This qualitative assessment supports the replacement of the Acme Nuclear Power Station (ANPS) safety related Chiller Controllers, supporting 50.59 Evaluation Number 2017-yyyy.

This assessment synthesizes data from all references provided in Section 8 to reach these conclusions, including several references (e.g., microprocessor datasheets) embedded in some of the cited references. As this assessment and the 50.59 Evaluation were written concurrently, this assessment references the 50.59 Evaluation for some materials, rather than duplicating the text in multiple places.

1. Activity Identification

The proposed activity replaces the safety related controls only in the existing, original, safety related chillers in the two unit ANPS with new safety related digital chiller controls. The 50.59 Evaluation provides a complete description of the change, in the opening paragraph before Question 1.

Each of the safety related chillers is a divisionally independent island of control. The chillers are in no way tied to, or dependent on, the operation of the Reactor Trip System or the Engineered Safety Features System. IEEE Std. 603 classifies the chillers as auxiliary supporting features.

At the conclusion of this activity, ANPS will replace the obsolete chiller controllers completely. Since the existing compressors, evaporators, motors, valves can support the new more environmentally friendly refrigerant, and since the mechanical equipment is in good condition (with minor maintenance and component replacement to be performed concurrently with the controller installation), only the controllers will be replaced.

With digital controls, additional display capabilities are provided. For this installation, safety related displays are provided local to the chiller and duplicated in the control room. Each display shows only the status for the chiller, avoiding any appearance of cross-connection between chiller controllers. For the control room display, only display capabilities are provided. At the local chiller, the displays provide control and monitoring capabilities for use by a technician or engineer. In order to protect the operation of the chillers, the technician or engineer must log in to the display with a protected, modifiable password, which the software automatically logs out after a short period of inactivity. In the control room, the displays replace existing incandescent lamps used for indication, with less power and heat generation from the upgraded operator displays.

2. Design Function Identification

The Design Function of the safety related chillers and chiller controls is identified in the 50.59 Evaluation, including references to all reviewed UFSAR sections.

The safety related Design Function is to provide chilled water to the air handlers for controlling temperature in a set of defined, conditioned spaces. The combined Unit 1 and Unit 2 control room is conditioned using chilled water from both the Unit 1 and Unit 2 Chilled Water Systems. The unit-specific conditioned spaces include safety related I&C equipment required for controlling and mitigating accidents and transients.

Although not specifically described in the UFSAR, the failure of the digital controls for one chiller would result in loss of that chiller, which is described in the UFSAR, and thus bounded. The failure of the digital controls in any single chiller cannot affect the operation of the digital controls in any other chiller. Single failure tolerance is provided by use of two 100% chillers. Both chillers in each unit must be in service, else the Limiting Condition of Operations (LCOs) requires transition to cold shutdown.

The replacement digital controllers operate, monitor, and alarm off normal conditions for the replacement chillers. The original, obsolete controls controlled the original chillers but had minimal monitoring and alarming capability.

The proposed modification does not create any new design functions that were not part of the original plant design. The new design does not merge control or monitoring for any other function with the chillers chiller controls. The same spaces that are currently conditioned by the chillers will be the only spaces that will be conditioned using the chilled water system after the modification.

3. Failure Mode Comparison

The improved design of the replacement chiller controllers results from several decades of knowledge gained since design of the original chillers, which eliminates several of the existing internal failure modes in the existing chiller controls. The replacement digital chiller controls have self-test and self-diagnostic features that the designers could not even consider in the original analog controls. Detection of faults and failures in the new digital chillers should result in more timely detection of those faults and failures, with new control room indication provided for each of the chillers.

There are three paths to failure for the digital controllers. Each potential failure mode is evaluated below and an evaluation made between the failure modes of the existing and replacement controllers. Evaluations of the failure modes indicate that the failure mechanisms are likely different, but that the end result is a failure mode for the replacement system that is at least similar or bounded by the failure mode for the existing equipment.

a. Failure due to an Internal Defect

> The commercial grade dedicators evaluated the response of the commercial chiller controls to various faults and failures from internal defects, using a single failure assumption, in a Hazards Analysis and a Failure Modes and Effects Analysis. The evaluations are based on single failures occurring in a single chiller controller. Neither the original nor the replacement chillers or chiller controllers are single failure tolerant individually, as each has many single points of vulnerability, but the dual chiller system redundancy provides single failure tolerance. The analyses did not identify any unexpected failure modes. There are no identified failure modes that are not identified automatically by the controller or manually through plant surveillance. The failure modes of the original equipment are equivalent to those of the replacement equipment, although the failure mechanisms are different in some cases.

