LICENSING REPORT FOR
NEW NARROW RANGE TEMPERATURE MEASUREMENT SYSTEM
(RTD BYPASS ELIMINATION)
UNION ELECTRIC COMPANY
CALLAWAY PLANT

(NON-PROPRIETARY VERSION)

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

1.0 INTRODUCTION

The existing RTD bypass piping is scheduled to be removed during the 1990 refueling outage in September at Callaway Plant. A new Narrow Range Inline Thermowell Mounted Reactor Coolant System (RCS) Temperature Measurement system will be installed during the same outage in lieu of the bypass system. Combustion Engineering (CE) has been selected by Union Electric to perform the detailed engineering and installation of the new system. This report is submitted in support of continued operation of the Callaway Plant with the new RTD system installed.

2.0 BACKGROUND

The current method of measuring the hot and cold leg reactor coolant temperatures uses the RTD bypass system. This system was designed to address temperature streaming in the hot legs and to allow replacement of the direct immersion RTDs without draindown of the RCS. For increased accuracy in measuring the hot leg temperatures, mixing scoops are located in each hot leg at three locations of a cross section, 120 degrees apart. Each scoop has five orifices which sample the hot leg flow. The flow from the scoops is piped to a manifold where a direct immersion RTD measures the hot leg loop temperature upstream of the steam generator. The cold leg temperature is measured in a similar manner with piping to a separate bypass manifold, except that no scoops are used as temperature streaming is not a problem due to the mixing action of the RCS pump. The resulting system consists of nearly 400 feet of Reactor Coolant Pressure Boundary (RCPB) piping, 64 associated valves, 85 hangers which include 59 snubbers, 8 sets of flanges and 8 RTD manifolds. Plant experience has demonstrated two major drawbacks to this design:

- ° Lack of Reliability, Forced Outages - Plant shutdowns have been required because of leakage (from valve packing or mechanical joints) or because of flow reductions due to valve problems.
- ° High Radiation Dose - The RTD Bypass Piping (B/P) System is a significant contributor to man-rem exposure because the numerous valves and socket-welded pipes are crud traps. Man-rem is expended not only in maintaining and inspecting the RTD B/P System but in performing any work near the RTD B/P System such as Steam Generator and Reactor Coolant Pump maintenance.

These problems are not unique to Callaway but appear to be common to all plants with a RTD B/P System. The proposed narrow range, RTD System eliminates all the bypass piping, and its associated problems, while maintaining a fast response time, accurate hot leg temperature determination, and the capability to replace RTDs without draining down the RCS. An

overview of the new system is provided in Section 3.0. Detailed descriptions are provided in Sections 4.0, 5.0, 6.0 and 7.0.

3.0 OVERVIEW OF THE PROPOSED SYSTEM

3.1 Mechanical Changes:

All the bypass piping, associated valves, and RTD manifolds will be removed.

The three mixing scoops in each hot leg will be retained. [

] The top of the hot leg mixing scoops will be modified to allow welding in a thermowell. The thermowell becomes part of the RCPB. The RTD nipple and pigtail assembly screws into the thermowell (three RTDs for each hot leg). The use of thermowells allows RTD replacement without draindown.

The nozzle on the cold leg will be modified to allow welding in a thermowell. The cold leg configuration is simpler because the Steam Generator and RCP provide adequate mixing of the fluid in that piping.

The crossover leg connection, through which the RTD B/P System fluid is returned to the main RCS piping, will no longer be required and, therefore, will be capped.

3.2 RTD Design:

Weed Instrument Co., Inc. dual element RTDs will be used in the new design. Each RTD element will be shop tested inside a thermowell to ensure that the time response of both elements is within the required time. Response time of the RTDs will be verified in the field using Loop Current Step Response (LCSR) methodology. RTD accuracy will be improved over the accuracy of the present RdF RTDs. The spare RTD element will be wired to the 7300 Process Protection System cabinets (hereinafter referred to as 7300 cabinets) so that switchover to the spare element can be done from the Control Room.

3.3 Electronic Modifications:

Each of the three T-Hot RTDs per loop will be wired up to an RTD amplifier (R/E converter or NRA) card and the three signals then averaged to

produce one T-Hot signal which will replace the loop's T-Hot signal of the existing system. The added electronics will be identical to the existing 7300 electronic hardware now used. Figure 5-1 shows the concept and outlines the added modules required.

3.4 System Accuracy:

[ ]

CE has compared the temperature measurement accuracy of the new system with that of the old system, using Salem post-modification scoop temperature data with CE scoop test results. In addition, PSE&G compared T-Hot before the modification with T-Hot after the modification on Salem 1 and 2 using 100% power calorimetrics. Agreement was obtained on both units within the accuracy of the data. CE has established the temperature measurement bias as [ ].

By retention of the mixing concept at the hot leg scoops, the sampling performed by the existing system and, therefore, the process measurement accuracies will be preserved. A conservative temperature measurement bias of 0.27°F has been included in the setpoint calculations discussed in Section 7.5 to reflect hot leg streaming effects. Secondly, the electronic modifications represent an accuracy improvement, due to the use of three hot leg RTDs and their separate RTD amplifier cards, that virtually offsets the effects of the hot leg streaming bias and the revised Delta-T gain discussed in Attachment 6 (reflects actual 100% Delta-T span at Callaway).

The same rack functional checks and calibration accuracy requirements will be maintained. Thirdly, the proposed Weed RTD has an overall sensor accuracy, shown in Table 5-1, which is an improvement over the existing RdF RTDs as discussed in Sections 3.1.1 and 3.1.2 of Attachment 6.

3.5 ALARA Benefits:

A 2000 man-rem dose savings is projected over the remaining life of the plant as a result of this modification assuming a 40-year Operating License. This ALARA and cost benefit analysis takes into account the reduced radiation levels, reduced outage time, increased accessibility in the loop compartments, installation/demolition doses, maintenance requirements and the plant's reliability over the life of the plant.

3.6 RTD System Time Response:

The RTD system response time is the time lag from when the hot leg temperature reaches trip conditions at the scoop until the control rods start to drop into the core. The Technical Specification (TS) Required Response Time includes only that portion which can be tested. At Callaway this is six seconds. The testable response time of the new system design, listed in Table 7-1, will be less than six seconds. The total system response time is reduced from that of the current system through the reduction of loop travel and thermal lag time from the scoop inlet ports to the RTD. Since the response time of the new system is less than the TS requirement, no TS changes to response time are necessary. The time response used in the FSAR safety analyses and in WCAP-10961-P, "Steamline Break Mass/Energy Releases for Equipment Environmental Qualification Outside Containment," is eight seconds and, therefore, will also remain unchanged (refer to FSAR Table 15.0-4). Response times listed in Technical Specification Tables 3.3-2 and 3.3-5 will continue to be verified every refueling outage.

4.0 DESCRIPTION OF MECHANICAL MODIFICATIONS

4.1 Hot Leg:

The hot leg installation has three nozzles, 120° apart, around its circumference. The nozzles extend into the pipe to form scoops to sample the flow. The scoops will be retained in the new

design and will collect a flow sample in a manner equivalent to the present configuration. A thermowell will be mounted inside each scoop. The scoops will be modified so that the flow goes past the thermowell (Figure 4-1).

Since the existing sample scoops are being retained, the method of sampling the stratified flow in the hot legs will remain unchanged. [

]

The portion of overall response time attributable to the flow through the scoop is 0.25 seconds or less. This value includes fluid transit and heat capacity effects and was conservatively estimated using:

[ ]

4.2 Cold Leg:

The cold leg has a single nozzle without a flow sampling scoop. The nozzle is a 2" IPS socket-weld nozzle. The cold leg thermowell will be installed directly into the nozzle (Figure 4-2). As is the case with the present system, no flow sampling will be necessary because the Reactor Coolant Pumps will provide mixing of the flow after it exits the steam generator.

