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Plant Protection System Selection of Trip Setpoint Values

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ABSTRACT

This report describes the Combustion Engineering "explicit" method of determining trip setpoint values for Southern California Edison San Onofre Nuclear Generating Station Units 2 & 3 Plant Protection System. The "explicit" method has been established, in part, to ensure that the Plant Protection System response will be consistent with the response assumed in the Safety Analysis, and to ensure that the methodology used will be consistent with current licensing requirements and industry standards.

This report includes a tabulation of specific data used in the setpoint determination process. This data provides the information requested by the Nuclear Regulatory Commission concerning the selection of trip setpoints for the SONGS Plant Protection System.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACRS	Advisory Committee on Reactor Safeguards
A/D	Analog to Digital Converter
ASP	Analysis Setpoint
AV	Allowable Value
CCAS	Containment Cooling Actuation Signal
C-E	Combustion Engineering
CEA	Control Element Assembly
CEAC	Control Element Assembly Calculator
CEDM	Control Element Drive Mechanism
CFR	Code of Federal Regulations
CIAS	Containment Isolation Actuation Signal
CSAS	Containment Spray Actuation Signal
DBE	Design Basis Event
DNBR	Departure from Nucleate Boiling Ratio
EFAS	Emergency Feedwater Actuation Signal
ESF	Engineered Safety Features
ESFAS	Engineered Safety Features Actuation System
FSAR	Final Safety Analysis Report
IEEE	Institute of Electrical and Electronics Engineers
LCO	Limiting Conditions for Operation
LER	Licensee Event Report
LPD	Local Power Density
MSIS	Main Steam Isolation Actuation Signal
N.A.	Not Applicable
NRC	Nuclear Regulatory Commission
OL	Operating License
PPS	Plant Protection System
RCP	Reactor Coolant Pump
R.G.	Regulatory Guide
RPS	Reactor Protection System
RWT	Refueling Water Tank
SA	Safety Analysis
SCE	Southern California Edison

LIST OF ACRONYMS AND ABBREVIATIONS (Cont'd)

SIAS	Safety Injection Actuation Signal
SONGS	San Onofre Nuclear Generating Station
STS	Standard Technical Specifications
Tech Spec	Technical Specification

LIST OF DEFINITIONS

Analysis Setpoint

The Analysis Setpoint is the parameter value for the initiation of PPS actions assumed in the Safety Analysis to show acceptable consequences for Design Basis Events.

Trip Setpoint

The Trip Setpoint is the defined value in the Technical Specification which is the least conservative value which may be set into the protective equipment and still be consistent with the Safety Analysis setpoint assumptions.

Allowable Value

The Allowable Value is the defined value in the Technical Specification which is the least conservative value that the Equipment Setpoint may have, when checked during the Functional Channel Check, and still be consistent with the Safety Analysis setpoint assumptions.

Equipment Setpoint

The Equipment Setpoint is the actual value which is set into the protective equipment by the technician. The Equipment Setpoint must be set conservative or equal to the Trip Setpoint value defined in the Technical Specification.

Limiting Safety System Setting (LSSS)

The LSSS, which includes both the Trip Setpoint and Allowable Value, is the generic name for the Technical Specification setpoint compliance values.

Initial Uncertainty

The Initial Uncertainty is the uncertainty which must be taken into account if the protective equipment was required to respond immediately following calibration in the calibration environment.

Periodic Test Uncertainty

The Periodic Test Uncertainty is the uncertainty which must be taken into account if the equipment was required to respond at the end of the periodic surveillance interval in the normal environment.

Total Instrument Channel Uncertainty

The Total Instrument Channel Uncertainty is the combined total of all errors which must be taken into account if the equipment was required to respond at the end of the Periodic Surveillance interval under the limiting accident environment conditions.

Plant Protection System

The Plant Protection System (PPS) is made up of both the Reactor Protection System (RPS) and the Engineered Safety Features Actuation System (ESFAS). The RPS includes all equipment from the sensor up to and including the Reactor Trip Switchgear. The ESFAS includes all equipment from the sensor to and including the Auxiliary Relay Cabinet.

Nominal Value

The Nominal Value is the initial estimated value of the Trip Setpoint which is shown in the Safety Analysis Report (SAR) Chapter 7. The Nominal Value is based on estimated instrument uncertainties and anticipated environmental effects, as well as knowledge gained in efforts for previous plants.

1.0 INTRODUCTION

1.1 SCOPE

By Reference 5.1 the Nuclear Regulatory Commission (NRC) requested specific setpoint related data for the San Onofre Nuclear Generating Station Units 2 & 3 (SONGS 2 & 3) Plant Protection System (PPS) from Southern California Edison (SCE). This document provides the requested information and also describes the Combustion Engineering (C-E) setpoint methodology used to determine SONGS PPS setpoints.

Section 1.2 provides the background which led up to the current setpoint related requirements and industry standards. Section 1.2 also describes the general requirements that were in effect for the PPS until approximately 1975, and the more specific requirements on setpoint determination that have evolved since that time.

Section 2.0 describes the present C-E method of determining protection system setpoints that is used to assure consistency with current requirements and standards. Section 2.0 begins by explaining, in general, how setpoints are determined and how the different aspects of setpoint determination are related to the Safety Analysis (SA) and to the plant Technical Specifications (Tech. Specs.). The remainder of Section 2.0 describes in more detail the specific components of the C-E explicit setpoint methodology.

Section 3.0 describes the equipment calibration and periodic test procedures which ensure that the equipment is operating in accordance with the assumptions and uncertainties used in the setpoint determination. This section ties the actual equipment operation to the setpoint calculation and is an integral part of demonstrating that plant operation will be consistent with the Safety Analysis.

Section 4.0 provides the specific data requested by Reference 5.1. The section begins with an explanation of the data in the tables and relates the data to the explanation of the C-E setpoint methodology. The remainder of Section 4.0 consists of tables which contain the requested information.

Section 5.0 lists the references referred to in this document.

1.2 BACKGROUND

On April 11, 1977 the NRC transmitted a letter to SCE concerning SONGS instrumentation setpoints (Reference 5.1). This letter stated that NRC review of facility operating experience indicates the need for additional information regarding the proper selection of instrumentation trip setpoint values. This conclusion was supported by the large number of Licensee Event Reports (LERs) received related to instrument setpoint drift beyond the limits permitted by the Technical Specifications. As a result, the letter requested explicit information concerning each Reactor Protection System (RPS) and Engineered Safety Features Actuation System (ESFAS) trip setpoint value.

NRC documents and industry standards have been developed to provide requirements and guidance concerning the proper selection of trip setpoint values. For example:

1. 10CFR50 (Reference 5.3) Section 50.36, Technical Specifications, specifies that Limiting Safety System Settings (LSSSs) are to be chosen so that automatic protective action will correct abnormal situations before a safety limit is exceeded.

2. 10CFR50 (Reference 5.3) Section 50.55, Codes and Standards, specifies that protection systems shall meet the requirements of IEEE 279-1971 (Reference 5.4).

3. 10CFR50 (Reference 5.3) Appendix A, Criterion 20, Protection System Functions, specifies that the protection system shall function automatically to assure acceptable consequences during postulated events.

4. IEEE 279-1971 (Reference 5.4) specifies that the protection system shall automatically initiate protective action whenever monitored conditions reach preset levels.

These requirements in general, apply to both the RPS and the ESFAS, which collectively make up the Plant Protection System (PPS). These requirements state that protection systems (and their setpoints) shall be designed to assure their proper operation (at the proper setpoint) during events that require protective action. Recent NRC documents which have provided setpoint guidance include:

1. The NRC issued Standard Technical Specifications (STS) (Reference 5.5) which call for specific accounting of instrument drift in the setpoint determination process.

2. R.G.1.105 (Reference 5.6) includes specific requirements on setpoint margin, drift allowance, uncertainty components and documentation of setpoint methodology.

3. The Advisory Committee on Reactor Safeguards (ACRS) transcript on Item 13 (Reference 5.7) discusses two methods of setpoint determination the "generalized" method and the "explicit" method. The "generalized" method includes a bulk uncertainty that characterizes a typical measurement channel. On the other hand, the "explicit" method includes an explicit treatment of drift, instrument error, calibration error and environmental error. As pointed out in the transcript, the NRC is moving toward requiring that the explicit method be used for setpoint determination as a prerequisite for receiving an Operating License.

4. In Reference 5.1, the NRC has recently requested more explicit data from SCE concerning setpoint methodology.

The Combustion Engineering RPS and ESFAS is designed to meet all of the above requirements. The methodology employed to calculate equipment setpoints is consistent with these requirements and is an "explicit" method as discussed in References 5.6 and 5.7.

This document describes the C-E "explicit" method of setpoint determination. It also provides the specific information requested of SCE by Reference 5.1. This information is contained in Tables 1-7 at the end of the report. Section 4.0 describes how the information is compiled in the Tables and provides a one-to-one correlation between the specific information requested in Reference 5.1 and the data in the Tables.

2.0 SETPOINT METHODOLOGY

2.1 BASIC DESCRIPTION

The SONGS Plant Protection System consists of both RPS and ESFAS trip functions. The RPS includes 14 trip functions, two which are generated by the CPC digital computer. Both the CPC trip paths and the non-CPC trip paths include sources of uncertainty and drift. The C-E "explicit" method of calculating setpoints is used to ensure that all identified equipment uncertainties are accommodated. Section 2.5 describes the C-E setpoint method for CPC generated trips, the remaining portions of Section 2.0 discuss the setpoint methodology applicable to the non-CPC portion of the RPS and all the ESFAS trips.

Figure 1 describes the C-E PPS Setpoint methodology in block diagram form.

The Setpoint methodology begins when a Safety Analysis is performed to show that the consequences of Design Basis Events (DBEs) will be acceptable. The Safety Analysis assumes protective action is initiated when the process variables reach established values. The values assumed in the Safety Analysis are defined as Analysis Setpoints (ASP).

A detailed equipment error calculation which combines the individual uncertainty components into a Total Instrument Channel Uncertainty is performed for each PPS function. This Total Instrument Channel Uncertainty and the Analysis Setpoint are used to establish the Trip Setpoint. The Trip Setpoint is set in a conservative direction from the Analysis Setpoint a distance representing the Total Instrument Channel Uncertainty. The Trip Setpoint becomes part of the plant Technical Specifications (Reference 5.2).

