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Director, Office of Nuclear Reactor Regulation
Attention: D. M. Crutchfield, Chief
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U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

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Gentlemen:

Subject: Docket No. 50-206
SEP Topic III-4.C
San Onofre Nuclear Generating Station
Unit 1

Enclosed is the draft assessment for SEP Topic III-4.C, Internally Generated Missiles. If you have any questions on this draft topic assessment or require additional information, please let me know.

Very truly yours,

RW Krieger

R. W. Krieger
Supervising Engineer,
San Onofre Unit 1 Licensing

Enclosure

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DRAFT ASSESSMENT

OF

SEP TOPIC III-4.C

INTERNALLY GENERATED MISSILES

SAN ONOFRE NUCLEAR GENERATING STATION

UNIT 1

I. INTRODUCTION

Missiles that are generated internally to the reactor facility (inside or outside containment) may lead to damage of structures, systems and components that are necessary for the safe shutdown of the reactor facility or accident mitigation and to the structures, systems and components whose failure could result in a significant release of radioactivity. The sources of such missiles are valve bonnets and hardware retaining bolts, relief valve parts and instrument wells, pressure containing equipment such as accumulators and high pressure bottles, high speed rotating machinery, and rotating segments (e.g., impellers and fan blades).

Scope of Review

The scope of the review is as outlined in the Standard Review Plan (SRP) Section 3.5.1.1, "Internally Generated Missiles (Outside Containment)," and SRP Section 3.5.1.2, "Internally Generated Missiles (Inside Containment)." The review specifically excludes SRP Section 3.6.1, "Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," 3.6.2, "Determination of Break Locations and Dynamic Effects Associated with the Postulated Rupture of Piping," as well as those SRP sections dealing with natural phenomena (including missiles generated by natural phenomena), missiles generated outside the facility, and turbine missiles.

II. REVIEW CRITERIA

The acceptability of the design of protection of facility structures, systems, and components from internally generated missiles is based on meeting the following criteria:

1. General Design Criterion 4, with respect to protecting structures, systems and components against the effects of internally generated missiles to maintain their essential safety functions.

2. Regulatory Guide 1.13, as related to the spent fuel pool systems and structures being capable of withstanding the effects of internally generated missiles and preventing missiles from impacting stored fuel assemblies.

3. Regulatory Guide 1.27, as related to the ultimate heat sink and connecting conduits being capable of withstanding the effects of internally generated missiles.

In addition, the following specific criteria are used in this evaluation:

1. Safe shutdown is assumed to be cold shutdown.

2. No single failure in addition to the missile and its consequences is assumed.

3. Except where specifically discussed, when equipment is struck by a missile, failure of the equipment is assumed. This is based on failure of the equipment itself or on failure of auxiliary equipment, such as switches, power supplies, pipe supports or other related equipment.

III. RELATED SAFETY TOPICS AND INTERFACES

Review Areas Outside the Scope of this Topic

As stated previously, this review specifically excludes the following:

1. SRP Section 3.6.1, "Plant Design for Protection Against Postulated Piping Failure in Fluid Systems Outside Containment" - This matter will be covered under SEP topic III-5.B, "Piping Break Outside Containment."

2. SRP Section 3.6.2, "Determination of Break Locations and Dynamic Effects Associated with the Postulated Rupture of Piping" - This matter will be covered under SEP topic III-5.A "Effects of Pipe Break on Structures, Systems and Components Inside Containment."

3. Natural Phenomena - This matter will be covered under SEP topic III-6, "Seismic Design Considerations" and III-4.A, "Tornado Missiles."

4. Turbine Missiles - This matter will be covered under SEP topic III-4.B, "Turbine Missiles."

Interfaces with Other SEP Safety Topics

Satisfactory resolution of the following SEP topics will depend, at least in part, on satisfactory resolution of this topic:

1. Topic VII-3 "Systems Required for Safe Shutdown"

2. Topic VII-4 "Effects of Failure in Non-Safety Related Systems on Selected Engineered Safety Features"

3. Topic IX-1 "Fuel Storage"

4. Topic IX-3 "Station Service and Cooling Water System"

5. Topic II-3.C "Safety Related Water Supply" (Ultimate Heat Sink)

IV. REVIEW GUIDELINES

1. Systems and components needed to perform safety functions were identified as those listed in SRP Section 3.2.2, "System Quality Group Classification".

   Systems needed to perform safety functions:

   a. Reactor Coolant System

   b. Chemical and Volume Control System (portions)

c. Auxiliary Coolant System

d. Safety Injection System

e. Main Steam System (portions)

f. Circulating Water System (portions)

g. Miscellaneous Water System (portions)

h. Feedwater and Condensate Systems (portions)

i. Compressed Air System

j. Air Conditioning System (portions)

k. Diesel Generator System

l. Auxiliary Feedwater System

2. Systems whose failure may result in release of unacceptable amounts of radioactivity:

a. Reactor Cycle Sampling System

b. Radioactive Waste Disposal Systems

c. Air Conditioning System

d. Auxiliary Coolant System (portions)

3. Electrical systems which are necessary to support those fluid systems needed to perform safety functions are:

a. 4160-Volt System (See item 1.k for Diesel Generators)

b. 480-Volt System

c. 125-Volt DC System

d. 120-Volt AC System

4. Additionally, the control room was evaluated because of its importance to safety.

V. REVIEW AND EVALUATION

V.1. Systems needed to perform safety functions:

V.1.a. Reactor Coolant System

The reactor coolant system serves as the pressure retaining boundary for the primary coolant. The system is comprised of a reactor pressure vessel and three parallel heat transfer loops. Each loop contains one steam generator, one pump, connecting piping and instrumentation. The pressurizer and associated relief and safety valves are connected by the surge and spray lines to two of the reactor coolant lines. The purpose of the pressurizer is to maintain primary coolant pressure and compensate for coolant volume changes as the heat load changes. All components of the primary coolant system are located within the containment building. Overpressure protection is provided to assure that the coolant system pressure does not exceed design limits.

The reactor vessel is enclosed in a concrete shield with a removable concrete cover and it is therefore concluded that the vessel will not be affected by missiles outside the shield. There are no potential sources of missiles which could affect the vessel within the shield. This shield will also prevent any missiles originating from the reactor vessel from affecting other components. The control rod drive mechanisms are mounted on the top of the reactor vessel and are considered as an extension of the reactor vessel head. Because of this design, we do not consider the drive mechanisms as likely missiles. The concrete cover is further protection against potential missile damage to safety systems.