4.3 Crossover Leg:

The return for the bypass loops is a 3" nozzle in the crossover leg. This connection will no longer be used. A 3" schedule 160 buttweld cap will be installed on this connection (Figure 4-3).

4.4 Inspection, Welding and Hydrostatic Test Requirements:

4.4.1 Hot Leg and Cold Leg Thermowells

The following requirements are applicable to the 12 hot leg RTD scoops and 4 cold leg connections:

1. Liquid penetrant inspect all accessible field machined surfaces in accordance with the 1980 Edition through Winter 1981 Addendum of Section XI of the ASME B&PV Code.

2. Welding to be in accordance with the 1980 Edition through Winter 1981 Addendum of Section XI of the ASME B&PV Code. (Root Pass-GTAA, Fill-GTAA or GTAW)

3. Liquid penetrant inspect the root weld pass in accordance with the 1980 Edition through Winter 1981 Addendum of Section XI of the ASME B&PV Code.

4. Liquid penetrant inspect final weld pass in accordance with the 1980 Edition through Winter 1981 Addendum of Section XI of the ASME B&PV Code.

5. Weld material to be supplied in accordance with ASME Section II with additional requirements of ASME Section III NB-2400 (1974 Edition through Summer 1975 Addenda).

4.4.2 Crossover Piping

The following inspection and welding requirements are applicable to capping of the 3" crossover piping at four locations in addition to the five requirements noted in Section 4.4.1:

1. Radiographically inspect the completed weld in accordance with the 1980 Edition through Winter 1981 Addendum of Section XI of the ASME B&PV Code.

2. An open butt weld configuration will be used with argon as purge gas.

4.4.3 Hydrostatic Test Requirements

Hydrostatic testing of all nozzles will be done during inservice testing in accordance with the 1980 Edition through Winter 1981 Addendum of the ASME Section XI IWB 5000.

4.5 Analysis of RCS Penetrations:

The thermowells are pressure boundary parts which completely enclose the RTD. They will be machined from a solid bar of SB-166, a nickel-chromium-iron alloy and will be shop hydrotested to 1.25 times the RCS design pressure. The external design pressure and design temperature will be the reactor coolant system design pressure and temperature. The RTD, therefore, will not be part of the pressure boundary.

For both the hot leg and cold leg, the nozzle, thermowell, and the entire thermowell/nozzle assembly will each be analyzed to the ASME B&PV Code, Section III, Class 1. The analysis of the entire assembly will consider the weight of the RTD, the connectors as applicable, and an assumed length of cabling. The effect of seismic and flow-induced loads will also be considered. Seismic response spectra enveloping Callaway will be used. Flow-induced vibration will also be evaluated. This stress analysis will be completed by July 1, 1990; however, based on CE's past experience, Code allowables will be satisfied. The crossover leg connection will be analyzed to the same requirements as the hot and cold leg connections. Since the connection will be capped and have no piping loads, stress levels will be lower than what exists in the current system.

4.6 Debris Control During Modification:

Control of metal chips and fragments will be as follows:

Hot Leg Scoop Modifications: (12 locations)

For those locations which are done with the system full of water, a freeze plug will be installed prior to any cut-off operation. A mechanical plug will be installed after the freeze plug is removed and prior to any machining which would develop metal chips or fragments. Any chips or fragments will be removed by vacuum prior to removal of the mechanical plug. The holes in the scoops will be made using the Electrical Discharge Machining (EDM) process.

EDM is a process that utilizes electrical discharges, or sparks, to machine metal. The surface being machined is bombarded with high intensity electrical energy pulses that gradually melt away the stock until the desired configuration is obtained.

A high energy spark, through vaporization, melting, and an explosive effect, dislodges a minute particle of metal from the workpiece, leaving a small crater. The dislodged particle is then solidified and washed away by the dielectric fluid.

Some or all of the four top scoops may have the pipe cut-off operation performed at part-loop drain making a freeze plug unnecessary.

Cold Leg Nozzle: (4 locations)

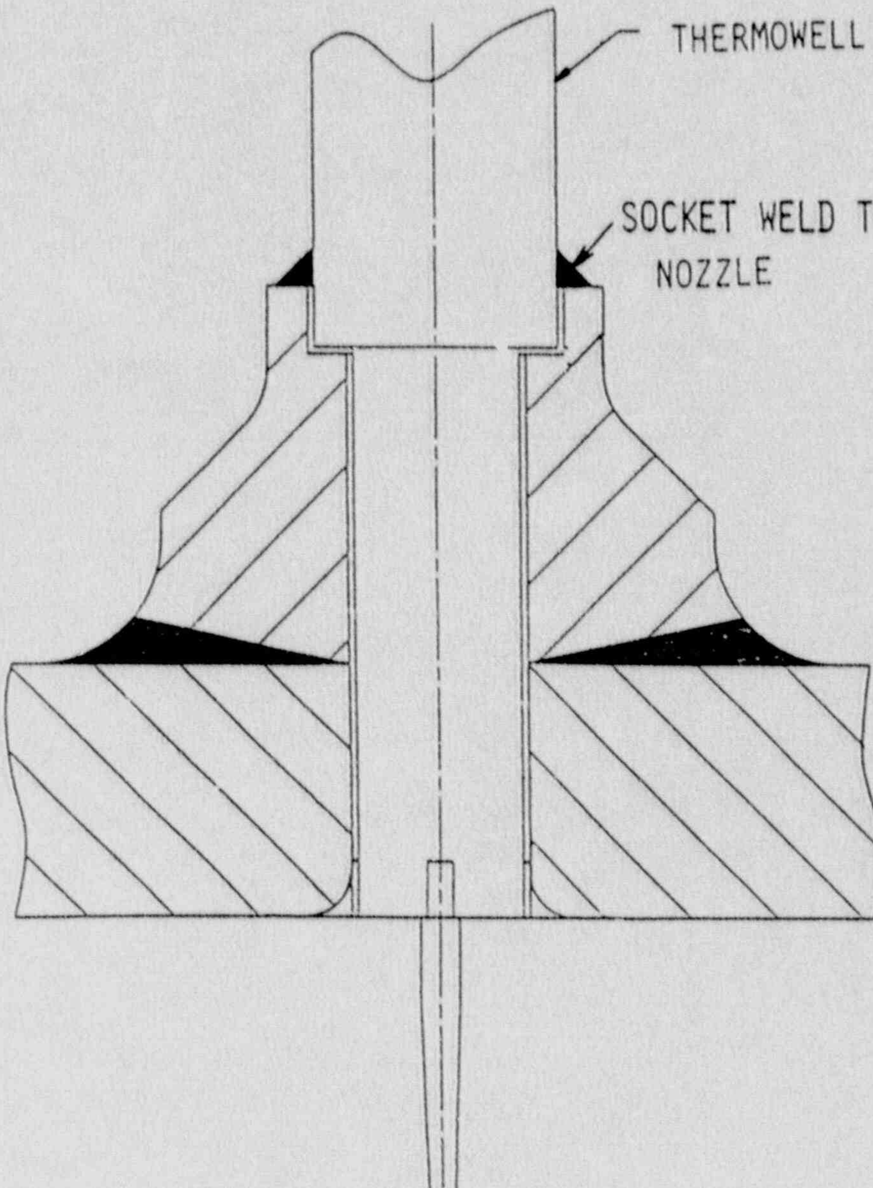
The cold leg nozzle will be cut-off after draindown of the RCS. A barrier will be installed prior to cut-off to catch chips or fragments which will then be removed by vacuum. There will also be a barrier in place during weld preparation machining of the nozzle.

Crossover Leg Nozzle: (4 locations)

The primary system will be drained prior to any cutting operation on the crossover leg nozzle. The cutting operation will be performed using an abrasive cut-off wheel which does not develop metal chips. A mechanical plug will be installed prior to machining of the weld preparation and the nozzle vacuum cleaned prior to removal.

