Atomic Alchemy Inc. Topical Report:

Chapter 3, Appendix F

Atomic Alchemy NPUF Principal Design Criteria

Non-Proprietary

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INTRODUCTION

This Appendix describes the Atomic Alchemy principal design criteria for safety-related structures, systems, and components.

The NRC staff suggests, in NUREG-1537 Part 2, Section 3.5b, that meeting the minimum requirements for principal design criteria of 10 CFR 70.64 would be acceptable for radioisotope production facilities under a 10 CFR Part 50 license. The staff, however, has not established minimum requirements for principal design criteria for Non-Power Reactors (NPR). Therefore, Atomic Alchemy will use 10 CFR Part 50 Appendix A as a minimum basis for establishing its NPUF principal general design criteria to meet the regulatory requirements of 10 CFR 50.34(a)(3) as referenced in NUREG-1537 Part 1, Appendix A for both reactors and radioisotope production. Atomic Alchemy has included a review of 10 CFR 70.64 (baseline design criteria) in developing its NPUF principal design criteria.

As presented herein, each criterion is first quoted and then discussed. While the 10 CFR Part 50 Appendix A GDC's are not directly applicable to Atomic Alchemy NPUF design, they present an established basis in providing the NRC with reasonable assurance of the safety of the design of the Atomic Alchemy facility and its compliance with the appropriate Title 10 regulations.

Some of the Atomic Alchemy NPUF design features are deemed to be significantly different in certain specific areas from those principal design features considered when the 10 CFR Part 50, Appendix A General Design Criteria for nuclear power plants were formulated. In these instances, the means by which the Atomic Alchemy principal design either complies with the intent of the Part 50 General Design Criterion or why the Part 50 General Design Criterion is not applicable and strict adherence to the power plant criteria is not warranted and should not be considered necessary in conforming to NUREG-1537 is detailed. Where additional information may be required for a complete discussion, the appropriate FSAR sections are referenced.

The Atomic Alchemy expectation upon NRC review of these principal design criterion is NRC acceptance that the design criterion meets 10 CFR 50.34(a)(3)(i) for its forthcoming construction permit application and PSAR submittal.

CRITERION 1 – QUALITY STANDARDS AND RECORDS

Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified, as necessary, to assure a quality product, in keeping with the required safety function.

A quality assurance program shall be established and implemented in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions. Appropriate records of the design, fabrication, erection, and testing of structures, systems, and components important to safety shall be maintained by or under the control of the nuclear power unit licensee throughout the life of the unit.

Atomic Alchemy Compliance

The Quality Assurance Program for the Atomic Alchemy facility provides confidence that safety-related items and services are designed, procured, fabricated, inspected, and tested to quality standards commensurate with the safety-related functions to be performed. Design, procurement, fabrication, inspection, and testing are performed according to recognized codes, standards, and design criteria that comply with the requirements of 10 CFR 50.55a. The Atomic Alchemy Versatile Isotope Production Reactor (VIPR) modular design features four non-power VIPRs, each located in their own respective light-water cooled pool and operate at ambient atmospheric pressure. In the passively safe, modular Atomic Alchemy VIPR design, systems necessary to provide the reactor coolant boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, and the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR 50.34 are designated as safety systems. Additionally, for simplicity, Items Relied On For Safety (IROFS) as defined in 10 CFR 70.65(b)(4), 10 CFR 70.61(b) and 10 CFR 70.61(c) are also identified as “safety related” and covered by Atomic Alchemy’s Quality Assurance Program Description (QAPD).

Appropriate records documenting that design, procurement, fabrication, inspection, and testing comply with the applicable codes, standards, and design criteria are maintained according to appropriate, applicable laws and NRC regulations. Atomic Alchemy Technical Specification Section 5.8 will describe the records that the design was properly accomplished, include not only the final design output and revisions to the final output, but also the important design steps (e.g., calculations, tests, inspections, materials, qualifications, analyses, design basis inputs, and computer programs), and the sources of input that support the final output.

Atomic Alchemy FSAR Chapter 3, Section 2 will describe the principal design criteria, design bases, codes, and standards applied to the facility.

The Atomic Alchemy QAPD was submitted as a topical report (AA0-VIPR-20-QAPD(NP) Rev. 0) to the NRC in letter number AAL-2020-003. The Atomic Alchemy QAPD conforms to ASME NQA-1-2017, ASME NEQ-1-2017, and ASME BPVC Section III, 2017.

This also satisfies the intent of 10 CFR 70.64(a)(1).

CRITERION 2 – DESIGN BASES FOR PROTECTION AGAINST NATURAL PHENOMENA

Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without the loss of the capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed.

Atomic Alchemy Compliance

The safety-related structures, systems, and components that are vital to mitigating the effects of accidents and provide the shutdown capability of the reactor and to the radioisotope production processes are designed to withstand the maximum probable natural phenomena at the Atomic Alchemy NPUF site without loss of the capability to perform their safety-related functions. Seismic and quality group classifications are conservatively applied to systems, structures, and components (SSC) related to safety. Atomic Alchemy's FSAR Chapter 15 will identify the co-incident conservative site conditions for each postulated accident transient. Appropriate combinations of structural loadings from transients, normal operation and environmental phenomena are accounted for in the facility design.

FSAR Chapter 1, Appendix B, Section 2 will describe Atomic Alchemy's compliance with Site Characteristics.

This also satisfies the intent of 10 CFR 70.64(a)(2).

CRITERION 3 – FIRE PROTECTION

Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat-resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety. Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.

Atomic Alchemy Compliance

The safety-related structures, systems, and components are designed to minimize the probability and effect of fires and explosions. Noncombustible and fire-resistant materials are used on components of safety-related systems, and elsewhere in the facility where fire is a potential risk to safety-related systems. Firefighting systems are designed such that their rupture or inadvertent operation will not prevent any safety-related systems from performing their design functions.

Atomic Alchemy will perform a Fire Hazards Analysis of each area within the facility. FSAR Chapter 9, Appendix A will describe Atomic Alchemy's fire protection program and fire hazards analysis. The Atomic Alchemy Fire Protection Program will comply with BTP CMEB 9.5-1 and the following industry guidance:

a. NFPA 4 – "Organization for Fire Services"
b. NFPA 4A – "Organization of a Fire Department"
c. NFPA 6 – "Industrial Fire Loss Prevention"
d. NFPA 7 – "Management of Fire Emergencies"
e. NFPA 8 – "Management Responsibilities for Effects of Fire on Operations"
f. NFPA 27 – "Private Fire Brigades"
g. NFPA 101,"Life Safety Code."
h. NFPA 802 – "Recommended Fire Protection Practice for Nuclear Reactors."
i. NFPA 801 – "Standard for Fire Protection for Facilities Handling Radioactive Materials"

The Fire Hazard Analysis will be provided in FSAR Chapter 9, Appendix A will also evaluate the Loss of Large Area (LOLA) of the facility due to fires or explosions.

Fires will also be analyzed in FSAR Chapter 15 and in FSAR Chapter 1, Appendix F, Atomic Alchemy's conformance to non-power reactors on multi-unit sites, construction activity hazards caused by fires and FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's conformance to SRP 9.5.1.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 9.1.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.78, 1.101, 1.120, 1.189, and regulatory guide 1.205.

This also satisfies the intent of 10 CFR 70.64(a)(3).

CRITERION 4 – ENVIRONMENTAL AND MISSILE DESIGN BASES

Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.

Atomic Alchemy Compliance

Safety-related structures, systems, and components are designed to accommodate the effects of both interior and exterior generated missiles. Protection from external missiles, including those generated by natural phenomena, is provided by the external walls and roof of the Seismic Category I module building structures. Details of the design features and construction of these structures, systems, and components to protect against these effects are described in

FSAR Chapter 3, Section 6 and Section 8. The analysis of the postulated events is discussed in FSAR Chapter 15, Section 6 Reactor Accidents and Section 8, Radioisotope Production Process Accidents.

The Atomic Alchemy Versatile Isotope Production Reactor (VIPR) is a design akin to a university research reactor and differs greatly from that of a power reactor. For example, internal missiles generated from turbine blades do not exist in the design basis, and the dynamic effects of postulated pipe ruptures and pipe whip are minimized based on the application of the leak-before-break approach to safety related ASME Class 1 and 2 piping. Because the reactors are located within light water pools open to the atmosphere the probability of fluid systems piping over pressurization and rupture is also not credible accident scenarios.

Atomic Alchemy high energy and moderate energy piping located outside of the confinement module building will also be analyzed for breaks. A pipe break hazards evaluation will be part of the Atomic Alchemy piping design. The evaluation will be performed for high and moderate energy piping to confirm the protection of systems, structures, and components which are required to be functional during and following a design basis event.

The NPUF reactor modules will be constructed in phases. In FSAR Chapter 1, Appendix F, Atomic Alchemy's conformance to non-power reactors on multi-unit sites, missiles created from on-going construction activities or from environmental conditions that could impact construction activities will also be analyzed.

The Atomic Alchemy VIPR has been designed to be passively safe; it will have the capability to be shut down and maintain a safe shutdown condition and the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR 50.34 without the use of any active systems.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy compliance with SRP 3.5.1.1, 3.5.1.2, 3.5.1.3, 3.5.1.4, and SRP 3.5.1.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.76, 1.115, 1.117, and regulatory guide 1.221.

This also satisfies the intent of 10 CFR 70.64(a)(4).

CRITERION 5 – SHARING OF STRUCTURES, SYSTEMS, AND COMPONENTS

Structures, systems, and components important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining unit.

Atomic Alchemy Compliance

The VIPR light water pool (which also contains each reactor's spent fuel) shares a common light water radioisotope transfer canal (TTW) system with one other VIPR light water pool. The TTW system also functions as an "emergency core cooling" type of system, identified as the reactor decay heat removal system (DHR) which is an additional source of water for both reactor light water pools. The sharing of this DHR makeup water does not impair the capability of either reactor safety related systems to perform their intended safety functions.

The volume of water stored in the light water transfer canal pool is sufficient for the decay heat removal from each reactor pool for 72 hours. After 72 hours the reactor light water pools are capable of dissipating decay heat of both the reactor and the spent fuel located within the light water pool for 30 days.

The Atomic Alchemy facility shares the 1E DC UPS systems between radioisotope, target fabrication, and radwaste processes (See GDC 17, and Atomic Alchemy compliance with regulatory guide 1.81 position C.3 in FSAR Chapter 1, Appendix A). Each reactor has its own dedicated 1E DC UPS system.

With this one exception (the Light Water Radioisotope Transfer Canal), only non-safety-related systems are shared between the reactors. Although non-safety-related, the shared systems will be designed for operational reliability and availability to minimize restrictions on VIPR operating configurations during normal modes of operation. The non-safety related shared systems will include design features such as redundancy, spare capacity, isolation, and consideration of system interfaces. These features minimize the effects of reactor out-of-service and testing configurations in order to allow continued full-power operation of the other reactors.

Atomic Alchemy does not intend to apply GDC 5 criterion to the radioisotope production process related SSC's (e.g., the SSC's located in the radwaste module or Target Fabrication Module) all of which may share additional SSC's that perform safety related functions. These shared systems will be designed with conservative assumptions in considering radioactive releases and include redundancy and isolation design features for out of service and testing, which will prevent the uncontrolled release of radioactivity to the environment.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy compliance with SRP 8.3.1, 8.3.2, and 9.2.5 and FSAR Chapter 1, Appendix A, will describe Atomic Alchemy compliance with regulatory guides 1.26, 1.27 and 1.81.

CRITERION 10 – REACTOR DESIGN

The reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

Atomic Alchemy Compliance

The information in FSAR Chapters 4a and Chapter 5 will support the FSAR Chapter 15 accident analysis and the ability of the Atomic Alchemy facility to ensure that fuel design limits are not exceeded during Condition I and II events, to safely provide adequate cooling for Condition III events, and that the core remains intact with acceptable heat transfer geometry following condition IV events. The reactor protection system will be designed to actuate a reactor trip whenever necessary to prevent exceeding the fuel design limits.

Specified Acceptable Fuel Design Limits (SAFDL) will be provided in Atomic Alchemy FSAR Chapter 15, Table 15.7-03.

FSAR Chapter 4a, Reactor Description, will describe the design of the mechanical components of the reactor and reactor core, including the fuel rods and fuel assemblies, the mechanical design, nuclear design, and the thermal hydraulic design.

FSAR Chapter 5, Reactor Coolant System, will describe the design of the mechanical components of the coolant system.

FSAR Chapter 7 Instrument and Control Systems, will describe the safe shutdown methods as follows:

a. Safe Shutdown Using Safety Related Systems.
b. Safe Shutdown using Safety Related and Non-Safety Related Systems.
c. Safe Shutdown Using Non-Safety Related Systems.
d. Safe Shutdown from Outside the Main Control Room, e.g., Remote Shutdown Room, Controls at Other Locations, e.g., MCC, Electrical Switchgear Rooms, and Technical Support Center Workstation.

FSAR Chapter 15, Section 2 will provide a description of anticipated operational occurrences that will be considered in the accident analysis for the VIPR.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy compliance with SRP 4.2, 4.3, 4.4, 15.2.6, 15.3.1, 15.4.1, 15.4.2, 15.4.3, 15.5.1 and 15.8. Also see FSAR Chapter 1, Appendix A, Atomic Alchemy compliance with regulatory guides 1.53, 1.68, 1.77, 1.83, 1.93, 1.97, 1.105, 1.126, 1.157, 1.195, and 1.196.

CRITERION 11 – REACTOR INHERENT PROTECTION

The reactor core and associated coolant systems shall be designed so that in the power-operating range the net effect of the prompt inherent nuclear feedback characteristics tends to compensate for a rapid increase in reactivity.

Atomic Alchemy Compliance

The negative fuel temperature reactivity effects provide prompt reactivity feedback to compensate for a rapid, uncontrolled reactivity excursion. The negative Doppler coefficient of reactivity is provided by the use of a low-enrichment fuel design. This Doppler feedback is the primary reactivity feedback mechanism to provide the inherent core reactivity protection during rapid core reactivity excursions. FSAR Chapter 4a, Section 2, "Reactor Core and Fuel Design," will describe the Atomic Alchemy VIPR core design.

CRITERION 12 – SUPPRESSION OF REACTOR POWER OSCILLATIONS

The reactor core and associated coolant, control, and protection systems shall be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed.

Atomic Alchemy Compliance

Oscillations of the total power output of the core, from whatever cause, are readily detected by the nuclear instrumentation. The Atomic Alchemy reactor core is small enough so that oscillations due to spatial xenon effects are not credible transients. The monitoring system processes information provided by the fixed in-core detectors and in-core thermocouples. A reactor trip occurs if power increases unacceptably, thereby preserving the design margins to fuel design limits.

Confidence that fuel design limits are not exceeded is provided by reactor protection system overpower and overtemperature trip functions. FSAR Chapter 4a, Section 2, “Reactor Core and Fuel Design,” will describe the Atomic Alchemy VIPR design. Details of the instrumentation design and logic will be described in FSAR Chapter 7, Sections 4, 5, and 6 (“Reactor Power Control”, “Reactor Protection System” and “Reactor Trip System” respectively).

CRITERION 13 – INSTRUMENTATION AND CONTROL

Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety, including those variables and systems that can affect the fission process, the integrity of the reactor core, the reactor coolant pressure boundary, and the containment and its associated systems. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements’ phases of the I&C Design Process, at the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design conformance with respect to GDC 13.