The pressurizer is enclosed with steam generator B in a concrete shield with a removable concrete cover and is therefore unlikely to be affected by missiles outside the shield. This shield will also prevent any missiles originating from the pressurizer (primarily the relief valves at the top of the pressurizer) from affecting components outside the steam generator B compartment. The most likely trajectory for missiles from pressurizer relief valves is vertical. Since the pressurizer is next to steam generator B, it is unlikely that any such missiles will affect steam generator B.

The possibility that missiles may result from destructive overspeeding of one of the primary coolant pumps was also examined. It was concluded that potentially damaging impeller missile ejection from the broken pipe is minimized by a massive steel pump casing. Generation of missiles from overspeed of the motor, flywheel, and the impeller is a generic issue which is being reviewed under Task Action Plan B-68, "Pump Overspeed During a LOCA".

The steam generators are partially enclosed in concrete compartments and are therefore unlikely to be affected by missiles from outside the compartments. If the primary side of a steam generator is affected by a missile at least one safety injection line would remain intact and could therefore mitigate the effect of the LOCA. Any missile affecting the secondary side of the steam generator would not impair the plant's ability to achieve safe shutdown. This is because the location of the RHR pumps and heat exchangers at the -10' level of the containment provides separation from the secondary side of the steam generators which are located from approximately elevation 18' to 55'.

The pressurizer relief tank is used to condense steam from the discharge of the pressurizer relief valves. Loss of this tank by a missile would not impact the plant's ability to achieve safe shutdown. The rupture disc on this tank is integral with the manhole cover and could become a missile. Because of the manhole's location on the top of the tank, there is no essential equipment which could be damaged by this missile.

The three loops of the reactor coolant piping are arranged so that one missile or its consequences would not damage all three safety injection points. This would allow the safety injection system to mitigate the effects of any condition requiring safety injection.

Based on the above, it is concluded that this system's function will not be impaired considering internally generated missiles as identified above. Further, should a missile create a break in the primary system, the safety injection system would mitigate the effects of the LOCA.

V.1.b. <u>Chemical and Volume Control System</u>

The Chemical and Volume Control System controls and maintains reactor coolant system inventory and purity through the process of letdown, purification and makeup. The system consists of a regenerative heat exchanger (and an excess letdown heat exchanger), which reduces the letdown flow temperature, orifices to reduce the pressure, RHR heat exchanger to cool letdown water treatment equipment to remove impurities, a volume control tank which provides a reservoir for volume changes, chemical mixing equipment, charging pumps which return the treated water to the reactor coolant system, and a seal water heat exchanger which reduces the temperature of the reactor coolant pump seal water.

The charging pumps and seal water heat exchanger are located in a separate room in the reactor auxiliary building which contains no equipment from other systems which might produce missiles. The only sources of missiles in this room are the charging pumps themselves and the test pump. The charging pumps are not missile sources because the impellers, if broken, will not penetrate the thick steel casing (see Appendix 1).

The test pump is not used during plant operation. Non-safety related fans are provided for backup charging pump cooling. These fans are not normally used during plant operation.

The regenerative heat exchanger is located inside the containment at approximately elevation 16 feet. If this heat exchanger is damaged by a missile, charging could be accomplished by the reactor coolant pump seal water lines.

All other equipment in the chemical and volume control system, with the exception of the refueling water storage tank, is located on the reactor auxiliary building roof. The refueling water storage tank can act as an alternate source for charging pump suction and is located 100 feet from the equipment. It is unlikely to be damaged by any missile which could damage the chemical and volume control system equipment because of the distance and intervening equipment. This tank can therefore be used as an alternate source for charging pump suction to achieve safe shutdown. The CVCS equipment on the reactor auxiliary building roof is not required to mitigate the consequences of a LOCA or to safety shut down the plant.

Additionally, if charging flow is lost, the safety injection system would be available to achieve safe shut down. In addition, the residual heat removal system and the auxiliary feedwater system would be available.

Based on the above, it is concluded that this system's function will not be impaired considering internally generated missiles as identified above.

V.1.c. Auxiliary Coolant System

The auxiliary coolant system includes the component cooling water system and the residual heat removal system.

V.1.c.1. Component Cooling Water System

The component cooling water system transfers heat from various components to the circulating water system. The component cooling water system is a closed system with three motor driven pumps, two horizontal heat exchangers and a surge tank. This equipment is located outside on the reactor auxiliary building roof. The spent fuel pit heat exchanger and the recirculation heat exchanger which are also cooled by the component cooling water system are located in the same area on the roof of the reactor auxiliary building.

A component cooling water pump could become a missile source and damage the other component cooling water pumps, (including their electric motors or cable) or the component cooling water surge tank.

The safety injection and refueling water pumps, which are located in this area are not missile sources (see Appendix 1). The spent fuel pit pump, which is also in the area, has a case made of stainless steel, which is a ductile material, and is therefore unlikely to become a missile source.

The spent fuel pit heat exchangers, recirculation heat exchanger, and component cooling water heat exchangers are not vulnerable to missiles from the component cooling water pumps when the assumed trajectory of missiles from these pumps is considered. The auxiliary cooling pump, because its characteristics are similar to the component cooling water pumps, could become a missile source. The auxiliary cooling pump is located beside the reactor auxiliary building, approximately 6' below the elevation of the roof. Because of the elevation difference, the probability that missiles from the auxiliary cooling pump would affect these heat exchangers is low.

Heat exchangers required for accident mitigation or safe shutdown which are cooled by component cooling water are the residual heat removal heat exchangers, residual heat removal pump bearing cooling heat exchangers, seal water heat exchanger, reactor coolant pump thermal barrier and bearing cooling heat exchangers, and charging pump oil cooling heat exchangers. The residual heat removal pumps and heat exchangers are discussed in section (V.1.c.2). The reactor coolant pump cooling coils are included in the discussion of the reactor coolant pumps (V.1.a.). The seal water heat exchanger and charging pump cooling are included in the discussion of the CVCS (V.1.b.).

High pressure nitrogen bottles are stored in the area of the component cooling water system equipment. These bottles are restrained by a rack and partially enclosed by a concrete wall and therefore are unlikely to damage the component cooling water system equipment. The shutoff valves on the nitrogen bottles face away from the component cooling water system equipment.

A liquid nitrogen storage vessel is located to the west of the spent fuel pit heat exchanger, recirculation heat exchanger, and component cooling water heat exchangers. This vessel could generate missiles that could damage these heat exchangers.

Based on the above, it is concluded that the function of the component cooling water pumps, component cooling water surge tanks, and the recirculation heat exchanger could be impaired by missiles from component cooling water pumps. It is concluded that the remainder of the system's function will not be impaired considering internally generated missiles as identified above.