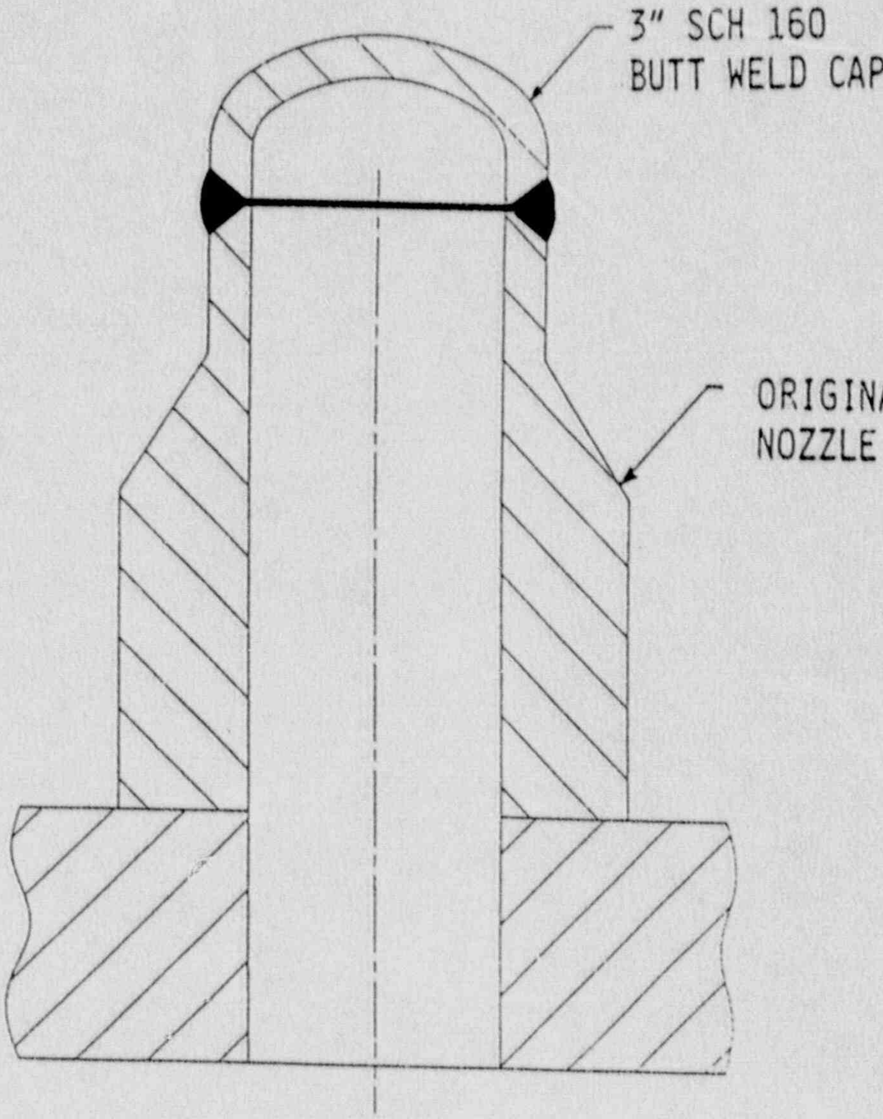
HOT LEG THERMOWELL

FIGURE 4-1



COLD LEG THERMOWELL

FIGURE 4-2
LICENSING REPORT



CROSSOVER LEG CONNECTION

FIGURE 4-3

5.0 DESCRIPTION OF ELECTRICAL/INSTRUMENTATION MODIFICATIONS

5.1 T-Hot Averaging:

5.1.1 Existing System

The fluid from the three scoops for each loop is mixed together before being directed to the T-Hot RTD bypass manifold. At the manifold, a single RTD is used to measure the temperature. The resistance across this RTD is connected to a resistance bridge. The resultant differential voltage is amplified to provide an amplified voltage output (R/E) before being combined with the T-Cold signal to generate the loop's Delta-T and T-AVG signals used by the 7300 cabinets. Refer to Figure 5-1.

5.1.2 Proposed System

The proposed system will locate a dual element RTD in each of the three scoops. Averaging of the RTDs at the three locations will be done electronically. Refer to Figure 5-1. The resistance across one RTD element at each location will be connected to its respective RTD amplifier. The amplified signal from the three RTD amplifiers will be averaged together to generate a single T-Hot signal for that loop, T-HAVG, which along with the T-Cold signal is then used to generate the loop's Delta-T and T-AVG signal.

The second RTD element at each location is considered an installed spare. They will be wired up to the Master Test (NMT) cards in the 7300 cabinets, but not normally connected to the RTD amplifier cards. On failure of the first element, the second element is available. (Refer to Section 5.6.)

The existing RTD amplifier cards (R/E converter or NRA) are designed to accept 3 wires. The 4th RTD lead wires are connected to the NMT cards in the 7300 cabinets.

5.2 T-Cold Monitoring:

The impact on the T-Cold portion of the system is limited to:

(1) Relocation of the RTD from the bypass manifold into a thermowell directly in the RCS cold leg piping.

(2) Use of one dual element RTD instead of two single element RTDs. As with the hot leg RTDs, both elements will be wired to the 7300 cabinets but only one element will input into the RTD amplifier cards.

As before, the RCS fluid is mixed by the Reactor Coolant Pump before reaching the cold leg. No sampling scoop is required. The intended location of the cold leg RTD/thermowell is the nozzle used as a tap-off point for the existing cold leg RTD bypass line.

5.3 Weed RTD:

Dual element RTDs have been supplied and are in use at other operating plants including Waterford Steam Electric Station Unit-3 and Salem Units 1 and 2. The RTDs are provided with Resistance vs. Temperature (R vs. T) calibration curves which are accurate to a specification of ± 0.3°F. The RTD drift is specified to be within ± 1°F over a five (5) year period. See Table 5-1 which is based on the drift term being linear with respect to time.

The Weed RTD initial shop calibration is performed by immersion in ice and oil baths whose temperature is monitored by a standard RTD calibrated to NBS standards. The RTD/thermowell response time is measured by plunge method by causing a step change from ambient room temperature to elevated temperature. All RTDs must meet a specified response time requirement and will, therefore, be interchangeable.

The dual element design provides an installed spare wired up to the 7300 cabinets for use when primary element failure is detected. For this reason, both elements of each RTD will be tested by Loop Current Step Response (LCSR) for in-situ response times on a refueling outage interval after installation.

The contact between the RTD and thermowell is a critical item in maintaining the response time. [

] The above provides high assurance of consistent response time.

5.4 In-situ Testing:

The Weed RTD is capable of being tested by the in-situ LCSR method. A continuous current of 20-40mA will not damage the RTD.

5.5 Equipment Qualification:

The Weed model N9004 is qualified to IEEE 323-1974, IEEE 344-1975 and NUREG-0588/10CFR50.49 to levels which envelope Callaway Plant requirements, as specified in FSAR Sections 3.7(N), 3.9(N), and 3.11(B). Based on an RTD service temperature of 135°F at the epoxy-sealed RTD-lead wire transition, to be established by shop testing with consideration given to process fluid heat rise effects, a qualified life of 40 years has been established.

The 4-wire dual element Weed RTD to be used in this modification is qualified by similarity to the combined features of two of eight RTD test specimens in Southwest Research Institute Report #06-8680-003. One of these two, a fast response dual element 3-wire RTD/thermowell assembly, also featured a sealed NEMA-4 head. The other specimen taken credit for is a direct immersion RTD assembly with Swagelok fittings and 316 SST flexible tubing, seal welded or brazed to the fittings. Callaway will use a 4-wire, fast response dual element RTD/thermowell assembly (no head) with the required fittings and sealed flexible tubing necessary to mate up with the quick disconnect assemblies discussed below. The 4-wire leads are made of the same insulation and jacket as that tested. The test RTDs were calibrated after the LOCA simulation and demonstrated only a ± 0.1°F change from the baseline calibration data. See Figure 5-2 for a schematic of the RTD assembly.