All of the identified failures are detected and alarmed. Any failure that the software does not detect and alarm is expected to be detected during periodic surveillance tests and calibration checks (i.e., there are no silent failures associated with the new equipment).

b. Failure from Loss of Power

Each chiller compressor motor and chiller controller is supplied from a common safety related vital power source, backed by a separate emergency diesel generator (EDG). Each chiller is supplied from a different electrical division. The chiller shuts down on loss of power. For both original and replacement controls, the chiller restarts automatically when power is restored. For additional equipment protection, the replacement chiller adds detection of a loss of a phase and shuts the compressor motor down before damage occurs.

The replacement chiller controller provides a controlled sequence for startup and shutdown, based on the previous conditions (see the Software Requirements Specification for details). The replacement chiller controller takes longer to restart the chiller than the original chiller controls, such that starts after loss of offsite power (LOOP) do not load the chiller motor to the emergency diesel generator (EDG) at the same time in the sequence. The original controls started the compressor motor at 10 seconds after the EDG restores power to the input bus. The software in the replacement controls does not start the compressor for an additional 40 seconds after power is restored. The loss of chilled water for an additional minute after a LOOP has been determined to not be an issue, based on the thermal inertia in the conditioned spaces. The effects of this minor increase do not cause significant issues in the post-LOOP plant conditions, as demonstrated by the calculation referenced in the 50.59 Evaluation.

c. Failure Resulting from Environmental Factors

The replacement chiller controls have been qualified to operate in the environment in which they will be installed. Failures should not result from exposure to temperature, humidity, seismic, radiation, or electromagnetic compatibility (EMC) stressors that are within the equipment qualification envelope. Exposure to high temperatures will reduce the life of the equipment. The licensee has evaluated each of the listed stressors. Each of the plant stressor levels are well within the generic equipment qualification tests performed by the commercial grade dedicator. Since the equipment is installed in a mild environment, failed equipment can be readily replaced, so there is no requirement for qualified life calculations. Since the EMC tests were performed in accordance with the test requirements, the chiller control cabinet door does not have to be closed to meet EMC requirements. However, the chiller control cabinet door is expected to be closed and secured unless actively working in the cabinet.

4. Failure Results

No new failure modes have been identified that differ between the original and replacement chiller controls. The replacement controls perform self-tests and self-diagnostics that were not performed by the original equipment, supporting more timely detection of faults and failures. Timely detection of failures supports timely maintenance and correction of the failures and thus maximizes reliability. For these auxiliary supporting features, reliable operation reduces temperature and humidity challenges for the safety systems and provides fewer distractions for control room operators. (Section 5.a.viii below discusses software common cause failure.) The identified failure modes for both the original and replacement chillers include:

- Fail as-is, in the current state, leaving the equipment running in the last valid conditions
- Erroneously stop with no demand to stop
- Erroneously start with no demand to start
- Fail to start when demanded
- Fail to stop when demanded
- Partial advance to the next demanded state
- Failure to respond in a timely manner
- Fail to load or unload to match demanded conditions

Indication of failure detection by the controllers can be:

- On the local display
- On the control room display
- No indication of the failure on either the local display or the control room display
- With an incorrect identification of the failure mode or mechanism

Maintenance will be initiated on indicated failures when detected by the control room operator or by an operator on rounds. Failures can be detected by:

- Visually and audibly annunciated in the control room annunciator from a fail-safe dry contact on the chiller controller,
- Indicated status on the control room display,
- Observation of inappropriate system operation,
- By an operator on rounds through either the local fail-safe Unit Okay (i.e., not Alarm) light or on the local display, or
- By a technician or engineer during surveillance test or calibration activities.

5. Assertions

a. Design Attributes

i. Quality and Reliability

Commercial grade dedication of the hardware and software for both the digital chiller controller and the display was performed in accordance with EPRI TR-106439 and the generic EPRI CGD guidance. The NRC staff has determined that EPRI TR-106439 provides an acceptable method for dedicating commercial grade digital equipment for use as basic components, including requirements for 10 CFR 21 reporting. The commercial vendor built and assembled the mechanical and electronic components, and the dedicator then commercial grade dedicated the assembled controllers and displays. Adherence to the applicable industry and regulatory standards provides a high degree of software, hardware, and equipment quality and reliability. This assertion is demonstrated by the high reliability of these digital controllers in commercial service (see Section 5.a.viii).