V.1.c.2. Residual Heat Removal (RHR) System

The residual heat removal heat exchanger and pumps are provided to remove heat from the reactor coolant system when the reactor coolant system is below 350°F and 350 psig. The residual heat removal heat exchanger is also used during normal operation to further cool the letdown after it leaves the regenerative or excess letdown heat exchanger. To achieve cold shutdown, the RHR pumps take suction from the reactor coolant system and pump reactor coolant through the RHR heat exchangers where it is cooled by component cooling water. The cooled reactor coolant is then returned to the reactor coolant system. This system is not used after LOCA. The RHR pumps and heat exchangers are located inside the containment at elevation -10 feet.

The RHR pumps and heat exchangers are required after a loss of secondary coolant, such as a Main Steam Line Break (MSLB). Any missile causing a MSLB is unlikely to damage the RHR pumps and heat exchangers.

The power supply to the RHR pumps and the main steam lines are located in the same area. However, it is unlikely that a missile could damage both items.

The RHR heat exchangers are located below and to the southeast of the pressurizer relief tank. This tank is constructed to ASME Section VIII Standards and is equipped with a power operated pressure control valve and a rupture disc. Since the rupture disc is integral with the manway and is located on the top of the tank, the RHR heat exchangers are not likely to be targets of missiles from this source. No other missile sources are in the area of the RHR heat exchangers.

The RHR pumps are located adjacent to each other. However, the RHR pump cases are made of stainless steel and are therefore unlikely to become missile sources. The only other potential missile source which could impact the RHR pumps is the reactor cavity dewatering pump. This pump is only used to dewater the reactor cavity after refueling and is also made of stainless steel. It is unlikely to be a missile source.

Based on the above, it is concluded that the RHR system's function will not be impaired considering internally generated missiles as identified above.

V.1.d. Safety Injection System

The SONGS 1 safety injection system provides water to the reactor coolant system in the event of a loss of primary coolant. Water is pumped from the refueling water storage tank by the safety injection pumps to the suction of the main feedwater pumps which are used to pump the water to the reactor coolant system. During the recirculation mode of operation the recirculation pumps supply water from the containment sump through the recirculation heat exchanger to the suction of the charging pumps which are used to return the water to the reactor cold leg injection lines.

The equipment evaluated in this section will be limited to the safety injection pumps and the recirculation pumps. The charging pumps are evaluated in section V.1.b. The refueling water storage tank is evaluated in section V.1.g. The main feedwater pumps are evaluated in section V.1.h.

The safety injection pumps are located outside to the west of the turbine building next to the refueling water storage tank and auxiliary transformers 2 and 3. The nearby 4160/480V service transformers 2 and 3 east of the safety injection pumps could explode but would not generate missiles (see Appendix 2). The safety injection pumps will not generate missiles (see Appendix 1).

The recirculation pumps are located next to each other in the containment sump at approximately elevation -14 feet. The only other items that could become missile sources in this area are the sphere sump pumps. The sphere sump pumps are not used during a LOCA. They are made of stainless steel and are therefore not likely to become missile sources. The recirculation pumps are also made of stainless steel and are not likely to become missile sources.

V.1.e. Main Steam System (Portions)

The main steam system transports steam from the steam generators through the steam lines to the turbine. The safety related portion of the main steam system includes the steam generators, the main steam lines down to the turbine stop valves, the auxiliary feedwater pump turbine steam supply line, the power operated relief valves, and the safety valves. The steam generators are discussed in Section V.1.a.

The steam generators discharge into a common header at approximately elevation 39' inside the containment. The two ends of the header form two main steam lines which then penetrate the containment and enter the turbine building. The safety valves and steam dump valves are located on a header off each main steam line. Both headers are located between the containment and the turbine building. A supply line for the auxiliary feedwater pump turbine is connected to one steam line. The two main steam lines then run parallel to each other under the turbine deck. The lines then penetrate the turbine deck and are connected to the turbine stop valves.

The steam lines are of heavy walled design and construction and are not likely to be affected by missiles. The consequences of a main steam line break are discussed in Topic XV-2, Spectrum of Steam System Piping Failure Inside and Outside Containment.

The atmospheric dump and safety valves can produce missiles. However, the Sphere Enclosure Building and the Control Building on one side and the Spent Fuel Building on the other will contain any missiles and direct them in a vertical direction. There is no equipment above these valves, however, equipment located outside could be damaged by falling valve parts. However, the probability is considered low that such a missile could impact a safety related component and it is considered improbable that redundant safety related components could be impacted. There are no other missile sources in the vicinity of the valves.

Based on the above, it is concluded that this system's function will not be impaired considering internally generated missiles as identified above.

V.1.f. Circulating Water System (Portions)

The portions of the circulating water system which are used for safe shutdown or accident mitigation are the salt water cooling pumps, the auxiliary salt water cooling pump, and the component cooling water heat exchangers. The component cooling water heat exchangers are discussed in Section V.c.1.

The salt water cooling pumps take suction from the intake structure and pump sea water through the tube side of the component cooling water heat exchangers where heat is removed from the component cooling water. An auxiliary salt water cooling pump is provided for cooling if the salt water cooling pumps fail. The auxiliary salt water cooling pump takes suction from the plant intake line upstream of the stop gates.

The salt water cooling pumps are located in the open intake structure. The auxiliary salt water cooling pump is located in a separate pit remote from the salt water cooling pumps. It is therefore incredible that a missile could damage both the auxiliary salt water cooling pump and the salt water cooling pumps.

Since credit is not taken for the auxiliary salt water cooling pump in determining the operability of the salt water cooling system, the effects of internally generated missiles on the salt water cooling pumps were evaluated.

The salt water cooling pumps are vertical pumps which take suction from the intake structure. Their cases are stainless steel and are continuously submerged. The ductile nature of the case material and the dissipative effect of the water on impeller fragment energy make it unlikely that a missile from one salt water cooling pump could affect the other.

Other items that could affect the salt water cooling pumps are the circulating water pumps which are located approximately 27' from the salt water cooling pumps and the screen wash pumps which are located 7' from the salt water cooling pumps.

These pumps are made of the same materials and are of the same type as the salt water cooling pumps. The same conclusions that were reached for the salt water cooling pumps apply to these pumps. The circulating water pumps normally turn slowly (200-300 rpm) and cannot produce a very energetic missile.