Containment Penetration Module Assemblies:

The Bunker Ramo 85#16 AWG and 20#16 AWG penetration modules with shielded twisted quad pigtail assemblies are qualified for Callaway applications, including IEEE 317-1976 and IEEE 323-1974, as discussed in ULNRC-1992 dated 4-27-89 and as documented in Wyle Labs Test Report #17040-1 performed on two spare penetration module/pigtail assemblies obtained from Callaway.

RTD Quick Disconnect Assemblies:

The Patel/EGS Quick Disconnects are supplied by Weed as part of the RTD assembly. One connector half will be connected approximately 5 feet from the RTD and be made an integral part of the RTD assembly. The other connector half will be provided with a 25 foot pigtail having a qualified Patel/EGS conduit seal with #20 AWG wires for splicing to field cable. The assembly also provides an environmental seal for protecting the RTD lead wires from harsh environments during accident conditions.

The Patel/EGS connector assembly is qualified to IEEE 323-1974 and IEEE 344-1975. The qualification levels exceed Callaway Plant requirements. Two of the connector assembly test specimens included Weed #20 AWG leads and used the Weed potting procedure.

Sealed Flexible Tubing:

A sealed flexible SST tubing will be installed between the RTD Quick Disconnect Assembly and the existing Junction Box. The 3/4" SST flexible tubing is qualified to IEEE 344-1975. The qualification levels exceed Callaway Plant requirements.

Field Cables:

The new field cable to be used for this modification is Rockbestos 32/C, 8 shielded twisted quads, #16 AWG tinned copper, insulated and jacketed with flame retardant cross-linked polyethylene (FR-XLPE). Each quad is twisted with

a #18AWG drain wire in contact with an aluminum/mylar shield. This cable is qualified to IEEE 323-1974 and IEEE 383-1974 by Rockbestos Test Reports QR-5805 and QR-7804 and satisfies Callaway Plant requirements.

Junction Boxes and Splices:

Current plans call for existing junction boxes to be used to house the splices between the extension leads from the quick disconnect assemblies and the field cable. These junction boxes are NEMA 3R, Hoffmann terminal boxes with low point drain holes. If needed, additional junction boxes of this type will be added. The conductors to be spliced will be joined by either ring tongue terminals bolted together (Wyle Labs Test Report #58722-2) or by Burndy type YSV (or approved equal) butt splices (Wyle Labs Test Report #58442-1) and then sealed with Raychem WCSF-N heat shrink tubing. This splicing methodology is also used at the containment penetration and is qualified to IEEE 323-1974 and IEEE 383-1974 for Callaway Plant requirements.

Reactor Protection System (RPS) Hardware:

The added test cards (Temperature Channel Test, NTC and Master Test, NMT), RTD amplifier cards (R/E converter or NRA), summing amplifier cards (NSA), and isolator cards (NLP) are identical to the existing 7300 electronic components used at Callaway.

The electronic module used to derive the loop's average T-Hot signal (T-HAVG) from the individual T-Hot inputs is identical to the module now in use to derive the loop's average temperature (T-AVG) from the T-Hot and T-Cold inputs.

The added electronics will be installed in spare card locations in the existing 7300 cabinets. Existing divisional separation will be maintained. All additional mounting hardware will be identical to existing mounting hardware. All new electronics and mounting hardware will be procured through the same source used to supply the present equipment. Cabinet wiring will meet Class 1E requirements.

The 7300 Process Protection System cabinets were qualified per WCAP-8687, EQTR E13A through E13D, to IEEE 344-1975. The 3-bay test cabinet was loaded with cardframes, power supplies, and dummy weights to simulate possible loading extremes that

could exist. The dummy weights included an allowance to simulate internal cable weights. Five OBE's and four SSE's were simulated with fully loaded cabinets to g-levels more than 3 times higher than anticipated at Callaway. The additional mass due to new cards and cables associated with this modification has been determined to be enveloped by this test program. The above ensures that the added electronics will be compatible with existing electronics. It also minimizes the impact on present training and procedures. In addition, all the equipment has been fully qualified and has a demonstrated high reliability.

5.6 Detection of a Failed RTD:

A failed RTD would be picked up by the loop Delta-T vs. auctioneered (high) Delta-T deviation alarm currently set at ± 7.41% rated thermal power and/or the loop T-AVG vs. auctioneered (high) T-AVG deviation alarm currently set at ± 3°F. Also, each channel is checked once per 12 hours as required by the Technical Specifications. On failure of an RTD, the channel would be tripped and the Technical Specification Action Statement would go in effect. Since the Delta-T protection functions require 2 out of 4 logic, the failed channel would have no impact on the safe operation or shutdown of the plant.

As discussed in Sections 5.1.2 (Hot Leg) and 5.2 (Cold Leg), the second element of each RTD is an "installed spare" which is wired all the way to the Master Test (NMT) cards in the 7300 cabinets. This facilitates changing to the spare element as well as minimizing the time that one channel would have to be tripped.

TABLE 5-1

WEED RTD ACCURACY*

ACCURACY (INCLUDES HYSTERESIS AND REPEATABILITY)	$\pm$ 0.3°F
DRIFT (@ 24 MONTHS)	$\pm$ 0.4°F
TOTAL UNCERTAINTY	$\pm$ 0.7°F

* The more conservative RdF values were retained in the new Callaway setpoint calculations in Attachment 6.