The vendor performed software verification and validation activities under the vendor's ISO-9001 quality program. The dedicator performed additional activities, including a more complete review of the design documentation, code review, and additional unit, integration, and system testing. Issues and concerns uncovered through the V&V efforts were fed back to the vendor, who resolved the issues under their quality program. The completed software was returned and appropriate portions of the dedicator's V&V program were repeated. The final software version was returned to the dedicator and became the vendor's standard commercial software. No safety concerns were uncovered during the review.

ii. Appropriately Simple

The commercial chiller controller has sufficient simplicity. The commercial chiller controller is designed to control chillers of various types. One basic improvement from the previous version is that all compressor types are incorporated into a single firmware version, rather than having multiple firmware versions, with each version only supporting a single chiller variant. The combination of chillers into a single software source simplifies software maintenance, in that corrections are made to a single source code, thus not requiring manual actions to duplicate the software change across multiple chiller control software sets. The commercial chiller controller includes configuration data to set the compressor type, and thus the algorithms to run. The configuration data also selects the inputs and outputs required by the algorithm as well as mapping the inputs and outputs to the hardware. The licensee can modify only a subset of the chiller parameters, with the commercial vendor controlling critical parameters. The software used by the vendor to set these critical parameters is not provided to either the dedicator or the licensee.

The commercial chiller controller software uses a state machine to step through the sequences required to start, operate, load, modulate the chiller loading, unload, and secure the chiller. Some of the advantages offered by state machine based controls include that each controller is always in a defined state, the total number of different states that the controller can be in are defined, and the transitions between all states are well defined and visible in the software (and displayed on the local and control room displays). Well-designed state machine based controls are inherently well defined, visible in the design and in the software, easier to review (during V&V), offer a clearly defined path to testing (during V&V), and more reliable than controls that do not utilize state machine techniques.

The code is made more complex by the addition of self-tests and self-diagnostics. While these features do increase code complexity, these features also provide fault and failure detection, thus protecting the overall health of the chiller mechanical equipment and ensuring that each chiller does not fail silently for all identified failure modes and mechanisms. Experience with the commercial equipment shows that the complexity added by the self-test and diagnostic features supports reliability, including the potential to shut down the equipment before extensive damage occurs, based on early detection of failing equipment.

iii. Non-Concurrent Triggers

Each of the chillers operates independently of all other chillers. There are no cross-linkages between chillers.

A different, independent safety related bus powers each chiller. A separate, independent emergency diesel generator provides backup power for each chiller.

The same types of sensors are provided for each chiller. The sensors are simple, and are not digital. The potential of common cause failure from the sensors is thus considered unlikely. The software constrains the engineering units into valid ranges, over which the software is designed to remain operable. The software alarms any sensor that provides values outside of valid ranges, and conservatively shuts down the chiller for critical inputs found operating outside valid ranges.

There are two indirect cross-connects between the chillers. One is the chilled water system piping and the chilled water temperature that each chiller independently measures. Both chillers are also cross-connected through the common Service Water System, with each controller individual sampling a permissive for service water flow.

Maintaining chilled water temperature below a maximum value in a plant common chilled water system is an independent safety function in each chiller, helping to maintain the equipment qualification of the safety related I&C cooled by the chilled water system. Each chiller is configured through a separate selector switch wired just to that chiller controller, defining whether the chiller will operate as the lead or lag controller. The selector switch positions are set by manual operator action every few months, rotating through both chillers to provide even wear. Each selector switch sets operating ranges and action limits for each chiller based on the position of the switch, forcing the lead chiller to be the primary by setting the controlled temperature at a low value, and setting the lag chiller to control at pre-set higher chilled water temperature, thus sequentially activating each of the chillers as needed to control chilled water temperature. The lag chiller will only operate as long as required to bring the chilled water temperature down below their action levels, configured in software based on the individual selector switch position. The lag (Position 2) chiller action temperature is set higher than the lead (Position 1) unit. The current state and the software trajectory for each chiller is exceedingly unlikely to be close enough to another chiller to have the potential generate software common cause failures through concurrent triggers.

