4 References

AREVA, *NGNP Component Test Facility*, Section 3, February 2008.

Westinghouse Electric Company LLC, *HTGR Component Test Facility (CTF) Feasibility and Recommendation, NGNP and Hydrogen Production Facility,* Revision 0, February 15, 2008.

Idaho National Environmental and Engineering Laboratory, *Infrastructure Requirements for a Nuclear Hydrogen Pilot Plant,* NEEL/EXT-04-01791, Draft Revision 0, March 2004.

Seward, Linda, et al, Minutes from the February 21, 2008, CTF functional and requirements identification meeting, Idaho National Laboratory.

E-mail from Daryl Lopez to Harold Heydt, *WEC F&ORs,* February 22, 2008.

1.5 Overview of the Document

The Technical and Functional Requirements document addresses the assumptions and functions necessary for the development of a conceptual design of the HTGR CTF. Section 1 describes this document and the purposes of the test facility. Section 2 provides a system description, mission, and a statement of need for the facility. Section 3 addresses the technical functions of the CTF and its associated testing program. Section 4 addresses the functions for security, safety, laboratory sterility, environmental conditions, etc. Section 5 introduces the general categories for the Engineering Design Requirements to be developed. Section 6 contains support documentation referred to in this document.

2. GENERAL DESCRIPTION

2.1 System Description

The CTF will provide for the enclosed space, its environmental conditions, furnishings, tools, instruments, and equipment necessary to meet the CTF mission; improved areas for parking, access, and egress; and an area for testing components, materials, and processes related to the NHI.

The CTF does not include space or furnishings for reactor operator training and for the analysis, modeling, or simulation of the test operations and test data. The CTF is not physically connected to the NGNP facility.

2.2 Relation to Current Systems

The CTF is not related to any existing systems.

2.3 CTF Mission

The CTF Mission Statement calls for a facility that provides:

- Qualification and testing of large scale components in a high-temperature, high-pressure environment such as the:
  - Intermediate Heat Exchanger (IHX)
  - Ducting and insulation
  - Mixing chambers
  - Steam generator
  - High temperature valves
  - Specific application high-temperature instrumentation
  - Industrial hydrogen components
  - Helium circulators
  - Scaled reactor pressure vessel integration and reactor internals testing
  - Chemistry control systems for helium coolant with associated contaminants and impurities
  - Steady-state and transient analysis of coupled systems and components
- Design code development verification and validation collaboration
- Materials development and qualification
- Manufacturer and supplier evaluation and development.

See INL/MIS-08-14156*, HIGH LEVEL REQUIREMENTS High Temperature Gas Reactor (HTGR) - Component Test Facility (CTF),* April 2008, for further information.

2.4 Needs Justification

A full-scale helium test facility is necessary to provide prototype testing and qualification of heat transfer system components (e.g., IHX, valves, hot gas duct), reactor internals, and hydrogen generation processing to mitigate the associated technical risks and to increase the technology readiness levels (TRLs) for these components. Since such a facility does not exist at the capacity needed for NGNP or as an international HTGR user facility, one needs to be built. Failure to complete the facility in time to perform prototype testing could delay NGNP startup or could result in incomplete risk mitigation with potential adverse impact on plant performance. See INL/MIS-08-14156*, HIGH LEVEL REQUIREMENTS High Temperature Gas Reactor (HTGR) - Component Test Facility (CTF),* April 2008, for further information.

2.5 User Needs

The NGNP project requires an adequately sized, equipped, and operational test facility to test, examine, and calibrate instrumentation and to test, examine, and qualify materials, fluids, components, and component integration to ensure Nuclear Regulatory Commission (NRC) acceptability for use in the NGNP.

2.6 General Constraints

The public-private partnership and the NGNP project will select the location for the CTF after initial conceptual design. Ultimately, the CTF will be available to the entire nuclear community that contributes to the NGNP, to further the state of the art in nuclear reactors and applications.

The assumptions made in the preparation of this document are as follows:

1. The CTF is anticipated to be a high hazard, non-radiological facility.
2. DOE funding will be available to support the project throughout its design and construction schedule to support the NGNP.
3. The CTF will be subject to the National Environmental Policy Act (NEPA) process.
4. The CTF will provide the necessary testing infrastructure, utilities, and space for tests and test equipment of the NGNP and NHI testing and licensing programs. End users will provide new or modified CTF infrastructure, utilities, or space for tests and test support equipment that cannot be accommodated within the CTF capabilities.
5. The NGNP testing program will have the highest priority in the use of the CTF capabilities.
6. Although there is a need for a thermal hydraulic scaled integrated test of reactor internals and reactor pressure vessel (RPV), the CTF will NOT accommodate the larger envelope that might be required for integrated thermal hydraulic reactor core testing.

7. There is a need for up to full-scale testing of the NGNP heat exchangers and circulators that will contribute to the basis for sizing the facility, associated test systems, test stations, and utilities.