RTD BYPASS ELIMINATION ANALOG RTD AVERAGING
CALLAWAY PLANT

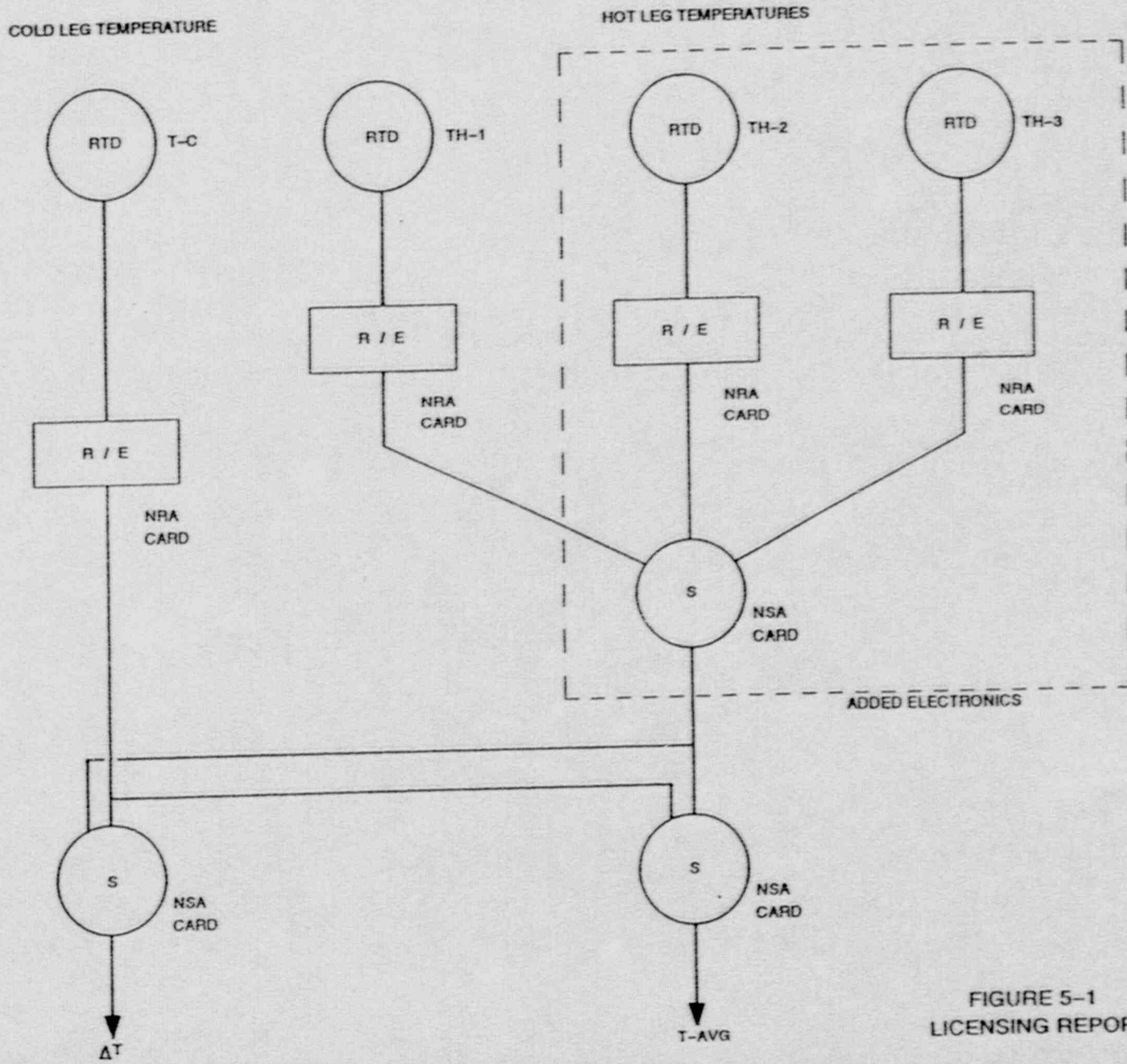


FIGURE 5-1
LICENSING REPORT

FIGURE 5-1
LICENSING REPORT

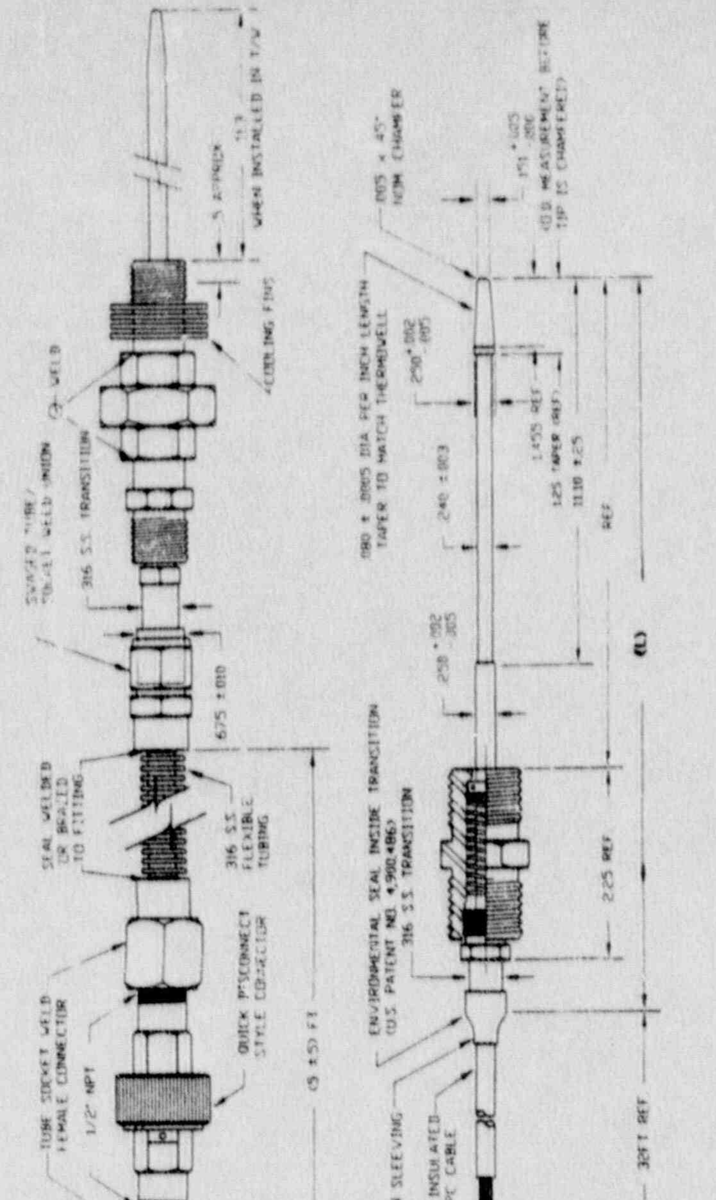


FIGURE 5-2
LICENSING REPORT

6.0 ALARA

6.1 Description:

The project will involve the removal of all of the RTD bypass manifold piping which consist of about 400 feet of piping and 64 valves. Following the removal of the piping, existing penetrations into the RCS piping will be modified to allow the installation of the new thermowells.

The major steps involved in installation of the hot leg thermowells are:

1) Cut the pipe stubs remaining.

2) Prepare the end of the nozzle for acceptance of the thermowell.

3) Using the EDM tool, bore out the new flow holes.

4) Install thermowells and weld.

The major steps involved in installation of the cold leg thermowells are:

1) Cut the pipe stubs remaining.

2) Prepare the end of the nozzle.

3) Bore out the cold leg nozzle to accommodate the new thermowell.

4) Install thermowells and weld.

The major steps involved at the cross over leg are:

1) Cut the pipe stubs remaining.

2) Prepare the end of the nozzle.

3) Weld on the new caps.

The isolation valves and the RTD manifolds are the major sources of radiation in the existing system. It is expected that the removal of these components will be the most exposure intensive portion of the demolition phase.

The radiation exposure rates at the RCS penetration work areas will be reduced by the removal of the isolation valves and RTD manifolds as well as the installation of large quantities of temporary shielding on the RCS piping.

6.2 Dose Savings:

The arrangement of the Callaway RTD manifold piping is such that the high radiation fields generated by them increase the collective exposure received during steam generator and reactor coolant pump inspections or maintenance. Although temporary shielding is used to reduce these radiation levels during long outages, it is not used for forced outages as it requires at least 1.5 days to erect. Even with the use of temporary shielding, approximately half of the dose received during steam generator and reactor coolant pump maintenance is attributed to the RTD bypass piping which is in the same area. The removal of the RTD bypass manifolds is expected to reduce the collective exposure by about 2000 man-rem over the remaining life of the plant assuming a 40 year operating license. In addition, forced outages will be avoided due to the avoidance of leaks and equipment failures.

6.3 ALARA Methods:

The project is being reviewed and planned in accordance with ALARA procedures. Use of temporary shielding is planned for the modification of the RCS piping penetrations. The use of respirators will be minimized by local decontamination and by the use of a containment system during the machining process.

6.4 Radioactive Waste:

The waste generated by this project will consist largely of the removed piping and semi-encapsulated insulation. It is expected that a waste volume of less than 800 ft^3 (including piping, insulation, valves, and supports) will result. The disposal method will be the usual low level waste burial process.

6.5 Radiological Problems and Dosimetry:

Although some components of the RTD bypass manifold piping system do present rather high exposure rates, these can be managed by the use of the ALARA planning process. Containment systems

will contain almost all of the loose surface contamination and/or airborne radioactivity that might be produced during the machining process.

7.0 SYSTEM FUNCTIONAL IMPACTS

The narrow range RTD temperature outputs are used for a number of purposes including reactor trips and Engineered Safety Features (ESF) actuation, as well as electrically isolated control systems, alarms, computer inputs, and indicators.

7.1 System Accuracy:

The effect on accuracy of the proposed system is insignificant because of the following:

- o Hot leg scoop mixing has been retained as discussed in Section 4.1.

- o The replacement RTD is specified to have an improved accuracy/drift over the existing RTDs. The accuracy of the new RTD is discussed in Section 5.3. Since the new RTDs will not be in contact with the primary fluid and will be provided with a quick disconnect at approximately 5 feet beyond the union along the pigtail, they can be readily removed. Little, if any, decontamination would be required to allow transport to a testing facility to check calibration of the RTDs.