The Westinghouse Common Qualified (Common Q) platform modified[1] for an NPUF is planned to be the basis of the Atomic Alchemy I&C Architecture. The standard Common Q platform is defined in Topical Report WCAP-16097, which was approved by the NRC. Instrumentation and controls are provided to monitor and/or control such parameters as: neutron flux (source, intermediate, power), neutron flux differences, thermal power, reactor coolant pump bearing water temperature, water level in the confinement pool, reactor coolant flow, speed of either reactor coolant pump, cold leg temperature (T-cold), hot leg temperature (T-hot), status of each manual reactor trip control, reactor core cooling, core pool inventory, radioisotope

[1] Atomic Alchemy intends to base its I&C architecture on the Westinghouse Common Qualified (Common Q) platform. It is a computer system consisting of a set of commercial-grade hardware and previously developed software components dedicated and safety related qualified for use in nuclear power plants. Since the number of safety related systems in a non-power, <20 MW reactor are substantially less than those required in a 1500 MW power reactor, and since the challenges to these systems are also not as severe, the overall Atomic Alchemy Common Q I&C architecture will be modified to suit these differences while maintaining the same NRC approved system design elements.

The Westinghouse Common Q Platform consists of the following Class 1E major building blocks that can be used to design any specific safety related system: Advant Controller 160 (AC160) with PM646 Processor Module, S600 Input and Output Modules, Flat Panel Display System for human-machine interface consisting of the MTP, Safety/QDPS display and Operators Module, Component Interface Module (CIM), Termination Units, and Cabinets.

transfer pool inventory, core pool temperature, transfer canal pool temperature, N16 quantity and levels, etc. to maintain the VIPR in a safe mode of operation.

Following the standard Common Q Platform I&C architectural design, Atomic Alchemy provides a similar Protection and Safety Monitoring System (IMS) which consists of four redundant divisions, designated A, B, C, and D. The Atomic Alchemy IMS system will be based on a modified for NPUF Common Q design I&C architecture similar to what was submitted to the NRC as WCAP-16675-NP, "AP1000 Protection and Safety Monitoring System Architecture Technical Report". The Atomic Alchemy IMS performs the necessary safety-related signal acquisition, calculations, setpoint comparison, coincidence logic, automatic reactor trip/ESF actuation functions, and automatic component control functions to achieve and maintain the plant in a safe shutdown condition. The IMS provides signal conditioning, communications, and display functions for regulatory guide 1.97 Category I variables and for Category 2 variables that are energized from Class 1E power supply systems. The Atomic Alchemy Protection and Safety Monitoring System (IMS) is actuated when safety system setpoints are reached for selected plant parameters.

In the event of a postulated common mode failure of the IMS system, certain ESF functions can be actuated though diverse means. Following the standard Common Q I&C architectural design, Atomic Alchemy employs a similar Diverse Actuation System, (IDA). The IDA is a defense-in-depth, non-safety-related system, providing a backup to the reactor protection system. The diverse actuation system functional requirements are based on a deterministic assessment of the protection system instrumentation common mode failures combined with the event failures.

The IMS implements data flows between safety and non-safety equipment using division separated unidirectional gateways and individual digital signals.

The IMS uses the standard Common Q type High Speed Links (HSL) to transfer ESF system-level actuations and related status information calculated in the Local Coincident Logic (LCL) controllers to Integrated Logic Processor (ILP) that control the safety components.

The portion of the Atomic Alchemy Operation and Control System (IOC) that is dedicated to the safety-related display function is referred to as the "Qualified Data Processing Subsystem" (IQD). The Atomic Alchemy IQD provides safety-related display of selected parameters in the control room, safe shutdown panel room and at the technical support center workstation. The IQD consists of a redundant configuration of sensors, QDPS hardware, and qualified displays.

Safety-related display instrumentation provides the operator with information to determine the effect of automatic and manual actions taken following reactor trip due to a Condition II, III, or IV event which will be defined in the Atomic Alchemy FSAR Chapter 15 accident analysis.

In FSAR Chapter 7, each Atomic Alchemy I&C safety related system will describe, at a minimum, their respective independence, diversity, single failure criteria, separation between monitoring and controls, trip functions and trip conformance.

Atomic Alchemy systems required for safe shutdown of the reactor and/or the radioisotope production processes will be provided in FSAR Chapter 7, Section 12 and Section 13, respectively.

The Atomic Alchemy's Engineered Safety Features (ESF) system will be described in FSAR Chapter 7, Section 11 which includes descriptions of ESF Monitoring Parameters, ESF Blocks, Permissives and Bypasses, ESF Signal Selector Algorithm ESF Coincidence Logic, and ESF Component Testing and Inspections.

FSAR Chapter 15.0 will provide a description of fifteen anticipated operational occurrences that have been considered in the accident analysis for the VIPR.

Criteria regarding the Atomic Alchemy human factors engineering program will be found in FSAR Chapter 18. The human system interface includes the design of the Operation and Control System (IOC) and each of the human system interface resources. The operation and control system includes the main control room, the technical support center, the remote shutdown room, emergency operations facility, and associated workstations for each of these centers.

This also satisfies the intent of 10 CFR 70.64(a)(10).

CRITERION 14 – REACTOR COOLANT PRESSURE BOUNDARY

The reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

Atomic Alchemy Compliance

The Atomic Alchemy facility does not use a nuclear reactor pressurized vessel in its VIPR design. The Atomic Alchemy reactor coolant piping system is designed as an "open piping system," that discharges directly into an open-to-atmosphere light water pool located within the Reactor Confinement Module (RCM) building. Therefore, ASME Code III pressure relief devices are not required. The only pressurization of the RCS system is created by the pump head, to this degree there is a maintainable "pressure boundary". The reactor coolant piping boundary is designed to accommodate the system pressures (pump head) and temperatures attained under the expected modes of VIPR operation, including anticipated transients, while maintaining stresses within applicable limits, including loadings under both normal and abnormal operating conditions (including seismic).

With respect to this GDC (and the 10 CFR 50.2 definition, applicable code requirements or references) the RCS pressure boundary, will be re-defined as just an RCS boundary. Atomic Alchemy specifically defines this fission product barrier as follows:

a. The RCS piping up to the connection to the light water pool, RCS pump the primary coolant loop (tube side) of the RCS Heat Exchanger.
b. Connections to the RCS system up to and including:
    1. The outermost confinement valve capable of an automatic design isolation function in the RCS system piping that is located inside of the boundary of the primary reactor confinement building module or,
    2. The second of two valves capable of an automatic design isolation function during normal reactor operation in the RCS system piping that is located immediately outside the primary reactor confinement building module, or,

3. The second of two valves normally closed during normal reactor operation connected to the RCS system piping that does not penetrate primary reactor confinement building module.

The RCS design incorporates piping bends instead of welded fittings, thus reducing the overall number of welds and potential break locations.

The RCS pumps and heat exchanger are in a separate module (Reactor Auxiliary Module (RAM)) building. The reactor coolant piping passes between the RCM and RAM in a piping chase, the piping system does not utilize any motorized control, isolation, or locked closed valves.

The VIPR coolant system design will incorporate pipe-break criteria (leak-before-break) to reduce or eliminate the need to consider the dynamic effects of pipe breaks. The design layout configuration and materials of the reactor coolant system have been selected such that the pipe stresses meet the leak-before-break criteria.

The qualification program for valves that are part of the reactor coolant boundary shall include testing or analysis that demonstrate that these valves will not experience leakage beyond the design criteria when subjected to design loading.

The Atomic Alchemy design does not utilize pressure relieving devices in the primary reactor coolant system.

The portions of the Chemical and Volume Control System (CVC) that is defined as reactor coolant boundary is Seismic Class C-II, non-safety-related. This portion of the system is capable of being automatically isolated by the activation of passive safety-related valves.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy compliance with SRP 3.6.3, 5.2.3, 5.2.4, 6.2.4, and 15.6.5.

The Atomic Alchemy reactor coolant piping design includes compliance with the requirements of the QAPD “ISI/IST design for inspectability program” (this will be described in FSAR Chapter 13, Appendix A).

CRITERION 15 – REACTOR COOLANT SYSTEM DESIGN

The reactor coolant system and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during normal operation, including anticipated operational occurrences.

Atomic Alchemy Compliance

Some typical PWR reactor coolant anticipated operational occurrences are either not applicable to the VIPR design or pose a substantially reduced risk to impacting the safe operation of the reactor. For example, the Atomic Alchemy RCS, CVC and DHR systems are boron-free, therefore increases in RCS inventory only poses a potential temperature decrease risk which is bounded by other accident analyses in FSAR Chapter 15.

Protection and control setpoints are based on accident analyses in FSAR Chapter 15, Section 7, Table 15.7-04, which ensures that the RCS does not exceed design basis conditions during operations and anticipated operational occurrences.

See FSAR Chapter 15.0 for a description of the fifteen anticipated operational occurrences that have been considered in the accident analysis for the VIPR (There are five non-reactor AOO's considered in the accident analysis).

The use of mechanistic pipe break criteria permits the elimination of the evaluation of dynamic effects of sudden circumferential and longitudinal pipe breaks in the design basis analysis of structures, systems, and components. General Design Criterion 4 of Appendix A, 10 CFR Part 50 allows the use of analyses to eliminate from the design basis the dynamic effects of pipe ruptures.

An RCS piping hazard analysis and leak before break analysis will be performed, see FSAR Chapter 3, Section 6.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP's 3.6.2, 3.9.2, 3.9.3, 6.2.1.3, and 6.2.1.4.

CRITERION 16 – CONTAINMENT DESIGN

The reactor containment and associated systems shall be provided to establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

Atomic Alchemy Compliance

The Atomic Alchemy facility does not use a pressurized containment vessel in the VIPR design. The Atomic Alchemy reactors' module building design does not include a secondary steel containment structure. The reactors are located within open to atmosphere light water pools inside a reactor confinement module building. There are no cylindrical or other shaped steel containment structures containing the light water pool. Therefore, any applicable general design criteria or references to a "containment design" will be re-defined as a "confinement design" by Atomic Alchemy as follows:

a. The outermost steel and concrete structure of the NPUF's Reactor Confinement Module Building, a seismic Category C-I structure.
b. The outermost steel and concrete structures of the Radioisotope Production Process Module, Radwaste Module and Target Fabrication Module Buildings, also seismic Category C-I structures.
c. The NPUF's Reactor Confinement Module Filtration System (RCF) of the Reactor Confinement Module Building, the Reactor Auxiliary Module Cascade Exhaust System (RAE) of the Reactor Auxiliary Module Building, the Radioisotope Production Process Module Air Filtration Systems (PMF), the Rad Waste Handling Module Air Filtration System (WHF), and the Mo-99 Target, Production, Processing Module Air Filtration System (TPF).

The light water pool, which houses both the reactor core, and the spent fuel is the safety-related ultimate heat sink for the removal of the reactor coolant system sensible heat, core decay heat, spent fuel heat and stored energy.

The location (situated between other buildings) and design of the NPUF confinement module building protects against postulated missiles from external sources as well as missiles produced by internal equipment failures.

The reactor confinement building module is capable of maintaining a negative pressure in relation to the atmosphere during normal operation and have a measurable leakage rate less than 5% over 24 hours.

The design of the confinement module building, and ventilation systems prevents the rapid, uncontrolled release of radioactive material to the environment. The Atomic Alchemy reactor confinement module and process module buildings establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the design conditions important to safety are not exceeded for as long as postulated accident conditions require.

The Atomic Alchemy design incorporates a significant reduction (from what is typical in PWR and BWR designs) in the number of penetrations between the reactor confinement module building and the reactor auxiliary module building and radioisotope production module building, respectively.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP's 3.8.3, 3.8.4, 6.2.3, 6.2.4, and 6.2.6.

CRITERION 17 – ELECTRICAL POWER SYSTEMS

An onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for each system (assuming that the other system is not functioning) shall be to provide sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled, and containment integrity and other vital functions are maintained in the event of postulated accidents.

The onsite electric power supplies, including the batteries, and the onsite electric distribution system shall have sufficient independence, redundancy, and testability to perform their safety functions, assuming a single failure.

Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights-of-way) designed and located so as to minimize, to the extent practical, the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. A switchyard common to both circuits is acceptable. Each of these circuits shall be designed to be available in sufficient time, following a loss of all onsite alternating current power supplies and other offsite electric power circuit, to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded. One of these circuits shall be designed to be available within a few seconds following a loss of coolant accident to assure that core cooling, containment integrity, and other vital safety functions are maintained.

Provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.

Atomic Alchemy Compliance

The Atomic Alchemy facility takes an exception to the conditions of General Design Criterion 17 with respect to safety related onsite and offsite AC power availability and the sharing of 1E DC UPS systems. Atomic Alchemy takes a specific exception to the sharing of 1E DC UPS systems between multiple radioisotope related processes (regulatory guide 1.81 position C.3). Each VIPR has its own dedicated DC 1E UPS system located in the reactor auxiliary module building of each reactor.

The Atomic Alchemy DC 1E UPS system for the radioisotope production processes includes augmented design provisions for sharing 1E power across radioisotope and radwaste processes that prevents adverse interactions and the introduction of other failures of systems that are required to ensure a safe shutdown of any radioisotope, target fabrication or radwaste ongoing process.

The Atomic Alchemy facility is designed with reliable, non-safety-related offsite and onsite AC power that are normally expected to be available for important facility functions. Non-safety-related AC power is not relied upon to maintain the core and spent fuel cooling, confinement module integrity, radioisotope module integrity or radwaste module integrity. Although not relied on for facility safety-related functions, the AC power systems are designed with reliability considerations, including independence, redundancy, and testability.

Offsite AC power has no safety-related function due to the passively safe design of the Atomic Alchemy VIPR. The VIPR is designed to maintain light water pool cooling and reactor confinement module building integrity independent of a safety-related AC power source indefinitely.

The onsite power system is comprised of the main AC power system and the DC power system. The main AC power system is a non-Class 1E system. The DC power system consists of Class 1E and non-Class 1E DC power systems. Each DC system consists of ungrounded batteries, DC distribution equipment, and a UPS. The Class 1E DC and UPS system are the only safety-related power sources required to monitor and actuate the safety-related passive systems in multiple reactors and for radioisotope related processes.

The Class 1E DC and UPS systems for each reactor are located in their respective Reactor Auxiliary Module building. Each reactor has four independent, Class 1E DC divisions, A, B, C, and D. Divisions A and D each are comprised of one battery bank, one switchboard, and one battery charger. The battery bank is connected to Class 1E DC switchboard through a set of fuses and a disconnect switch. Divisions B and C each are composed of two battery banks, two switchboards, and two battery chargers. The first battery bank in all four divisions is designated as 24-hour battery bank, it provides power to the safety related loads for their respective VIPRs required for the first 24 hours following an event of loss of all AC power sources concurrent with any postulated DBA. The second battery bank in divisions B and C are designated as 72-

hour battery bank and is used for those potential loads requiring safety related power for 72 hours following the same event and for the same multiple systems and components.

(The 1E DC and UPS systems for the radioisotope production process, target fabrication and radwaste module buildings will also feature several independent Class 1E DC divisions to be designed similar to the Reactor modules for diversity and redundancy.)