As an integral part of the equipment error calculation, a number is determined which represents the expected measurable equipment drift over a specified period between calibrations. This value is the Periodic Test Uncertainty. An Allowable

Value is defined by moving from the Trip Setpoint toward the Analysis Setpoint by the amount calculated for the Periodic Test Uncertainty. This Allowable Value also becomes part of the plant Technical Specifications and represents the value to which the Equipment Setpoint can drift between calibrations and still be consistent with the Safety Analysis.

Thus the C-E setpoint methodology results in a Trip Setpoint and an Allowable Value which, assuming the equipment is operated as designed, assure that protective action will be initiated conservatively relative to the Analysis Setpoint used in the Safety Analysis. The Trip Setpoint and Allowable Value together make up the Limiting Safety System Setting (LSSS) required in the Technical Specifications.

The remainder of Section 2.0 discusses in greater detail the specific components of the C-E "explicit" setpoint methodology.

2.2 ANALYSIS SETPOINT

As a basic requirement, setpoints must be chosen to (1) ensure initiation of required protective action to show acceptable consequences for safety related Design Basis Events (DBEs) and, (2) to ensure that performance related DBEs can be accommodated without initiating protective action. Refer to Figure 2 during the discussion on determining Analysis Setpoints.

As an initial step in setpoint determination the equipment errors for each trip function are estimated using known equipment characteristics, the anticipated environmental effects, and knowledge gained in previous efforts for different plants. Additionally, the operating ranges for the measured parameters are determined for normal steady-state conditions and during performance related DBEs. These are combined to form the basis for the initial setpoint.

This setpoint is called the Nominal Value and represents the approximate value of the expected final setpoint. The Nominal Value is used in the Preliminary Safety Analysis Report (PSAR). Before the final Safety Analysis is completed and incorporated into the Final Safety Analysis Report (FSAR)

the Nominal Value is adjusted, again considering the estimated total equipment error, to result in a value that represents the expected most limiting point at which a protective action would be initiated if the equipment setpoint was set at the Nominal Value. This resulting value is the Analysis Setpoint which is input to the Safety Analysis. Analysis Setpoints are, in some cases, results of parametric studies conducted until a setpoint is determined which will result in an acceptable Safety Analysis and acceptable plant performance.

In the Safety Analysis, the Analysis Setpoint is the value of the measured parameter at the measurement point which is assumed to initiate protection system actuation. The Safety Analysis is described in the Final Safety Analysis Report (FSAR) and is part of the documentation required to receive an Operating License. Some events analyzed in the Safety Analysis result in a more severe environment for protection system equipment than other events. As a result the expected total equipment error can be different for different events (i.e., event specific). Therefore, a trip function can have different Analysis Setpoints for different design basis events. The final Analysis Setpoints used in the Safety Analysis are then used in the setpoint calculation to determine Trip Setpoints and Allowable Values as described in subsequent sections of this report.

2.3 EQUIPMENT ERRORS

2.3.1 General

Good engineering practice and current setpoint requirements dictate that all factors which can affect the operation of equipment be considered when determining errors in the setpoint calculation. In the C-E setpoint methodology, each error component that can have an impact on equipment performance is determined separately and then the individual errors are combined by a statistically valid method to arrive at a total equipment uncertainty. The individual errors are plant-specific and equipment-specific and thus must be determined for each plant on a case-by-case basis. The following paragraphs describe the individual error components. These are:

1. PPS Cabinet Initial Uncertainty;

2. PPS Cabinet Periodic Test Uncertainty;

3. Process Equipment Initial Uncertainty;

4. Process Equipment Periodic Test Uncertainty;

5. Accident Environment Error;

6. Process Error;

7. Dynamic Allowance.

For means of setpoint calculation, the PPS is divided into two major regions (Figure 3.) The first region is the process equipment. This consists of the sensor, transmitter, power supply and signal processing equipment - all equipment up to the PPS cabinet. The second region is the PPS cabinet itself. Each of these regions provide individual error components.

2.3.2 Individual Errors

2.3.2.1 PPS Cabinet Initial Uncertainty

The PPS Cabinet Initial Uncertainty is the uncertainty inherent in the equipment and calibration of the PPS cabinet instrumentation and represents the error that would have to be accounted for if the instrumentation was required for protective action immediately after the calibration procedure was performed. This uncertainty is determined for the specific equipment installed in the PPS cabinet from information supplied by the manufacturer and actual calibration requirements of the equipment.

2.3.2.2 PPS Cabinet Periodic Test Uncertainty

The PPS Cabinet Periodic Test Uncertainty accounts for the expected drift of the PPS cabinet equipment over the period from when the setpoint was set

until the monthly Channel Functional Check is performed to check the setpoint. When determining this uncertainty, the following aspects are considered: the error associated with setting and checking the setpoint, errors because of the difference in PPS cabinet environment at the time the setpoint is checked and the environment when the setpoint was set, and errors due to anticipated drift of the PPS cabinet equipment. These component errors are combined to determine the PPS Cabinet Periodic Test Uncertainty in a manner similar to that described in section 2.3.3 for determining total equipment errors. The PPS Cabinet Periodic Test Uncertainty is calculated using information supplied by the equipment manufacturer and from actual testing of the equipment.

2.3.2.3 Process Equipment Initial Uncertainty

This uncertainty is analogous to the PPS Cabinet Initial Uncertainty but applies to the process equipment as shown on Figure 3, instead of the PPS cabinet. This is the error inherent in the calibration and operation of the process equipment and represents the error that would have to be accounted for if the equipment was required for protective action immediately after the calibration procedure was performed. As with the previous errors, the Process Equipment Initial Uncertainty is determined for the specific equipment installed at the plant from information supplied by the manufacturer and actual calibration requirements on the equipment.

2.3.2.4 Process Equipment Periodic Test Uncertainty

The Process Equipment Periodic Test Uncert inty is analogous to the PPS cabinet Periodic Test Uncertainty but appl to the process equipment. This uncertainty accounts for the expected measurable drift of the process equipment during the time between channel calibrations, which are performed as a minimum every 18 months as required by the plant Technical Specifications (Reference 5.2). The same aspects are considered when calculating this error as are considered when determining the PPS Cabinet Periodic Test Uncertainty described above and the components are combined in a similar manner.

2.3.2.5 Accident Environment Error

During certain design basis events, combinations of atmospheric changes and seismic events are considered to occur simultaneously. These changes in environment introduce additional errors in the process equipment which must be considered in the overall setpoint calculation. Examples of specific environmental effects on equipment error which are considered are: temperature effects, pressure effects, reference leg effects, seismic effects, and radiation effects. The individual accident environment errors are combined in a manner similar to that used to calculate total equipment errors described in section 2.3.3. The environment considered when determining these errors is the most detrimental realistic environment calculated or postulated to exist up to the time of the required Reactor Trip or Engineered Safety Features (ESF) actuation.

This environment may be different for different events analyzed. In most cases, for setpoint calculation, the accident environment error calculation for process equipment uses the environmental conditions that result in the largest errors, thus adding additional conservativism (i.e., greater margin) for the events with smaller errors. In some cases, however, the accident environment errors for some events are much larger then those for events with little or no containment environment change. In these cases, specific errors are calculated for different events. The event specific errors are then used in calculating total equipment errors which also become event specific.

2.3.2.6 Process Error

The Process Error accounts for the uncertainty in the value of the process parameter (e.g., neutron flux power, temperature variation) at the sensor. In most cases the errors which exist between the actual process parameter and the value at the sensor are incorporated into the Safety Analysis instead of becoming part of the setpoint calculation. When included as part of the setpoint calculation, the process errors are combined with the other equipment errors to determine the Total Instrument Channel Uncertainty.

2.3.2.7 Dynamic Allowance

As part of the Safety Analysis, a time delay is used to account for the delays inherent in the PPS equipment. For the RPS, this time delay represents the time from when the process value at the sensor reaches the trip point to the time when the Reactor Trip Switchgear is de-energized. For the ESFAS this time delay represents the time from when the process value at the sensor reaches the actuation point to when the actuation signal is output from the Auxiliary Relay Cabinet. When the actual PPS equipment is tested, time delays of the various components are determined and verified. The total time delay is then determined.

In certain cases, if it is determined that the actual delay time for the equipment is longer than the delay time used in the Safety Analysis, a Dynamic Allowance may be incorporated into the setpoint to compensate for this time response difference. To assure that a protective action occurs at or before the time assumed in the Safety Analysis, the Trip Setpoint is altered in a conservative direction by the Dynamic Allowance to compensate for the sensor response characteristics.

2.3.3 Total Instrument Channel Uncertainty

After the individual error components have been determined, they are combined to arrive at a Total Instrument Channel Uncertainty which is used in calculating the Trip Setpoint. Each individual error can consist of both random and non-random components. Random errors are errors of uncertain algebraic sign (+ or -). Non-random errors are errors having a known sign. The resulting total error is a statistical combination of a random error component and a non-random component. The Total Instrument Channel Uncertainty represents the maximum uncertainty calculated that could occur at any time during the periodic surveillance interval for the limiting event for which the function is required to operate. In the case of different accident environment errors, for different events, event specific total equipment errors are calculated for each function. The event specific Total Instrument Channel Uncertainties are used to determine the Trip Setpoints.

2.4 SETPOINT DETERMINATION

2.4.1 General

The plant Technical Specifications (Reference 5.2) require Trip Setpoints and Allowable Values for PPS functions. The Trip Setpoints and Allowable Values are determined using the Analysis Setpoint (Sec. 2.2) and the Total Instrument Channel Uncertainties (Sec. 2.3). The following sections describe the method used for calculating Trip Setpoints and Allowable Values.

2.4.2 Trip Setpoint

Section 2.3.3 discusses how the Total Instrument Channel Uncertainty is determined for each PPS function. This error represents the total uncertainty which must be accommodated and accounts for all the individual errors which can affect the accuracy of the equipment being used. To accomodate these errors in the setpoint calculations, the Trip Setpoint is established in a conservative direction from the Analysis Setpoint by the amount of the Total Instrument Channel Uncertainty. When different total equipment errors and different Analysis Setpoints are determined for different analyzed events, the event specific Trip Setpoints are set in a conservative direction by the corresponding event specific Total Instrument Channel Uncertainties. The most conservative resulting value is then used as the Trip Setpoint.