Like the chilled water temperature, each chiller controller monitors the chilled water flow through the chiller's evaporator, which the software uses as a permissive to allow the chiller to run. Each of the chiller controllers monitors the flow independently, and shuts down the unit when insufficient chilled water flow occurs through the evaporator (Software Requirements Specification).

Thus, this evaluation concludes that there are no credible concurrent triggers that would initiate a hardware or software common cause failure simultaneously affecting both chillers.

iv. Watchdog Timer

Watchdog timers exist in the commercial chiller controller microprocessor.

For the commercial chiller controller watchdog, the watchdog timer uses the internal microprocessor's count down watchdog timer. The watchdog timer causes a hard reset if the counter counts down through zero. The software resets the watchdog timer using two separate instructions, which the software must execute sequentially to reset the watchdog timer counter. Software watchdog timers are provided within the software to ensure that tasks (threads) are operating correctly. An appropriate clock source has been chosen. Failure of the board or timing out the watchdog timer causes all discrete outputs to de-energize, turning off all motors and solenoids. This de-energization occurs in the hardware, based on the watchdog timer output. Failure of the on-board crystal clock is detected in a simple resistor-capacitor (RC) timer within the microprocessor, which forces a timeout indication if the internal clock should stop, using different, non-clocked microprocessor paths than the internal watchdog timer. Either timeout forces all outputs off, including the fail-safe output relay that drives the Unit Okay (not Alarm) lamp on the chiller control front panel and provides dry contacts to be annunciated in the control room.

v. Diverse Indication of Failure

Failure of a single chiller can be determined by using one of several different methods that the commercial chiller controller supports to display status. These include: 1) annunciation of failure in the control room under either program control or through watchdog timer time out, 2) examination of the control room display for that chiller, 3) examination of the local display, or 4) observation of the extinguished Unit Okay (i.e. not Alarm) lamp on the local chiller panel.

A perceptible rise in control room temperature is not a diverse indication of failure or trouble in multiple chillers, because the air temperature in the single, merged Unit 1 and Unit 2 control room envelope is unlikely to change significantly based on the other unit's chillers and air movement from heating, ventilation, and air conditioning (HVAC) fans.

However, several rooms exist whose temperature is useful as a diverse means of detecting chiller failure. The unit-specific control room annunciator will annunciate a high temperature in the unit-specific Relay Room. In addition, high temperature in the unit-specific Electrical Equipment Room is annunciated. Loss of both chillers will result in annunciation of over-temperature alarms in both rooms (Reference 8.g) in a timely manner, allowing Operations, Maintenance, and Security to cope with the failures using an approved procedure prior to any of the affected I&C equipment exceeding its environmental qualification.

vi. Digital Communications

Each safety related digital chiller controller (controlling a single chiller) communicates with the local and control room displays independently. The digital communication uses an industry standard protocol over Ethernet. The digital chiller controller has two separate digital communication links, and sends data to each of the displays. Each of the displays communicates with the digital chiller controller to set the data to be broadcast. Each communication path uses full duplex fiber optic cables, to provide electrical and EMC isolation. The commercial grade dedicator tested specifically for broadcast storms of various messages, and used a commercial test set to stress and validate the cyber security of the digital communications for both the digital chiller controller and the display. These tests did not adversely affect the digital chiller controller or the display.

The digital chiller controller microprocessor has two separate Ethernet media access controllers, each with a separate set of electrical to optical and optical to electrical converters. The Ethernet controllers run separately from the microprocessor, and use direct memory access to send and receive messages of constrained lengths to a separate random access memory integrated circuit used only for communications. The Ethernet controllers have no access to memory used by the microprocessor for program execution. When new messages are received or when a message has been transmitted, the Ethernet media access controller causes an interrupt, which is handled by the digital chiller controller software. No credible faults or failures have been identified that would affect the operation of the safety related chiller control software through message traffic.

Each local and control room display provides data and status indication for the local chiller. Each local and control room display only has data for the chiller with which the display communicates. Both displays attached to a single digital controller are provided with data through separate, safety related full duplex fiber optic communication links. When no one is logged in to the local display, the local display provides display only access. When a user logs in to the local display, the local display provides the ability to control the chiller and to change selected portions of the configuration. The control room display has no ability to control the chiller, both through configuration in the chiller, and from the digital chiller controller's software that allocates the display control features to the local display port only.