The Class 1E DC and UPS system is designed to accommodate component failures, such as the loss of a battery charger, a battery, or an inverter, without the loss of power to either the DC bus or the AC instrumentation and control power bus. The Class 1E DC power systems include a spare Class 1E battery bank with a spare battery, battery charger, and permanently installed cable connections that allow the spare bank to be connected to the affected bus by operator actions.

Both the Class 1E and non-Class 1E inverters and battery chargers are located in a controlled environment within the reactor auxiliary module buildings, similarly, the shared radioisotope production related Class 1E and non-Class 1E will be located within controlled environments. The UPS equipment is rated for continuous operation at an ambient temperature of 104°F. In addition, the temperature-sensitive components such as capacitors, transformers, and semiconductors, used in the UPS equipment are designed to continuously withstand higher temperatures of 158° F. All Class 1E electrical components are environmentally qualified in accordance with the Atomic Alchemy EEQ program.

In the event of a Loss of Offsite Power (LOOP) AC power to the battery chargers, AC power is provided from the non-Class 1E onsite standby diesel generator. Preassigned loads and equipment are automatically loaded on the diesel-generator in a predetermined sequence.

Additional loads can be manually added to the standby diesel generator as required. The onsite standby diesel generator power system is not required for safe shutdown of any reactor, or any radioisotope or radwaste process.

The Class 1E battery chargers and Class 1E regulating transformers are designed to limit the input AC current to an acceptable value under faulted conditions on the output side. Circuit breakers exist at the input and output sides for protection and isolation. The circuit breakers are coordinated and periodically tested to verify their current-limiting characteristics.

The NPUF will be constructed in phases. In FSAR Chapter 1, Appendix F, Atomic Alchemy's conformance to non-power reactors on multi-unit sites presents the analysis of construction work impact to existing reactor and radioisotope production process operations. Work control processes and procedures will ensure proper considerations for electrical power system interfaces and continued safe operations of the existing reactors and radioisotope production processes. In some instances, existing reactor or radioisotope operations and processes may be required to be temporarily halted for some electrical AC or DC power construction or testing activities.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP's 8.1, 8.2, 8.3.1, and 8.3.2. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.6, 1.9, 1.32, 1.47, 1.75 and 1.81.

FSAR Chapter 1, Appendix D, "Compliance with Generic Safety Issues" (NUREG-0933) will address generic issues and operational experience relevant to the design of the Atomic Alchemy electrical power systems (A24, A25, B35, B44, B53, B56).

This also satisfies the intent of 10 CFR 70.64(a)(7).

CRITERION 18 – INSPECTION AND TESTING OF ELECTRIC POWER SYSTEMS

Electric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of important areas and features, such as wiring, insulation, connections, and switchboards, to assess the continuity of the systems and the condition of their components. The systems shall be designed with a capability to test periodically (1) the operability and functional performance of the components of the systems, such as onsite power sources, relays, switches, and buses, and (2) the operability of the systems as a whole and, under conditions as close to design as practical, the full operation sequence that brings the systems into operation, including operation of applicable portions of the protection system, and the transfer of power among the nuclear power unit, the offsite power system, and the onsite power system.

Atomic Alchemy Compliance

The Atomic Alchemy facility takes an exception to some of the inspection and testing conditions of General Design Criterion 18 with respect to AC power. The Atomic Alchemy facility is designed with reliable non-safety-related offsite and onsite AC power that are normally expected to be available for important facility functions, but non-safety-related AC power is not relied upon to maintain the reactor core or spent fuel cooling or the confinement integrity of the RCM, RAM, PPM, or RWM buildings.

Offsite AC power has no safety-related function due to the passively safe design of the Atomic Alchemy VIPR. The VIPR is designed to maintain core cooling and confinement integrity independent of a non-safety-related ac power source indefinitely.

Therefore, in the Atomic Alchemy electric power design basis, only the Class 1E DC and UPS system is required to actuate the systems necessary for initiating safe shutdown of the VIPR (or any radioisotope or radwaste process), maintaining VIPR core cooling, spent fuel cooling, and confinement integrity. The Atomic Alchemy safety-related DC power system design complies with GDC 18.

Atomic Alchemy will comply with IEEE-603-1991, and the latest revisions of IEEE-308, IEEE-323, IEEE-344, IEEE-450, IEEE-484, IEEE-485, and IEEE-535. Some of the latest versions are not endorsed by a regulatory guide, but its use should not result in deviations from the design philosophy otherwise stated in any regulatory guides.

Atomic Alchemy will determine which non-safety related AC electrical SSCs should fall within the scope of 10 CFR 50.65(b).

The surveillance testing of the Class 1E DC UPS systems will be performed as required by technical specification. Atomic Alchemy Technical Specification LCO 3.8.1, 3.8.2 and 3.8.5 will be provided for this purpose.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 7.1, Table 1 SRP 8.1, and SRP 8.3.1.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.22, 1.30, 1.32, 1.41, 1.75, 1.81, 1.93, 1.118, 1.131, 1.158, 1.160, and 1.218.

FSAR Chapter 1, Appendix D, will describe Atomic Alchemy's compliance with NUREG-0933, Section 1, TMI Action Plans Task I.G, Section 2, Task Action Plans Item A-25, Item A-30, and Item B-70, Section 3, New Generic Issues, Issue 17, Issue 47, Issue 128, and Issue 168.

This also satisfies the intent of 10 CFR 70.64(a)(8).

CRITERION 19 – CONTROL ROOM

A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including loss of coolant accidents. Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem whole body, or its equivalent, to any part of the body, for the duration of the accident.

Equipment at appropriate locations outside the control room shall be provided (1) with a design capability for prompt hot shutdown of the reactor, including necessary instrumentation and controls to maintain the unit in a safe condition during hot shutdown and (2) with a potential capability for subsequent cold shutdown of the reactor through the use of suitable procedures.

Atomic Alchemy Compliance

The Atomic Alchemy main control room provides the instrumentation and controls required to operate the plant safely under normal conditions and to safely shutdown the VIPRs and any radioisotope or radwaste processes under accident conditions. Passive safety-related system designs are provided that do not rely upon control room operator action to maintain core or spent fuel pool cooling for design basis accidents.

Conservative assumptions have been made in considering design basis accident radioactive releases from the VIPR confinement module, target fabrication module, radwaste module and radioisotope production process module buildings to permit access to and continued occupancy of the main control room.

The beyond design basis severe accident dictates the shielding requirements for the control room. Consideration is given to shielding provided by the Reactor Module and Radioisotope production process Module building structures. Shielding combined with other engineered safety features is provided to permit access and continued occupancy of the control room following a postulated beyond design basis severe accident, so that radiation doses are limited to five rem whole body from contributing modes of exposure for the duration of the accident, in accordance with General Design Criterion 19.

The main control room is centrally located in the Administrative / Service Module building and is shielded from direct gamma radiation and inhalation doses resulting from the postulated release of fission products from any of the reactor confinement module buildings or from radioisotope production process module building.

The functional design and layout of control room ventilation systems are designed in accordance with ASME Code AG-1 including the AG-1a Addenda with single failure criteria applied to safety related systems.

If AC power is unavailable for more than 10 minutes or if "high-high" particulate is detected, or if iodine radioactivity is detected in the main control room supply air duct (CRV system), which would lead to exceeding General Design Criteria 19 operator dose limits, the Protection and Safety Monitoring System (IMS system) automatically shuts down the four VIPRs and isolates the main control room. Operator habitability requirements are then met by the Control Room Emergency Habitability System (CRE system). The control room emergency habitability system also allows access to and occupancy of the main control room under these accident conditions. The control room emergency habitability system is designed to satisfy seismic Cat-I requirements.

The VIPRs will be constructed in phases. In FSAR Chapter 1, Appendix F, “Non-Power Reactors on Multi-Unit Sites,” Atomic Alchemy will address potential hazardous radioactive releases created by accidents involving on-going construction activities that might challenge the continued occupancy of the control room are analyzed and evaluated.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy’s compliance with SRP 6.4, 9.4.1, and SRP 18. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy’s compliance with regulatory guides 1.195, 1.196, and 1.197.

CRITERION 20 – PROTECTION SYSTEM FUNCTIONS

The protection system shall be designed (1) to initiate automatically the operation of appropriate systems, including the reactivity control systems, to assure that specified acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences and (2) to sense accident conditions and to initiate the operation of systems and components important to safety.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 20.

The Atomic Alchemy radioisotope production processes (including radwaste and target fabrication) facility will share I&C systems and subsystems as well as interface with each other and the reactor systems. The Protection and Safety Monitoring System (IMS) interfaces with both the Reactor Protection System (IRP) and the Reactor Trip System (IRT). All three provide detection of off-nominal conditions and actuation of appropriate safety-related functions necessary to achieve and maintain the facility in a safe shutdown condition. The protection and safety monitoring system initiates a reactor trip whenever a condition monitored by the system reaches a preset level. The protection and safety monitoring system monitors key variables related to the main control room, as well as equipment mechanical limitations in both the reactor and in selected radioisotope and radwaste processes' components. The reactor trip portion (IRT system) of the protection system includes four independent, redundant, physically separated, and electrically isolated divisions.

FSAR Chapter 15.0 will provide a description of anticipated operational occurrences that have been considered in the accident analysis for the VIPR.

FSAR Chapter 7, sections 7.3, 7.5, and 7.6 will provide a description of the IMS, IRP and IRT systems, respectively.

The VIPRs will be constructed in phases. In FSAR Chapter 1, Appendix F, Atomic Alchemy's conformance to non-power reactors on multi-unit sites will present the analysis of construction work impact to existing reactor and radioisotope production process operations. Future reactor and process module I&C SSCs with connections to existing operating components will be isolated or partitioned at locations outside of the operating modules. Work control processes and procedures will ensure proper considerations for construction system interfaces and continued safe operations of existing reactors. In some instances, existing reactor or radioisotope operations may be required to be temporarily halted for future component connections and testing of new interfaces.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 7.2 and 7.4.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.53.

CRITERION 21 – PROTECTION SYSTEM RELIABILITY AND TESTABILITY

The protection system shall be designed for high functional reliability and in-service testability commensurate with the safety functions to be performed. Redundancy and independence designed into the protection system shall be sufficient to assure that (l) no single failure results in the loss of the protection function and (2) removal from service of any component or channel does not result in the loss of the required minimum redundancy unless the acceptable reliability of operation of the protection system can be otherwise demonstrated. The protection system shall be designed to permit periodic testing of its functioning when the reactor is in operation, including a capability to test channels independently to determine failures and losses of redundancy that may have occurred.

<u>Atomic Alchemy Compliance</u>

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 21.

The VIPR protection systems are design to be reliable and tested while in service. The design employs redundant logic trains and component diversity.

The automatic actuation processors, in each of the two redundant automatic subsystems of the IMS system are provided with the capability for channel calibration and testing while the plant is operating. The protection system, including the engineered safety features are tested at power to the greatest extent practical.

The Atomic Alchemy instrumentation architecture will conform to NUREG/CR-6303 and meets IEEE-603-1991, and the latest revision of IEEE-379, IEEE-497, 338 standards. Some of the latest versions are not endorsed by a regulatory guide, but its use should not result in deviations from the design philosophy otherwise stated in any of the regulatory guides.

Control functions, reactor trip functions, engineered safety features functions, and monitoring & indication functions are divided into three levels containing: non-safety systems, safety systems, and non-safety diverse systems.

During testing or maintenance, protection system functions will be provided to bypass a channel monitoring a variable for reactor trip. Although no setpoints need to be changed for bypassing, the coincidence logic is automatically adjusted.

A test simulating the total loss of instrument air to safety-related systems will not be performed since this type of testing would adversely affect continued plant operation since the safety-related air-operated components fail to their safeguards actuation position on a loss of air. The unnecessary actuation of the safety-related components can adversely affect plant operation and plant safety.

The VIPRs will be constructed in phases. In FSAR Chapter 1, Appendix F, Atomic Alchemy's conformance to non-power reactors on multi-unit sites will present the analysis of construction work impact to existing reactor and radioisotope production process operations. Future reactor and process module reactor protection I&C SSC's with connections to existing operating components will be isolated or partitioned at locations outside of the operating modules. Work control processes and procedures will ensure proper considerations for construction of new system interfaces and continued safe operations of the existing reactor units.

FSAR Chapter 7, Section 7.3 will provide a description of the reliability and testing of the IMS system. FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 7.1 Appendix C.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.22, 1.45, 1.53, 1.100, and 1.118.

CRITERION 22 – PROTECTION SYSTEM INDEPENDENCE

The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels do not result in the loss of the protection function or shall be demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principals of operation, shall be used to the extent practical to prevent loss of the protection function.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 22.

A modified[2] version of the Westinghouse Common Qualified, or Common Q™, safety-grade instrumentation and control (I&C) platform is planned to be the basis of the Atomic Alchemy I&C Architecture. Safety-related instrumentation & control (I&C) systems based on the application of Common Q platforms are designed to provide protection against unsafe reactor operation during steady state and transient power operations. They also initiate selected protective functions to mitigate the consequences of design-basis events and accidents, and to safely shut down the facility by either automatic means or manual actions. The standard Common Q platform is defined in Topical Report WCAP-16097, which was approved by the NRC.

The VIPR protection system (IRP) will be designed with sufficient functional diversity and redundancy for a variety of postulated accidents. Redundancy provides confidence that reactor trips are generated on demand, even when the protection system is degraded by a single failure. Reactor trips are four-way redundant. The single failure criterion is met even if one channel is bypassed. Diverse and redundant protection functions automatically serve to mitigate the consequences of a postulated transients. FSAR Chapter 15 will describe the extent to which the IRP functions for each event. In FSAR Chapter 7, Section 5, the IRP system will be described, including independence, diversity, single failure criteria, and separation between monitoring and controls.

Sufficient redundancy and independence will be designed into the protection systems so that no single failure or removal from service of any component or channel of a system results in loss of that protection function. Functional diversity and location diversity will be designed into the Atomic Alchemy system. High-quality components, conservative design and quality control, inspection, calibration, and tests will be used to guard against common-mode failure.

The VIPRs will be constructed in phases. In FSAR Chapter 1, Appendix F, Atomic Alchemy's conformance to non-power reactors on multi-unit sites will present the analysis of construction work impact to existing reactor and radioisotope production process operations. Future reactor and process module protection system I&C SSC's with connections to existing operating

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[2] Atomic Alchemy intends to base its I&C architecture on the Westinghouse Common Qualified (Common Q) platform. It is a computer system consisting of a set of commercial-grade hardware and previously developed software components dedicated and safety related qualified for use in nuclear power plants. Since the number of safety related systems in a non-power <20 MW reactor are substantially less than those required in a 1500 MW power reactor, and since the challenges to these systems are also not as severe, the overall Atomic Alchemy Common Q I&C architecture will be modified to suit these differences while maintaining the same NRC approved system design elements.

The Westinghouse Common Q Platform consists of the following Class 1E major building blocks that can be used to design any specific safety related system: Advant Controller 160 (AC160) with PM646 Processor Module, S600 Input and Output Modules, Flat Panel Display System for human-machine interface consisting of the MTP, Safety/QDPS display and Operators Module, Component Interface Module (CIM), Termination Units, and Cabinets components will be isolated or partitioned at locations outside of the operating modules. Potential challenges caused by construction activities of the remaining reactors to the independence of the reactor protection system is addressed. Work control processes and procedures will ensure proper considerations for system interfaces and continued safe operations of the existing reactor units. In some instances, existing reactor or radioisotope operations and processes may be required to be temporarily halted for some I&C construction or testing activities.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.2.2, 3.7.4, 3.10, and SRP 7.1 Appendix C.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.75 and 1.100.