This method assures a conservative setpoint in all cases. Figure 4 is a representation of Trip Setpoint calculations where different events are analyzed separately.

The calculated Trip Setpoint for each PPS function becomes part of the plant Technical Specifications and represents the least conservative value that may be set into the equipment during initial calibration. To be consistent with the STS format the Trip Setpoints shown in the plant Technical Specifications are prefaced with a $\leq$ or $\geq$, depending on whether the setpoint

is above or below the normal operating range, respectively. This assures setting the Equipment Setpoint, the actual value set into the bistable, equal to or more conservative than the Trip Setpoint values shown in the Technical Specifications.

2.4.3 Allowable Value

The PPS Cabinet Periodic Test Uncertainty represents the maximum anticipated measurable drift of the PPS cabinet equipment during the specified period of time between calibrations. (Section 2.3.2.2) This uncertainty is used when calculating the Allowable Value. The Allowable Value is defined by moving from the Trip Setpoint toward the Analysis Setpoint by the amount calculated for the PPS Cabinet Periodic Test Uncertainty. The resulting Allowable Values are listed in the plant Technical Specifications (Reference 5.2). The Technical Specifications require that if, upon checking a setpoint, it is found to be less conservative than the Allowable Value, the channel must be declared inoperable, specific action must be taken and the Equipment Setpoint must be reset.

By calculating the Allowable Value as described above the problem of anticipated equipment drift causing spurious trips during normal operations, or causing setpoint drift which is inconsistent with the Safety Analysis, is virtually eliminated.

2.4.4 Technical Specifications

For each PPS function, the Trip Setpoint and Allowable Value which have been calculated to assure that the equipment will operate as assumed in the Safety Analysis are incorporated into the plant Technical Specifications. These two values make up the Limiting Safety System Setting (LSSS) required by the Technical Specifications.

As part of the setpoint calculation used to arrive at the Trip Setpoints and Allowable Values, certain assumptions were made. These include: the accuracy of the equipment used; the calibration intervals; the method of

calibration; and other equipment characteristics. Section 3.0 explains how these assumptions are incorporated into the setpoint calculation.

2.5 CORE PROTECTION CALCULATOR SETPOINTS

2.5.1 General

The SONGS Reactor Protection System uses a Core Protection Calculator (CPC) to generate two of the fourteen reactor trip signals. For the purpose of this report, when the Core Protection Calculator is referred to, it includes the Control Element Assembly Calculator (CEAC) as part of the CPC system. The CPC inputs and trip functions are shown in Figure 5.

The CPC is a digital calculator, and as such requires a different method than the other PPS trips to ensure that all equipment uncertainties are accommodated in the decision to initiate a reactor trip. (See Sec. 3.5.1) Methods of incorporating uncertainty compensation into the CPC have been addressed in detail in documents previously submitted to the NRC (References 5.8, 5.9). The following discussion summarizes the information presented in these documents.

2.5.2 CPC Uncertainty Components

Calculations performed by the CPCs are modified to account for the following uncertainties and allowances:

1. Measurement uncertainties;

2. Algorithm modelling uncertainties;

3. Algorithm constants uncertainties;

4. CPC processing uncertainty;

5. Static allowances;

6. Dynamic allowances.

A general discussion of each of the listed items is given below.

2.5.2.1 Measurement Uncertainties

Sensor and measurement channel uncertainties for the CPC measured inputs make up the CPC measurement uncertainties. As shown in Figure 5, the CPC measured inputs include:

1. Reactor coolant cold leg temperature;
2. Reactor coolant hot leg temperature;
3. Pressurizer pressure;
4. Reactor coolant pump (RCP) rotational speed;
5. Ex-core detector neutron flux;
6. CEA position.

A measurement uncertainty is calculated for each of the above CPC inputs. Section 2.5.3 describes the method used to factor the CPC measurement uncertainties into the CPC algorithms. The uncertainties calculated for the CPC measured inputs are based on manufacturer's instrument specifications, type testing, calculations and previous operating experience. The specific uncertainties calculated contain allowances for all components in the measurement channel including sensor, transmitter, power supply, dropping resistor, multiplexer and analog to digital converter (A/D).

Figure 6 shows in block diagram form the CPC in relation to the SONGS PPS and those portions of the PPS that are considered when determining CPC measurement uncertainties.

For each component in the measurement channel, instrument linearity, repeatability, environmental effects, and drift between calibration periods are considered in the calculation of measurement uncertainties. The resulting measurement channel uncertainty is analogous to the uncertainty that would be obtained for the non-CPC portion of the RPS (described in Section 2.3) if the following uncertainties were combined:

1. Process Equipment Initial Uncertainty;

2. Process Equipment Periodic Test Uncertainty;

3. Accident Environment Error;

4. Process Error.

The method of combining the individual components to arrive at the measurement channel uncertainty is similar to the method described in Section 2.3.3.

The resulting CPC measurement uncertainty includes a random component and a non-random component.

2.5.2.2 Algorithm Modelling Uncertainties

Algorithm modelling uncertainties address the accuracy with which the CPC algorithms replicate the results of design codes, "best estimate" measurements and/or "best estimate" calculations.

2.5.2.3 Algorithm Constants Uncertainties

Algorithm constants uncertainties address the accuracy of the measurements and/or calculations used to obtain the CPC algorithm constants. This type of uncertainty depends upon both the accuracy of the instruments used in the measurements as well as the technique used to process the measurements. Algorithm constant uncertainties can consist of both random and non-random components.

2.5.2.4 CPC Processing Uncertainty

The CPC processing uncertainty is attributable to the effects that scaling, round-off and bit manipulation have on the CPC computed result. Testing of the CPCs and CPC calculations provide the information needed to determine this uncertainty. Comparison of actual CPC response to the results obtained using the CPC algorithm with the higher resolution computing facility used in the design process and the Safety Analysis provides a mechanism for quantifying and characterizing the processing uncertainty.

2.5.2.5 Static Allowances

Static allowances account for the effect on the margin to fuel design limits of (1) variations in parameters not monitored by the CPCs, and (2) allowed variations (action thresholds or deadbands) in the parameters monitored by the CPCs. The only parameter that falls into the first category is the azimuthal power tilt magnitude. An example of a parameter in the second category is the deadbands on CEA deviation provided in the CPC.

2.5.2.6 Dynamic Allowances

Dynamic allowances account for the time delays associated with the following:

1. CPC sensor delays;

2. CPC sampling intervals;

3. CPC processing times;

4. RPS trip logic delays;

5. CEA holding coil decay times;

6. CEA insertion times;

7. Transient delays associated with the heat flux and stored energy response following CEA insertion.

Accounting for these delays in the decision to initiate a Low DNBR or High Local Power Density (LPD) reactor trip ensures that the transients analyzed in the Safety Analysis will be terminated before the actual fuel design limits are exceeded.

2.5.3 Accommodating CPC Uncertainties

2.5.3.1 General Method

The CPCs are designed with the capability of accommodating uncertainties in a variety of ways with the choice being dependent upon the nature of the uncertainty component. Measurements can be biased prior to use in calculations to account for uncertainties and/or allowances; calculated results can be individually modified; or selected calculated values can be modified to account for the effect of all of the uncertainty components on the final trip comparison. The optimum method of accommodating uncertainties in the CPC will simultaneously ensure conservatism and maximize operating flexibility.

The method of accommodating CPC uncertainties for the SONGS Reactor Protection System involves determining constants which then become part of the CPC program. These constants result from combining the individual uncertainties discussed in Section 2.5.2 in a manner which ensures all uncertainties are accommodated. The combination of individual uncertainties to arrive at the CPC uncertainty adjustment constants is similar to the method described in Section 2.3.3 for combining errors in the non-CPC portion of the protection system.

Separate constants are determined and used for the DNBR and LPD trip calculations. The following sections discuss the constants used in the DNBR and LPD calculations.

2.5.3.2 DNBR Uncertainty Constants

There are three uncertainty constants used in the DNBR calculation which together ensure a low DNBR trip response that is conservative relative to the Safety Analysis. These are:

1. Uncertainty biases for power used in the DNBR calculation (B_{ERR2}, B_{ERRO})

2. Power uncertainty factor used in the DNBR calculation (B_{ERR1}).

2.5.3.2.1 Uncertainty Biases for Power Used in the DNBR Calculations (B_{ERR2}, B_{ERRO})

The uncertainty biases for power used in the DNBR calculation account for the uncertainties inherent in the inputs to the power calculation in the CPC. These include the power calibration uncertainty and the dynamic uncertainty in both the neutron flux power (B_{ERR2}) and the thermal power (B_{ERRO}). These uncertainties are measurement uncertainties and dynamic allowances (as discussed in Sections 2.5.2.1 and 2.5.2.6, respectively). The uncertainty biases for power used in the DNBR calculation are added to the calculated power level as:

$$POWER_{THERMAL} = B_{DT} + B_{ERRO}$$

$$POWER_{FLUX} = B_{NF} + B_{ERR2}$$

where B_{DT} = Calculated thermal power.

B_{NF} = Calculated neutron flux power.

$POWER_{THERMAL}$ = Adjusted thermal power.

$POWER_{FLUX}$ = Adjusted neutron flux power.

These adjusted powers are used as input to the compensation algorithms. The resulting "compensated" powers are auctioneered to give $POWER_{COMP}$.

2.5.3.2.2 Power Uncertainty Factor Used in the DNBR Calculation (B_{ERR1})

This factor accounts for the uncertainties not accounted for by the previous constants. The method of combining the individual uncertainty components to determine the actual values used for this constant is similar to the method described in Section 2.3.3 of this report. The compensated power level corrected for power measurement uncertainties is then multiplied by the appropriate constants to result in the power level used in the DNBR calculation, as:

$$POWER_{DNB\ ADJ} = POWER_{COMP} \cdot B_{ERR1}$$

Where $POWER_{DNB\ ADJ}$ = Corrected power level used in the DNBR calculation

B_{ERR1} = Power uncertainty factor used in the DNBR calculation.