Since there is no communication between redundant digital chiller controllers and since each chiller is provided with a separate digital chiller controller, independence is assured between the redundant chillers. The local and control room displays only provides chiller data and status indication for the chiller to which each is attached.

The chilled water controllers each measure the chilled water temperature through independent sensors, and control the operation of the chiller based on pre-configured temperature setpoints. Each chiller has a separate two position switch to select the unit as the Lead or Lag unit, which configures the pre-configured temperature setpoint values individually, without any wiring or communication between the chillers. If the operator misconfigures one or more switches or if the contact arrangement in a switch does not change appropriately, multiple chillers could be configured as Lead or no chillers could be configured as Lead, for example. In either case, the chilled water system would operate appropriately.

vii. Combining Functions

The functions performed by the chiller controls were originally individual controls for each chiller and remain individual controls for each chiller. The chiller controls still only control the operation of the chiller, with no additional functions added for control or monitoring of any other equipment or plant functions. Each replacement chiller does have improved self-test and self-diagnostic functions, but those functions are only for the single chiller controlled by a single digital chiller controller. Each replacement chiller control only controls the local chiller to which the chiller controller is connected. The chiller controls perform no other functions.

viii. Defense-in-Depth and Software Common Cause Failure

The safety related chillers provide heat removal for several safety related spaces, including the control room. The commercial vendor implemented and the dedicator evaluated the digital chiller control software to attempt to minimize the potential for software common cause failure. The dedicator uses the same commercial vendor software that the vendor provides for commercial chiller applications, which have equivalent criticality, without the two detected and now corrected chiller software errors that could have affected the safety function of generating chilled water (see Section 5.c).

The digital chiller controller and the display were designed by the vendor to minimize digital obsolescence issues. Both run a small, dedicated purpose commercial operating system. For the digital chiller controller, the software provides tasking, program storage, configuration, and startup sequencing to enable the controller to operate the local chiller, including sampling all inputs, driving all outputs, and communicating with the displays. The display microprocessor runs a modified version of the software which also provides tasking, program storage, configuration and startup sequencing for the display as well as message services for the fiber optic links, storage for a limited set of primitive graphics, and display services for those graphics. The same processing and quality assurance provided for the digital chiller controller (which implements the safety function) was implemented for the display software (which provides a manual control capability when logged in as well as data and status display at all times).

The chiller controls and the display have been commercial grade dedicated in accordance with EPRI TR-106439, to establish the software qualify and ensure that the likelihood of a latent software defect is low. As part of the CGD, the dedicator performed a Critical Digital Review (CDR) as well as an independent retrospective verification and validation of the software using the commercial vendor's system requirements and software and hardware design documents. The dedicator reviewed the source code. The CGD process, including the CDR, demonstrated that the software is equivalent to software developed under an Appendix B compliant software quality assurance program as defined in IEEE Std. 7-4.3.2. Low software defect likelihood (see Section 5.c) and the divisional independence of the chiller controls prevents a triggered defect in one division from propagating to another division, significantly reducing the probability for a software common cause failure disabling all two chillers.

Based on the quality of the code, the review of the software under an Appendix B nuclear quality assurance program, and the chillers' divisional independence, it is reasonable to conclude that a software common cause failure is unlikely. Further, there is reasonable assurance that failure due to software are no more likely than other potential common cause failures such as maintenance or calibration errors that are not considered in the UFSAR.

In the unlikely event of a software common cause failure across all chillers, ANPS has Operations procedures which remove non-critical heat loads, posts Security guards, opens doors, and sets fans in place to blow conditioned air from other non-safety related HVAC systems into the safety related spaces. The calculations supporting this defense-in-depth process demonstrate that the process, when implemented promptly, controls temperatures in all safety related spaces below the equipment qualification limits.

ix. Environmental Qualification

The dedicator provided the operating environment for the cabinet mounted chiller controls and panel mounted displays in the Equipment Qualification Summary Report. The tested and qualified upper design ambient temperature is 140^{o}F. The environmental testing demonstrates that the controller will operate in 95% relative humidity, with the enclosure door open or closed. ANPS has determined that the qualification limits for the chiller controls and the displays are not exceeded in the installed locations.