CRITERION 23 – PROTECTION SYSTEM FAILURE MODES

The protection system shall be designed to fail into a safe state or into a state demonstrated to be acceptable on some other defined basis if conditions such as disconnection of the system, loss of energy (e.g., electric power, instrument air) or postulated adverse environments (e.g., extreme heat or cold, fire, pressure, steam, water, and radiation) are experienced.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 23.

The Atomic Alchemy Protection system and components will be designed, tested, and qualified for operation in the postulated Design Basis Accident (DBA) environment in which the components are required to function. The most conservative failure modes are considered under various accident transients and the components are designed to fail to that determined conservative functional state.

Branch Technical Position (BTP) 7-19, "Guidance for Evaluation of Diversity and Defense-In Depth in Digital Computer-Based Instrumentation and Control Systems," identifies criteria for defense against common-mode and common cause failures. The Atomic Alchemy I&C architecture will comply with this guidance. The Staff considers defense-in-depth, and diversity to be key elements in a protection system design against failure modes.

Atomic Alchemy I&C architecture will conform with the intent of the latest requirements of IEEE Std 379, "Application of the Single Failure Criterion to Nuclear Power Generating Station Safety Systems" as applicable to DC safety related power systems.

The Atomic Alchemy protection systems will contain sufficient redundancy and independence in the protection systems so that no single failure or removal from service of any component or channel of a system results in loss of the protection function.

The VIPRs will be constructed in phases. In FSAR Chapter 1, Appendix F, Atomic Alchemy's conformance to non-power reactors on multi-unit sites will present the analysis of construction work impact to existing reactor and radioisotope production process operations. Interactions or transients caused by construction activities are also considered when determining the failure mode functional state of protection system SSCs. In some instances, existing reactor or radioisotope operations and processes may be required to be temporarily halted for some I&C construction or testing activities.

FSAR Chapter 7, section 11, will provide a description of the diversity of the engineered safety features (ESF).

FSAR Chapter 7, Section 2, will provide a description of the I&C Systems Reliability and Availability.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 7.8.

CRITERION 24 – SEPARATION OF PROTECTION AND CONTROL SYSTEMS

The protection system shall be separated from the control systems to the extent that failure of any single control system component or channel, or failure or removal from service of any single protection system component or channel which is common to the control and protection systems, leaves intact a system satisfying all reliability, redundancy, and independence requirements of the protection system. Interconnection of the protection and control systems shall be limited so as to assure that safety is not significantly impaired.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 24.

The Atomic Alchemy protection system (IMS) will be separate and distinct from the control systems. Control systems are dependent on the protection system for control signals that are derived from protection system measurements, where applicable. These signals are transferred to the control system by isolation devices classified as protection components.

The Atomic Alchemy Protection system and components will be designed, tested, and qualified for operation in the Design Basis Accident (DBA) environment in which the components are required to function. The protection systems are separate and distinct from the control systems.

The adequacy of system separation will be verified by pre-operational testing. The failure of a single control system component or channel, or the failure or removal from service of a single protection system component or channel common to the control and protection system, does not adversely impact the protective system from continuing to be able to perform its intended design basis safety related functions. The removal of a protection division from service is allowed during testing of that division.

The VIPRs will be constructed in phases. In FSAR Chapter 1, Appendix F Atomic Alchemy's conformance to non-power reactors on multi-unit sites presents the analysis of construction work impact to existing reactor and radioisotope production process operations. Separation of protection and control systems of newly added reactor components were also considered when determining the overall I&C architecture to maintain separation of functions. In some instances, existing reactor or radioisotope operations and processes may be required to be temporarily halted for some I&C construction or testing activities.

FSAR Chapter 7, Section 7.4, will provide a description of the I&C Systems instrumentation separation criteria.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 7.1 Table 7-1. FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.75.

CRITERION 25 – PROTECTION SYSTEM REQUIREMENTS FOR REACTIVITY CONTROL MALFUNCTIONS

The protection system shall be designed to assure that specified acceptable fuel design limits are not exceeded for any single malfunction of the reactivity control systems, such as accidental withdrawal (not ejection or dropout) of the control rods.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 25.

The Atomic Alchemy Reactor Trip system is independent of the control functions. Trip functions will interrupt power to the control rod mechanism's independent of control signals. Any trip demand signal from neutron flux, temperature, pressure, level, or flow signals will be generated independently of the control signals.

The VIPRs will be constructed in phases. In FSAR Chapter 1, Appendix F Atomic Alchemy's conformance to non-power reactors on multi-unit sites will present the analysis of construction work impact to existing reactor and radioisotope production process operations. The impact of construction activities on reactivity control components for malfunctions were also considered when determining the overall I&C architecture to maintain separation of reactor protection functions. In some instances, existing reactor or radioisotope operations and processes may be required to be temporarily halted for some I&C construction or testing activities.

FSAR Chapter 4a, Section 4, and FSAR Chapter 7, Section 6 will describe reactor trip functions.

FSAR Chapter 15, Section 7, will provide a description of transients involving reactivity control.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 7.2.

CRITERION 26 – REACTIVITY CONTROL SYSTEM REDUNDANCY AND CAPABILITY

Two independent reactivity control systems of different design principals shall be provided. One of the systems shall use control rods, preferably including a positive means for inserting the rods, and shall be capable of reliably controlling reactivity changes to assure that under conditions of normal operation, including anticipated operational occurrences, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded. The second reactivity control system shall be capable of reliably controlling the rate of reactivity changes resulting from planned, normal power changes (including xenon burnout) to assure that the acceptable fuel design limits are not exceeded. One of the systems shall be capable of holding the reactor core subcritical under cold conditions.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process, at the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 26.

The Atomic Alchemy design features two different design principles for reactivity control: 1) coarse-step control rods and a fine-step regulating rod and 2) burnable poison in the form of gadolinium (Gd_2O_3) that is introduced as an additive to some of the fuel rods in a zoned manner. The control rod clusters and regulating rod assembly are inserted into the VIPR core by the force of gravity. While the Atomic Alchemy VIPRs are non-power reactors, the design is consistent with PWR industry practices in taking burnup credit for assembly designs with burnable poisons. This satisfies the intent of GDC 26.

FSAR Chapter 15, Section 1 will provide the reactor characteristics, reactivity coefficients, assumptions, and analysis. The safety analysis assumes the most restrictive time in the core operating cycle.

FSAR Chapter 7, Section 19 (reactor) and Section 20 (radioisotope production processes) will provide the Reactor I&C System Permissive and Interlock Descriptions.

FSAR Chapter 15, Section 2 will describe the anticipated operational occurrences that have been considered in the accident analysis for the VIPR.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 4.2 Appendix B.

CRITERION 27 – COMBINED REACTIVITY CONTROL SYSTEMS CAPABILITY

The reactivity control systems shall be designed to have a combined capability, in conjunction with poison addition by the emergency core cooling system, of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained.

Atomic Alchemy Compliance

Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 27.

Atomic Alchemy takes an exception to the GDC 27 criteria for a poison addition by an emergency core cooling system (Atomic Alchemy's equivalent is the DHR system). The Atomic Alchemy VIPR is a non-power reactor. The reactivity control design provides sufficient means of making and holding the reactor core subcritical under any anticipated transient conditions and within an appropriate margin for contingencies without the necessity to add a soluble neutron poison. The single failure of the highest worth control rod assembly is assumed to be stuck in the fully withdrawn position for this determination. Even in this "N-1" configuration, light water pool cooling for both the reactor core and spent fuel is maintained by the overall passive cooling design of the light water pool and if necessary, additional water can be provided by the reactor core decay heat removal (DHR) system. This satisfies the intent of GDC 27.

FSAR Chapter 7, Sections 3, 4, 5, 6, for In-core Instrumentation System (IIC), Reactor Power Control (IRC), Reactor Protection System (IRP), and Reactor Trip System (IRT) respectively, will be provided.

Technical Specifications LCO 3.1, for Reactivity Control Systems (IRC, ICX), LCO 3.2, for Power Distribution (IRC, ICX) and LCO 3.3, for Instrumentation will be provided.

FSAR Chapter 15, Section 3 will describe reactor characteristics, reactivity coefficients, assumptions, and analysis.

FSAR Chapter 4a, Section 2, will provide a summary description of principal reactor design criteria, and FSAR Chapter 4a, Section 3 and 4 for reactor core and fuel design criteria.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 4.2 Appendix B. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.79.

CRITERION 28 – REACTIVITY LIMITS

The reactivity control systems shall be designed with appropriate limits on the potential amount and rate of reactivity increase to assure that the effects of postulated reactivity accidents can neither (l) result in damage to the reactor coolant pressure boundary greater than limited local yielding nor (2) sufficiently disturb the core, its support structures, or other reactor pressure vessel internals to impair significantly the capability to cool the core. These postulated reactivity accidents shall include consideration of rod ejection (unless prevented by positive means), rod dropout, steam line rupture, changes in reactor coolant temperature and pressure, and cold-water addition.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GD 28.

The Atomic Alchemy VIPRs are non-power reactors, therefore, some of the postulated accidents that could potentially impact reactivity limits identified in GDC 28 are not applicable because they are not credible accidents in the FSAR Chapter 15 analysis, i.e., reactor coolant pressure variants, rod ejection accidents (REA), steam line ruptures, etc.

FSAR Chapter 15, Section 7 will describe the postulated reactor accidents including cold water addition (from several sources), changes in RCS temperature, and control rod malfunctions.

Maximum rates of reactivity increase are limited by design and operating procedures. The Atomic Alchemy technical specifications will explicitly state the requirements for control rod bank alignment (T/S 3.1.4), and insertion limits (T/S 3.1.5) in addition to the shutdown margin (T/S 3.1.1) reactivity requirements. The control rod reactivity addition rate is determined by the allowable rod control system withdrawal speed, in conjunction with the control rod worth, which varies throughout the operating cycle.

Reactor core (as well as the spent fuel) light water pool cooling capability following any of the postulated reactivity transients is maintained by the overall passive design methodology of the light water pool decay heat removal system and if necessary, additional water from the reactor Decay Heat Removal System (DHR). This satisfies the intent of GDC 28.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.9.4, 15.0.2, and SRP 15.4.8.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.77, and 1.236.

CRITERION 29 – PROTECTION AGAINST ANTICIPATED OPERATIONAL OCCURRENCES

The protection and reactivity control systems shall be designed to assure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences.

Atomic Alchemy Compliance

Atomic Alchemy has completed the conceptual and requirements phases of the I&C Design Process. At the time of this Topical Report (TR) submittal Atomic Alchemy is working to complete the hardware and software developmental phases. This TR section therefore identifies and describes the design features and component requirements that will comprise the Atomic Alchemy I&C design with respect to GDC 29.

The Atomic Alchemy instrumentation architecture will conform to NUREG/CR-6303. Control functions, reactor trip functions, engineered safety features functions, and monitoring & indication functions are divided into three levels containing: non-safety systems, safety systems, and non-safety diverse systems. The protection and safety monitoring system monitors key variables related to equipment mechanical limitations in both the reactor and in selected radioisotope and radwaste processes' components.

The reactor trip portion (IRT system) of the protection system will include independent, redundant, physically separated, electrically isolated divisions.

This defense in depth design approach will ensure that the Atomic Alchemy I&C reactor protection systems maintain a high certainty of performing their intended safety related functions in the event of operational occurrences.

FSAR Chapter 7, Section 4 will describe the safety criteria for instrument redundancy, separation, and diversity.

FSAR Chapter 15.0 will describe the fifteen (15) reactor anticipated operational occurrences (AOO) and the 5 non-reactor AOO's that have been considered in the accident analysis for the NPUF.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 13.4. FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.97.

CRITERION 30 – QUALITY OF REACTOR COOLANT PRESSURE BOUNDARY

Components which are part of the reactor coolant pressure boundary shall be designed, fabricated, erected, and tested to the highest quality standards practical. Means shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor coolant leakage.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the reactor coolant pressure boundary for the VIPR as described in response to GDC 14.

The components in the Reactor Coolant System (RCS) are Atomic Alchemy Equipment Class A (equivalent to ANS Safety Class 1), Quality Group A, and are designed and fabricated according to ASME Code Section III, Class 1.

The qualification program for valves that are part of the reactor coolant boundary shall include testing or analysis that demonstrate that these valves will not experience leakage beyond the design criteria when subjected to design loading.

The reactor coolant piping boundary leakage detection monitoring provides a means of detecting and to the extent practical, identifying the source and quantifying the reactor coolant leakage. The detection monitors perform the detection and monitoring function in conformance with the recommendations of regulatory guide 1.45. Leakage from the reactor coolant boundary may result in an increase in the radioactivity levels inside either the Reactor Confinement Module or the Reactor Auxiliary Module buildings. The area's atmosphere is continuously monitored for airborne particulate radioactivity.

Substantial intersystem leakage from the reactor coolant piping boundary to other piping systems is not expected. A piping rupture hazards analysis will be performed on high and medium energy secondary sub-systems attached to the RCS system. However, possible leakage points across passive barriers or valves are considered in the Atomic Alchemy design. Sub-systems connected to the reactor coolant boundary incorporate design and administrative provisions that limit leakage.

Leakage detection monitoring is also maintained in support of the use of leak-before-break criteria.

FSAR Chapter 3, Section 6 will describe the application of leak-before-break criteria.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.2.2, and 5.2.3. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.45, 1.100.

CRITERION 31 – FRACTURE PREVENTION OF REACTOR COOLANT PRESSURE BOUNDARY

The reactor coolant pressure boundary shall be designed with sufficient margin to assure that when stressed under operating, maintenance, testing, and postulated accident conditions (l) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The design shall reflect consideration of service temperatures and other conditions of the boundary material under operating, maintenance, testing, and postulated accident conditions and the uncertainties in determining (l) material properties, (2) the effects of irradiation on material properties, (3) residual, steady state, and transient stresses, and (4) size of flaws.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the reactor coolant pressure boundary for the VIPR as described in response to GDC 14.

Atomic Alchemy RCS reactor coolant system piping is designed and fabricated in accordance with ASME BPVC Section III and meets the requirements of fracture toughness of ferritic materials in Section III of the ASME Code. The reactor coolant boundary piping materials exposed to the coolant are corrosion resistant. Allowable pressure-temperature relationships for plant heat-up and cooldown rates are calculated using methods derived from the ASME Code, Section III, Appendix G. The VIPR does not have a reactor vessel; therefore, any other fracture toughness requirements of 10 CFR Part 50 Appendix G and 10 CFR Part 50 Appendix H do not apply to the VIPR RCS boundary. The reactor core is located in an open-to-atmosphere light water pool that has an aluminum liner.

Similar material surveillance type programs will be described in FSAR Chapter 13, Appendix A and QAPD for Atomic Alchemy's "Material Control and Accountability Program", Reactor Light Water Pool Liner Inspection", and the "Reactor Coolant Piping Material Inspection Program".

FSAR Chapter 5, Section 3 will describe the functional design of the RCS components that comprise the RCS boundary.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 6.2.7.
FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.26.