- o Each hot leg RTD will be wired to an RTD amplifier card (R/E converter or NRA) which is then wired with the other hot leg RTDs in that RCS loop to a summing amplifier card (NSA) which averages the three signals to obtain the loop's T-Hot. By having three parallel path T-Hot RTDs, R/E converters, and interconnecting wiring, the sensor errors are noticeably reduced while the rack errors are only slightly reduced due to the added NSA card, as discussed in Attachment 6.

- The impact of the T-Hot electronics (Figure 5-1) has been evaluated as discussed in Section 3.4. The existing Technical Specification channel functional checks, response time tests, and calibration accuracy requirements will be maintained. The impact of rack drift has been considered in the evaluation.

- There is no change to the cold leg's electronics; and therefore, no impact to the accuracy other than the benefit obtained from a more accurate RTD.

- These factors virtually offset all of the effects of the hot leg streaming temperature measurement bias and the revised Delta-T gain.

7.2 Response Time Impact:

This modification will not impact the Technical Specification (TS) instrumentation response times. This is because the total testable response time of the proposed system is shorter than the time specified in the TS as shown in Table 7-1. With the proposed system, the response time of the RTDs will be determined with the RTDs in the thermowells (using LCSR methodology); therefore, the thermal lag associated with the thermowell will be included in the RTD tested response time. The response time of the proposed RTD/thermowell is 0.75 seconds slower than the existing direct immersion RTD's response time. However, the fluid travel time from the inlet port of the scoop to the RTD is reduced from 2.0 seconds to 0.25 seconds with the new system.

OTDT trip time response is modelled in two parts. The first part is a first order lag (i.e., thermal lags and RTD response time) and the second part is a pure delay (i.e., electronics delay). Depending on the transient and the OTDT equation, a first order lag can result in later rod motion than a pure delay of the same magnitude. Since the existing FSAR accident analyses and the Steamline Break topical (WCAP-10961-P) were performed with 6 seconds of first order lags and 2 seconds of pure delays, as shown on Table 7-1, no previous analyses are impacted since the total response time of the proposed system is faster than the current system.

The times listed in Table 7-1 bound best estimate response times. The allocated time for the RTDs includes a 10% error allowance for LCSR testing.

7.3 Relocation of RTD Instruments:

The function of the RTDs in the bypass piping manifolds is to measure the RCS hot leg and cold leg temperatures. Accordingly, physical relocation of the RTDs into thermowells mounted directly in the RCS piping is consistent with the function of the RTDs. At the proposed locations, the RTD thermowells will be directly in the RCS flow path and not have to rely on a subsystem.

7.4 Reactor Coolant System Flow:

Elimination of the RTD Bypass Piping System will have a very slight increase of approximately 0.1% in the flow through the Reactor Vessel and Steam Generator. Although this flow increase theoretically results in better heat removal at the core and better heat transfer at the Steam Generator, the change is too small to be significant.

7.5 Setpoint Studies

The effects on setpoint terms Z, S, and Allowable Value for the OPDT reactor trip and the Trip Time Delay (TTD) Delta T interlocks for steam generator low-low level reactor and ESFAS trip functions were assessed using previously approved setpoint methodologies, revised in Attachment 6 to account for the new hot leg RTDs and added electronics yet maintaining the basic approach (i.e. SQSS combination of independent uncertainties). Only minor changes to the Technical Specifications are needed to account for a worst case bounding value for the hot leg streaming temperature measurement bias, discussed in Section 3.4, and to reflect an updated Delta-T gain which converts temperature values in degrees F to the corresponding value in percent Delta-T span. This gain is based on recent plant data.

TABLE 7-1

	EXISTING	PROPOSED	SAFETY** ANALYSIS
I. FIRST ORDER LAGS			
a. Direct Immersion Bypass Manifold RTD Response Time	4.0 sec.*	N/A	
b. Combined RTD/Thermowell Response Time	N/A	4.75 sec.*	
c. RTD Bypass Line Fluid Transport Delay and Piping Thermal Lag	2.0 sec.	N/A	
d. Scoop Transport Delay and Thermal Lag	Included in c	0.25 sec.	
SUBTOTAL FIRST ORDER LAGS	6.0 sec.	5.0 sec.	6.0 sec.
II. PURE TIME DELAYS			
a. Electronics	1.5 sec.	1.0 sec.	
b. SSPS	0.010 sec.	0.010 sec.	
c. Reactor Trip Breakers	0.150 sec.	0.150 sec.	
SUBTOTAL PURE DELAYS	1.66 sec.	1.16 sec.	2.0 sec.
TOTAL TESTABLE TIME DELAYS ***	5.66 sec.	5.91 sec.	
TOTAL TIME DELAYS	7.66 sec.	6.16 sec.	8.0 sec.

* Includes 10% test allowance for LCSR testing. Existing RTD response time makes use of time margin available in the OTDT analyses.

** See FSAR Table 15.0-4.

*** Tech. Spec. limit is 6.0 sec. (excludes transport delays and thermal lags).

ATTACHMENT 2

SAFETY EVALUATION

FOR

RTD BYPASS ELIMINATION

SAFETY EVALUATION

This amendment application includes revisions to Technical Specification Tables 2.2-1, 3.3-4, and 4.3-1 to accommodate the proposed replacement of the current RTD bypass system with an RTD/thermowell system incorporated directly into the hot and cold legs of the reactor coolant system. This modification is desirable in order to increase plant availability and reliability due to the removal of several valves that have been the source of leakage inside containment and to reduce man-rem exposures in keeping with the objectives of our ALARA program.

As described in Final Safety Analysis Report (FSAR) Section 5.1, Reactor Coolant System (RCS) hot and cold leg temperatures are measured by narrow range, direct immersion RTDs located in bypass manifolds. Through the use of a bypass manifold around each steam generator, hot leg temperatures are obtained by mixing the flow from three scoop connections which extend into the flow stream at locations 120° apart circumferentially. Flow for the cold leg manifold is obtained downstream of the reactor coolant pump. Both hot leg and cold leg bypass flows enter a common return line to the cross over leg (see FSAR Figure 5.1-1, Sheet 1 for the existing configuration).

As discussed in FSAR Section 7.2, the existing RTD temperature outputs are used for a number of purposes. They are used by the Reactor Protection System for the Overtemperature Delta-T (OTDT) and Overpower Delta-T (OPDT) trip functions. The OTDT reactor trip function is a primary trip credited in the accident analyses (FSAR Chapter 15) and WCAP-10961-P (Steamline Break Mass/Energy Releases for Equipment Environmental Qualification Outside Containment). The OPDT reactor trip function provides backup protection against excessive power (fuel rod integrity protection). No credit is explicitly taken for OPDT trips in the Callaway FSAR Chapter 15 accident analyses. The steam generator low-low level reactor trip and AFW initiation circuitry has Delta-T interlocks that provide Trip Time Delays (TTD) at low power conditions. Rod control is based upon T-AVG signals isolated from protection system channels. The T-AVG signals are also provided to the pressurizer level control system, the steam dump control system (in the T-AVG mode), control rod insertion limits, rod stops and turbine runbacks, and certain interlocks. The functions that utilize temperature input from the existing narrow range RTDs will not be affected by their proposed removal and replacement because the signals derived from the proposed replacements will be equivalent to those provided by the existing RTDs.

The proposed change involves removal of the existing bypass lines and replacement of the existing RTDs with thermowell RTDs. Three dual element RTDs will be used for each hot leg. These will be located in the existing scoops. One dual element thermowell RTD will be located in the existing cold leg penetration. The

nozzles in the crossover legs for the return lines will no longer be needed, and they will be capped. The proposed replacement of the existing RTD and bypass line elimination does not involve an unreviewed safety question as discussed hereinafter.