One of the screen wash pumps is powered by a gasoline engine. The fuel storage tank is located immediately outside and at the edge of the intake structure. It is possible that this engine or its local fuel storage tank could be a source of missiles. A failure of this engine could disable the salt water cooling pump (including its electric motor or cable) immediately adjacent to it as well as the other salt water cooling pump (including its electric motor or cable). An explosion of the fuel storage tank could damage both pumps (including their electric motors or cables).

The circulating water system is not a potential source of damaging missiles. However, the salt water cooling pumps are susceptible to loss of function due to missile damage. If the remote auxiliary salt water cooling pump can be used, the essential function of the system can be maintained. Certain piping located in the salt water cooling pump area, if damaged by a missile, could affect cooling from all three salt water cooling pumps.

Connections are provided to connect fire water to the component cooling water side of the heat exchanger in the event that all salt water cooling capabilities are lost.

V.1.g. Miscellaneous Water Systems (Portions)

The miscellaneous water system includes the containment spray system and the plant makeup system.

V.1.g.1. Containment Spray System

The containment spray system is an open heat exchange system designed to remove heat from the containment during and after a LOCA or MSLB/FWLB. It consists of the refueling water storage tank, the refueling water pumps, the containment spray nozzles, the recirculation pumps, and the recirculation heat exchanger. The refueling water pumps provide water to the containment spray nozzles. The containment spray water collects in the containment sump. The recirculation pumps supply water from the sump through the recirculation heat exchanger to the suction of the refueling water pumps.

The refueling water storage tank acts as the source of water for the safety injection pumps and also acts as the source for the refueling water pumps and charging pumps.

The refueling water storage tank is also used as an alternate source of water for safe shutdown when certain CVCS equipment is unavailable. The containment spray system is used only after a LOCA and MSLB/FWLB. The recirculation heat exchanger is also discussed in Section V.1.d.

The refueling water pumps, located to the west of the turbine building, could be struck by missiles from the auxiliary cooling pump which is also located to the west of the turbine building. Since there is a six foot elevation difference between the roof of the reactor auxiliary building, where the component cooling pumps are located, and the location of the refueling water pumps, the refueling water pumps will not be affected by missiles from the component cooling pump.

The refueling water pumps will not generate destructive missiles (see Appendix 1). The spent fuel pit pump also has a stainless steel case which would contain any missiles generated by the impeller.

The refueling water storage tank is located near the refueling water pumps and is subject to missiles from both the component cooling water pumps and the auxiliary cooling pump. The refueling water storage tank is adjacent to auxiliary transformers 2 and 3. These transformers could explode, but will not generate damaging missiles (see Appendix 2). The refueling water storage tank could also be subject to missiles from the primary plant makeup pumps. These pumps are made of stainless steel and are, therefore, unlikely to generate missiles.

The containment spray nozzles are on top of the containment and are protected from damaging missiles by the concrete shielding around the reactor, pressurizer, and steam generators.

V.1.g.2. Plant Makeup System

The plant makeup system consists of the primary plant makeup tank, the primary plant makeup pumps and the condensate storage tank. The safety function of this system is to provide water to the suction of the auxiliary feedwater pumps. The condensate storage tank is connected to the condenser hotwell and to the auxiliary feedwater pump suction. When the condensate storage tank reaches a low level, the primary plant makeup pumps can be activated to fill the condensate storage tank from the primary plant makeup tank.

A backup water source to the auxiliary feedwater pumps is provided by means of a hose connection through the fire protection system from the service water reservoir. At least 30 minutes is available to realign the suction of the auxiliary feedwater pumps. The service water reservoir is remote from the condensate storage tank and the primary plant makeup tank and pumps. It is therefore incredible that it could be damaged by any missile which could damage the plant makeup system equipment. Safe shutdown can be achieved in the event of missile damage to the plant makeup system.

Based on the above, it is concluded that the refueling water storage tank and refueling water pumps are vulnerable to damage from missiles from the component cooling water pump and the auxiliary coolant pump as identified above. The containment spray system is not a source of missiles. It is concluded that the plant makeup system's function will not be impaired considering internally generated missiles as identified above.

V.1.h. Feedwater and Condensate Systems (Portions)

The feedwater system is arranged such that the main feedwater pumps are used in conjunction with the safety injection pumps to provide flow to the reactor coolant system in the event of a safety injection system actuation.

The essential portions of the feedwater system are the feedwater pumps and the main feedwater lines between the first check valves upstream of the containment and the steam generators. The individual feedwater lines downstream of the check valves are not likely to be damaged by internally generated missiles because of their location and routing.

During activation of the safety injection system, the main feedwater pumps are used in series with the safety injection pumps to provide borated water from the RWST to the reactor coolant system through the safety injection lines. This requires realignment of valves to terminate feedwater flow and establish safety injection flow.

The main feedwater pumps are located on opposite sides of the turbine building and could not be affected by the same missile. Either pump alone can provide sufficient safety injection flow. Because the main feedwater pumps are motor driven with stainless steel cases, it is unlikely that they will become missile sources.

The valves used to realign the feedwater pump suction and discharge from feedwater to safety injection are powered by hydraulic actuators. The actuator and its associated accumulator are designed and fabricated to ASME Section III, Class 2. The volume of the accumulator is 1000 in^3 with a design pressure of 4000 psig. The small volume of gas used in these actuators will limit the energy of any missiles generated. The valves are located on opposite sides of the turbine building adjacent to the feedwater pumps. Therefore, potential missiles from the valves in one train could not affect the other train. The auxiliary feedwater pumps are located in the vicinity of the valves on the west side of the building; however, they are protected by a massive steel pipe whip barrier.

Based on the above, it is concluded that this system's function will not be impaired considering internally generated missiles as identified above.

V.1.i. Compressed Air System

The compressed air system consists of the service air system and instrument air system.

V.1.i.1. Service Air System

The service air system provides compressed air for the instrument air system (see V.1.i.2).

The system consists of three service air compressors, three aftercoolers, and three air receivers. The compressors and aftercoolers are located in the turbine building. The air receivers are located outside, south of the turbine building.

While the service air system provides compressed air to the instrument air system under normal conditions, during abnormal conditions instrument air can be provided by the emergency air compressor and receiver or by local accumulators. Local nitrogen bottles are also provided for some equipment. In addition, there is a portable diesel driven air compressor available. Because these backups are provided, the service air system does not require evaluation as a possible missile target.

The service air compressors could generate missiles. The only safety related equipment that would be affected by these missiles would be the emergency air compressor. The service air receivers (located outside) are ASME Section VIII pressure vessels and are provided with safety valves on top. These relief valves could generate missiles. There is no equipment above these safety valves. However, outside equipment could be damaged by the falling debris. The probability is considered low that such a missile could impact a safety related component and it is considered improbable that redundant safety related components could be impacted.