8. The functionality of the building may evolve, as the CTF testing program is refined and further detailed. This may require incorporation of additional functional scope in the CTF.

9. The CTF will be a government-owned, contractor-operated facility. The U.S. Department of Energy (DOE) and the host state will provide the necessary regulatory and safety oversight of CTF construction and operations.

10. The CTF will provide the capability to test reactor and ancillary components to demonstrate the licensability of components and associated operations. These tests can be demonstrated without requiring the CTF to be NRC-licensed.

11. The CTF will be designed for an operational life span of 40 years. However, the design lives of individual test equipment and engineering-scale demonstrations will vary according to need.

12. The functionality needed to ensure protection of CTF and vendor assets will be determined during initial conceptual design.

13. Unless otherwise stated, planned tests are for an indirect cycle, power conversion system.

3. REQUIREMENTS AND BASES

3.1 Functional Requirements

The **Component Test Facility Functional Diagram** (see Section 6) depicts the functions necessary to support the CTF mission. Below each of the seven high-level functions are the associated subfunctions. A brief description of each function and subfunction follows.

3.1.1 House and Equip CTF Program Administrative and Support Functions

3.1.1.1 **Function:** Provide space and equip workspaces for personnel and associated NGNP CTF test program needs.

The CTF will provide adequate space and appropriate equipment for the workspace occupation of CTF personnel, researchers, users, and visitors.

The CTF will allow reconfiguration of personnel workspace(s), as necessary, to accommodate the needs of the NGNP program and, ultimately, international end users.

3.1.1.2 **Function:** Provide necessary amenities.

The CTF will include adequate square footage and the associated fixtures and equipment for supplying amenities to the peak anticipated number of CTF personnel. The amenities include, for example, parking areas, CTF occupants' rest areas in case of inclement weather, restrooms, locker

rooms, and break rooms. The facility may need to include other necessary amenities as derived during CTF design.

3.1.1.3 **Function:** Provide and equip conferencing capability.

The CTF will provide adequate space and appropriate equipment for conference rooms.

3.1.1.4 **Function:** Provide and equip storage areas.

The CTF will provide adequate space and appropriate equipment for administrative (e.g., files) and administrative personnel supply (e.g., ink, computer and printer supplies, and office supplies) storage areas.

3.1.1.5 **Function:** Provide space and equip security capabilities.

The CTF will provide adequate space and appropriate equipment to enable security capabilities for facility, personnel, area(s), components, data, and intellectual property control.

3.1.1.6 **Function:** Provide space and equip facility maintenance capabilities.

The CTF will provide adequate space and equipment to enable facility maintenance capabilities, such as mechanical maintenance, electrical maintenance, and Instrumentation and Controls (I&C) calibration and maintenance. As pre-conceptual design progresses, additional capabilities may be added.

3.1.1.7 **Function:** Provide and equip test support and maintenance capabilities.

The CTF will provide adequate space and equipment to perform test support maintenance capabilities, including mechanical maintenance, electrical maintenance, and I&C calibration and maintenance. The CTF may need to include other capabilities as developed during CTF design.

3.1.2 House and Equip CTF Program Training Functions

3.1.2.1 **Function:** Provide and equip classroom training areas.

The CTF will provide adequate space and equipment for ancillary training.

3.1.2.2 **Function:** Provide and equip NGNP maintenance training mockup.

The CTF will provide adequate space and be adequately equipped for an NGNP Maintenance Mockup capability.

3.1.3 Enable and Equip CTF Program Testing and Qualification Functions.

The CTF will provide the flexibility to test a range of component designs, configurations, operating conditions, materials, and heat transport fluids. The heat transport fluids might have controlled levels of impurities. In the absence of a specific NGNP design, the options proposed by the NGNP Preconceptual Design

vendor teams are the basis for evaluating the potential range of development requirements from the NGNP testing program and plans.

Mockups or scaled representative component concepts need testing in representative environments with operating conditions comparable to anticipated NGNP conditions including large scale testing.

3.1.3.0 **Function:** Provide space for the testing, qualification, and calibration of instrumentation.

The CTF will provide adequate workspace for the testing, calibration, and qualification, of instrumentation associated with all of the subfunctions listed under Section 3.1.3 to ensure meeting NGNP's startup date.

3.1.3.1 **Function:** Enable primary loop component tests with consideration of test scales, types, scenarios, components, heat transfer (HT) gas environment, and impurity control.

The CTF will provide helium (i.e., the NGNP primary loop coolant) at the pressures, temperatures (including temperature transient rate), mass flow rates, energies, and purity (impurity controls) anticipated for the primary loop. The helium is necessary to support the types, scales, and range of the test types identified for the development of selected NGNP primary loop components as well as materials and instruments qualification and for subsequent high temperature gas-cooled reactor (HTGR) user-facility component tests. To keep the number of design options open in initial conceptual design, the term Primary Heat Transport Capability (PHTC) is used.