The removal and replacement of the existing RTDs will not increase the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the FSAR. The consequences of an accident or malfunction of equipment important to safety previously evaluated are considered first. There are six non-LOCA analyses of interest:

a) FSAR Section 15.2.3, Turbine Trip (specifically the case with pressurizer sprays and PORVs available with maximum reactivity feedback)

b) FSAR Section 15.4.2, Uncontrolled Rod Cluster Control Assembly (RCCA) Bank Withdrawal at Power (specifically the case with a 1 pcm/sec reactivity insertion rate)

c) FSAR Section 15.4.3, RCCA Misoperation (specifically the case for a single RCCA withdrawal at power)

d) FSAR Section 15.4.6, CVCS Malfunction that Results in a Decrease in the Boron Concentration of the Reactor Coolant (specifically the case at full power with manual rod control)

e) FSAR Section 15.6.1, Inadvertent Opening of a Pressurizer Safety or Relief Valve (safety valve opening is limiting)

f) WCAP-10961-P, Steamline Break Mass/Energy Releases for Equipment Environmental Qualification Outside Containment

These events are of interest because the OTDT trip is the primary trip assumed in the analyses, with a total response time of 8 seconds (6 seconds of first order lags and 2 seconds of pure delay). No OPDT trips are assumed in the analyses.

The OTDT, OPDT, and steam generator low-low level trips will continue to function in a manner consistent with the existing analyses assumptions for these events. The total response time of the proposed system is less than that for the current system. Further, the elimination of the RTD bypass system will not affect the LOCA analyses input and the results of these analyses will be unaffected. Therefore, the plant design changes due to the RTD bypass elimination are acceptable from a LOCA analysis standpoint without requiring any reanalysis.

Hence, there will be no increase in the consequences of an accident or malfunction of equipment important to safety previously evaluated.

There will be no increase in the probability of occurrence of an accident or malfunction of equipment important to safety previously evaluated in the FSAR. The events of interest are those initiated by a failure of those systems that use temperature inputs from the narrow range RTDs (T-AVG) or could be initiated by a mechanical failure of components affected by the proposed change. There are four such events. These are:

a) FSAR Section 15.4.2, Uncontrolled RCCA Bank Withdrawal at Power

b) FSAR Section 15.1.3, Excessive Increase in Secondary Steam Flow

c) FSAR Section 15.1.4, Inadvertent Opening of a Steam Generator Relief or Safety Valve

d) FSAR Section 15.6.5, Small Break Loss of Coolant Accident (SBLOCA)

The Uncontrolled RCCA Bank Withdrawal event is an ANS Condition II (moderate frequency) event potentially initiated by a failure of the rod control system. The Excessive Steam Flow and Inadvertent Steam Generator Depressurization events are also Condition II events. They are potentially initiated by a failure of the steam dump control system. The input to the rod control system and steam dump control system from the replacement RTDs will be equivalent to that currently provided by the existing RTDs. The proposed modification will be done in a manner consistent with the plant design bases. As such there will be no degradation in the performance of or increase in the number of challenges to equipment assumed to function during an accident situation. Furthermore, there will be no increase in the probability of failure or degradation in the performance of the systems designed to reduce the number of challenges to equipment assumed to function during an accident situation. Hence, the first three events will remain Condition II events.

The SBLOCA is an ANS Condition III (infrequent) event. It could be initiated by the highly unlikely ejection of a thermowell or the failure of one of the caps that will cover one of the existing cross over leg penetrations. All changes will preserve the qualification of the Reactor Coolant System pressure boundary. The scoops, cross over leg buttweld caps, and thermowells will be analyzed to the ASME Boiler and Pressure Vessel Code, Section III, Class 1 and installed in accordance with Section XI of this code. This stress analysis will be completed by July 1, 1990. Based on CE's past experience, Code allowables will be satisfied. The SBLOCA will remain a Condition III event. Hence, there will be no increase in the probability

of occurrence of an accident or malfunction of equipment important to safety previously evaluated in the FSAR. Additionally, approximately 400 feet of small diameter piping and the associated valves will be removed from the primary system pressure boundary, thereby eliminating the possibility of a SBLOCA caused by a failure in this section of piping. An increase in the RTD/thermowell response time will not increase the probability of occurrence of a previously evaluated accident or malfunction of equipment important to safety because the numerical value of response time is not the initiator of such an event. The total response time of the functions that use signals from the narrow range RTDs will be reduced after the proposed modification.

The probability and consequences of flooding and jet impingement have been reviewed. The thermowells and caps will be in the same or immediate locations of the existing RTD bypass loop connections. Therefore, the consequences of a postulated flooding of the proposed RTDs or the impingement of a jet on the proposed RTDs are bounded by the results of existing analyses. There is no increase in the probability of flooding or jet impingement as the number of components and welded joints will be reduced considerably.

The consequences of a missile due to the postulated ejection of a thermowell has been reviewed. The cold leg thermowells are considered first. If ejected, these thermowells will impact either the RCP supports or the underside of the operating deck floor with no appreciable damage.

A missile created by the postulated ejection of one of the hot leg thermowells is considered next. If ejected, these thermowells with impact floors, walls, pipe supports or other steel structures which will not be affected adversely by impact. Therefore, since no vital components which could sustain damage by impact are in the direct path of an ejected thermowell, the consequences of an ejected thermowell are bounded by the current small break LOCA analyses.

The possibility of an accident or malfunction of a different type than any evaluated previously in the FSAR is not created. The proposed changes will be performed in a manner consistent with applicable standards, preserve the existing design bases, and will not adversely impact the qualification of any plant systems. This will preclude adverse control and protection system interactions. The design installation and inspection of the new equipment will be done in accordance with ASME Boiler and

Pressure Vessel Code criteria. By adherence to industry standards, the pressure boundary integrity will be preserved. Hence, the possibility of a different type of accident than any evaluated in the safety analysis will not be created.

There will be no significant reduction in the margin of safety, as defined in the bases of any technical specification, since the Improved Thermal Design Procedure (ITDP) analyses remain bounding. The applicable margins of safety are defined in Bases Sections 2.1.1 and 2.1.2. Bases Section 2.1.1 states that the minimum value of the Departure from Nucleate Boiling Ratio (DNBR) during steady state operation, normal operational transients, and anticipated transients is limited to 1.17. This value corresponds to a 95 percent probability at a 95 percent confidence level that Departure from Nucleate Boiling (DNB) will not occur. The restrictions of this fuel cladding integrity safety limit prevent overheating of the fuel and possible cladding perforation which would result in the release of fission products to the coolant. The minimum DNBR reported in the accident analyses will be unaffected by the proposed change.

Bases Section 2.1.2 states that the Safety Limit on maximum RCS pressure is 2735 psig. This Safety Limit protects the integrity of the RCS from overpressurization and thereby prevents the release of radionuclides contained in the reactor coolant from reaching the containment atmosphere. The maximum RCS pressure reported in the accident analyses is unaffected by the proposed change.

The proposed change will not result in a decrease of these margins of safety. As discussed earlier, the response time and setpoints of the SG low-low level trip functions and the OPDT and OTDT reactor trip functions will remain within the assumptions used in the safety analyses. As such, the analysis of the events which credit these functions will remain as presented in the FSAR, WCAP-10961-P, and WCAP-11883. Consequently, the margins of safety between the Fuel Cladding Safety Limit (i.e., DNBR) and RCS pressure boundary Safety Limit and the actual failure of these barriers will not be reduced.

The setpoint calculations incorporate an uncertainty to account for the difference between the actual hot leg temperature and the measured hot leg temperature caused by the incomplete mixing of coolant leaving regions of the reactor core at different temperatures. This uncertainty is made up of two parts -- a temperature streaming uncertainty and a scoop mixing bias. The temperature streaming uncertainty is unchanged from the previous calculations as discussed in Section 2.0 of Attachment 6. The scoop mixing bias is based upon an analysis of the effect of the modified hot leg scoop-thermowell design to be employed at Callaway. The scoop mixing bias used in the setpoint calculations, in conjunction with a revised Delta-T gain (used to convert temperature in degrees F to percent Delta-T span) has been established as requiring only minor Technical Specification changes.