V.1.i.2. Instrument Air System

The Instrument Air System provides clean, dry air to operate various safety related items.

The system consists of an emergency air compressor, a two-vessel dryer, two air filters, and accumulators at various locations in the plant. Backup nitrogen bottles are provided for the safety related instrumentation required for safe shutdown or accident mitigation.

The Instrument Air System could produce missiles. The nitrogen bottles used for instrument air backup could impact an instrument air header directly overhead. In the Ventilation Building, another nitrogen bottle could impact an overhead instrument air header.

The containment instrument air has only six pneumatic valves with no instrument air headers above them.

It is concluded that the instrument air system's function could be impaired considering internally generated missiles as identified above.

V.1.j. Air Conditioning System (Portions)

The Air Conditioning System consists of several subsystems which will be described separately.

V.1.j.1. Reactor Auxiliary Building Ventilating System

The Reactor Auxiliary Building Ventilating System (RABVS) provides ventilation to the reactor auxiliary building. Essential equipment required for safe shutdown or accident mitigation located in the reactor auxiliary building are the charging pumps. Failure of the RABVS is discussed in topic IX-5 Ventilation Systems.

The system consists of one air handling unit, which provides air to the reactor auxiliary building. The Containment Sphere Purging and Exhaust System provides exhaust fans to remove the air from the building. The air handling unit is located in the reactor auxiliary building above the flash tank pumps.

Equipment which can generate missiles which could damage the air handling unit are monitor tank pumps, flash tank pumps, the gas stripper pump, the decontamination drain tank pump and the radio-chemistry laboratory drain tank pump. These pumps all have cases of either ductile iron or stainless steel and are therefore not likely to generate missiles.

The air handling unit could generate missiles. However, these missiles will not effect any equipment which would impair the plant's ability to achieve safe shutdown or mitigate an accident.

V.1.j.2. Control Area Heating Ventilating and Air Conditioning System

The control room HVAC is going to be replaced as part of TMI related requirements. The new design will be protected against the effects of missiles.

The Control Area Heating Ventilating and Air Conditioning System (CAHVACS) maintains a habitable environment in the Control Room. The system consists of a heat pump air conditioning unit, an emergency air intake unit, high efficiency and activated charcoal filters and exhaust fans.

The equipment for this system is located on the second floor of the control and administration building. Missiles from the heat pump air conditioning unit could damage the Emergency Air Intake Unit. Missiles from the emergency air handling units could damge the heat pump air conditioning unit. Additionally, exhaust fan units could produce missiles that could disable the CAHVACS.

V.1.j.3. Diesel Generator Building Heating and Ventilating System

The Diesel Generator Building Heating and Ventilating System provides ventilation to the Diesel Generator Building during normal and abnormal conditions.

The essential portions on this system consist of four fans for each diesel generator room. Since each train of the system is separated from the other, it is incredible that any missile affecting one train could affect the other (see Section V.1.k).

V.1.j.4. 4160V Room Ventilating System

This system provides ventilation for the 4160V Switchgear Room. This system consists of one exhaust fan.

If the fan is damaged by a missile, sufficient time is available to arrange alternate cooling before excessive temperatures are reached.

No items required for safe shutdown or accident mitigation can be damaged by missiles from the fan.

V.1.j.5. 480V Room Ventilating System

This system provides ventilation for the 480V switchgear room. This system consists of one exhaust fan.

If the fan is damaged by a missile sufficient time is available to arrange alternate cooling before excessive temperatures are reached.

No items required for safe shutdown or accident mitigation can be damaged by missiles from the fan.

It is concluded that these systems' function will not be impaired considering internally generated missiles as identified above.

V.1.k. Diesel Generators and Auxiliary Systems

The diesel generators and their auxiliaries provide a source of AC power when the turbine generator is not in operation and offsite power is unavailable.

Two diesel generators are located in a separate building. The two units and their auxiliaries are separated by concrete walls. Each diesel generator has its own separate buried fuel oil storage tank. The pumps which supply fuel to the diesel generators are approximately 70' apart and are not likely to be disabled by the same missile.

It is concluded that this system's function will not be impaired considering internally generated missiles as identified above.

V.1.1. Auxiliary Feedwater System

The safety function of the auxiliary feedwater system is to provide an assured source of feedwater to the steam generators when the main feedwater pumps are not available. The system consists of one turbine driven pump and one electric motor driven pump. These pumps take suction from the condensate storage tank and inject water into the main feedwater lines immediately upstream of the containment penetrations. The condensate storage tank is discussed in Section V.g.2.

Both auxiliary feedwater pumps are located in the turbine building at elevation 14'. The pumps are partially enclosed by a 1/8" thick steel enclosure originally designed for pipe whip and jet impingement protection. The most likely source of missiles affecting the auxiliary feedwater system is the pumps themselves. Both pumps have cast steel casings. Because of the thickness of these casings and their ductility it is unlikely that they could produce missiles. The steam turbine also has a cast steel case which would tend to contain any missiles generated by a turbine rotor failure. The turbine is equipped with normal and emergency governors to prevent overspeed. The steel enclosure would tend to prevent the effects of missiles on the pumps and contain any missiles generated by them.

Other sources of missiles that could affect the auxiliary feedwater pumps or their auxiliaries are the west feedwater/safety injection realignment valves actuators and the emergency air compressor.

A safety valve is provided on the steam supply line to the turbine. This valve is only under pressure when the steam driven auxiliary feedwater pump is in operation. This safety valve is located on the west wall of the turbine building and could become a missile. While no equipment is located above this safety valve, damages could occur to safety related equipment when debris falls back to the ground. However, the probability is considered low that such a missile could impact a safety related component and it is considered improbable that redundant safety related components could be impacted.

Based on the above, it is concluded that this system's function will not be impaired considering internally generated missiles as identified above.

V.2. Systems whose failure may result in release of unacceptable amounts of radioactivity:

V.2.a. <u>Reactor Cycle Sampling System</u>

The reactor cycle sampling system provides samples for laboratory analyses which serve to guide the operation of the reactor coolant system and the chemical and volume control system. The system consists of a delay coil, sample heat exchangers, and sample pressure vessels. Samples are obtained by conducting the sample through a heat exchanger into a sample pressure vessel. A delay coil is provided for reactor coolant samples. The system is operated intermittently.

If a missile strikes the system while it is not in operation, no significant release of radioactivity will result. If a missile strikes the system while it is in operation, the containment isolation valves provided will be closed and no significant release of radioactivity will result.