2.5.3.3 Local Power Density Uncertainty Constants

There are two uncertainty constants used in the LPD calculation which, together, ensure a high LPD trip response that is conservative relative to the Safety Analysis. These are:

1. Uncertainty bias for power used in the LPD calculation (B_{ERR4})

2. Power uncertainty factor used in the LPD calculation (B_{ERR3})

2.5.3.3.1 Uncertainty Bias for Power Used in the LPD Calculation (B_{ERR4})

The uncertainty biases for power used in the LPD calculation accounts for the uncertainties inherent in the power measurement process input to the CPC. This includes the power calibration uncertainty and the dynamic uncertainty in both the neutron flux power and the thermal power. These uncertainties are measurement uncertainties and dynamic allowances (as discussed in Sections 2.5.2.1 and 2.5.2.6, respectively). The uncorrected power level used in the LPD calculation is the same as that used in the DNBR calculation and the uncertainty components of the uncertainty bias for power used in the LPD calculation are identical to the components of the uncertainty bias for power used in the DNBR calculation. The uncertainty bias for power used in the LPD calculation is added to the calculated power level as:

$$POWER_{LPD} = POWER_{CALC} + B_{ERR4}$$

where $POWER_{LPD}$ = Power level input to the LPD calculation corrected for power measurement uncertainties

$POWER_{CALC}$ = Power level calculated from neutron flux or thermal measurements

B_{ERR4} = Uncertainty bias for power used in the LPD calculation.

2.5.3.3.2 Power Uncertainty Factor Used in the LPD Calculation (B_{ERR3})

The power uncertainty factor used in the LPD calculation accounts for the uncertainties not accounted for by the LPD power measurement. This is analogous to the DNBR constant B_{ERR1} described in Section 2.5.3.2.3. The method of combining the individual uncertainty components to determine the constant is similar to the method described in Section 2.3.3 of this report. The power level already corrected for power measurement uncertainties is then multiplied by the power uncertainty factor used in the LPD calculation to result in the power level used in the LPD calculation, as:

$$POWER_{LPD\ ADJ} = POWER_{LPD} \cdot B_{ERR3}$$

where $POWER_{LPD\ ADJ}$ = Corrected power level used in the LPD calculation

B_{ERR3} = Power uncertainty factor used in the LPD calculation.

OR:

$$POWER_{LPD\ ADJ} = (POWER_{CALC} + B_{ERR4}) \cdot B_{ERR3}$$

2.5.3.4 Technical Specifications

As shown in the Technical Specifications (Reference 5.2) and in Table 5 of this report, the Analysis Setpoint, Trip Setpoint and Allowable Value for the Low DNBR trip are identical. This is also true for the High Local Power Density Trip function. As has been discussed in Section 2.5.3, all uncertainties in the CPC system, including dynamic responses and equipment drift are accommodated as correction constants in the calculation of DNBR and Local Power Density. This ensures that when the calculated DNBR or LPD reaches its respective Trip Setpoint value and the RPS sends out a reactor trip signal, the response of the protection system will provide protection during the Design Basis Events analyzed. Because of this method of accommodating uncertainties in the CPCs, for each CPC trip function, the Trip Setpoint is identical to the Analysis Setpoint used in the Safety Analysis. Also, the CPC, being a digital computer system, is not subject to setpoint drift like the non-CPC analog trip functions. Thus no allowance for setpoint drift is required and the Trip Setpoint and Allowable Value are identical for each CPC trip function.

2.6 RATE LIMITED VARIABLE SETPOINTS

This section describes the uncertainties applied to the RPS trip used to mitigate the RCP sheared shaft event; as described in Section 7.2 of the FSAR, and will be provided by July, 1981.

3.0 EQUIPMENT CALIBRATION

3.1 BASIC DESCRIPTION

The C-E "explicit" setpoint methodology determines Trip Setpoints and Allowable Values for the PPS trip functions. When the setpoint calculation is performed, it is assumed the equipment will be maintained and will operate in accordance with the Technical Specification requirements. These requirements include: surveillance requirements on how often equipment calibration must be performed; setpoint data which specifies the value the equipment is to be set to and the value allowed during scheduled testing; and response time requirements on how rapidly the equipment must operate. The C-E setpoint procedures provide an input to the plant Technical Specifications to ensure that the Plant Protection System operational requirements are in accordance with the assumptions and requirements used in the setpoint calculations.

Additional assumptions are made about the actual operation of the PPS equipment which are not directly reflected in the Technical Specifications. These include such things as accuracy of the instruments used in the calibration, and the environmental conditions during calibration. To ensure that these assumptions are validated, Combustion Engineering supplies Southern California Edison with PPS Calibration and Testing Data and Guidelines. SCE incorporates this information into their calibration and testing procedures.

This system ensures the equipment is operated in a manner such that the setpoint calculation remains valid. The equipment will then perform conservatively with respect to the Safety Analysis.

3.2 SETPOINT DETERMINATION ASSUMPTIONS

An integral part of the setpoint determination process is determining the individual error contributions that must be considered in calculating a total equipment error.

To determine these individual error components, specific data is obtained such as: inherent equipment accuracy from the manufacturer and equipment testing; equipment response during transients; equipment response with environment changes; equipment drift with time; and environment response during Design Basis Events. However, the data obtained is not sufficient, in itself, to enable the error components to be determined. Certain assumptions must be made concerning the operation, testing and calibration of the actual equipment installed at the plant.

As part of the calculation process, these specific assumptions are documented. This is the first step in ensuring that these assumptions are verified and thus ensuring that the setpoint calculations remain valid.

3.3 TECHNICAL SPECIFICATIONS

The major method of ensuring the assumptions made during the setpoint calculations process are valid is via the plant Technical Specifications (Reference 5.2). These Technical Specifications are requirements imposed by the NRC on the operation of the plant which must be met to continue operation. The Limiting Conditions for Operation (LCO) and the Surveillance Requirements for the Reactor Protective Instrumentation are Sections 3.3.1 and 4.3.1, and for the ESFAS Instrumentation these are Sections 3.3.2 and 4.3.2, of the technical specifications. Included in these sections are requirements for:

1. The frequency that the instrumentation is to be calibrated and the types of testing and calibration to be performed at these required intervals;

2. The frequency that the instrumentation response time is to be verified and the maximum acceptable response times during testing.

These requirements correspond to certain assumptions made and documented during the setpoint calculation. As one of the final steps in the setpoint calculation process, the specific data input to these technical specifications is provided consistent with the corresponding assumptions.

3.4 CALIBRATION GUIDELINES

The final method of ensuring that the assumptions made in the setpoint calculation remain valid during plant operation is via calibration guidelines. These calibration guidelines are prepared by Combustion Engineering as part of the setpoint calculation process and are transmitted to Southern California Edison. SCE then incorporates these guidelines into their detailed operating, testing and calibrating procedures.

Included in the calibration guidelines are the assumptions made in the setpoint calculation not specifically verified by the Technical Specification requirements. Also included in the calibration guidelines are the equipment voltages corresponding to the Trip Setpoints and Allowable Values. This assists the plant staff in ensuring the equipment is calibrated and tested correctly because the Technical Specification data is in measured parameter values (e.g., psia, % of rated thermal power) and the actual equipment values are voltages.

Thus, the combination of incorporating the calibration guidelines into plant procedures and operating in accordance with the plant Technical Specifications ensures that the assumptions made in the setpoint calculations remain valid during the operation of the plant.

3.5 CPC CALIBRATION

3.5.1 General

As previously described, the CPC is a digital computer system. It processes measured input parameters and generates a Low DNBR or a High Local Power Density reactor trip signal when the calculated values reach a predetermined setpoint. The difference between these trip functions and the other trip functions in the Plant Protection System is that the decision to initiate a reactor trip is performed by a digital computer in the CPCs instead of by reaching a predetermined value in an analog bistable. For calibration and testing purposes the CPC trip channel is divided into two parts as shown in

Figure 6. The first part is the process equipment which provides the input signals to the CPC computer and the second part is the CPC computer system itself. Calibration of each of these parts is discussed in the following sections.

3.5.2 CPC Process Equipment Calibration

The CPC process equipment includes all equipment in the chain from the sensor up to and including the analog to digital converter (A/D) which provides the digital measurement signal to the CPC (see Figure 6). Except for the A/D, this is identical to the non-CPC portion of the protection system previously discussed. The A/D is treated in a manner similar to the rest of the process equipment in the setpoint calculation process. All uncertainties are considered which can affect the accuracy of the A/D; these uncertainties are combined to determine an A/D total uncertainty; and the A/D total uncertainty is combined with the other process measurement uncertainties when determining the total process measurement uncertainty. As with the rest of the process equipment, certain assumptions must be made about the operation, calibration, and testing of the A/D when determining its uncertainty. These assumptions are verified during plant operation to ensure the setpoint calculation remains valid.

Thus the entire process equipment calibration procedure for the CPC inputs is identical to the procedures for the non-CPC process equipment.

3.5.3 CPC Computer System Calibration

The remainder of the CPC portion of the protection system is the CPC computer system itself. The CPC digital computer is different from the rest of the RPS trip decision logic in that the CPC trip setpoint is not subject to drift and thus drift was not considered as part of the CPC uncertainty calculation discussed in Section 2.5. There are however numerous similarities between the CPC and non-CPC portions of the protection system concerning equipment calibration; and hence, the majority of the preceding sections also apply to the CPCs.

When determining equipment uncertainties for the CPC, certain assumptions are made that require verification to ensure the CPC method of accomodating uncertainties remains valid. As with the rest of the protection system these assumptions are documented during the design process. It is then ensured that the Technical Specifications include requirements that, when met, will verify these assumptions. This in turn ensures CPC operation consistent with setpoint requirements.

Because the CPC is a digital computer the algorithm is also not subject to drift. As such the monthly Channel Functional Test required by the technical specifications is different from the tests performed on non-CPC channels. For the CPC, functional testing involves such tasks as verifying, one-for-one, that the information stored in protected memory agrees with the data on the test disc, and using test inputs to check the CPC outputs for correctness.