The PHTC will provide adequate component material and calibration test locations capable of accepting components up to full-scale. The PHTC needs the number of test stations necessary to meet the needs of the CTF test program and test plans and the NGNP schedule, as well as the inventory and chemistry control necessary to maintain oxidation levels on metals. The PHTC and the secondary heat transfer loop need to interface with each other to perform IHX testing. The PHTC may also need to run the same test multiple times due to component, material, or test failure.

The PHTC will provide the capability to perform the following tests and any additional tests, as necessary, based on NGNP component, material, and instrumentation development plans:

- Performance verification testing, which could serve as empirical validation for thermal-hydraulic design methods and analysis.
- Life prediction and durability testing to evaluate design and fabrication methods, as well as data generated by material laboratories. Evaluation of the thermal-mechanical aspects of concepts will occur during these tests, which typically include interface development.

- Seals testing on various sealing interfaces, as well as the influence on leak rates due to various process parameters.
- Flow induced vibration tests and tests on alternative component configurations and their associated piping, together with frequency spectra and sound pressure levels caused by different flow velocities.
- Long-term testing sufficient to provide confidence in the operating life of the intermediate heat exchanger (IHX) components

The PHTC will provide the capability to test the following components at various scales, including full-scale, as necessary based upon NGNP component development plans:

a. IHX (to include, for example, shell and tube, helical, and printed circuit design alternatives)
b. Mixing chambers
c. High-temperature ducting and insulation
d. Steam generator (SG)
e. Helium circulator
f. Isolation valves
g. Auxiliary systems
h. Components of NGNP loop control systems
i. Instrumentation
j. Other heat exchanger (HX) equipment
k. General functions.

3.1.3.2 **Function:** Enable secondary loop component tests with consideration of test scales, types, scenarios, components, high-temperature gas environment, and impurity control.

The CTF will provide high-temperature gas working fluids—simulating the conditions of the NGNP secondary loop—at the pressures, temperatures and temperature transients, mass flow rates, energies, and purity or impurities necessary to support the range and scales of tests identified for development of anticipated NGNP components and subsequent HTGR user-facility component tests. To keep the number of design options open in initial conceptual design,, the term Secondary Heat Transport Capability (SHTC) is used.

The SHTC will provide the number of test stations necessary to meet the needs of the CTF test program and test plans. The CTF will provide the power necessary to circulate, heat, and cool the helium, helium/nitrogen mixture or steam/water for any scale, test type, component or material, and scenario. The CTF will also provide the power to enable the range of tests anticipated. The SHTC will include a component test location capable of accepting components of up to full-scale. The PHTC and the SHTC need to interface with each other to perform IHX testing. The SHTC may also need to run the same test multiple times due to component, material, or test failure.

The SHTC will provide the capability to perform the following tests and any additional tests, as necessary, based on NGNP test plans:

- Performance verification testing, which could serve as empirical validation for thermal-hydraulic design methods and analysis.
- Life prediction and durability testing to evaluate design and fabrication methods, as well as data generated by material laboratories. Evaluation of the thermal-mechanical aspects of concepts will occur during these tests, which typically include interface development.
- Seals testing on various sealing interfaces, as well as the influence on leak rates due to various process parameters.
- Flow induced vibration tests and tests on alternative component configurations and their associated piping, together with frequency spectra and sound pressure levels caused by different flow velocities.
- Long-term testing sufficient to provide confidence in the operating life of the IHX components

The SHTC will provide the capability to test the following components at various scales, including full-scale, as necessary based on NGNP component development plans:

- IHX (to include, for example, shell and tube, helical, and printed circuit design alternatives)
- Mixing chambers
- High-temperature ducting and insulation
- Steam generator (SG)
- Helium circulator
- Isolation valves
- Auxiliary systems
- Control and Instrumentation
- Other HX equipment
- General functions.

3.1.3.3 **Function:** Enable tertiary/process heat applications component tests with consideration of test scales, types, and scenarios; components; HT gas environment; and impurity control.

The CTF will provide high-temperature gas working fluids—simulating the conditions of the NGNP secondary loop—at the pressures, temperatures and temperature transients, mass flow rates, energies, and purity or impurities level necessary to support the range and scales of tests identified for development of anticipated NGNP components, NHI processes, and subsequent HTGR user-facility component tests. To keep the number of design options open in initial conceptual design, this section uses the term Tertiary Heat Transport Capability (THTC).

The THTC needs an adequate number of test stations to meet the schedule of the CTF test program and test plans. The THTC will provide the power necessary to cool, circulate, and heat the helium or helium/nitrogen mixture for any scale, test type, component or material, and scenario.

The THTC needs sufficient power to enable the range of tests anticipated in the NHI tests. The THTC also needs the capability to run continuously for a specific number of hours to meet process steam or NHI testing requirements. The THTC may need to run the same test multiple times due to component, material, or test failure.