CRITERION 32 – INSPECTION OF REACTOR COOLANT PRESSURE BOUNDARY

Components which are part of the reactor coolant pressure boundary shall be designed to permit (l) periodic inspection and testing of important areas and features to assess their structural and leak-tight integrity and (2) an appropriate material surveillance program for the reactor pressure vessel.

Atomic Alchemy Compliance

Per 10 CFR 50.2, the reactor coolant pressure boundary includes all pressure-retaining components such as pressure vessels, piping, pumps, and valves, which are part of the RCS, or connected to the RCS. As an NPUF, Atomic Alchemy re-defines the reactor coolant pressure boundary for the VIPR as described in response to GDC 14.

The examination requirements of ASME Section XI, Subsection IWB, apply to all Class 1 pressure retaining components and their welded attachments. Atomic Alchemy (or its subcontractors) maintain control over material selection and fabrication for the reactor coolant pressure boundary components so that the boundary behaves in a nonbrittle manner.

The VIPR does not have a reactor vessel; therefore, the fracture toughness surveillance requirements of Part 50 Appendix H do not apply to the RCS boundary.

Piping bends are used in lieu of pipe fittings to minimize the number of welded connections. RCS piping is routed through concrete pipe chases which have adequate removable HELB hatches for ASME Section XI inspections. The connection of the RCS piping to the reactor core light water pool is also accessible for inspection in this manner.

FSAR Chapter 5, Section 3 will describe the functional design of RCS Piping Boundary Integrity.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.6.2, 3.6.3, and 5.2.4. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.45.

CRITERION 33 – REACTOR COOLANT MAKEUP

A system to supply reactor coolant makeup for protection against small breaks in the reactor coolant pressure boundary shall be provided. The system safety function shall be to assure that specified acceptable fuel design limits are not exceeded as a result of reactor coolant loss due to leakage from the reactor coolant pressure boundary and rupture of small piping or other small components which are part of the boundary. The system shall be designed to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished using the piping, pumps, and valves used to maintain coolant inventory during normal reactor operation.

Atomic Alchemy Compliance

The reactor coolant makeup system is the Chemical Volume and Control System (CVC). Atomic Alchemy takes an exception to this general design criterion in that they are not applicable, because the Atomic Alchemy CVC system does not perform a safety related function and it is not powered by safety related onsite or offsite power.

The VIPR does not use a pressure vessel for the reactor core. The VIPR coolant piping system is designed so that it discharges directly into an open-to-atmosphere reactor light water pool.

Atomic Alchemy uses a "leak before break" analysis of ASME Section III piping (RCS). A piping rupture hazards analysis is also performed on high and medium energy secondary systems that connect to the RCS system. The Atomic Alchemy technical specifications will establish conservative limits on the total volume of acceptable light water pool and RCS piping leakage.

A nozzle connection to the RCS piping provides for purification flow and makeup flow from a non-safety related Chemical and Volume Control (CVC) System (Non-Category Seismic I piping attached to Category Seismic I systems satisfy the SRP 3.9.2 guidelines) to the reactor coolant system.

The non-safety-related chemical and volume control system automatically provides inventory control to accommodate minor leakage from the reactor coolant system, any potential expansion during heat-up from cold shutdown, and any potential contraction during cooldown during normal operations. The CVC system can also be powered by a non-safety related diesel generator system when offsite AC power is unavailable during normal operations.

The passive nature of the design of the light water pool ensures fuel design limits are not exceeded as a result of loss of reactor coolant inventory due to RCS boundary leakage or rupture of components that comprise the RCS boundary.

FSAR Chapter 5, Section 4 will describe the RCS makeup water system.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.9.2 and 9.2.5.

CRITERION 34 – RESIDUAL HEAT REMOVAL

A system to remove residual heat shall be provided. The system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded.

Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure.

Atomic Alchemy Compliance

The Atomic Alchemy VIPR core and spent fuel light water pool do not require any post-accident forced cooling; it relies on convection cooling for decay heat or residual heat removal.

The Atomic Alchemy design satisfies the intent of this criterion by further reducing any potential risk associated with loss of the decay heat removal function through a combination of safety-related passive systems and non-safety-related active systems. The VIPR design therefore does not rely on a designated safety-related Residual Heat Removal system.

The VIPR core is located on top of a reactor coolant supply (RCS) plenum, located at the bottom of an open-to-atmosphere reactor light water confinement pool (which also houses the spent fuel in a lower cavity opposite to the core).

In the event that the primary reactor coolant flow is interrupted, re-circulation slots located on each side of the RCS supply plenum (which is located directly under the reactor core) will provide a path for natural convection cooling to be established within the light water pool. In order to prevent any debris from obstructing the slot openings, recirculation screens are provided.

Additionally, the screens are protected from any obstructing debris by protective plates that are located above the top of and extend past the of sides of the screens. The plate dimensions are relative to the portion of the screens where water flow enters the screen openings. Slot openings are sized such that any postulated reactor pool debris would not prevent the light water-cooling convection function.

A nozzle connection from the non-safety related CVC pumps (that can be powered from the non-safety related diesel generator) to the RCS piping can also be utilized to assist in creating a small nominal minimum flow across the core in the light water pool to further enhance convection cooling.

However, the design of the light water pool is such that natural convection cooling is all that is necessary to maintain acceptable fuel design limits.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 4.4, 5.4.7, and 9.2.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.29, 1.82, and 1.139.

CRITERION 35 – EMERGENCY CORE COOLING

A system to provide abundant emergency core cooling shall be provided. The system safety function shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that (1) fuel and clad damage that could interfere with continued effective core cooling is prevented and (2) clad metal-water reaction is limited to negligible amounts.

Suitable redundancy in components and features and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure.

Atomic Alchemy Compliance

The VIPR core and spent fuel located in the light water pool does not require any post-accident active systems for cooling; it relies on convection cooling for decay heat or residual heat removal.

The Atomic Alchemy design, however, will provide an additional Reactor Decay Heat Removal (DHR) safety related system that meets the intent of this GDC, and functions independent of onsite or offsite AC power supplies, assuming single active failures. This Atomic Alchemy reactor decay heat removal system also does not rely on the non-safety-related diesel-generators or the 1E UPS power system for electrical power to either actuate or operate the various DHR system components.

The Atomic Alchemy Facility utilizes the volume of light water contained in the molybdenum target transfer light water canal system (TTW) as an “emergency core cooling” (ECC) type of system. Components of the TTW system that provide this function are separately designated as a DHR system component. DHR system components are Safety Class A, Quality Class A, and Seismic Cat-I.

Each pair of VIPR light water pools share one common light water target transfer canal (TTW). The sharing of this backup makeup water source does not impair the capability of either VIPR safety-related systems to perform intended safety functions. The volume of water stored in the TTW system transfer canal pool is sufficiently sized for decay heat removal for two reactor pools on a loss of coolant accident if needed.

Additionally, the TTW system also includes a manually activated non-safety related makeup water storage tank located within the radioisotope production process module building with the capacity to refill the transfer canal if needed.

Even without ECC system activation, a postulated LOCA in the Atomic Alchemy accident analysis does not cause the core to become uncovered, therefore, even in the low-level water state the reactor light water pools alone are capable of dissipating decay heat of both the VIPR core and the spent fuel for 30 days by convection alone.

During a loss of coolant accident, in-series swing check valves whose function is to open on reversal of pressure differential between the Light Water Pool and the TTW canal pool (located below the canal water level) in the water/air lock dikes automatically open allowing the volume of the canal water (TTW system) to refill the VIPR pool by gravity alone.

FSAR Chapter 6, Section 3 will describe the Reactor Decay Heat Removal system.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy’s compliance with SRP 6.2.2, and 9.2.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy’s compliance with regulatory guides 1.27, and 1.157.

CRITERION 36 – INSPECTION OF EMERGENCY CORE COOLING SYSTEM

The emergency core cooling system shall be designed to permit appropriate periodic inspection of important components, such as spray rings in the reactor pressure vessel, water injection nozzles, and piping, to assure the integrity and capability of the system.

Atomic Alchemy Compliance

The Atomic Alchemy utilizes the molybdenum target transfer light water canal system (TTW) as its only designated safety-related “emergency core cooling” type of system. The components of the TTW system that function in this capacity are designated as reactor decay heat removal (DHR) system components and are Safety Class A, Quality Class A, and Seismic Cat-I. This a passive system that does not utilize any components that require any onsite or offsite AC power.

Additionally, the TTW system also includes a manual activated non-safety-related makeup water storage tank located within the radioisotope production process module building with the capacity to refill the transfer canal if needed.

The system piping and components are designed to permit access for periodic inspection of equipment, according to the ASME Code and technical specification requirements, to provide confidence in the integrity and capability of the systems.

FSAR Chapter 6, Section 6 will describe the Inservice Testing and Inspection of Quality Class Components.

Technical Specifications LCO 3.5 will describe the Reactor Decay Heat Removal limited conditions of operation and surveillances.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 5.2.4, and 5.4.2.2.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.116, 1.178 and 1.192.

CRITERION 37 – TESTING OF EMERGENCY CORE COOLING SYSTEM

The emergency core cooling system shall be designed to permit appropriate periodic pressure and functional testing to assure (1) the structural and leak-tight integrity of its components, (2) the operability and performance of the active components of the system, and (3) the operability of the system as a whole and under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including operation of applicable portions of the protection system, the transfer between normal and emergency power sources, and the operation of the associated cooling water system.

Atomic Alchemy Compliance

The Atomic Alchemy utilizes the molybdenum target transfer light water canal system (TTW) as its only designated safety-related "emergency core cooling" type of system. The components of the TTW system that function as DHR components are Safety Class A, Quality Class A, and Seismic Cat-I. The DHR system is a passive system that does not utilize any components that require any onsite or offsite AC power.

Because of these passive design features, Atomic Alchemy takes an exception to this general design criterion requirement for full operational periodic functional testing of active components under design conditions. The only active component (as defined by the IAEA Safety Glossary) in the Atomic Alchemy DHR system are the in-series check valves whose function is to open on reversal of pressure differential between the Light Water Pool and the TTW canal pool.

The DHR system components are designed to permit access for periodic testing according to the ASME Section XI Code and technical specification requirements, to provide confidence in the integrity and capability of the system. Atomic Alchemy will determine the acceptance criteria within certain OM Code-defined expectations including bi-directional testing when it establishes an IST acceptance criterion for these type A and type C check valves.

Initial verification of the water transfer capability and functional operation of the reactor decay heat removal system under design conditions is performed by conducting a natural circulation flow test.

This test will be conducted during hot functional testing of the reactor coolant system which will include testing the DHR check valves under a drain down of the light water pool before fuel load.

The Decay Heat Removal System (a subsystem of the TTW) design has significantly reduced the number of I&C support systems required for system operation. Atomic Alchemy will determine which non-safety related TTW SSCs should fall within the scope of 10 CFR 50.65(b).

Based on the above design elements, the Atomic Alchemy design conforms with the intent of GDC 37.

Technical Specifications LCO 3.5 will describe the Reactor Decay Heat Removal limited conditions of operations and surveillances.

FSAR Chapter 6, Section 3 will describe the pre-operational and periodic testing requirements of the emergency core cooling system.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.9.2, 5.2.4, 6.2.6, and SRP 7.1 Table 7-1.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.22, 1.68.2, 1.79, 1.116, 1.171, 1.192, and regulatory guide 3.22.

CRITERION 38 – CONTAINMENT HEAT REMOVAL SYSTEM

A system to remove heat from the reactor containment shall be provided. The system safety function shall be to reduce rapidly, consistent with the functioning of other associated systems, the containment pressure and temperature following any loss of coolant accident and maintain them at acceptably low levels.

Suitable redundancy in components and features and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electrical power system operation (assuming offsite power is not available) and for offsite electrical power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in Atomic Alchemy's response to GDC 16.

The Atomic Alchemy design only uses passive systems for post loss of coolant accident heat removal in the confinement module building. The reactor light water pool, which houses both the reactor core and the spent fuel assemblies, is the safety-related ultimate heat sink for the removal of the reactor coolant system sensible heat, core decay heat, spent fuel decay heat and stored energy.

An over pressurization failure of the confinement module building by a LOCA is not a credible transient in the Atomic Alchemy NPUF FSAR, Chapter 15 accident analysis. Following the loss of the reactor coolant system, the reactor will be scrammed, and should the Reactor Decay Heat Removal system (DHR) also suffer a catastrophic failure, the confinement atmosphere will continue to cool down by natural convection alone, maintaining the structure pressure and temperature at an acceptable level.

Heat from the light water pool is transferred to the confinement module atmosphere which is then transferred to the confinement module building structure by natural convection and condensation.

The Reactor Confinement Module HVAC System (RCV) and the Reactor Confinement Module Re-Circulating Sensible Cooling/Heating System (RCX) are redundant non-safety related systems that perform cooling/heating functions during normal operations. Both systems can also be powered from the non-safety related Diesel Generator.

Atomic Alchemy will determine which non-safety related ventilation cooling systems and respective components will fall within the scope of the Atomic Alchemy 10 CFR 50.65(b) program.

Based on the above design features, Atomic Alchemy meets the intent of GDC 38.

Technical Requirements Manual Section 3.6 will describe for Confinement Module HVAC systems availability requirements.

See FSAR Chapter 6, Section 2, and Section 7 for a description of the passive reactor confinement module building heat removal system.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 4.4, 6.1.1, 6.2.2 and SRP 9.2.5. Also, see FSAR Chapter 1, Appendix A, which will describe Atomic Alchemy's compliance with regulatory guide 1.7, 1.27, and regulatory guide 1.157.

CRITERION 39 – INSPECTION OF CONTAINMENT HEAT REMOVAL SYSTEM

The containment heat removal system shall be designed to permit appropriate periodic inspection of important components, such as the torus, sumps, spray nozzles and piping, to assure the integrity and capability of the system.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in Atomic Alchemy's response to GDC 16.

The Atomic Alchemy design uses a passive system for post loss of coolant accident heat removal from the atmosphere of the confinement module building as described in its response to GDC 38. The system components are designed to permit access for periodic inspection of equipment, according to the ASME Code and technical specification requirements, to provide confidence in the integrity and capability of the system.

FSAR Chapter 6, Section 7 will describe the inspection of components that comprise the reactor confinement module building passive heat removal system.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 9.2.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.27.

CRITERION 40 – TESTING OF CONTAINMENT HEAT REMOVAL SYSTEM

The containment heat removal system shall be designed to permit appropriate periodic pressure and functional testing to assure (1) the structural and leak tight integrity of its components, (2) the operability and performance of the active components of the system, and (3) the operability of the system as a whole, and, under conditions as close to the design as practical the performance of the full operational sequence that brings the system into operation, including operation of applicable portions of the protection system, the transfer between normal and emergency power sources, and the operation of the associated cooling water system.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in Atomic Alchemy's response to GDC 16.

The Atomic Alchemy design uses a passive system for post loss of coolant accident heat removal in the confinement module building as described in response to GDC 38. Atomic Alchemy takes an exception to GDC 40 periodic functional testing of this passive system. The system relies upon natural convection and condensation to occur within the confinement module building to reduce internal pressure of the building. Initial testing verification of the heat transfer capability of the passive confinement heat removal system is performed by conducting a natural circulation test. This test is conducted during hot functional testing of the RCS system.