4.0 DETAILED SETPOINT DATA

4.1 NRC REQUEST

On April 11, 1977, the NRC sent a letter on "Instrument Trip Setpoint Values - San Onofre Nuclear Generating Station - Units 2 and 3" to SCE (Reference 5.1). This letter stated that NRC review of facility operating experience indicates the need for additional information regarding the proper selection of instrumentation trip setpoint values. This conclusion is supported, the letter states, by the large number of Licensee Event Reports (LERs) received by the NRC related to instrument setpoint drift beyond the limits permitted by the facility Technical Specifications. As a result, the NRC requested explicit information concerning each RPS and ESFAS instrumentation channel trip setpoint value. The specific information requested was:

1. The technical specification trip setpoint value;

2. The technical specification allowable value;

3. The instrument drift assumed to occur during the interval between technical specification surveillance tests;

4. The components of the cumulative instrument bias;

5. The minimum margin between the technical specification trip setpoint and the trip value assumed in the accident analysis.

The information requested is purely numerical data. This report has explained the Combustion Engineering "explicit" setpoint methodology so that the data, will be more easily understood. Tables 1 - 7 contain the required data. The remainder of Section 4.0 is an explanation of these tables and ties the data in the tables with the setpoint methodology previously discussed.

4.2 EXPLANATION OF TABLES

4.2.1 General

Tables 1 - 7 contain explicit data on the RPS and ESFAS used in the equipment setpoint determination process. This provides the information requested in Reference 5.1. Tables 1 - 4 contain information for the non-CPC portion of the Plant Protection System and Tables 5 - 7 contain the requested information for the CPC portion.

Many values given in the tables contain both a random (±) and a non-random (+) or (-) component.

The following sections 4.2.2 - 4.2.6 provide an explanation of the columns of data contained in Tables 1 - 7. Section 4.2.7 discusses additional items by PPS function where further clarification is helpful.

4.2.2 Table 1

Table 1 contains the Trip Setpoint, Allowable Value and the Drift Allowance for each discussed PPS function. The Trip Setpoint is the least conservative value which may be set into the PPS equipment at calibration to ensure protective action before the Analysis Setpoint is exceeded. The Trip Setpoint corresponds to the data requests in item 1 of the NRC letter. (see Section 4.1). The Allowable Value is the limit on the Trip Setpoint at any time during normal plant operation and is checked during the monthly Channel Functional Test as required by the technical specifications. Operation with an Equipment setpoint conservative with respect to the Allowable Value is necessary to assure the equipment will operate as assumed in the Safety Analysis. The Allowable Value data presented corresponds to item 2 of the NRC request. The third column corresponds to item 3 of the NRC request. The PPS Cabinet Periodic Test Uncertainty represents the allowance which must be made for measurable drift in the PPS Cabinet. This allowance represents the time dependent drift and the measurement and equipment uncertainties inherent in verifying that the anticipated drift does not cause the Equipment Setpoint to exceed the Allowable Value between surveillance intervals.

4.2.3 Tables 2 and 3

Tables 2 and 3 contain the values for the components used in the total equipment error calculation. This corresponds to item 4 of the NRC request. A discussion of each of these components is contained in Section 2.3 of this report.

Table 2 contains PPS cabinet and PPS measurement channel data. For each equipment area the uncertainty calculated for initial and periodic testing is listed. The Initial Uncertainty accounts for basic inaccuracies in the equipment used during calibration and in the equipment being calibrated. The periodic testing procedure uses the same equipment as during calibration. Therefore, the Initial Uncertainty is included in the calculation of the Periodic Test Uncertainty in addition to the other components, as discussed in Section 2.3.

The Total Measurement Channel Uncertainty includes the total uncertainty accommodated between the sensor and the input to the PPS Cabinet. The Total Measurement Channel Uncertainty combined with the PPS Cabinet Uncertainty provides the Total Instrument Channel Uncertainty.

Table 3 contains data for the remainder of the uncertainty components as discussed in Section 2.3.

No Dynamic Allowances are presently applied in the non-CPC portions of the SONGS Setpoint Analysis.

The process uncertainty applied in the High Linear Power Setpoint calculation reflects maximum uncertainties in the calorimetric determination used during calibration.

4.2.4 Table 4

Table 4 contains the Analysis Setpoint data and the margin between the Analysis Setpoint and the Trip Setpoint. The Analysis Setpoint is the value used in the Safety Analysis at which protection system actuation is assumed to start. The margin between the Analysis Setpoint and the Trip Setpoint is the mathematical difference between the two values. This corresponds to item 5 of the NRC request. In all cases this margin is larger than or equal to the total equipment error determined in the setpoint calculation. This ensures that a trip actuation will occur prior to the point used in the Safety Analysis.

4.2.5 Table 5

Table 5 contains the Trip Setpoint, Allowable Value and Analysis Setpoint data for the reactor trips generated by the CPCs. As shown, all three values for the low DNBR trip are identical as are all three values for the High Local Power Density trip. The data in Table 5 corresponds to items 1 and 2 of the NRC request. Because the Trip Setpoint and Allowable Value are identical, the instrument drift allowance for the CPCs - item 3 of the NRC request is zero. The reason for the identical values is explained in Section 2.5.3.4. Basically, the CPC is a digital computer system and is not subject to drift. Because the Trip Setpoint and Analysis Setpoint are identical, the margin between these two values - item 5 of the NRC request is zero. The reasons for these identical values are also explained in Section 2.5.3.4. Basically, the margin is incorporated into the CPC computer algorithms rather than in the Trip Setpoint value itself.

4.2.6 Tables 6 and 7

Tables 6 and 7 contain data on the bias components associated with the measurement signals input to the CPCs. This corresponds to item 4 of the NRC request. Table 7 also gives the total allowance for each input. This is the value used in the determination of the CPC uncertainty constants.

Table 6 contains measurement channel uncertainties for calibration and periodic testing. This is analogous to the same data presented in Table 2. The A/D conversion allowance represents the calculated uncertainty that must be accounted for at any time between calibrations. This value was used in calculating the total allowance for each instrument input channel.

Table 7 contains the allowances for environmental effects and software roundoff. Also shown is the total allowance for each instrument channel. The environmental effects data is analogous to the accident environment data presented in Table 3 for the non-CPC functions. Software round-off accounts for the conversion from the data in the binary register after the A/D to the value in the first register where the data is represented in engineering units. This is included in the total process equipment allowance calculation. The final column of Table 7 contains the total allowance for the instrument channel. This total allowance is the value of the measurement uncertainty discussed in Section 2.5.2.1.

4.2.7 Additional Notes

1. High Logarithmic Power - RPS: The relation between power and millivolts is not linear for this function. All error components are determined and combined in millivolts.

2. High Steam Generator Water Level - RPS: No credit is taken in the Safety Analysis for the operation of this trip function.

3. High Steam Generator Delta Pressure - EFAS: Two separate sensors are used to determine the pressure difference between the steam generators. The uncertainties associated with each sensor are included in the total uncertainty calculation.

4. Low Refueling Water Tank Level - RAS: Two Analysis Setpoints were used in the Safety Analysis. A higher level actuation was analyzed to ensure enough borated water was in the

containment sump before the RAS was generated. The lower level actuation was analyzed to ensure the RAS was generated while the Refueling Water Tank (RWT) still contains enough water for proper operation. Where two values are listed, the first applies to the lower Analysis Setpoint and the second to the higher Analysis Setpoint. Where one value is listed, it applies to both calculations. The Trip Setpoint allows a range for setting, consistent with the calibration uncertainties.

5. CPC RCP Shaft Speed: For both size discs the A/D conversion allowance is not applicable because a binary signal is transmitted to the CPCs.

5.0 REFERENCES

5.1 Nuclear Regulatory Commission, "San Onofre Nuclear Generating Station Units 2 & 3, Instrument Trip Setpoint Values," letter to Southern California Edison Company, Docket No. 50-361 and 50-362, April 11, 1977.

5.2 Southern California Edison Company, "San Onofre Nuclear Generating Station Units 2 & 3 Technical Specifications."

5.3 Nuclear Regulatory Commission, "Licensing of Production and Utilization Facilities," Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations - Energy, Part 50.

5.4 Institute of Electrical and Electronics Engineers, "Criteria for Protection Systems for Nuclear Power Generating Stations," IEEE 279-1971 September 20, 1974.

5.5 Nuclear Regulatory Commission, "Standard Technical Specifications for Combustion Engineering Pressurized Water Reactors," September 20, 1974.

5.6 Nuclear Regulatory Commission, "Instrument Setpoints," Regulatory Guide 1.105, Revision 1, November 1976.

5.7 Advisory Committee on Reactor Safeguards, "Assessment of Light Water Reactor Safety Matters," Transcript of December 3, 1976. Page 241 discussion of Item 13 - instrumentation setpoints and related technical specifications.

5.8 C-E Power Systems, Combustion Engineering, Inc., "CPC - Assessment of the Accuracy of PWR Safety System Actuation as Performed by the Core Protection Calculators," CENPD-170-P, July 1975.

5.9 C-E Power Systems, Combustion Engineering, Inc., "CPC - Assessment of the Accuracy of PWR Sat ty System Actuation as Performed by the Core Protection Calculators," C.NDPD-170 Supplement 1-P, November 1975.