x. Seismic Qualification

The dedicator tested the cabinet mounted chiller controls and panel mounted displays and determined that the equipment is qualified for use before, during, and after a seismic event. ANPS has verified that the magnitude and spectra envelope the installation locations. The Equipment Qualification Summary Report provides installation and operational conditions to ensure compliance with the seismic qualification. ANPS will mount the chiller control cabinets and displays in accordance with these requirements.

xi. Radiation Qualification

The cabinet mounted chiller controls and panel mounted displays are installed in mild environments. The radiation exposure and dose rate are small, and well within the capabilities of modern solid state equipment. No further evaluation of radiation qualification is required.

xii. Electromagnetic Compatibility (EMC) Qualification

The cabinet mounted chiller controls and panel mounted displays were tested for EMC based on the requirements of USNRC RG 1.180, Revision 1. The dedicator provides installation and operational conditions in the Equipment Qualification Summary Report to ensure compliance with the EMC qualification. ANPS will install the equipment in accordance with the equipment qualification requirements.

xiii. Hardware Common Cause Failure

By performing adequate equipment qualification tests and by using industrial grade parts, it is reasonable to conclude that hardware CCF is no more likely than other potential common cause failures such as maintenance or calibration errors that are not considered in the UFSAR.

b. Quality Design and Commercial Grade Dedication Process

The standards to which the software documents and V&V were performed are provided in the commercial grade dedicator's nuclear Quality Assurance Manual and in the qualification project documentation.

See Discussion in Section 5.a.viii above.

c. Operating Experience

The operating experience for the unit shows a reasonable number of commercial units operating. Nuclear experience with this controller, as with the previous model, is limited. As noted in Section 8.7, Performance History Evaluation, in the Critical Digital Review (CDR), over 2,000 of the commercial digital controllers and displays were in operation when the dedicator performed CDR, for a conservative operational history of over 43,000,000 hours across five years, or about 5000 unit-years. Over that operating history, 50 hardware failures occurred on the commercial chiller controller and 40 hardware failures occurred on the display board. Over the period, only two software defects were reported that had the potential to affect the safety function. There were several significant enhancements, adding new display capabilities (e.g., trending, historical data, and graphics capabilities) and new chiller compressor types. Several of the modifications were associated with administrative or testing functionality.

The application software in the chiller controls and displays is a copy of this commercial software, with configuration control and change management provided by the dedicator, and maintained by the commercial vendor. The vendor continues to augment the commercial software with new compressor types, which are not added to the dedicated version unless required for a safety related application. Any errors, concerns, or issues identified by the commercial vendor, or by the dedicator, and resolved, and will be included in the nuclear version.

As noted elsewhere, the dedicator did find errors in the software, which the commercial vendor has corrected, as noted in the software version history (see CDR). The CDR reports on two defects that had the potential to affect the safety function, which the dedicator found as part of the software qualification activities, prior to completion of commercial grade dedication.

6. Rationale

The chillers are not accident initiators. The chillers are not credited directly with mitigating accidents. The chillers do not protect the barriers directly, including the fuel, fuel cladding, reactor coolant system boundary, or containment boundary. Rather, the chillers are support systems that protect the controls for the systems that mitigate accidents and protect the barriers, along with cooling the control room. As demonstrated in this evaluation, the commercial vendor and the dedicator have worked to minimize the probability of hardware and software common cause failure, which is also demonstrated in the operating history. In the unlikely event of a hardware or software common cause failure that makes all unit chillers inoperable, a procedural means for limiting temperature rise in controlled spaces is available, which maintains temperatures in the controlled spaces within the equipment qualification limits, which would not affect the immediate operability of the controls that mitigate accident conditions.

7. Conclusion

Based on the evidence provided above, ANPS can install the replacement chiller controls under 10 CFR 50.59 without prior approval by the USNRC.

8. Documentation of Evidence and References Consulted

The following sources contain the evidence to support the conclusions in this document:

a. The UFSAR, Technical Specifications, and commitments reviewed as listed in the 50.59 Screening Form
b. *Dedicator's* Critical Digital Review
c. *Dedicator's* Software Verification and Validation Plan
d. *Dedicator's* Software Quality Assurance Plan
e. *Dedicator's* Hazards Analysis
f. *Dedicator's* Failure Modes and Effects Analysis
g. ANPS Operations Procedures, *Loss of Unit 1 Safety Related HVAC* and *Loss of Unit 2 Safety Related HVAC*