The sample pressure vessels are designed for 2585 psig and 650°F, and have a maximum volume of 75 ml. Because of their small size, it is highly unlikely that they could become damaging missiles.

It is concluded that this system's ability to contain radioactivity will not be impaired considering internally generated missiles as identified above.

V.2.b. <u>Radioactive Waste Disposal Systems</u>

The radioactive waste disposal system consists of four subsystems which will be described separately.

V.2.b.1. Radioactive Liquid Waste System

The radioactive liquid waste system holds liquid wastes for radioactive decay of short half-life radioactive contaminants, processes liquid wastes to remove long half-life radioactive contaminants, and discharge liquid wastes to the environment under controlled conditions. The system consists of a flash tank, flash tank pumps, a radiochemistry laboratory drain tank, a radiochemistry laboratory drain tank pump, a decontamination drain tank, a decontamination drain tank pump, liquid radwaste holdup tanks, holdup tank pumps, a circulating pump, radwaste ion exchangers, a gas stripper, a gas stripper pump, monitor tanks, and monitor tank pumps.

All the radioactive liquid wastes system equipment is located in the lower level of the reactor auxiliary building. If damaged by a missile, the liquid would be contained within the reactor auxiliary building and would not result in a significant release of radioactivity. Any gases or suspended particles would be controlled by the Containment Sphere Purging and Exhaust System.

It is concluded that this system's ability to control radioactivity will not be impaired considering internally generated missiles as identified above.

V.2.b.2. Radioactive Gaseous Waste System

The radioactive gaseous waste system holds gaseous wastes for radioactive decay of short half-life radioactive contaminants and discharges gaseous wastes to the environment under controlled conditions. This system consists of a waste gas surge tank, waste gas compressors, and waste gas decay tanks.

The equipment for this system is located in the lower level of the reactor auxiliary building. The waste gas system is operated at pressures less than 120 psig. The total pressurized gas volume is approximately 500 ft^3. Missile damage to this system could result in release of radioactivity.

The waste gas surge tank and the waste gas decay tanks are located in a common shielded room. The shielding will prevent any missiles from entering the room. The tanks are all designed to the ASME Code and are equipped with relief valves. The relief valves are located outside the room. It is our judgement that these tanks are unlikely to generate missiles. Missile damage to the waste gas compressor will not result in a significant release of radioactivity.

It is concluded that this system's ability to control radioactivity will not be impaired considering internally generated missiles as identified above.

V.2.b.3. Radioactive Solid Waste System

The Radioactive Solid Waste System holds wastes for radioactive decay of short half-life radioactive contaminants. This system consists of a baler and shipping drums.

The baler compresses soft material into a compact form for placement in drums. Noncompressible solids are also to be placed in drums. This equipment is located on the roof of the reactor auxiliary building. Missile damage to this system will not result in a significant release of radioactivity.

It is concluded that this system's ability to control radioactivity will not be impaired considering internally generated missiles as identified above.

V.2.b.4. Resin Supply and Removal System

The resin supply and removal system removes depleted radioactive resins from various plant demineralizers, stores such resins prior to removal, and provides new resins to ion exchangers. The system consists of a new resin slurry tank and a spent resin storage tank.

This equipment is located on the lower level of the reactor auxiliary building. If damaged by a missile, the contents of the system would be contained within the reactor auxiliary building and would not result in a significant release of radioactivity.

It is concluded that this system's ability to control radioactivity will not be impaired considering internally generated missiles as identified above.

V.2.c. Air Conditioning System (Portions)

V.2.c.1. Containment Sphere Cooling and Filtering System, Control Rod Drive Mechanism Cooling System, Reactor Cavity Cooling System, Reactor Auxiliary Building Ventilating System (RABVS), Control Area Heating Ventilating and Air Conditioning System, Administration Building Heating, Ventilating and Air Conditioning System, Diesel Generator Building Heating and Ventilating System, 4160V Room Ventilating System; and 480 Room Ventilating System.

Failure of these systems will not result in significant release of radioactivity.

V.2.c.2. Fuel Storage Building Ventilation System

The function of the Fuel Storage Building Ventilation System (FSBVS) is to maintain ventilation in the spent fuel pool equipment areas, to permit personnel access, and to control airborne radioactivity in the area during normal operation, anticipated operational transients, and following postulated fuel handling accidents.

Based on our review of the FSBVS fuel handling accident analysis in the SONGS I FSA, we find that the system is not required to prevent an unacceptable release of radioactivity.

V.2.c.3. Containment Sphere Purging and Exhaust System

The function of the Containment Sphere Purging and Exhaust System (CSPES) is to exhaust air from the RABVS and the FSBVS after filtration or other treatment and also to supply outside air to the containment sphere when personnel access is required. During normal operation, the CSPES is used to exhaust air from the RABVS and the FSBVS. Purging and exhaust from the containment is used only during shutdown and is isolated during normal operation by isolation valves.

The CSPES consists of three air handling units, A-21, A-22 and A-24 and associated ducting. Suction dampers (PO-19 and PO-20) and discharge dampers (PO-17 and PO-18) are also provided on air handling units A-22 and A-24, respectively. HEPA filters are provided on Units A-22 and A-24. A prefilter is provided on Unit A-21. Failure of both air handling units A-22 and A-24 simultaneously would result in loss of ventilation to the reactor auxiliary building or containment sphere.

The equipment used in the CSPES is located in an equipment room located adjacent to the spent fuel building. The only equipment located in this room that could be the source of missiles is the ventilation equipment itself. Air handling units A-22 and A-24 are arranged so that missiles from either of these items will not impact other equipment. However, a missile from air handling unit A-21 could disable both air handling units A-22 and A-24 simultaneously. However, this air handling unit has a case which would probably contain any missiles. In any case, there should be ample time to effect repairs to this system.

Two hydrogen recombiners are provided to remove hydrogen from the containment after a LOCA. They are located on opposite sides of the containment so that a missile damaging one will not damage the other.

It is concluded that this system's ability to contain radioactivity will not be impaired considering internally generated missiles as identified above.

V.2.d. Auxiliary Coolant System (Portions)

The auxiliary coolant system provides cooling to the spent fuel pool which is used to prevent boiling and a subsequent release of unacceptable amounts of radioactivity. The system is a closed loop system consisting of one spent fuel pit pump and one spent fuel pit heat exchanger. The pump takes suction from the spent fuel pit and provides borated water to the spent fuel pit heat exchanger. The cooled borated water is then returned to spent fuel pool.