To determine the impact of the removal of the RTD Bypass piping and manifolds on the Callaway temperature-related control and protection functions, Union Electric performed instrument uncertainty calculations which utilized the latest available information on plant installed instrumentation and the Combustion Engineering scoop/thermowell design as well as previously approved setpoint methodology (revised slightly to reflect the additional RTDs and electronics). As a direct result of this work, it can be concluded that the Rod Control system will operate within assumed tolerances, and the temperature-related protection functions, i.e., Overtemperature Delta-T and Overpower Delta-T reactor trips and Delta-T Trip Time Delays for SG Low-Low Level trips, will maintain their current Technical Specification Nominal Trip Setpoints. Changes to the Technical Specification Z, S, and Allowable Values for OPDT and TTD Delta-T Power 1 and Power 2 will be necessary.

Based on these setpoint studies, the OTDT, OPDT, and SG Low-Low Level TTD instrument loops see reductions in the theoretical sensor and rack calibration uncertainty for each, primarily due to the increase in the number of RTDs and R/E converters used for the measurement of T-Hot. The uncertainties used for the instrumentation remain specific to the type and manufacturer of the hardware and are not a function of the presence, or absence, of the RTD Bypass piping. The only uncertainties that change as a direct result of the removal of the RTD Bypass piping are the T-Hot streaming values.

It was determined that the CE scoop/thermowell design results in a small temperature measurement bias. However, net reductions are seen in the instrument uncertainties which offset this bias and the revised Delta-T gain to the extent that only minor Technical Specification changes are required.

In conclusion, the removal and replacement of the existing narrow range RTDs and elimination of the bypass lines does not involve an unreviewed safety question. Neither the probability of occurrence nor the consequences of an accident or malfunction of equipment important to safety previously evaluated in the FSAR is created. The possibility for an accident or malfunction of a different type than any evaluated previously in the FSAR is not created. There will be no significant reduction in the margin of safety as defined in the basis of any technical specification.

Therefore, the proposed revisions do not adversely affect or endanger the health or safety of the general public or involve a significant safety hazard.

ATTACHMENT 3

SIGNIFICANT HAZARDS EVALUATION

FOR

RTD BYPASS ELIMINATION

SIGNIFICANT HAZARDS EVALUATION

This amendment application includes revisions to Technical Specification Tables 2-2-1, 3.3-4, and 4.3-1 to accommodate the proposed replacement of the current RTD bypass system with an RTD/thermowell system incorporated directly into the hot and cold legs of the reactor coolant system.

The proposed change does not involve a significant hazards consideration because operation of Callaway Plant in accordance with this change would not:

(1) Involve a significant increase in the probability or consequences of an accident previously evaluated. The probability of previously analyzed accidents is discussed first. The proposed change in RTD/thermowell response time will not increase the probability of such an accident because the response time is not a factor in the initiation of a previously evaluated accident. The events of interest are those initiated by a failure of those components affected by the proposed change. There are four such events:

a) FSAR Section 15.4.2, Uncontrolled RCCA Bank Withdrawal at Power

b) FSAR Section 15.1.3, Excessive Increase in Secondary Steam Flow

c) FSAR Section 15.1.4, Inadvertent Opening of a Steam Generator Relief or Safety Valve

d) FSAR Section 15.6.5, Small Break Loss of Coolant Accident (SBLOCA)

The Uncontrolled RCCA Bank Withdrawal event is an ANS Condition II (moderate frequency) event potentially initiated by a failure of the rod control system. Excessive Steam Flow and Inadvertent Steam Generator Depressurization events are also Condition II events. They are potentially initiated by a failure of the steam dump control system. The input to the rod cont l system and steam dump control system from the replacement RTDs will be equivalent to that currently provided by the existing RTDs. The proposed modification will be done in a manner consistent with the plant design bases. As such, there will be no degradation in the performance of or increase in the number of challenges to safety systems assumed to function in the accident analysis. Furthermore, there will be no increase in the probability of failure of or degradation of the performance of the systems designed to reduce the number of challenges to safety systems. Hence, the first three events will remain Condition II events.

The SBLOCA is an ANS Condition III (infrequent) event. It could be initiated by the highly unlikely ejection of a thermowell or the failure of one of the caps that will cover one of the existing cross over leg penetrations. The scoops, cross over leg buttweld caps, and thermowells will be analyzed to the ASME Boiler and Pressure Vessel Code, Section III, Class 1 and installed in accordance with the requirements of Section XI of this Code. As such, the RCS pressure boundary will not be degraded. The SBLOCA will thus remain a Condition III event. Additionally, approximately 400 feet of small diameter piping and the associated valves will be removed from the primary system pressure boundary, eliminating the possibility of a SBLOCA from these locations.

Hence, there will be no significant increase in the probability of occurrence of an accident previously evaluated in the FSAR.

There will be no increase in the consequences of a previously evaluated accident. In assessing the impact on the consequences of a previously evaluated accident, there are six non-LOCA analyses of interest:

a) FSAR Section 15.2.3, Turbine Trip

b) FSAR Section 15.4.2, Uncontrolled RCCA Bank Withdrawal at Power

c) FSAR Section 15.4.3, RCCA Misoperation

d) FSAR Section 15.4.6, CVCS Malfunction that Results in a Decrease in the Boron Concentration of the Reactor Coolant

e) FSAR Section 15.6.1, Inadvertent Opening of a Pressurizer Safety or Relief Valve

f) WCAP-10961-P, Steamline Break Mass/Energy Releases for Equipment Environmental Qualification Outside Containment

These events are of interest because the OTDT trip is the primary trip assumed in the analyses, with a total response time of 8 seconds (6 seconds of first order lags and 2 seconds of pure delay). No OPDT trips are assumed in the analyses.

The OTDT, OPDT, and steam generator low-low level trips will continue to function in a manner consistent with the existing analyses assumptions for these events. The total response time of the proposed system will be less than that

for the current system. Further, the elimination of the RTD bypass system will not affect the LOCA analyses input and the results of these analyses will be unaffected. Therefore, the plant design changes due to the RTD bypass elimination are acceptable from a LOCA analysis standpoint without requiring any reanalysis.

Hence, there will be no increase in the consequences of previously evaluated accidents.

(2) Create the possibility of a new or different kind of accident from any previously analyzed. The proposed change will be performed in a manner consistent with applicable standards, preserve the existing design bases, and will not adversely impact the qualification of any plant systems. This will preclude adverse control/protection system interactions. The design, installation, and inspection of the new equipment will be done in accordance with ASME Boiler and Pressure Vessel Code criteria. By adherence to industry standards, the reactor coolant pressure boundary integrity will be preserved. As such, the possibility of a new or different kind of accident is not created.

(3) Involve a significant reduction in a margin of safety. The applicable margins of safety are defined in Technical Specification Bases Sections 2.1.1 and 2.1.2. Bases Section 2.1.1 states that the minimum value of the Departure from Nucleate Boiling Ratio (DNBR) during steady state operation, normal operational transients, and anticipated transients is limited to 1.17. This value corresponds to a 95 percent probability at a 95 percent confidence level that Departure from Nucleate Boiling (DNB) will not occur. The restrictions of this fuel cladding integrity safety limit prevent overheating of the fuel and possible cladding perforation which would result in the release of fission products to the coolant. The proposed change will not result in a decrease in the minimum DNBR reported in the FSAR accident analyses.

Bases Section 2.1.2 states that the Safety Limit on maximum RCS pressure is 2735 psig. This Safety Limit protects the integrity of the RCS from overpressurization and thereby prevents the release of radionuclides contained in the reactor coolant from reaching the containment atmosphere. The proposed change will not result in an increase in the maximum RCS pressure reported in the FSAR accident analyses.

The proposed changes to the Callaway Technical Specifications are similar to changes approved at Byron Station Units 1 and 2 and at Salem Units 1 and 2. As discussed earlier, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated or create the

possibility of a new or different kind of accident from any previously evaluated. It does not result in a significant reduction in any associated safety limit or limiting condition of operation.

Therefore, based on the above considerations, it has been determined that the proposed change does not involve a significant hazards consideration.