The THTC will include a minimum of one test station capable of accepting NHI components or processes measuring up to approximately 40 meters high (Sulfur-Iodine [S-I] cycle). The THTC needs the capability to accommodate different heat transfer fluids and heat exchanger designs. The THTC will demonstrate that NHI processes or components meet NRC requirements.

The THTC will have the capability to collect and remove unwanted gases (e.g., oxidizer emissions, fugitive emissions, flare emissions, other emergency releases) from the tests, as well as the analytical laboratory capability necessary to support NHI processes and components testing. The THTC will also have the material handling capability necessary to handle the process and test components.

The THTC will have the capability and capacity to provide adequate amounts of demineralized purified water and power.

The THTC will have the capability to test the following components, NHI processes at various scales, including full-scale, as necessary, based on NGNP component development, and NHI plans:

A. Steam generator (SG) for process steam
B. Isolation valves
C. Auxiliary systems
D. Control and Instrumentation
E. NHI processes including:
    1. High-temperature electrolysis
    2. S-I process
    3. Hybrid Sulfur-Electrolysis cycle
    4. Calcium-Bromine cycle.

3.1.3.4 **Function:** Enable testing of scaled models of the NGNP reactor vessel and associated components/systems

The CTF will have the necessary equipment to enable concurrent reactor component or integrated testing (e.g., control rod drive mechanism [CRDM], graphite blocks, graphite reflectors, reactor blocks, core structure, plenum, graphite core, and reactor cavity cooling system

[RCCS]) with other testing listed in this section (3.1.3). It will need integrated reactor component testing capability for up to five days/test. In addition, the CTF needs the capability for shutdown cooling and control tests.

3.1.3.5 **Function:** Enable full-scale circulator testing capability.

The CTF will provide a continuously operating full-scale circulator testing capability that will not affect any of the other testing occurring in the CTF.

3.1.3.6 **Function**: Provide off-line trouble shooting of component and system problems**.**

The CTF will provide the capability for off-line trouble shooting of component and system problems.

3.1.3.7 **Function:** Enable coolant and heat transfer fluid tests.

The CTF will enable coolant and HT fluid tests for various test scales, types, and scenarios and fluid types.

3.1.3.8 **Function:** Enable direct-cycle power conversion component testing capability.

The CTF will enable direct-cycle power conversion component and instrumentation testing capability for various test scales, types, scenarios, components, and HT fluid conditions.

3.1.3.9 **Function:** Equip areas for conducting instrumentation testing, qualification, and calibration.

The CTF will provide for the testing, qualification, and calibration of instrumentation under comparable conditions to that envisaged for NGNP operating conditions.

3.1.3.10 **Function:** Provide facility features for protection of test/CTF assets.

The CTF will provide safety and security features necessary to protect tests, test components, supporting testing equipment, and other facility assets in test-adjacent areas.

3.1.3.11 **Function:** Provide and equip test monitoring and control areas.

The CTF will provide adequately equipped test monitoring and control spaces.

3.1.3.12 **Function:** Enable test data collection, processing, recording, storage, transmission, and archiving capability.

The CTF will provide the equipment to enable test data collection, processing, recording, and transmission, storage, and archiving capability.

3.1.3.13 **Function:** Provide and equip test component/HT materials/working HT fluids receiving area.

The CTF will have adequately sized and equipped receiving space for test component, HT materials, and working HT fluids receipt capability.

3.1.3.14 **Function:** Provide and equip test component inspection and testing capability.

The CTF needs to be of adequate size and with the necessary equipment to enable the test component and instrumentation for post-test inspection and testing (non-destructive and destructive) capability.

3.1.3.15 **Function:** Provide and equip test component and support equipment storage area(s).

The CTF will be of adequate size and with the necessary equipment to enable test component, materials, fluids, and support equipment storage.

3.1.3.16 **Function:** Provide and equip test support fabrication/assembly/ disassembly capability.

The CTF needs to accommodate having two or more fully assembled components in staging for pre-and post testing. The CTF will have adequate equipment to enable test support fabrication, assembly, and disassembly capability. In addition, the CTF needs mock up assembly areas for multiple users and/or concurrent testing.

3.1.3.17 **Function:** Provide test component and material handling capability (e.g., test loop crane (s)).

The CTF needs adequate equipment to enable the access, egress, vertical, horizontal, or rotational movement of components, test equipment, and test spools throughout the CTF life cycle.

3.1.3.18 **Function:** Provide test component/material/test equipment and associated facility equipment packaging and shipping capability.

The CTF needs to be adequately equipped to enable test component, material, and test equipment and associated facility equipment, and instrumentation packaging and shipping capability.

3.1.3.19 **Function:** Enable vibration and seismic testing capability.

The facility needs vibration and seismic testing capability, including various test scales, types, and scenarios, components, and HT fluid conditions.

3.1.3.20 **Function:** Enable materials testing capability.