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TABLE 1

PPS TRIP SETPOINTS, ALLOWABLE VALUES AND DRIFT ALLOWANCES

PPS FUNCTION	TRIP SETPOINT	ALLOWABLE VALUE	DRIFT ALLOWANCE
High Logarithmic Power Level-RPS	0.89 %	0.96 %	0.07 %
High Linear Power Level-RPS	120% FP	121.3 % FP	1.3 % FP
High Pressurizer Pressure-RPS	2382 psia	2389 psia	7 psia
Low Pressurizer Pressure-RPS/CCAS/ SIAS/CSAS/CIAS	1806 psia	1763 psia	43 psia
High Steam Generator Water Level-RPS	90 % tap span	90.74 % tap span	0.74 % tap span
Low Steam Generator Water Level-RPS/EFAS	23 % tap span	22.23 % tap span	0.77 % tap span
Low Steam Generator Press-RPS/MSIS/EFAS	729 psia	711 psia	18 psia
High Steam Generator Delta Press-EFAS	50.0 psid	66.25 psid	16.25 psid
High Containment Press-RPS/CCAS/ SIAS/CIAS/CSAS	2.95 psig	3.14 psig	0.19 psig
High High Containment Press-CSAS	8.14 psig	8.83 psig	0.69 psig
Low Refueling water Tank Level-RAS	18.5 % tap span	17.74 % tap span 19.26 % tap span	$\pm$ 0.76 % tap span

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TABLE 2

PPS INSTRUMENT BIAS COMPONENTS

PPS FUNCTION	PPS CABINET		PPS MEASUREMENT CHANNEL	
	INITIAL	PERIODIC	INITIAL	PERIODIC TEST
High Logarithmic Power Level-RPS	± 5.0 mV	+ 30.30 mV - 29.20 mV	± 344.70 mV	± 346.71 mV
High Linear Power Level-RPS	± 0.10% FP	+ 1.26% FP - 1.21% FP	± 1.43% FP	± 1.46% FP
High Pressurizer Pressure-RPS	± 1.25 psi	+ 7.03 psi - 7.57 psi	± 7.18 psi	± 17.37 psi
Low Pressurizer Pressure-RPS/CCAS/ SIAS/CSAS/CIAS	± 3.75 psi	+ 43.12 psi - 37.72 psi	± 11.25 psi	± 26.25 psi
High Steam Generator Water Level-RPS	± 0.13 %	+ 0.77 % - 0.71 %	± 0.89 %	± 1.01 %
Low Steam Generator Water Level-RPS/EFAS	± 0.13 %	+ 0.77 % - 0.71 %	± 0.89 %	± 1.01 %
Low Steam Generator Press-RPS/MSIS/EFAS	± 1.50 psi	+ 17.35 psi - 16.25 psi	± 8.62 psi	± 20.84 psi
High Steam Generator Delta Press-EFAS	± 1.50 psi	+ 11.49 psi - 9.29 psi	± 12.19 psi	± 29.48
High Containment Press-RPS/CCAS/SIAS CIAS/CSAS	± 0.03 psi	+ 0.18 psi - 0.19 psi	± 0.18 psi	± 0.42 psi
High High Containment Press-CSAS	± 0.12 psi	+ 0.66 psi - 0.69 psi	± 0.65 psi	± 1.55 psi
Low Refueling Water Tank Level-RAS	± 0.13 %	± 0.76 %	± 0.80 %	± 1.24 %

TABLE 3

PPS INSTRUMENT BIAS COMPONENTS, CONTINUED

PPS FUNCTION	TOTAL MEASUREMENT CHANNEL UNCERTAINTY	DYNAMIC ALLOWANCE	PROCESS ERROR
High Logarithmic Power Level-RPS	± 346.71 mV	-	-
High Linear Power Level-RPS	± 1.46 % FP	-	± 4.0% FP
High Pressurizer Pressure-RPS	+ 28.87 psi - 81.87 psi	-	-
Low Pressurizer Pressure-RPS/CCAS/SIAS/CSAS/CIAS	+ 239.10 psi - 299.10 psi	-	-
High Steam Generator Water Level-RPS	+ 2.67 % - 2.77 %	-	-
Low Steam Generator Water Level-RPS/EFAS	+ 17.27 % - 3.40 %	-	-
Low Steam Generator Press-RPS/MSIS/EFAS	+ 45.44 psi - 112.64 psi	-	-
High Steam Generator Delta Press-EFAS	± 47.30 psi	-	-
High Containment Press-RPS/CCAS/SIAS/CIAS	+ 0.65 psi - 1.01 psi	-	-
High High Containment Press-CSAS	+ 2.44 psi - 3.75 psi	-	-
Low Refueling Water Tank Level-RAS	+ 2.81 % - 3.58 %	-	-

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TABLE 4

PPS ANALYSIS SETPOINTS AND SETPOINT MARGINS

PPS FUNCTION	ANALYSIS SETPOINT	MARGIN BETWEEN ANALYSIS SETPOINT & TRIP SETPOINT
High Logarithmic Power Level-RPS	2 % of rated full power	1.11 %
High Linear Power Level-RPS	125 %	5%
High Pressurizer Pressure-RPS	2422 psia	40 psia
Low Pressurizer Pressure-RPS/CCAS/SIAS/CSAS/CIAS	1560 psia	246 psi
High Steam Generator Water Level-RPS	93% tap span	3%
Low Steam Generator Water Level RPS/EFAS	5% tap span	18%
Low Steam Generator Press-RPS/MSIS/EFAS	678 psia	51 psia
High Steam Generator Delta Press-EFAS	100 psid	50.0 psi
High Containment Press-RPS/CCAS/SIAS/CIAS/CSAS	4.0 psig	1.05 psi
High High Containment Press-CSAS	12.0 psig	3.86 psi
Low REfueling WAter Tank Level-RAS	18.5% (1)	(1)

(1) The 18.5% level allows sufficient margin to account for all uncertainties in both the positive and negative direction.

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TABLE 5

PPS CORE PROTECTION CALCULATOR TRIP SETPOINT DATA

PPS FUNCTION	TRIP SETPOINT	ALLOWABLE VALUE	ANALYSIS SETPOINT
Low DNBR-RPS	1.19	1.19	1.19
High Local Power Density-RPS	21 kw/ft	21 kw/ft	21 kw/ft

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TABLE 6

PPS CORE PROTECTION CALCULATOR PROCESS EQUIPMENT BIAS COMPONENTS

CPC INPUT FUNCTION	MEASUREMENT CHANNEL INITIAL	PERIODIC TEST	A/D CONVERSION
Pressurizer Pressure	± 7.19 psi	± 17.37 psi	+ 3.31 psi - 3.38 psi
Hot Leg Temperature	± 1.08°F	± 1.24°F	+0.49°F -0.51°F
Cold Leg Temperature	± 1.08°F	± 1.24°F	+0.49°F -0.51°F
CEA Position	+ 2.89 in - 3.09 in	+ 2.89 in - 3.09 in	+ 0.35 in - 0.47 in
Ex-Core Linear Subchannels	± 1.03 FP	± 1.08% FP	+ 0.263% FP - 0.267% FP
RCP Shaft Speed-28 Inch Disc	± 1.456 RPM	± 1.456 RPM	+ 0.294 RPM - 0.247 RPM
RCP Shaft Speed-16.969 Inch Disc	± 3.329 RPM	± 3.329 RPM	+ 0.294 RPM - 0.247 RPM

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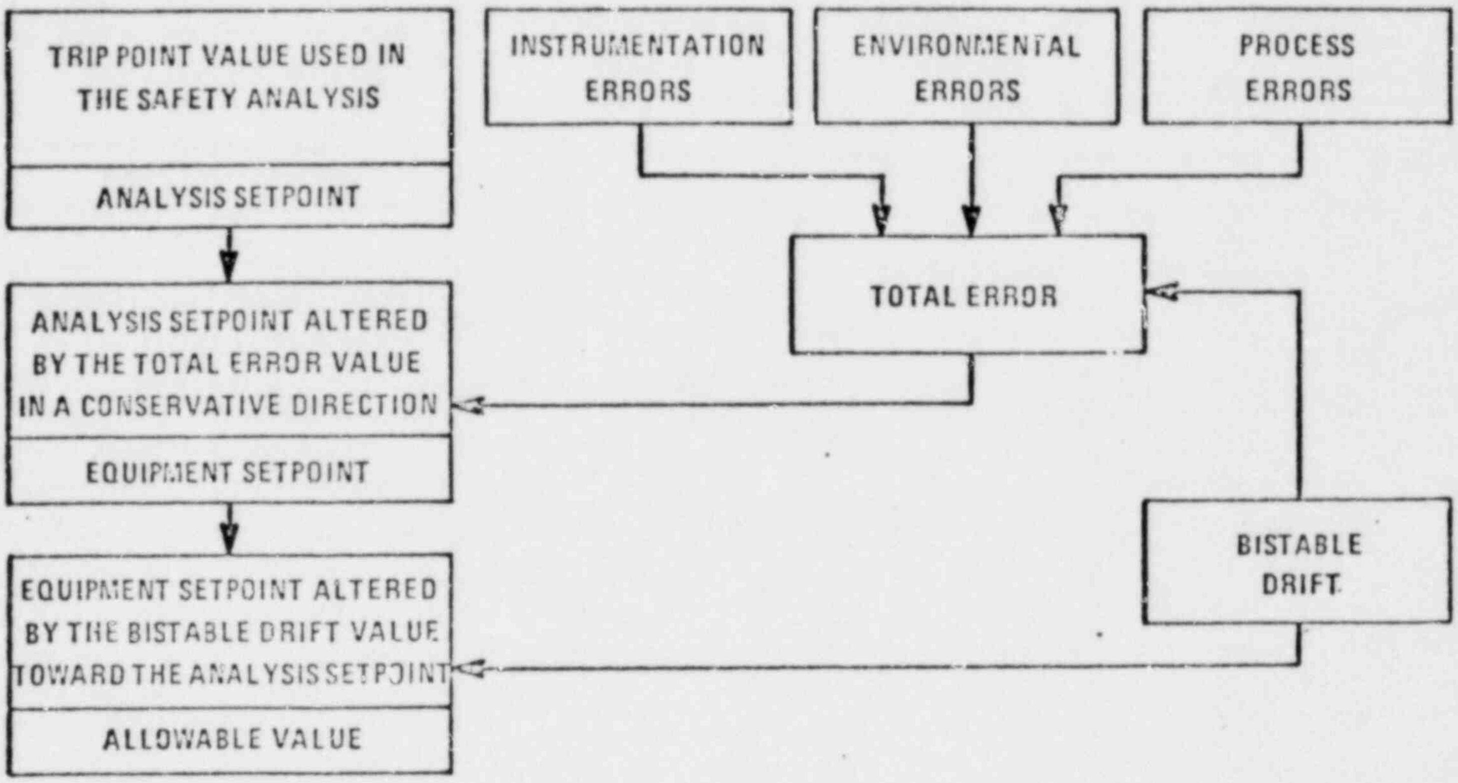
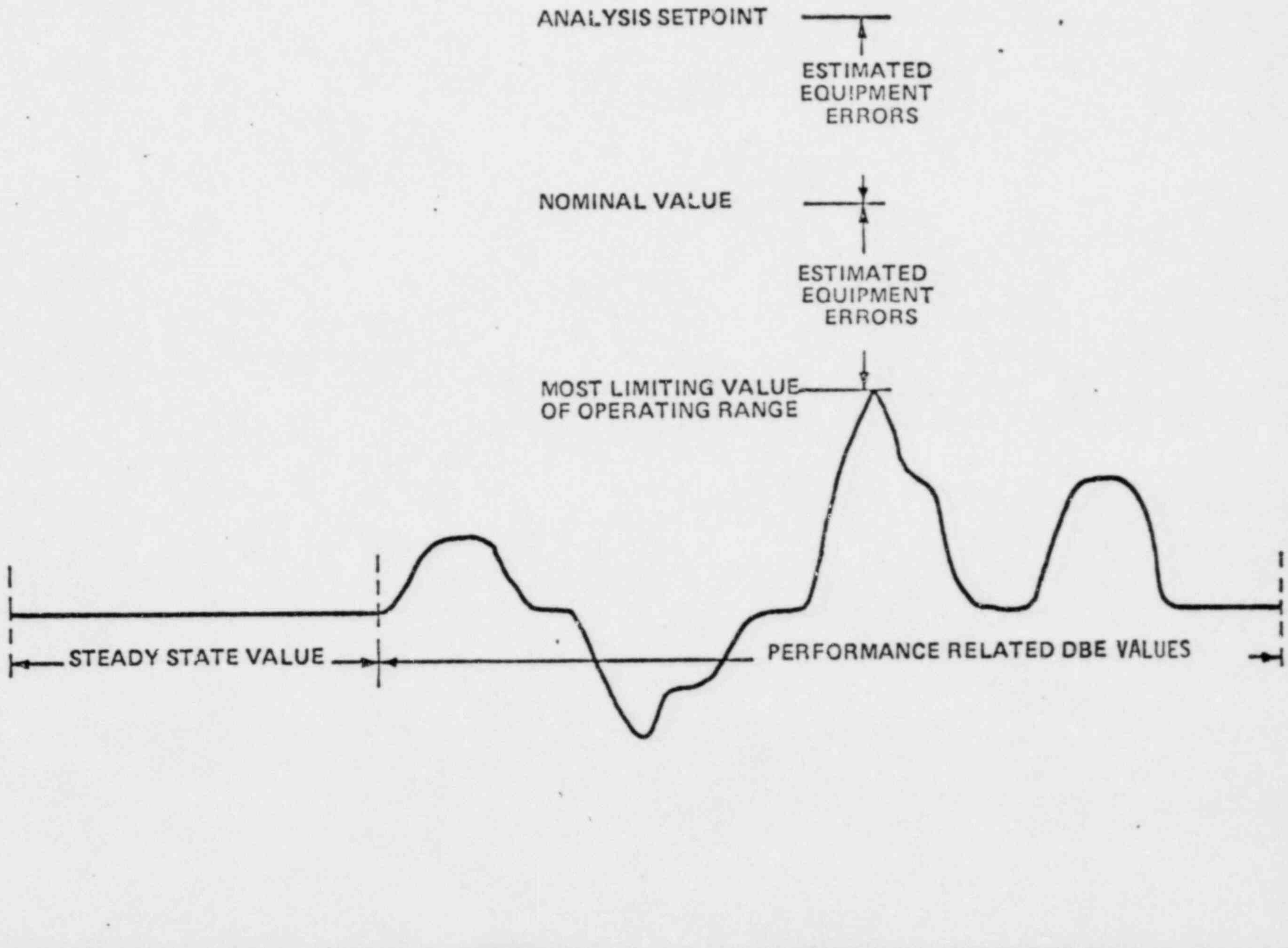
TABLE 7