The spent fuel pit heat exchanger is located on the roof of the reactor auxiliary building. The spent fuel pit pump is located next to the refueling water storage tank to the west of the turbine building.

Should any of this equipment become inoperable due to missile damage, there is sufficient time to make repairs or arrange alternate cooling. The spent fuel pit pump is made with a stainless steel case and is therefore unlikely to be a source of missiles.

It is concluded that this system's ability to contain radioactivity will not be impaired considering internally generated missiles as identified above.

V.3 Electrical Systems Needed to Support Systems Required to Perform Safety Functions

V.3.a <u>4160V System</u>

The 4160V System includes the 4160V Switchgears No. 1A, 1B, 1C, and 2C, and Emergency Diesel Generators Nos. 1 and 2.

Switchgears No. 1A and 1B provide power to Reactor Coolant Pumps A, B, and C, and the generator exciter. This equipment is not needed for a safe shutdown of the plant.

Switchgears No. 1C and 2C are redundant and provide power to equipment required for a safe shutdown of the plant. They are located in the 4 kV switchgear room in two cubicles facing each other five feet apart.

As indicated in Appendix 2, the compartment doors of the 4 kV switchgears could become missiles. A compartment door originating from one 4 kV switchgear could hit the other switchgear. However, the energy remaining at the impact would be limited because of the energy required to break the hinges and to displace a heavy door.

This could impact the safe shutdown of the plant because both redundant switchgears would be damaged. However, as indicated in Appendix 2, such an event has a very low probability.

480V Motor Control Center No. 1, located behind 4 kV switchgear 2C, could also be a source of missiles hitting 4 kV switchgear No. 2C; however, the backup 4 kV switchgear No. 1C would still be available for a safe shutdown of the plant.

With the exception of a small ventilating fan, the 4 kV switchgear room does not contain any mechanical equipment which could be a potential source of missiles. The small ventilating fan near the east door could possibly generate missiles, but the filter and fan shroud would probably absorb the fragments of the rotor. If a missile occurred, it could hit the nearby relay board and damage some relays; however, no safety function would be affected because these relays are generator protection relays and do not support safety related equipment.

Emergency Diesel Generators No. 1 and 2 are redundant and physically separated; therefore, any missiles generated in these areas would not affect the safe shutdown of the plant (see V.1.k).

Based on the above, it is concluded that this system's function could be impaired considering internally generated missiles from the 4 kV switchgear as identified above.

V.3.b <u>480V System</u>

The 480V System consists of 480V switchgears 1, 2, and 3 served respectively by 4160/480V service transformers 1, 2, and 3, and motor control centers 1 through 3.

480V switchgears 1 and 2 are redundant and provide power to equipment required for a safe shutdown of the plant (safety related load). 480V switchgear 3 serves only one safety related load; the Component Cooling Pump C.

Switchgear No. 1 is located in the 4 kV switchgear room separate from its backup switchgear No. 2 located in the 480V switchgear room with switchgear No. 3 and the lighting distribution switchboard.

480V Motor Control Center No. 2, located in front of 480V switchgears Nos. 2 and 3, could be a source of missiles hitting 480V switchgears 2 and 3; however, the backup 480V switchgear No. 1 would still be available for a safe shutdown of the plant.

As indicated by Appendix 2, 4160/480V service transformers 1, 2, and 3 cannot be a source of missiles. Redundant transformers 1 and 2 are physically separated (No. 1 near the health physics building, Nos. 2 and 3 west of the 480V switchgears No. 2 and 3 room).

Therefore, separation of the redundant 480V equipment will always ensure a safe shutdown of the plant.

Based on the above, it is concluded that this system's function will not be impaired considering internally generated missiles as identified above.

V.3.c 125V DC System

The 125V DC System consists of two redundant sets, No. 1 and No. 2; each containing a bus, a battery, and two battery chargers. No. 1 set is located in the south side of the administration and control building separate from No. 2 which is located in the Emergency Diesel building. In each location, the battery is located in a room separate from the room where the switchgear and the two battery chargers are located. Therefore, explosion of one battery as indicated in Appendix 2 would generate missiles affecting only this battery.

For each of the three motor operated safety injection valves 850 A, 850 B, and 850 C located inside containment an independent power source is provided. Valves 850 A and 850 B are served through Motor Control Centers 1 and 2 respectively, which are powered from 480V switchgear 1 and 2. Valve 850 C is served through Motor Control Center 3 which is powered from 480V switchgear No. 3, with an uninterruptible power supply system.

This uninterrupted power supply includes a separate 125V DC battery used as a backup. This battery is located south of the condenser near the hydrogen seal unit. Explosion and generation of missiles from this battery would not affect the normal operation of the valve, assuming only single failure. The battery is isolated by a fence from the battery charger and the inverter. In addition, the other two valves and their power supplies could not be affected.

Because of this separation of the redundant equipment, the safe shutdown of the plant would not be affected by internally generated missiles.

Based on the above, it is concluded that this system's function will not be impaired considering internally generated missiles as identified above.

V.3.e 120V AC System

The 120V AC System required for the safety functions of the plant includes 120V ac Vital Buses 1 through 6, located in the control room. Inverters 1, 2, and 3 serving 120V AC Vital Buses 1 through 3A are located in the DC switchgear room of 125V DC Bus No. 1. Inverter 5 serving 120 V AC vital buses 5 and 6 is located in the 480V switchgear room near the lighting switchboard. An additional inverter, served from 125V DC bus No. 2, providing 120V AC power for the containment spray activation system, is located in the control room.

None of this equipment has the potential of generating missiles or being damaged by missiles generated by other equipment.

It is concluded that this system's function will not be impaired considering internally generated missiles as identified above.

V.4 The control room is designed to provide a central location from which the status of the plant can be determined and modified as required.

The control room is located at elevation 42' 0" immediately east of the turbine deck. It is enclosed with walls on the north, east, and west that would deflect or stop any internally generated missile originating outside the control room. The south wall and roof provide less resistance to missiles. However, no missiles can reach the control room from the south wall. The roof can be impacted by missiles generated by main steam, safety valves, the steam dump valves, the auxiliary feedwater pump steam supply safety valve, and the air receiver safety valves. However, it is considered improbable that such a missile would impact safety related equipment in the control room. In addition, safe shutdown can be achieved from the remote shutdown panel (C-38). LOCA mitigation requires access to the control room.