The CTF needs to enable a materials testing capability for various test scales, types, scenarios, components, and HT fluid conditions.

3.1.3.21 **Function:** Enable in-service inspection and testing capability.

The CTF needs to enable an in-service inspection capability for various test scales, types, scenarios, components, and HT fluid conditions.

3.1.3.22 **Function:** Enable development and qualification capabilities.

The CTF needs to enable the development and qualification capabilities including various test scales, types, scenarios, components, and HT fluid conditions.

3.1.3.23 **Function:** Enable maintainability testing capability.

The CTF needs to enable a maintainability testing capability for various test scales, types, scenarios, components, and HT fluid conditions.

3.1.3.24 **Function:** Enable mechanical properties testing capability.

The CTF needs to enable a mechanical properties testing capability for various test scales, types, scenarios, components, and HT fluid conditions.

3.1.4 House and Equip CTF Program Research Function(s)

The CTF researchers need adequate spaces to enable the researchers to perform their designated work functions. This is the basis for design of the CTF Program Research Function(s) for all functions in Section 3.1.4.

3.1.4.1 **Function:** Provide and equip laboratories and researcher workspaces.

The CTF will be equipped for researchers to perform work efficiently.

3.1.4.2 **Function:** Provide equipped analytical laboratory.

The CTF will provide adequate equipment, lab benches, ventilation, fume hoods, etc. to enable analytical laboratory capabilities.

3.1.4.3 **Function:** Provide space and equipment for CTF to acquire high-fidelity data capability for off-site modeling, code development, simulation, and analysis.

The CTF will provide adequate equipment and instrumentation to support operational test data processing for NGNP software development, modeling, simulation, analysis, code cases support, and verification and validation (V&V). That data will then be transmitted off site to conduct the software development, modeling, simulation, analysis, code cases support, and V&V.

3.1.4.4 **Function:** Provide component/process/system control loop philosophy, evaluation, and analysis resources.

The CTF will provide the component, process, or system control-loop philosophy, evaluation, and analysis capabilities.

3.1.5 House and Equip CTF Testing Operations Functions

3.1.5.1 **Function:** House and equip CTF operations monitoring and control function (e.g., loop(s), control room(s)).

The CTF will provide the necessary CTF operation's monitoring and control capabilities.

3.1.5.2 **Function:** Provide for inventory control and testing under certain contamination conditions, including loop-to-loop leak detection.

The CTF will provide for inventory control of HT fluids and loop-to-loop leak detection.

3.1.5.3 **Function:** Provide space and equip for operational data collection, recording, and management capability.

The CTF will provide operational data collection, recording, and management capabilities**.**

3.1.5.4 **Function:** Provide and equip CTF operations ancillary/support areas**.**

The CTF needs the equipment to accommodate CTF operations ancillary and support areas.

3.1.5.5 **Function:** Enable and control heat rejection.

The CTF will provide the capability for controlled heat rejection from the testing areas.

3.1.6 Enable CTF Life Cycle Functions

3.1.6.1 **Function:** Provide features to facilitate commissioning/ decommissioning.

The CTF will have features to facilitate commissioning, decommissioning of the CTF and its contents.

3.1.6.2 **Function:** Provide features for expandability and test space reconfigurability for qualification/international user facility applications.

The CTF will provide the capability to expand to include other applications, such as, component qualification and international user needs. Examples of what might need expansion are size of overhead cranes, lift equipment, material handling equipment, facility, etc. The CTF will also provide the capability for test and personnel space reconfiguration for varying test component sizes, NGNP and NHI program needs, qualification and calibration needs, and international user facility applications.

3.1.6.3 **Function:** Provide features for recovery from anticipated failure events/modes.

The CTF will provide the capability for recovery from failure events and modes identified during pre-conceptual design.

3.1.7 Provide CTF Program Utilities

3.1.7.1 **Function:** Supply/generate and distribute electrical power.

The CTF needs to distribute and supply the electrical power needed within the building for testing, operations, and associated workspaces, and to the exterior of the building for access, egress, parking lighting, car heater receptacles, etc.

3.1.7.2 **Function:** Supply and distribute potable water.

CTF testing and operations will need potable water.

3.1.7.3 **Function:** Supply and distribute industrial water.

CTF testing and operations will need industrial water for fire suppression, demineralized water, waste heat cooling, etc.

3.1.7.4 **Function:** Supply and distribute compressed/instrument air.

CTF testing and operations needs an adequate supply of conditioned compressed air and instrument air routed where needed.

3.1.7.5 **Function:** Supply, control, distribute, and condition raw coolants and HT media.

The CTF needs to supply, control, distribute, and condition raw coolants and HT media necessary for operations and ancillary functions of the CTF test program.

3.1.7.6 **Function:** Supply and distribute telecommunications and network connectivity.

CTF personnel need telephone and video conference capability. Additionally, personnel and associated CTF testing need network connectivity capability for associated CTF testing.