FSAR Chapter 6, Section 7 will describe the inspection of components that comprise the confinement module building heat removal system.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 9.2.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.27.

CRITERION 41 – CONTAINMENT ATMOSPHERE CLEANUP

Systems to control fission products, hydrogen, oxygen, and other substances which may be released into the reactor containment shall be provided, as necessary, to reduce, consistent with the functioning of other associated systems, the concentration and quantity of fission products released to the environment following postulated accidents and to control the concentration of hydrogen or oxygen and other substances in the containment atmosphere following postulated accidents to assure that containment integrity is maintained.

Each system shall have suitable redundancy in components and features and suitable interconnections, leak detection, isolation, and containment capabilities to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation *(assuming onsite power is not available) its safety function can be accomplished, assuming a single failure.*

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPRs as a "confinement boundary". This is described in Atomic Alchemy's response to GDC 16.

As a further conservatism, Atomic Alchemy will apply a review of GDC 41, 42 and 43 criterions to the Radioisotope Production Process module, Target Fabrication Module and Radwaste module buildings as they each may present a potential for a release of radioactive products to the environment following postulated transients described in the FSAR Chapter 15 accident analysis.

The Atomic Alchemy's fission products control strategy does not require onsite or offsite AC power and does not depend on active systems to remove airborne particulates or elemental iodine from the confinement atmospheres of the Reactor Module, Radioisotope Production Process Module, Target Fabrication Module, or Radwaste Module following a postulated accident in any of these building modules. Atomic Alchemy fission product control is provided via natural removal processes such as deposition and sedimentation within the reactor confinement module, the radioisotope production process module, and radwaste module buildings and by limiting the module building's leakage. These naturally occurring removal processes provide significant removal capability such that airborne elemental iodine is reduced to very low levels within a few hours and the airborne particulates are reduced to extremely low levels within 12 hours.

The Atomic Alchemy Reactor Confinement Module, Radioisotope Production Process Module, Target Fabrication Module, and Radwaste Module buildings do not require engineered safety feature (ESF) atmosphere cleanup systems to meet limits on doses offsite or onsite. The reactor Confinement Air Filtration System (RCF), Radioisotope Production Process Module Air Filtration Systems (PMF), Mo99 Target Fabrication Module Air Filtration system (TPF), and the Radwaste Module Air Filtration system (WHF) are non-safety related systems. The purpose of these filter ventilation systems is to control normal operating releases. These systems may also be powered by the non-safety related Diesel Generator. The RCF, PMF, TPF, and WHF systems are not required for any post-accident scenarios.

The generation of hydrogen in the reactor confinement module or within the radioisotope production process modules under post-accident conditions has been evaluated. The concentration of uniformly distributed hydrogen produced by the equivalent of a 75 percent active fuel-clad metal water reaction does not exceed 13% by volume during and following any postulated degraded core event. Similarly, there is no credible transient that can occur within the radioisotope production process modules that could produce a significant amount of combustible gases. The potential for hydrogen or combustible gas buildup greater than 10% is not a credible transient in the Atomic Alchemy FSAR Chapter 15 accident analysis. For the purposes of good business practice, however, a non-safety combustion gas monitoring system is employed. The non-safety related fire protection smoke exhaust system can be utilized to purge any combustible gases, and natural convection will minimize any accumulation of combustible gases inside the confinement module, radioisotope production process module, or radwaste module buildings.

FSAR Chapter 15, Appendix B- “Removal of Airborne Activity from the Reactor Confinement Module Atmosphere Following a Design Basis Accident”, and FSAR Chapter 15, Appendix C - “Removal of Airborne Activity from the Radioisotope production process Production Module, Radioisotope Target Fabrication Module and Radwaste Processing Module Atmosphere Following a Design Basis Accident” will describe the Atomic Alchemy atmosphere cleanup methodology.

FSAR Chapter 9, Section 4 will describe the components that comprise the reactor confinement module, reactor auxiliary module, radioisotope production process module and radwaste module building air filtration systems.

For hydrogen related issues, FSAR Chapter 1, Appendix D, will describe Atomic Alchemy’s compliance with Generic Safety Issues, Section 2.0 - Task Action Plan Items, and Section 3.0 – New Generic Issues

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy’s compliance with SRP 6.2.3, 6.2.5, 6.5.1, 6.5.2, 9.1.3, and SRP 9.4.2. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy’s compliance with regulatory guide 1.7, and 1.52.

This also satisfies the intent of 10 CFR 70.64(a)(6).

CRITERION 42 – INSPECTION OF CONTAINMENT ATMOSPHERE CLEANUP SYSTEM

The containment atmosphere cleanup systems shall be designed to permit appropriate periodic inspection of important components such as filter frames, ducts, and piping, to assure the integrity and capability of the systems.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in Atomic Alchemy’s response to GDC 16.

As previously described in the Atomic Alchemy response to GDC 41, the atmosphere cleanup systems have no safety-related post-accident cleanup functions. Atomic Alchemy therefore takes an exception to this General Design Criterion requirement on the basis that it is not applicable. Dose mitigation is passively provided by the confinement module, radioisotope module, target fabrication, and radwaste module building isolation and integrity, natural removal processes, and limited module building leakage.

For good business practice, however Atomic Alchemy intends to perform inspections for component integrity, availability of active components, availability of these systems (RCF, PMF, TPF and WHF) as a whole, and performance of the sequence that brings the system into operation. Further, Atomic Alchemy will determine which non-safety related filtration systems and components will fall within the scope of the Atomic Alchemy 10 CFR 50.65(b) program.

FSAR Chapter 9, Section 4 will describe the periodic inspection of the components that comprise the confinement, radioisotope production process module, and radwaste module building air filtration systems.

FSAR Chapter 13, Appendix A, will describe the Atomic Alchemy Maintenance Rule program.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.9.2, 6.2.6, Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.7, and 1.52.

This also satisfies the intent of 10 CFR 70.64(a)(8).

CRITERION 43 – TESTING OF CONTAINMENT ATMOSPHERE CLEANUP SYSTEMS

The containment atmosphere cleanup systems shall be designed to permit appropriate periodic pressure and functional testing to assure (1) the structural and leak-tight integrity of its components, (2) the operability and performance of the active components of the systems such as fans, filters, dampers, pumps, and valves, and (3) the operability of the systems as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the systems into operation, including operation of applicable portions of the protection system, the transfer between normal and emergency power sources, and the operation of associated systems.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in Atomic Alchemy's response to GDC 16.

As further described in the Atomic Alchemy response to GDC 41, the atmosphere cleanup systems have no safety-related post-accident cleanup functions. Dose mitigation is passively provided by the confinement module, radioisotope module, Target Fabrication Module, and radwaste module building isolation and integrity, natural removal processes, and limited module building leakage.

However Atomic Alchemy intends to perform functional testing for component integrity, availability of active components, availability of the system as a whole, and performance of the sequence that brings the system into operation and Atomic Alchemy will determine which non-safety related components will fall within the scope of the Atomic Alchemy 10 CFR 50.65(b) program.

FSAR Chapter 9, Section 4 will describe the periodic inspection of the components that comprise the confinement, radioisotope production process module and radwaste module building air filtration systems.

FSAR Chapter 13, Appendix A, and the QAPD will describe the Atomic Alchemy Maintenance Rule program.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.9.2, 6.2.6, Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.7, 1.52 and 1.163.

This also satisfies the intent of 10 CFR 70.64(a)(8).

CRITERION 44 – COOLING WATER

A system to transfer heat from structures, systems, and components important to safety to an ultimate heat sink shall be provided. The system safety function shall be to transfer the combined heat load of these structures, systems, and components under normal operating and accident conditions.

Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished assuming a single failure.

Atomic Alchemy Compliance

The Atomic Alchemy facility design does not have a containment vessel or containment type structure. As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in the Atomic Alchemy response to GDC 16.

The VIPR core is located in open-to-atmosphere light water pool (along with the spent fuel) within a concrete and steel confinement module building. The light water pool is the ultimate heat sink for the Atomic Alchemy reactor confinement module building. Atmospheric heat within the confinement module building is removed by condensation and convection from the building structure. This meets the intent of GDC 44.

The building will be maintained at -0.25 W.G. with respect to the other contiguous plant areas and the environment under all wind conditions up to the wind speed at which diffusion becomes sufficient to assure site boundary exposures less than those calculated for the design basis accident even if exfiltration occurs.

The reactor and spent fuel light water pool can be cooled without onsite or offsite AC electric power. There are no additional safety-related active components performing cooling functions other than the RCS system (during normal operations) and the DHR system (during any transient conditions).

The ventilation cooling systems, Reactor Confinement Module HVAC System (RCV) and the Reactor Confinement Module Re-Circulating Sensible Cooling/Heating System (RCX) are redundant non-safety related systems that perform cooling/heating functions during normal operations.

The Atomic Alchemy ultimate heat sink does not rely on any external natural sources of water. Additionally, Atomic Alchemy has conservatively added a ECC type of system, designated as Reactor Decay Heat Removal (DHR). Emergency shutdown can utilize the cool water from the molybdenum target transfer light water canal system (TTW) as an “emergency core cooling” type of system. The target transfer light water canal is a passive seismically designed Cat-I system to meet this requirement (as described in GDC 35).

Additionally, the TTW system also includes a makeup water storage tank with the capacity to refill the transfer canal by operator action if needed.

Any postulated accident-initiated temperature or pressure buildup within the radioisotope production process module building or radwaste module building will also be mitigated by condensation and convection alone without onsite or offsite AC power. Any temperature or pressure transients that are initiated in the radioisotope module or radwaste module will be evaluated in FSAR Chapter 15, Section 9 for their impact on the reactor module functions.

FSAR Chapter 6, Section 2 will describe the inspection of components that comprise the confinement module, radioisotope production process module, and radwaste module building heat removal systems.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 2.4.8, 2.4.11, 9.1.3, 9.2.2, and SRP 9.2.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.27.

CRITERION 45 – INSPECTION OF COOLING WATER SYSTEM

The cooling water system shall be designed to permit appropriate periodic inspection of important components, such as heat exchangers and piping, to assure the integrity and capability of the system.

Atomic Alchemy Compliance

The Atomic Alchemy facility design only uses passive safety related methods for post loss of coolant accident heat removal in the reactor confinement module building. Therefore, Atomic Alchemy takes an exception to this general design criterion requirement for periodic inspections of "components such as HX's, piping and pumps etc." as it is not applicable to the Atomic Alchemy passive design methodology.

The reactor confinement structure is Seismic Cat-I, built to ACI 349, and AISC-N690 standards. The passive safety system relies upon natural convection and condensation to occur within the reactor confinement module building to reduce internal pressure of the building.

Initial inspection verification of the heat transfer capability of the passive confinement heat removal system is performed by conducting a natural circulation test. This test is conducted during hot functional testing.

Atomic Alchemy does intend to perform periodic inspections for component structure integrity. FSAR Chapter 13, Appendix A will describe the structures monitoring program, and Atomic Alchemy will determine if any non-safety related components fall within the scope of 10 CFR 50.65(b).

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 2.4.8, 2.4.11, 9.1.3, 9.2.2, and SRP 9.2.5.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.27.

CRITERION 46 – TESTING OF COOLING WATER SYSTEM

The cooling water system shall be designed to permit appropriate periodic pressure and functional testing to assure (1) the structural and leak-tight integrity of its components, (2) the operability and the performance of the active components of the system, and (3) the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence *that brings the system into operation for reactor shutdown and for loss of coolant accidents, including operation of applicable portions of the protection system and the transfer between normal and emergency power sources.*

Atomic Alchemy Compliance

The Atomic Alchemy facility design only uses passive safety related methods for post loss of coolant accident heat removal in the confinement module building. Therefore, Atomic Alchemy takes an exception to periodic "full operational" functional testing of "protection I&C systems, transfer of between power sources etc." as it is not applicable to the Atomic Alchemy passive design methodology.

The reactor confinement structure is Seismic Cat-I, built to ACI 349, and AISC-N690 standards. The cooling system relies upon natural convection and condensation to occur within the confinement module building to reduce internal pressure of the building. Initial testing verification of the heat transfer capability of the passive confinement heat removal system is performed by conducting a natural circulation test. This test will be conducted during hot functional testing of the RCS system.

Atomic Alchemy does intend to perform periodic tests for component structure integrity. FSAR Chapter 13, Appendix A will describe the structures monitoring program, and Atomic Alchemy will determine if any non-safety related components fall within the scope of 10 CFR 50.65(b).

FSAR Chapter 13, Appendix A will describe the Atomic Alchemy Maintenance Rule program.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 2.4.8, 2.4.11, 9.1.3, 9.2.2, and SRP 9.2.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.27.

CRITERION 50 – CONTAINMENT DESIGN BASIS

The reactor containment structure, including access opening, penetrations, and the containment heat removal system, shall be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any loss of coolant accident. This margin shall reflect consideration of (1) the effects of potential energy sources which have not been included in the determination of the peak conditions, such as energy in steam generators and energy from metal-water and other chemical reactions that may result from degraded emergency core cooling functioning, (2) the limited experience and experimental data available for defining accident phenomena and containment responses, and (3) the conservatism of the calculational model and input parameters.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in the Atomic Alchemy response to GDC 16.

The typical ALWR, PWR, and BWR reactor containment building structure and vessel critical pressures, leakage rates and temperatures criterion are not applicable to the design of the Atomic Alchemy reactor confinement module building. An over pressurization event caused by a pipe rupture within the reactor confinement module or any type of similar accident within the reactor auxiliary module, radioisotope module, or radwaste module buildings that can challenge the structural integrity of these buildings are not credible events in the FSAR Chapter 15 accident analysis.

The design of the Reactor Confinement module, Reactor Auxiliary module, Radioisotope Production Process module, Target Fabrication Module, and Radwaste module building prevents the rapid, uncontrolled release of radioactive material to the environment. The Atomic Alchemy module buildings establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the design conditions important to safety are not exceeded for as long as postulated accident conditions require.

The design of the Reactor Confinement module, Reactor Auxiliary module, Radioisotope Production Process module, Target Fabrication Module, and Radwaste module structures are based on their respective design basis accidents, which conservatively included the rupture of reactor coolant piping and loss of coolant for the reactor confinement module. These five buildings are constructed to Seismic Cat-I, built to ACI 349, and AISC-N690 standards. The maximum pressure and temperature reached, a description of the calculational model, and input parameters for the reactor confinement module building design basis accidents will be presented in FSAR Chapter 15, Table 15.7-01.

The Reactor Confinement module, Radioisotope module, Target Fabrication Module and Radwaste module buildings are capable of maintaining a negative pressure in relation to the atmosphere during normal operation and have a measurable leakage rate less than 5% over 24 hours.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 2.4.11, 3.6.3, 3.8.3, 6.2.1.2, 6.2.1.3, 6.2.1.4, 6.2.2, 6.2.3, and SRP 6.2.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.27, 1.29, 1.82, and regulatory guide 1.141.

This also satisfies the intent of 10 CFR 70.64(a)(9).

CRITERION 51 – FRACTURE PREVENTION OF CONTAINMENT PRESSURE BOUNDARY

The reactor containment boundary shall be designed with sufficient margin to assure that under operating, maintenance, testing, and postulated accident conditions (1) its ferritic materials behave in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The design shall reflect consideration of service temperatures and other conditions of the containment boundary material during operation, maintenance, testing, and postulated accident conditions, and the uncertainties in determining (1) material properties, (2) residual, steady-state, and transient stresses, and (3) size of flaws.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in the Atomic Alchemy response to GDC 16.