PPS CORE PROTECTION CALCULATOR PROCESS EQUIPMENT BIAS COMPONENTS, CONTINUED, AND TOTAL ALLOWANCES

CPC INPUT FUNCTION	ENVIRONMENTAL EFFECTS	SOFTWARE ROUND-OFF	TOTAL ALLOWANCES
Pressurizer Pressure	+ 21.00 psi - 91.70 psi	-	+ 27.80 psi - 98.47 psi
Hot Leg Temperature	± 0.44 °F	-	+ 1.40 °F - 1.41 °F
Cold Leg Temperature	± 0.42 °F	-	+ 1.39 °F - 1.41 °F
CEA Position	+ 2.00 in - 0.90 in	-	+ 5.03 in - 4.08 in
Ex-Core Linear Subchannels	N.A.	-	+ 1.11 % FP - 1.12 % FP
RCP Shaft Speed-28 Inch Disc	N.A.	-	+ 1.997 RPM - 1.503 RPM
RCP Shaft Speed-16.969 Inch Disc	N.A.	-	+ 3.870 RPM - 3.376 RPM

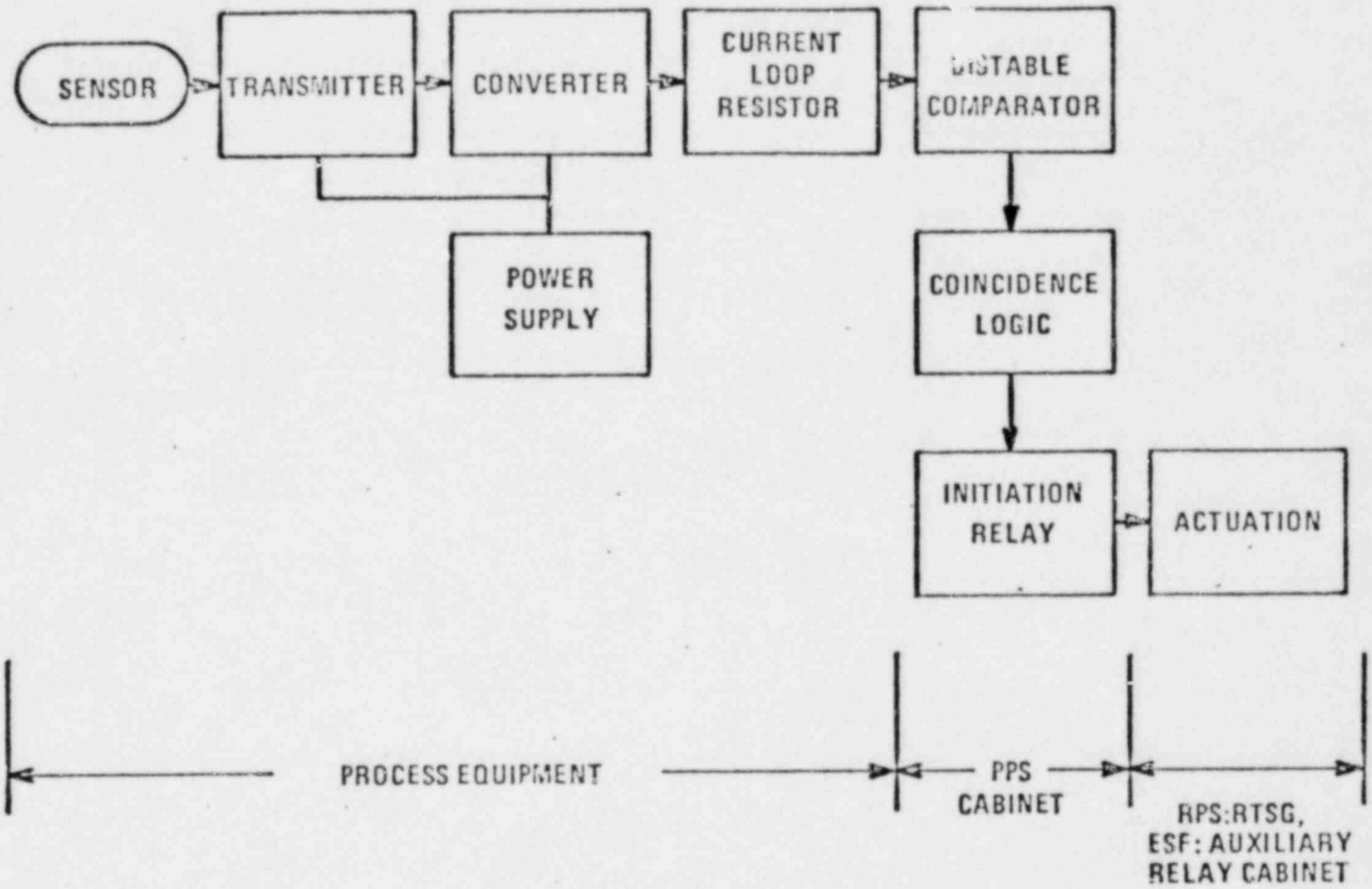


	SETPOINT CALCULATION METHODOLOGY	Figure 1

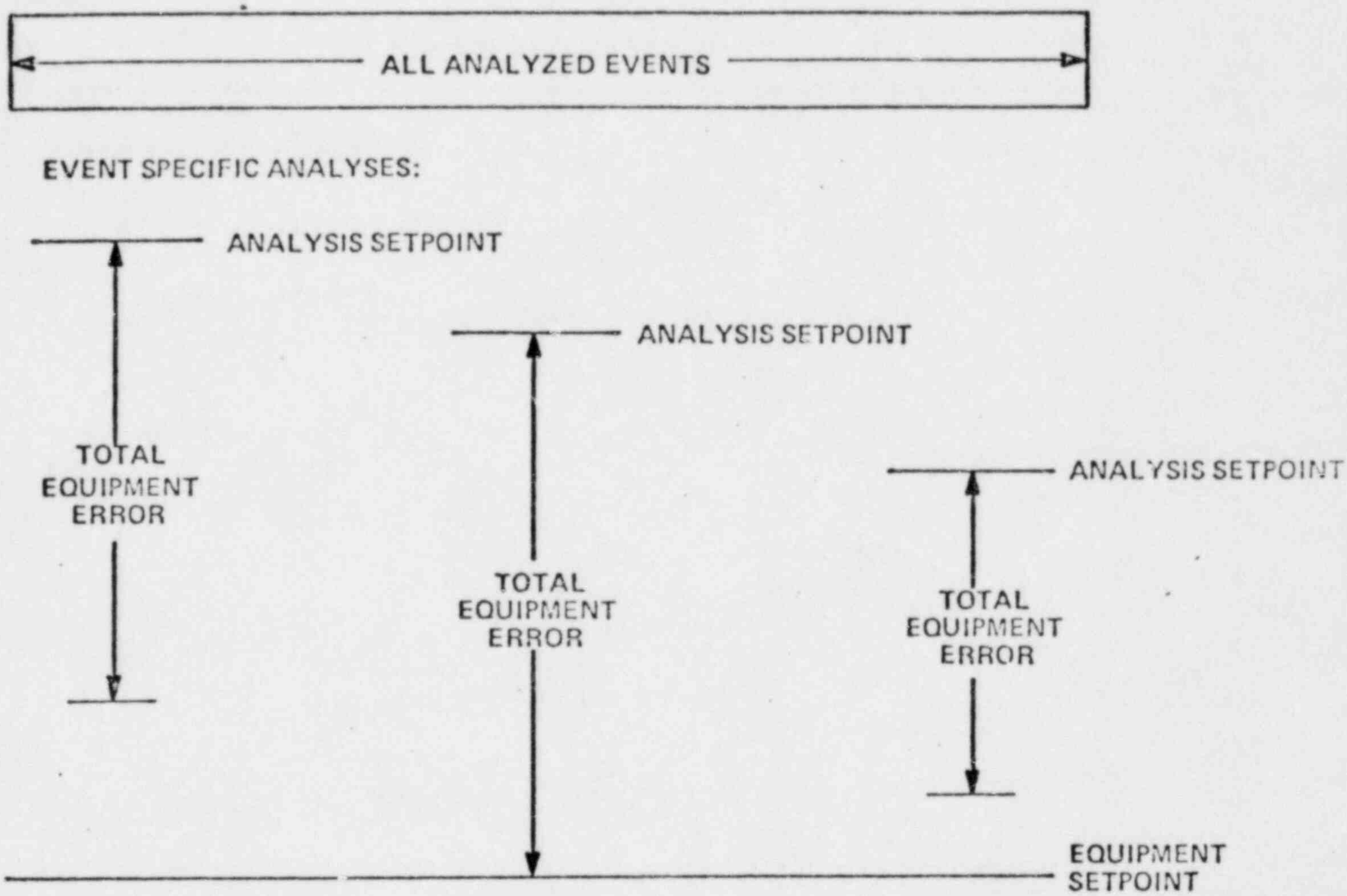


ANALYSIS SETPOINT INITIAL DETERMINATION

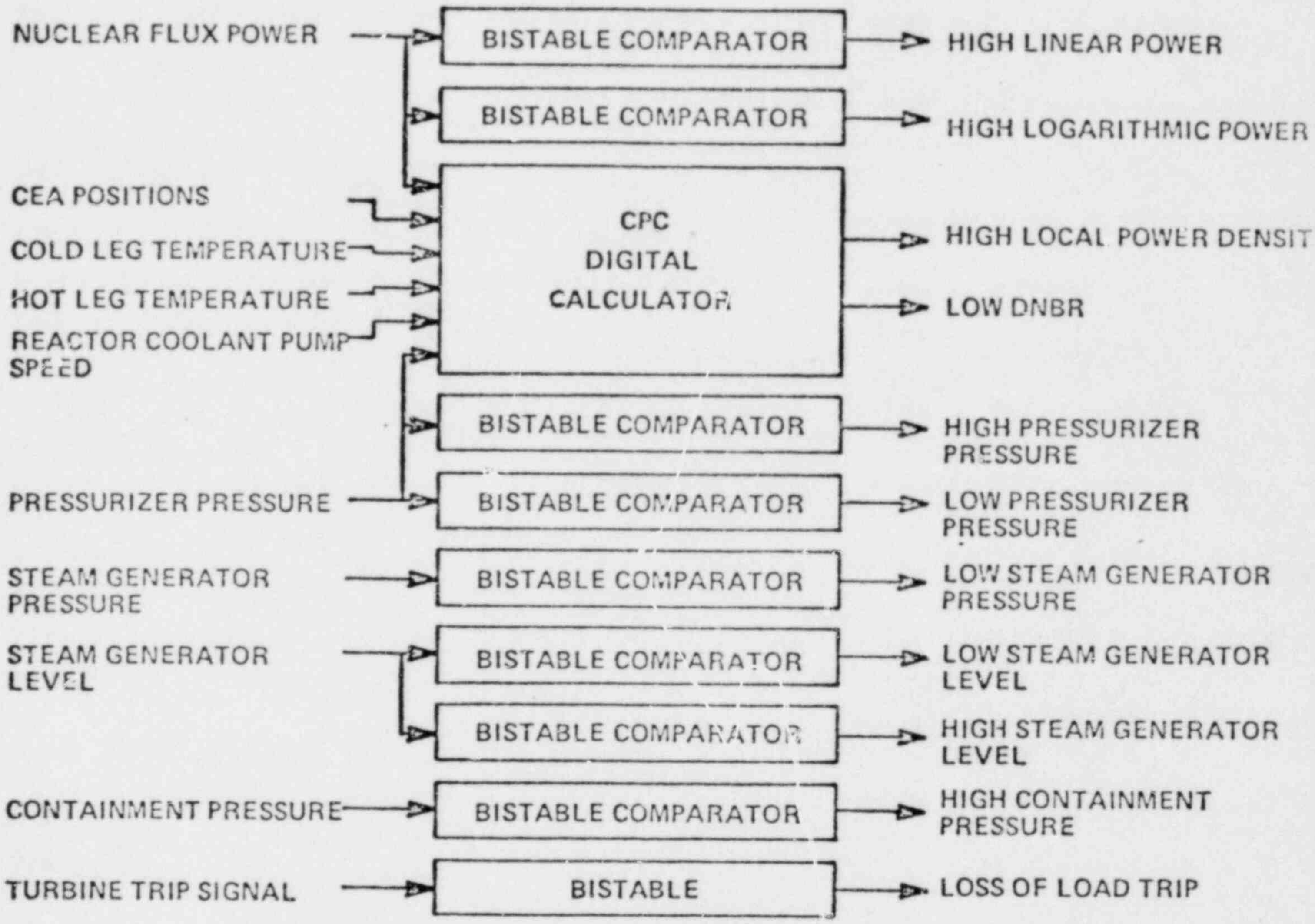
Figure 2



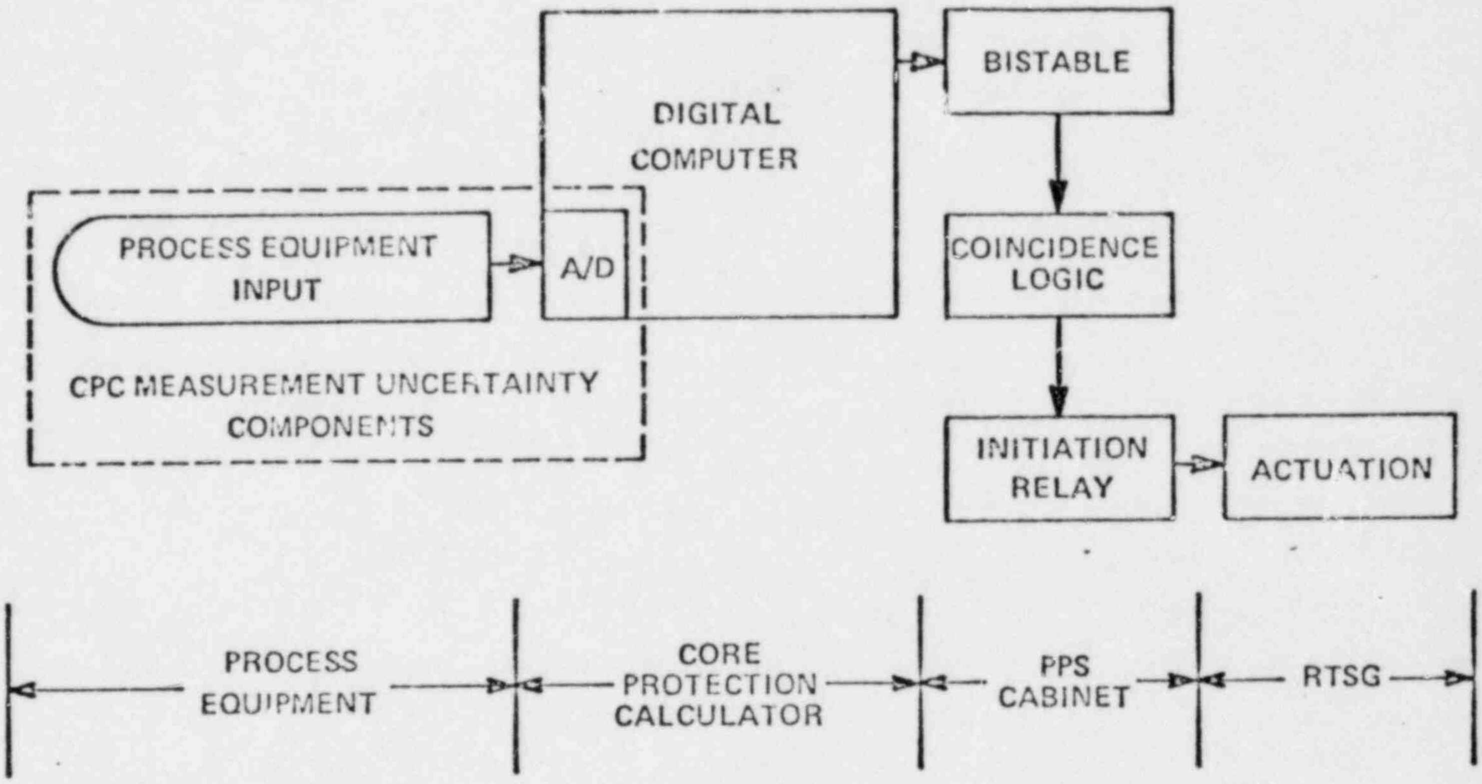
	PLANT PROTECTION SYSTEM BLOCK DIAGRAM	Figure 3



	EQUIPMENT SETPOINT DETERMINATION USING EVENT SPECIFIC DATA	Figure 4



	REACTOR PROTECTION SYSTEM INPUTS AND TRIP FUNCTIONS	Figure 5



	CORE PROTECTION CALCULATOR AS PART OF THE REACTOR PROTECTION SYSTEM	Figure 6