3.1.7.7 **Function:** Provide sanitary and industrial sewer treatment capability.

The CTF will provide treatment and disposal capability for sanitary and industrial water.

3.1.7.8 **Function:** Provide space and equip for waste collection, treatment, and disposal capability.

The CTF needs to have the capability for waste collection, treatment, and disposal; including RCRA waste and testing waste (e.g., resin beds).

3.1.7.9 **Function:** Enable storage, conditioning, circulating and cooling of He.

The NGNP testing program needs the ability to store, condition, circulate, and cool helium.

3.1.7.10 **Function:** Provide space and enable heating, ventilation, cooling, and conditioning of air for occupied spaces.

The air in occupied spaces needs to be appropriately heated, ventilated, cooled, and conditioned.

3.1.8 Systems, Subsystems, Major Components

The identification of systems, subsystems, and major components will evolve during initial conceptual design.

3.1.9 Boundaries and Interfaces

The boundaries and interfaces for the CTF and the utilities will evolve during initial conceptual design.

3.2 Performance Characteristics

Further detail of the performance characteristics will occur during initial conceptual design.

3.2.1 Limits and Tolerances

Further detail on the limits and tolerances will occur during initial conceptual design.

3.3 Interface Requirements

Further detail on the following interface requirements will occur during initial conceptual design.

3.3.1 Compatibility with Accessories/Auxiliary Devices

3.3.2 Compatibility with Environment of Intended Use

3.3.3 External Operating Environment

3.3.4 Labeling/Packaging

3.3.5 Toxicity and Biocompatibility

3.3.6 Electromagnetic Compatibility (EMC)

3.3.7 Physical/Chemical Characteristics

3.3.8 Laboratories' Sterility

3.3.9 Security

3.3.9.1 **Function:** Provide and equip access control capabilities.

The CTF needs the following access control capabilities:

- CTF access control capability
- Area access control capability

- Data access control capability
- Personnel access control capability
- Inventory capability.

This list is not be all-inclusive and will evolve during initial conceptual design.

3.3.10 Safety

3.3.10.1 Function: Comply with safety regulations.

The CTF needs to comply with all applicable federal, state, local, and INL safety requirements in place at the time of construction.

3.3.10.2 Function: Provide facility features for test safety.

The CTF needs to ensure protection of its occupants, equipment, components, and materials safety (test-adjacent areas) in the event of an operational, component, or integrated test failure.

3.4 Operational Requirements

The operational requirements are to be determined during initial conceptual design.

3.5 Resource Requirements

The resource requirements are to be determined during initial conceptual design.

3.6 Verification Requirements

3.6.1 Acceptance Testing Requirements

Prior to the start of CTF operations, a set of acceptance requirements needs development and met before facility turnover.

3.7 Documentation Requirements

The documentation requirements will be determined during initial conceptual design.

3.7.1 Organizational Requirements

- Security Requirements
- Portability Requirements
- Quality Requirements
- Reliability Requirements
- Maintainability Requirements
- Safety Requirements

3.7.2 Statutory and Regulatory Requirements

3.7.2.1 Function: Comply with statutory and regulatory requirements.

The design and construction of the CTF needs to comply with applicable statutory and regulatory requirements in place at time of construction.

3.7.3 User Needs vs. System Requirements Traceability

The CTF project will include the documentation necessary to trace the facility's requirements back to user needs.

4. SYSTEMS REQUIREMENTS

4.1 In-service Reliability

The CTF will provide an in-service reliability greater than TBD. The in-service reliability plan will be developed during design.

4.2 Maintainability

The CTF will provide a level of maintainability that minimizes the need for maintenance personnel and costs.

4.3 Design Life

The CTF will have a design life of 40 years, the standard for DOE capital assets.

4.4 Availability of Materials

To meet NGNP program needs, the availability of materials will be addressed in the engineering design and procurement of the facility, furnishings, tools, and equipment needs.

4.5 Transportability

During CTF construction, the construction contractor may need to bring construction personnel, equipment, and materials onto the facility site via initially unimproved dirt roads.

4.6 Codification

The design, procurement, and construction of the facility will adhere to applicable local, state, and federal building codes.

4.7 Cost

The CTF engineering, design, and construction will be less than $XXX million (TBD).

4.8 Schedule

4.8.1 **Function:** Meet NGNP mission schedule.

All tools, equipment, instrumentation, storage tanks, furnishings, and materials will be available in the quantity and quality necessary to meet the CTF completion date in order to meet the testing schedule for licensing and operation of the NGNP by 2021. The CTF will be ready for normal operations by March 2014.

4.9 Licensing

There are no identified licensing requirements for the CTF at this time.