The Atomic Alchemy design follows the code requirements for nuclear safety-related structures of ACI-349 and AISC-N690, thereby reducing the probability of fracture propagation. The concrete and steel module building walls are designed for dead, live, thermal, pressure, safe shutdown earthquake, and conservatively, loads due to postulated pipe breaks.

The Atomic Alchemy confinement design will apply the ASME Section III, Division 1, Class MC (Metal Containment) and/or Section III, Division 2, Class CC (concrete containment) fracture toughness testing requirements to the reactor confinement module and radioisotope production process module building materials as applicable. This will be further evaluated and subsequently detailed in construction specifications.

The VIPR is located within an open to atmosphere light water pool which has an aluminum liner. For similar material surveillance type programs see FSAR Chapter 13, Appendix A and QAPD will describe Atomic Alchemy's "Material Control and Accountability Program", Reactor Light Water Pool Liner Inspection", and the "Reactor Coolant Piping Material Inspection Program".

FSAR Chapter 3, Section 8 will describe the seismic category I structures and systems.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 5.2.3.

CRITERION 52 – CAPABILITY FOR CONTAINMENT LEAKAGE RATE TESTING

The reactor containment and other equipment which may be subjected to containment test conditions shall be designed so that periodic integrated leakage rate testing can be conducted at containment design pressure.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPRs as described in Atomic Alchemy's response to GDC 16.

Atomic Alchemy will develop a leakage test of the boundaries of the reactor confinement and radioisotope production process module buildings to be developed similar to 10 CFR Part 50, Appendix J, Option B with leak detection, isolation, and performance testing capabilities, this will be provided in the Technical Specifications LCO 3.6.7 and LCO 3.6.14 for confinement module building and radioisotope module building, respectively.

Atomic Alchemy will also develop test intervals, pre-test inspections, and as found inspections as part of the leakage tests, which will be provided in the Technical Specifications.

FSAR Chapter 3, Section 8 will describe the leakage testing requirements for the reactor confinement module building.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 6.2.3, and SRP 6.2.6. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guides 1.11, 1.26, 1.141, and regulatory guide 1.163.

CRITERION 53 – PROVISIONS FOR CONTAINMENT TESTING AND INSPECTION

The reactor containment shall be designed to permit (1) appropriate periodic inspection of all important areas, such as penetrations, (2) an appropriate surveillance program, and (3) periodic testing at containment design pressure of the leak-tightness of penetrations which have resilient seals and expansion bellows.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPRs as described in GDC 16.

Atomic Alchemy will develop a leakage test of penetrations of the reactor confinement and radioisotope building modules to be developed similar to 10 CFR Part 50 Appendix J, Option B with leak detection, isolation, and performance testing capabilities, this will be provided in the Technical Specifications, (or TRM as appropriate). The Atomic Alchemy technical specifications will establish conservative limits on the total fraction of allowable reactor confinement module building leakage. The technical specifications will also specify periodic testing to detect bypass leakage paths, determine leakage rates, and verify operability of the reactor confinement module building.

Technical Specifications LCO 3.6.1 – Reactor Coolant System, LCO 3.6.8 – Radioisotope production process System, and Administrative Controls Section 5.6 - Programs, will describe testing and inspection requirements for the reactor confinement module building and the radioisotope production process module building.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.10, 5.2.4, and SRP 6.2.6.

CRITERION 54 – PIPING SYSTEMS PENETRATING CONTAINMENT

Piping systems penetrating the primary reactor containment shall be provided with leak detection, isolation and containment capabilities having redundancy, reliability, and performance capabilities which reflect the importance to safety of isolating these piping systems. Such piping systems shall be designed with a capability to test periodically the operability of the isolation valves and associated apparatus and to determine if valve leakage is within acceptable limits.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in GDC 16.

The Atomic Alchemy design incorporates a significant reduction in the number of penetrations between the reactor confinement module and the reactor auxiliary module and radioisotope production module buildings, respectively.

The reactor coolant piping system passes between the light water pool located in the reactor confinement module and reactor auxiliary module buildings in a water-tight pipe chase.

The Atomic Alchemy technical specifications will establish conservative limits on the total fraction of reactor coolant leakage. The technical specifications also specify periodic testing to detect bypass leakage paths, determine leakage rates, and verify operability of the reactor coolant system isolation valves.

The VIPR design also utilizes a pneumatic "rabbit" system (Seismic Cat-II) to transport radioisotope samples from inside the reactor pool (located inside the reactor confinement module) to the radioisotope production process module building. Once inside the radioisotope production process module building, the samples are collected inside an isolated chamber (under negative pressure with respect to the process module environment) and subsequently re-routed to hot cells for processing. These tubing/pipes are provided with isolation mechanisms that automatically close on an ESF isolation signal inside the confinement module and immediately outside the confinement module.

Each reactor confinement module building is connected to the radioisotope production process module building via a common light water transfer canal (TWW system). For the purpose of this GDC, this will be conservatively considered as a piping system penetration, as it connects to the primary reactor coolant water in the light water pool. The portion of the canal system within the radioisotope production process building is separated by series of water-tight combination gates/air locks from the reactor confinement module building portion of the canal.

The Atomic Alchemy confinement piping penetration design will satisfy the current NRC requirements including the post-TMI requirements (which will be discussed in FSAR Chapter 1, Appendix C (Compliance with 10 CFR 50.34(f)) and FSAR Chapter 1, Appendix D (Compliance with Generic Safety Issues)).

In general, this means that for all piping/tubing/canals two barriers are provided, one inside the reactor confinement and the other outside the reactor confinement. In the Atomic Alchemy design these barriers are either automatic valves, automatic shut-off devices, or automatic canal gates, but in some cases, they are closed piping or pneumatic tubing systems not connected to the reactor coolant system or to the containment atmosphere.

Confinement isolation valves/dampers close automatically on a confinement isolation signal. The confinement isolation signal is actuated by the protection and safety monitoring system (IMS).

FSAR Chapter 7, Section 3 will describe the functional design of the IMS system.

FSAR Chapter 3, Section 2 will describe the functional design of the radioisotope target transfer canal system (TTW).

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 6.2.4, and 6.2.6. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.163.

CRITERION 55 – REACTOR COOLANT PRESSURE BOUNDARY PENETRATING CONTAINMENT

Each line that is part of the reactor coolant pressure boundary and that penetrates primary reactor containment shall be provided with containment isolation valves as follows, unless it can be demonstrated that the containment isolation provisions for a specific class of lines, such as instrument lines, are acceptable on some other defined basis:

1. One locked closed isolation valve inside and one locked closed isolation valve outside containment; or

2. One automatic isolation valve inside and one locked closed isolation valve outside containment; or

3. One locked closed isolation valve inside and one automatic isolation valve outside the containment. A simple check valve may not be used as the automatic isolation valve outside containment; or

4. One automatic isolation valve inside and one automatic isolation valve outside containment. A simple check valve may not be used as the automatic isolation valve outside containment.

Isolation valves outside containment shall be located as close to containment as practical and, upon loss of actuating power, automatic isolation valves shall be designed to take the position that provides greater safety.

Other appropriate requirements to minimize the probability or consequences of an accidental rupture of these lines or of lines connected to them shall be provided, as necessary, to assure adequate safety. Determination of the appropriateness of these requirements, such as higher quality in design, fabrication, and testing, additional provisions for in-service inspection, protection against more severe natural phenomena, and additional isolation valves and containment, shall include consideration of the population density, and use characteristics, and physical characteristics of the site environs.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the reactor coolant pressure boundary for the VIPR as described in Atomic Alchemy's response to GDC 14.

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in GDC 16.

Atomic Alchemy takes exception to the general design criterion requirement of isolation for the RCS boundary that penetrates the reactor confinement boundary and will demonstrate an alternative basis of conformance to the intent of this GDC.

The Atomic Alchemy reactor coolant piping system is an open-to-atmosphere system, routed between the light water pool located in the reactor confinement module and the reactor auxiliary module buildings in a water-tight piping chase. Over pressurization of the RCS piping is therefore not a credible transient in the FSAR Chapter 15 accident analysis.

There are no locked closed isolation valves or automatic power operated isolation valves in the RCS system. (There are small-bore piping RCS lines carrying primary coolant outside the confinement module building, e.g., sample lines and CVC piping to/from the chemical and volume control system. These lines are used only periodically and are provided with automatic isolation valves inside and outside of the confinement module building). The system utilizes two check valves in series whose function is to close on reversal of flow between the Light Water Pool and the RCS pumps. The maximum counter flow pressure exerted on a closed check valve would be the equivalent static head of the depth of the light water pool, which is easily bounded by the design performance of the check valve. Therefore, these valves can be relied upon in performing the automatic isolation design function inside and outside of the confinement module building.

To minimize the probability of an occurrence and the subsequent consequences of an accidental rupture, the RCS piping design will incorporate piping bends instead of welded fittings, thus reducing the overall number of welds subject to rupture or leakage.

Similarly, a higher quality in design, fabrication, and testing will be provided to minimize this risk.

The components in the Reactor Coolant System (RCS) are Atomic Alchemy Equipment Safety Class A (equivalent to ANS Safety Class 1), Quality Group A, and are designed and fabricated according to ASME Code Section III, Class 1. Atomic Alchemy also uses a “leak before break” analysis of ASME Section III piping.

The qualification program for valves that are part of the reactor coolant boundary shall include testing or analysis that demonstrate that these valves will not experience leakage beyond the design criteria when subjected to design loading.

A piping rupture hazards analysis will also be performed on high and medium energy secondary piping systems that connect to the RCS system.

The Atomic Alchemy Technical Specifications will establish conservative limits on the total volume of acceptable RCS leakage in the piping chase.

Additional measures for leak detection will also be provided, Atomic Alchemy will provide a leakage test of the reactor coolant system boundaries and piping chases to be developed similar to Appendix J, Option B with leak detection, isolation, and performance testing capabilities, this will be provided in the Technical Specifications.

Based on the above design elements, the reactor coolant boundary (penetrating the confinement boundary) design conforms with the intent of GDC 55 to minimize the probability or consequences of an accidental rupture.

Technical Specifications LCO 3.3 will describe the RCS operational leakage and leak detection instrumentation.

Atomic Alchemy Technical Requirements Manual, Section 5.6.7 will describe the Reactor Coolant Heat Exchanger Inspection Program

FSAR Chapter 15, Section 7 will describe credible transients of the RCS system.

FSAR Chapter 5, Sections 3 and 4 will describe the RCS system.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy’s compliance with SRP 3.6.3, 5.2.3, 5.2.4, 6.2.1.3, 6.2.3, 6.2.4, 6.2.7, and SRP 15.6.5. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy’s compliance with regulatory guide 1.50 and 1.141.

CRITERION 56 – PRIMARY CONTAINMENT ISOLATION

Each line that connects directly to the containment atmosphere and penetrates the primary reactor containment shall be provided with containment isolation valves as follows, unless it can be demonstrated that the containment isolation provisions for a specific class of lines, such as instrument lines, are acceptable on some other defined basis:

1. One locked closed isolation valve inside and one locked closed isolation valve outside the containment; or

2. One automatic isolation valve inside and one locked closed isolation valve outside the containment; or

3. One locked closed isolation valve inside and one automatic isolation valve outside the containment. A simple check valve may not be used as the automatic isolation valve outside containment; or

4. One automatic isolation valve inside and one automatic isolation valve outside the containment. A simple check valve may not be used as the automatic isolation valve outside the containment.

Isolation valves outside the containment shall be located as close to the containment as practical and, upon loss of actuating power, automatic isolation valves shall be designed to take the position that provides greater safety.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in Atomic Alchemy's response to GDC 16.

Atomic Alchemy compliance with this GDC for the primary confinement isolation is demonstrated by at least one automatic isolation device located both inside and outside of the confinement module building.

Over pressurization of the Reactor Confinement Module (RCM) building by a LOCA is not a credible transient in the FSAR Chapter 15 accident analysis.

The Reactor Confinement Air Filtration System (RCF) is a non-safety related, seismic Cat-II system. The purpose of the filtration system is to control normal operating releases and assist in maintaining a negative pressure with respect to the environment and adjacent module buildings. It is not provided for accident mitigation or for confinement module isolation. The RCF system ductwork provides a transfer duct that permits air to cascade from the RCM module building to the PPM module building. The RCF system can be isolated by any combination of the following 3 devices, a motorized barometric damper, a normally open motorized isolation damper (fail closed) both of which are located inside the RCM building and a passive backdraft damper located within the PPM building.

The Reactor Auxiliary Module Cascade Exhaust System (RAE) is a non-safety related, seismic Cat-II system. The purpose of the filtration system is to control normal operating releases and assist in maintaining a negative pressure with respect to the environment. It is also not necessary for accident mitigation or confinement isolation. RAE system ductwork provides a transfer duct that permits air to cascade from the RAM building to the RCM building, it can also be isolated by a combination of the following 3 devices, a motorized barometric damper, a normally open motorized isolation damper (fail closed) both of which are located inside the RCM building and a passive backdraft damper located within the RAM building.

A higher quality in design, fabrication, and testing will be provided for the RAE and RCF systems.

Atomic Alchemy intends to perform pre-operational functional testing of the RCF and RAE systems for component integrity, availability of active components, availability of the system as a whole and performance of the sequence that brings the system into operation.

The RCF and RAE ductwork is automatically isolated by radiation monitors located inside the confinement and auxiliary module areas. Ductwork radiation monitors provide an alarm signal to the control room for initiation of operator manual isolation.

The motorized ductwork Isolation devices will close automatically on receipt of engineered safety features confinement isolation signal. These devices will close in 60 seconds or less. This time frame is consistent with the physically based source term for non-power reactors.

Electrical containment penetrations are equipped with test connections and test vents or have other provisions to allow periodic leak rate testing so that leakage is within the acceptable limits established in Technical Specifications (or in the TRM).

Based on the above, the Atomic Alchemy design conforms with the intent of GDC 56.

FSAR Chapter 9, Section 4 will describe the functional design of the RCF system.

FSAR Chapter 9, Section 4 will describe the functional design of the RAE system.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 6.2.3, 6.2.4, 6.2.6, and SRP 6.5.1. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.141.

CRITERION 57 – CLOSED SYSTEM ISOLATION VALVES

Each line that penetrates the primary reactor containment and is neither part of the reactor coolant pressure boundary nor connected directly to the containment atmosphere shall have at least one containment isolation valve which shall be either automatic, locked closed, or capable of remote manual operation. This valve shall be outside the containment and located as close to the containment as practical. A simple check valve may not be used as the automatic isolation valve.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in Atomic Alchemy's response to GDC 16 and re-defines the reactor coolant pressure boundary for the VIPR as described in its response to GDC 14.

Lines that penetrate the Reactor Confinement boundary, and are neither part of the reactor coolant boundary nor connected directly to the confinement module (or process module) atmosphere are considered closed systems within the confinement module (or process module) and are equipped with at least one confinement isolation valve of one of the following types:

a. An automatic isolation valve (not a check valve)
b. Remote manual operation valve

c. A locked-closed valve

FSAR Chapter 3, Section 2 will describe the Atomic Alchemy Quality Group Class C and Class D components.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.8.3, 6.2.3, 6.2.4, 6.2.6, and SRP 15.6.5.