The only items capable of generating missiles inside the control room are oxygen bottles and fire extinguishers. The oxygen bottles are rated at 2500 psig and are of the type used in hospitals. They are not considered to be missile sources. The fire extinguishers are of two types; a CO_2 bottle pressurized at 1800 psig and a Halon bottle pressurized at 175 psig. If these items were to generate missiles from the valves at the top of the bottles, the ceiling would be the only location affected. There is no safety related equipment located on the ceiling.

It is concluded that the control room's function will not be impaired considering internally generated missiles, as identified above.

VI. CONCLUSIONS

From our review of the systems and components needed to perform safety functions, we conclude that the design of protection from internally generated missiles meet the intent of the criteria listed in Section II Review Criteria and are, therefore, considered to be acceptable except for those items listed below:

A. Component Cooling Water Pumps
B. Component Cooling Water Surge Tank
C. Recirculation Heat Exchanger
D. Salt Water Cooling Pumps
E. Refueling Water Pumps

F. Refueling Water Storage Tank
G. Instrument Air Header
H. Auxiliary Feedwater Pumps
I. 4 kV Switchgear

VII. REFERENCES

1. SONGS 1, Final Safety Analysis

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APPENDIX 1

PUMP MISSILE ANALYSIS

I. MISSILE SOURCES

We have performed an analysis of the Safety Injection Pumps, Refueling Water Pumps, Charging Pumps, and Component Cooling Water Pumps to determine whether these pumps can become missile sources. These pumps are located in the same area on or near the roof of the reactor auxiliary building.

In the analysis, pump impellers were assumed to fail in the manner that would generate a fragment of maximum energy. The fragment energy and trajectory was determined. The momentum and energy transfer between the fragment and the pump casing was evaluated. The energies available in the pump casing to prevent failure on fragment impact were determined. The various failure modes of the pump casings were evaluated to determine if a missile can be ejected from the pump. The analysis makes several conservative assumptions such as infinite impeller hardness, unreinforced pump casings and a maximum energy impeller fragment.

The analysis shows that no impeller fragment could penetrate the casing of any of the pumps analyzed, except for the component cooling water pumps.

The component cooling water pumps fail to contain missiles for two reasons:

1. The pump casing is made with cast iron which is a very poor absorber of energy because of its lack of ductility.

2. The pump casing walls are thin (3/8").

The auxiliary coolant pump has characteristics (speed, material and capacity) similar to the component cooling water pumps.

Therefore, the three component cooling water pumps and the auxiliary coolant pump can be considered as potential missile sources. All other pumps in the plant with ductile casings (stainless steel or cast steel) will not be assumed to be missile sources. This is based on the large margin of safety available for the pumps analyzed. These pumps all have stainless steel cases.

II. MISSILE TRAJECTORIES

When turbines, pumps or other rotating equipment fail, the most likely trajectory of the resulting missile is normal to the shaft axis. The data available for turbine missiles indicate that missiles have been ejected at angles at from 0^{o} to 22^{o} from normal to the shaft axis. (References 1.A and 1.B) The missiles not ejected at 0^{o} from normal were deflected by stationary parts of the turbine.

In order to define the space over which pump missile sources will act, it will be assumed that impeller fragments are ejected at angles from -30° to $+30^{\circ}$ from normal to the shaft axis. The range of the missiles will be limited by the first large item of equipment encountered. Missiles will also be assumed to be blocked by walls. This missile trajectory space would enclose all the missiles that have been ejected from the turbines of references 1.A and 1.B. Once a missile is ejected from a pump it is likely that other missiles will also be ejected from the same pump due to the unbalance and subsequent disintegration of the impeller. Therefore, it will be assumed that all equipment within the missile trajectory space could be affected.

III. REFERENCES

1.A S. H. Bush, "Probability of Damage to Nuclear Components Due to Turbine Failure," Vol. 14, No. 3, Nuclear Safety, May-June 1973, pp. 187-201

1.B S. N. Semanderes, "Methods of Determining the Probability of a Turbine Missile Hitting a Particular Plant Region", USAEC Report WCAP-7861 Westinghouse Electric Corp., February 1972

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APPENDIX 2

ELECTRICAL EQUIPMENT MISSILES ANALYSIS

I. ELECTRICAL EQUIPMENT AS POTENTIAL SOURCE OF MISSILES

The potential for generation of missiles was evaluated for the electrical equipment at the San Onofre nuclear plant Unit No. 1.

A. Transformers

Explosions of transformers with ensuing oil fires are caused by failure of winding insulation with arcing resulting in sudden generation of gas bubbles. If this generation of gas is too fast to be interrupted by sudden pressure relays, or if these relays fail to operate properly, or if spring loaded safety valves operate too late, excessive pressure can break and project the bushings and burst open the walls and seams of the oil tank. This is accompanied by projection of ignited oil. Therefore, only the bushings can become missiles.

The main 230/18 kV transformers, and the 230/4.16 kV auxiliary transformers A, B, and C, have bushings which can become missiles.

However, the 4160/480V service transformers 1, 2, and 3 have bushings which are within the enclosure of the ducts of the incoming cells. In case of transformer failure, this enclosure would prevent the bushings from becoming missiles.

B. Electric Motors

Generation of missiles by electric motors is such an unlikely event that it can be reasonably neglected. If a rotor fails, protection is provided by the stator and the stator enclosure which surround it, and by the motor casing. The fan blades on the ends of the rotor core can break and become missiles; but, because of their lightweight construction and small inertia, they are likely to remain within the motor casing.

C. 4160V and 480V Switchgears and Motor Control Centers

4160V and 480V switchgears and motor control centers can generate missiles as a result of failure of the incoming cables or the circuit breaker, which could be caused by failure of a relay to operate properly. Combustion of cable material due to excessive current generates gas, which can create excessive pressure and result in bursting open a compartment door if the door is not bolted shut. Depending on the pressure generated, the door can swing on its hinges, or break it's hinges and become a missile. This type of event has occurred at several nonnuclear locations during the operating history of Southern California Edison Company.

In the worst case, the hinges broke but the door was displaced by only one or two feet. Therefore, even though this type of event is possible, it is still a very unlikely event.

D. 125V DC Batteries

125V DC batteries can become a source of missiles. Batteries can explode if a spark is produced in their vicinity, where hydrogen accumulates and can form an explosive mixture with air. Sparks can be caused by accidental contact of battery terminals with metallic objects resulting in short circuits. The explosion can project battery caps or fragments of the battery walls.

II. ELECTRICAL EQUIPMENT AS POTENTIAL MISSILE IMPACT

All electrical equipment can be damaged by missiles generated by failure of other equipment (electrical or mechanical). In particular, electric motors and cables or cable trays could be damaged by missiles generated by failure of impellers of nearby pumps.

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