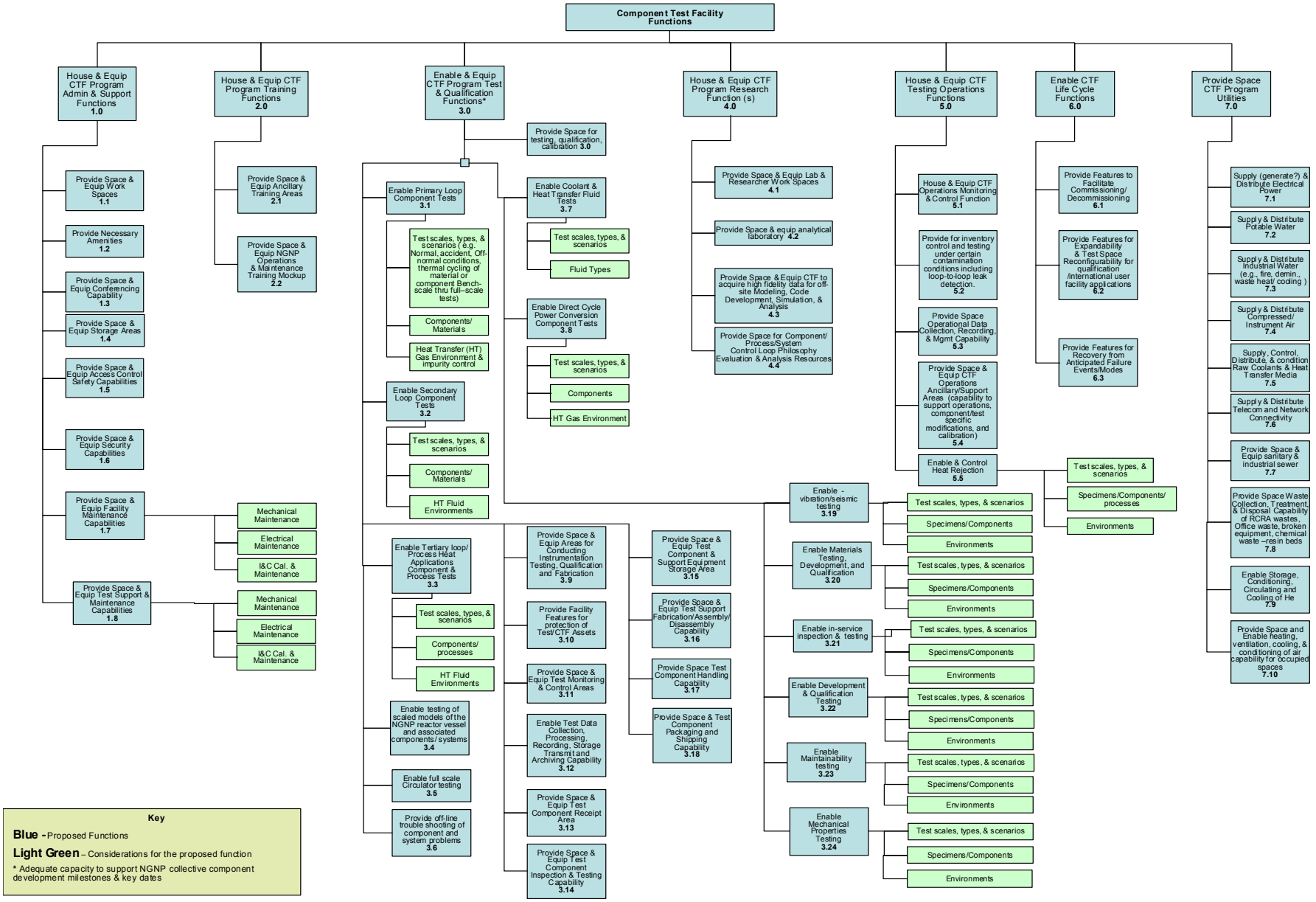
5. ENGINEERING DESIGN REQUIREMENTS

The engineering design requirements listed below will develop during initial conceptual design.

- Civil and Structural
- Mechanical and Materials
- Chemical and Process
- Electrical Power
- Instrumentation and Control
- Computer Hardware and Software
- Fire Protection
- Testing and Maintenance Requirements
- Other Requirements.

6. SUPPORT DOCUMENTATION

CTF Functional Breakdown Structure (shown on the next page).