CRITERION 60 – CONTROL OF RELEASES OF RADIOACTIVE MATERIALS TO THE ENVIRONMENT

The nuclear power unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal reactor operation, including anticipated operational occurrences. Sufficient holdup capacity shall be provided for the retention of gaseous and liquid effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment.

Atomic Alchemy Compliance

Atomic Alchemy will extend the evaluation of the requirements for control of releases of radioactive materials to the environment of GDC 60 to include the Radwaste Module, Target Fabrication Module, and the Radioisotope Production Process Module buildings in addition to applying the requirements to the reactor confinement and reactor auxiliary module buildings. Atomic Alchemy will also include criticality control requirements as appropriate.

Procedural processes and administrative controls are provided to control the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal reactor operation, target fabrication, radioisotope production, and radwaste processing including anticipated operational occurrences. These procedural processes and administrative controls also include criticality control features, to prevent a criticality from occurring as well as design features to minimize personnel exposure to hazardous chemicals. Radiological shielding is provided as necessary during radioisotope and target fabrication processes.

The radioactive waste management systems are designed to minimize the potential for a criticality and an inadvertent release of radioactivity from the facility and to provide confidence that the discharge of radioactive wastes is maintained below regulatory limits.

The design of the Reactor Confinement Module (RCM), Reactor Auxiliary Module (RAM), Target Fabrication Module (MTM), Radioisotope Production Process Module (PPM), and Radwaste Module (RWM) buildings prevent the rapid, uncontrolled release of radioactive material to the environment.

The Atomic Alchemy RCM, RAM, MTM, RWM, and PPM buildings establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the design conditions important to safety are not exceeded for as long as postulated accident conditions require.

The Atomic Alchemy facility design does not depend on active or safety related systems to remove airborne particulates or elemental iodine from the atmosphere of the RCM, RAM, MTM, RWM or PPM buildings following a postulated accident in any module building.

Naturally occurring passive removal processes provide significant removal capability such that airborne elemental iodine is reduced to very low levels within a few hours and the airborne particulates are reduced to extremely low levels within 12 hours.

The gaseous radwaste and liquid radwaste processing systems include continuous radiation monitoring of their discharge paths. Any high radiation detection automatically closes isolation valves in their respective trains.

The Atomic Alchemy Radwaste Program ensures compliance with the 10 CFR 20.1406 requirement that applicants describe how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment.

Radioactive processing, waste and management structures will be designed to the latest revision of ACI-318 for concrete structures and AISC-S326 for steel structures standards.

All Seismic Category I structures will be designed to the latest revision of AISC-N690. Where appropriate, the design of steel structures will incorporate provisions from the most recent AISC codes.

FSAR Chapter 3 Section 12 will describe hazardous waste and radwaste requirements and compliance with codes and standards.

FSAR Chapter 12, Section 2 will describe the hazardous chemicals that are used or may evolve during the radioisotope production process, along with the provisions to protect workers and the public from exposure.

FSAR Chapter 3, Section 2 will describe the RCM, RAM, MTM, RWM and PPM module buildings.

FSAR Chapter 3, Section 8 will describe the design of Seismic Category I structures.

FSAR Chapter 11, Section 3 will describe the Atomic Alchemy Radwaste Program.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 6.2.3, 6.2.4, and SRP 15.7.3.

FSAR Chapter 1, Appendix D, will describe Atomic Alchemy's compliance with NUREG-0933, Section 2, Task Action Plans Item A-28, Item A-36, and Item B-3, Section 3, and New Generic Issues, Issue 82, Issue 92, Issue 173, and Issue 202.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.21, 1.26, 1.143, and regulatory guide 5.11.

This also satisfies the intent of 10 CFR 70.64(a)(5) and 10 CFR 70.64(a)(9).

CRITERION 61 – FUEL STORAGE AND HANDLING AND RADIOACTIVITY CONTROL

The fuel storage and handling, radioactive waste, and other systems which may contain radioactivity shall be designed to assure adequate safety under normal and postulated accident conditions. These *systems shall be designed (1) with a capability to permit appropriate periodic inspection and testing of components important to safety, (2) with suitable shielding for radiation protection, (3) with appropriate containment, confinement, and filtering systems, (4) with a residual heat removal capability having reliability and testability that reflects the importance to safety of decay heat and other residual heat removal, and (5) to prevent significant reduction in fuel storage coolant inventory under accident conditions.*

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in its response to GDC 16.

The evaluation of applicable requirements for radioactivity control of GDC 61 that are applied to the Radwaste Module (RWM), Target Fabrication Module (MTM), and the Radioisotope Production Process Module (PPW) will instead be described in Atomic Alchemy's response to GDC 60 and GDC 63. This response to GDC 61 addresses the radioactivity controls for reactor fuel storage and reactor fuel handling, which is limited to the RCM building.

Again, procedural processes and administrative controls will be provided to handle both new fuel and spent fuel during normal reactor operation, including anticipated operational occurrences.

FSAR Chapter 9, Section 1 will describe new fuel, fuel loading, and spent fuel compliance with codes and standards, monitoring, testing, and inspections.

Both the VIPR core and spent fuel are located in a common light water pool. The spent fuel sits in a lower cavity below the level of the reactor core at the opposite end of the pool from the reactor.

The light water pool is designed so that a safe water level is maintained above the core and spent fuel assemblies for at least 72 hours following either a small-break or large-break LOCA, that level is sufficient to dissipate decay heat removal without AC power. After 72 hours the light water pool will continue to dissipate decay heat by natural convection alone for both the reactor core and the spent fuel for 30 days.

The walls of this pool are constructed using modular construction techniques. This allows higher quality than traditional construction. The advanced welding techniques used minimize the potential for weld failures during operation and allow for inspection to verify weld quality.

The pool leak detection system is zoned to allow identification of the area of the light water pool liner, which is leaking, even for very small leaks.

Sampling of the light water pool water (and RCS) for gross activity, tritium, and particulate matter is conducted periodically. The concentration of tritium in the spent fuel pool water is maintained at less than (TBD) microcuries per gram to provide confidence that the airborne concentration of tritium in the fuel handling area is within the limits specified in 10 CFR 20, Appendix B.

The non-safety related RCV and RCX HVAC systems provide the radiologically controlled area ventilation for the reactor confinement module building. FSAR Chapter 9, Section 4 will describe these systems. However, no credit is taken for operation of these systems in the evaluation of fuel handling accidents in the confinement module as will be discussed in FSAR Chapter 15, Section 8.

FSAR Chapter 3, Section 2 will describe the Atomic Alchemy spent fuel storage SSC's.

FSAR Chapter 13, Appendix A will describe the Fuel Loading Conditions Surveillance Program.

A description of the Spent Fuel Cooling System (SPF) components, which are a subsystem of the Reactor Coolant System (RCS) will be provided in FSAR Chapter 5, Section 3.

A description of the spent fuel pool radiation protection design features including testing and inspections, will be provided in FSAR Chapter 12, Section 3.

FSAR Chapter 1, Appendix B, will provide Atomic Alchemy's compliance with SRP 2.4.11, 5.2.4, 12.2, and SRP 15.6.5.

FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.13, 1.157, 1.227, and 1.45.

CRITERION 62 – PREVENTION OF CRITICALITY IN FUEL STORAGE AND HANDLING

Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in its response to GDC 16. Additionally, Atomic Alchemy will extend the evaluation of the requirements for prevention of a criticality of GDC 62 to the Radwaste Module, Target Fabrication Module, and the Radioisotope Production Process Module buildings.

A description of potential inadvertent nuclear criticality accidents will be provided in FSAR Chapter 15, Section 8 (RCM) and Section 9 (PPM, RWM and MTM). FSAR Chapter 9, Section 1 will describe the Atomic Alchemy criticality analysis for new fuel storage racks and an additional description of criticality monitoring.

Geometrically safe configurations as determined by an analysis of normal and abnormal fuel rack conditions and fuel rack designs will be performed and procedural processes, administrative controls, passive design features (shielding) will be provided to handle new fuel, spent fuel, and radioactive waste during normal reactor operations, including anticipated operational occurrences to prevent the possibility of a criticality event. The abnormal conditions include alternative depletion conditions, modified rack spacing, a single fuel assembly in various positions external to the spent fuel storage racks and filling various part-length rod locations with fuel material to represent dropped or damaged fuel configurations.

Procedural processes, administrative controls (i.e. material accountability), and passive design features (shielding) will be provided and geometrically safe configurations (including floor geometry, and layout of tanks, piping etc.), as determined by analysis of normal and abnormal facility conditions, will be performed for the handling and storage of raw inventory nuclear material and the physical transfer of radioisotope targets along the processing train (assembly, irradiation, disassembly) to prevent the possibility of a criticality event. The chemicals hazards associated with the processing of nuclear target material will be bounded by the radiological hazards. The design features and administrative controls preventing release of radioactive material and limiting radiation exposure from radioisotope processing will simultaneously protect employees from any chemical hazards.

Procedural processes, administrative controls, passive design features (shielding, containment dikes), will be provided and geometrically safe configurations (including floor geometry, and layout of tanks, piping etc.) as determined by analysis of normal and abnormal facility conditions will be performed for the handling, collection, (nuclear material recovery - possible future design feature), and storage of radioactive wastes (solid, liquid gaseous) to prevent the possibility of a criticality event. Waste volumes have not yet been determined. The chemicals hazards associated with the processing of nuclear waste material will be bounded by the radiological hazards. The design features and administrative controls preventing release of radioactive material and limiting radiation exposure from nuclear waste will simultaneously protect employees from any chemical hazards.

The Atomic Alchemy design also includes a Criticality Area Detection and Alarm System (ICA) and a separate Hot Cell Criticality Detection and Alarm System (ICC). FSAR Chapter 7, Section 9 will describe the criticality system and Section 9 will provide requirements and functional descriptions.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 9.1.1. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.13, 3.71.

FSAR Chapter 1, Appendix D, will describe Atomic Alchemy's compliance with NUREG-0933, Section 6, Nuclear Material Safety and Safeguards Issues, NMSS-0006, and NMSS-0015.

This also satisfies the intent of 10 CFR 70.64(a)(5) and 10 CFR 70.64(a)(9).

CRITERION 63 – MONITORING FUEL AND WASTE STORAGE

Appropriate systems shall be provided in the fuel storage and radioactive waste systems and associated handling areas (1) to detect conditions that may result in the loss of residual heat removal capability and excessive radiation levels and (2) to initiate appropriate safety actions.

Atomic Alchemy Compliance

Atomic Alchemy will extend the evaluation of the applicability of general design criterion requirements for monitoring fuel and radioactive waste storage of GDC 63 to the radwaste module, Target Fabrication Module, and the Radioisotope Production Process Module buildings in addition to the Reactor Confinement Module building.

As described in GDC 5, the Atomic Alchemy up to two light water pools share a common light water Transfer Canal System (TTW). Each reactor light water pool also stores its own spent fuel at the far end of the pool in a cavity below the core elevation. The light water pool spent fuel cavity is sized for a volume of 60 years + 10% margin worth of spent fuel. Spent fuel storage conditions will be administratively controlled by Atomic Alchemy programs.

Atomic Alchemy will describe the Reactor I&C Systems "Significant Monitored Parameters" in FSAR Chapter 7, Section 15 which includes: water level in the confinement light water pool, reactor core cooling, light water pool inventory, light water pool temperature, transfer canal pool inventory, transfer canal pool temperature, and N16 quantity.

Area radiation monitoring will be provided in the RCM, MTM, RWM, and PPM module buildings for personnel protection and general surveillance. Additionally, area radiation monitoring will be provided in the area of the RCS pumps and Heat Exchanger located in the RAM module building. The area monitor alarms locally and in the main control room.

Radiation levels are also monitored in the respective ventilation systems of each module building, should the levels reach a predetermined setpoint, an alarm is actuated in the main control room.

FSAR Chapter 7, Section 3 will describe the safety related instrumentation systems, including the Safety Related Reactor Instrument and Control Systems and the Safety Related Process Instrument and Control Systems.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy's compliance with SRP 3.8.4, 4.2, 9.1.1, 9.1.2, and 9.4.3. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy's compliance with regulatory guide 1.13, 1.227, and regulatory guide 3.71.

This also satisfies the intent of 10 CFR 70.64(a)(9).

CRITERION 64 – MONITORING RADIOACTIVITY RELEASES

Means shall be provided for monitoring the reactor containment atmosphere, spaces containing components for recirculation of loss of coolant accident fluids, effluent discharge paths, and the plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.

Atomic Alchemy Compliance

As an NPUF, Atomic Alchemy re-defines the containment boundary for the VIPR as described in Atomic Alchemy's response to GDC 16.

Atomic Alchemy will extend the evaluation of general design criterion requirements for monitoring radioactivity releases of GDC 64 to the Radwaste Module, Target Fabrication Module, and the Radioisotope Production Process Module buildings in addition to the Reactor Confinement module building.

The design of the reactor confinement module building prevents the rapid, uncontrolled release of radioactive material to the environment. The Reactor Confinement Module (RCM), Radwaste Module (RWM), Target Fabrication Module (MTM), and Radioisotope Production Process Module (PPM) buildings establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the design conditions important to safety are not exceeded for as long as postulated accident conditions require.

Area radiation monitoring is provided in the RCM, MTM, RWM, and PPM module buildings for personnel protection and general surveillance. The area monitor alarms locally and in the main control room. Radiation monitoring for the reactor auxiliary module building will be addressed by portal monitoring.

Radiation levels are also monitored in the respective ventilation systems of each module building. Should the levels reach a predetermined setpoint, an alarm is actuated in the main control room. A high radiation signal in a ventilation path causes an ESF automatic closure of the isolation damper or valve.

Radiation detection & monitoring and criticality detection & monitoring systems are Atomic Alchemy Seismic Class C-I, and Safety Class C.

Procedural processes and administrative controls will be provided to control the release of radioactive materials. Atomic Alchemy Offsite Dose Calculation Manual, Section ODM 5.6.1 will describe the Radioactive Process Effluent Control Program. The Standard Atomic Alchemy Radiological Effluent Controls (SREC) compiled in the ODM manual, and its accompanying procedures, will meet the requirements of 10 CFR 20.106, 40 CFR 190, 10 CFR 50.36(a), 10 CFR 70.59, and Appendix I to 10 CFR 50.

Atomic Alchemy will submit the following: Semiannual Radioactive Effluent Release Report (iaw 10 CFR 20.1302) and an Annual Radiological Environmental Operating Report. A list of all reports to be submitted by Atomic Alchemy will be provided in FSAR Chapter 13, Section 7.

Technical Specifications Administrative Controls section 5.6.5 will describe the Atomic Alchemy Radiation Protection Program.

Technical Specification Administrative Controls section 5.6.1 and FSAR Chapter 16, Appendix C will describe the Atomic Alchemy Offsite Dose Calculation Manual.

FSAR Chapter 1, Appendix B, will describe Atomic Alchemy’s compliance with SRP 2.4.13, 6.2.4, and 9.3.2. Also, FSAR Chapter 1, Appendix A, will describe Atomic Alchemy’s compliance with regulatory guides 1.21, 1.97, 3.71, 8.2, and 8.8.