Component Test Facility Functions
House & Equip CTF Program Admin & Support Functions 1.0
Provide Space & Equip Work Spaces 1.1
Provide Necessary Amenities 1.2
Provide Space & Equip Conferencing Capability 1.3
Provide Space & Equip Storage Areas 1.4
Provide Space & Equip Access Control Safety Capabilities 1.5
Provide Space & Equip Security Capabilities 1.6
Provide Space & Equip Facility Maintenance Capabilities 1.7
Mechanical Maintenance
Electrical Maintenance
I&C Cal. & Maintenance
Provide Space & Equip Test Support & Maintenance Capabilities 1.8
Mechanical Maintenance
Electrical Maintenance
I&C Cal. & Maintenance
House & Equip CTF Program Training Functions 2.0
Provide Space & Equip Ancillary Training Areas 2.1
Provide Space & Equip NGNP Operations & Maintenance Training Mockup 2.2
Enable & Equip CTF Program Test & Qualification Functions* 3.0
Provide Space for testing, qualification, calibration 3.0
Enable Primary Loop Component Tests 3.1
Test scales, types, & scenarios (e.g. Normal, accident, Off-normal conditions, thermal cycling of material or component Bench-scale thru full–scale tests)
Components/ Materials
Heat Transfer (HT) Gas Environment & impurity control
Enable Secondary Loop Component Tests 3.2
Test scales, types, & scenarios
Components/ Materials
HT Fluid Environments
Enable Coolant & Heat Transfer Fluid Tests 3.7
Test scales, types, & scenarios
Fluid Types
Enable Direct Cycle Power Conversion Component Tests 3.8
Test scales, types, & scenarios
Components
HT Gas Environment
Enable Tertiary loop/ Process Heat Applications Component & Process Tests 3.3
Test scales, types, & scenarios
Components/ processes
HT Fluid Environments
Enable testing of scaled models of the NGNP reactor vessel and associated components/ systems 3.4
Enable full scale Circulator testing 3.5
Provide off-line trouble shooting of component and system problems 3.6
Provide Space & Equip Areas for Conducting Instrumentation Testing, Qualification and Fabrication 3.9
Provide Facility Features for protection of Test/CTF Assets 3.10
Provide Space & Equip Test Monitoring & Control Areas 3.11
Enable Test Data Collection, Processing, Recording, Storage Transmit and Archiving Capability 3.12
Provide Space & Equip Test Component Receipt Area 3.13
Provide Space & Equip Test Component Inspection & Testing Capability 3.14
Provide Space & Equip Test Component & Support Equipment Storage Area 3.15
Provide Space & Equip Test Support Fabrication/Assembly/ Disassembly Capability 3.16
Provide Space Test Component Handling Capability 3.17
Provide Space & Test Component Packaging and Shipping Capability 3.18
House & Equip CTF Program Research Function (s) 4.0
Provide Space & Equip Lab & Researcher Work Spaces 4.1
Provide Space & equip analytical laboratory 4.2
Provide Space & Equip CTF to acquire high fidelity data for off-site Modeling, Code Development, Simulation, & Analysis 4.3
Provide Space for Component/ Process/System Control Loop Philosophy Evaluation & Analysis Resources 4.4
House & Equip CTF Testing Operations Functions 5.0
House & Equip CTF Operations Monitoring & Control Function 5.1
Provide for inventory control and testing under certain contamination conditions including loop-to-loop leak detection. 5.2
Provide Space Operational Data Collection, Recording, & Mgmt Capability 5.3
Provide Space & Equip CTF Operations Ancillary/Support Areas (capability to support operations, component/test specific modifications, and calibration) 5.4
Enable & Control Heat Rejection 5.5
Test scales, types, & scenarios
Specimens/Components/ processes
Environments
Enable - vibration/seismic testing 3.19
Test scales, types, & scenarios
Specimens/Components
Environments
Enable Materials Testing, Development, and Qualification 3.20
Test scales, types, & scenarios
Specimens/Components
Environments
Enable in-service inspection & testing 3.21
Test scales, types, & scenarios
Specimens/Components
Environments
Enable Development & Qualification Testing 3.22
Test scales, types, & scenarios
Specimens/Components
Environments
Enable Maintainability testing 3.23
Test scales, types, & scenarios
Specimens/Components
Environments
Enable Mechanical Properties Testing 3.24
Test scales, types, & scenarios
Specimens/Components
Environments
Enable CTF Life Cycle Functions 6.0
Provide Features to Facilitate Commissioning/ Decommissioning 6.1
Provide Features for Expandability & Test Space Reconfigurability for qualification /International user facility applications 6.2
Provide Features for Recovery from Anticipated Failure Events/Modes 6.3
Provide Space CTF Program Utilities 7.0
Supply (generate?) & Distribute Electrical Power 7.1
Supply & Distribute Potable Water 7.2
Supply & Distribute Industrial Water (e.g., fire, demin., waste heat/ cooling) 7.3
Supply & Distribute Compressed/ Instrument Air 7.4
Supply, Control, Distribute, & condition Raw Coolants & Heat Transfer Media 7.5
Supply & Distribute Telecom and Network Connectivity 7.6
Provide Space & Equip sanitary & industrial sewer 7.7
Provide Space Waste Collection, Treatment, & Disposal Capability of RCRA wastes, Office waste, broken equipment, chemical waste –resin beds 7.8
Enable Storage, Conditioning, Circulating and Cooling of He 7.9
Provide Space and Enable heating, ventilation, cooling, & conditioning of air capability for occupied spaces 7.10
Key
Blue - Proposed Functions
Light Green – Considerations for the proposed function
* Adequate capacity to support NGNP collective component development milestones & key dates