ARKANSAS POWER & LIGHT COMPANY

ARKANSAS NUCLEAR ONE UNIT 2

DETERMINATION OF PLANT PROTECTION SYSTEM TRIP SETPOINT VALUES

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LIST OF ACRONYMS AND ABBREVIATIONS

ACRS	Advisory Committee on Reactor Safeguards
A/D	Analog to Digital Converter
ANO-2	Arkansas Nuclear One - Unit 2
AP&L	Arkansas Power & Light Company
ASP	Analysis Setpoint
AV	Allowable Value
CCAS	Containment Cooling Actuation Signal
CE	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
RSS	Root Sum Squares
RWT	Refueling Water Tank
SA	Safety Analysis
SIAS	Safety Injection Actuation Signal
STS	Standard Technical Specification
Tech Spec	Technical Specification

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1.0 INTRODUCTION

1.1 Scope

By References 4.1 and 4.2 the Nuclear Regulatory Commission (NRC) requested specific setpoint related data for the Arkansas Nuclear One - Unit 2 (ANO-2) Plant Protection System (PPS) from Arkansas Power & Light Company (AP&L). This document provides the requested information and also describes the Combustion Engineering (CE) setpoint methodology used to determine ANO-2 setpoints. This methodology was established to assure consistency with current licensing requirements and industry standards.

Section 2.0 describes the present CE method of determining protection system setpoints that is used to assure consistency with current requirements and standards. This section 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 this CE setpoint methodology.

Section 3.0 provides the specific data requested by References 4.1 and 4.2. The section begins with an explanation of the data in the tables and relates the data to the explanation of the CE setpoint methodology previously given. The remainder of Section 3.0 consists of tables which contain the requested information.

Section 4.0 lists the references referred to in this document.

1.2 Background

This document provides the specific information requested of AP&L by References 4.1 and 4.2. This information is contained in Tables 1-7 at the end of the report. Section 3.0 describes how the information is compiled in the tables and provides a one-to-one correlation between the specific information requested in References 4.1 and 4.2 and the data in the tables. Information contained in this document describing methods of determining protection system setpoints and specific data requested in References 4.1 and 4.2 were supplied to Arkansas Power and Light by Combustion Engineering.

For the purpose of clarification in this document, where certain examples are given a high trip setpoint is shown. The information presented also applies to a low trip setpoint, however minor modifications to the example would be required to be specifically applicable.

2.0 SETPOINT METHODOLOGY

2.1 Basic Description

Figure 1 shows in block diagram the CE setpoint methodology.

This section describes the CE method of setpoint calculation. The ANO-2 Reactor Protection System (RPS) uses a Core Protection Calculator (CPC) to generate two of the eleven trip signals. The CPC is a digital computer system which uses a method that differs in some respects from the method used for the other trip functions to ensure all equipment uncertainties are accommodated in a decision to initiate a reactor trip. Section 2.5 describes the CPC method of uncertainty accommodation in particular. The other sections of Section 2.0 discuss the setpoint methodology applicable to the non-CPC portion of the RPS and the entire ESFAS.

As part of obtaining an operating license (OL), a Safety Analysis is performed to show that the consequences of Design Basis Events (DBEs) will be acceptable. This Safety Analysis assumes protective action is initiated at the point where the process variables reach established setpoints. These setpoints assumed in the Safety Analysys are defined as Analysis Setpoints (ASP).

A detailed equipment error calculation is then performed which statistically combines the individual uncertainty components associated with the specific equipment to determine the margin required between the Analysis Setpoint and the setpoint set into the equipment. The Analysis Setpoint is then adjusted in the conservative direction by this calculated margin and the resulting value is defined as the Equipment Setpoint (ESP). The Equipment Setpoint becomes part of the plant technical specifications (Reference 4.4) and represents the value the technician is to set into the equipment during required calibration and maintenance.

As an integral part of the equipment error calculation, a number is also determined which represents the maximum expected equipment drift over a specified period between calibrations. The Equipment Setpoint is now adjusted toward the Analysis Setpoint by the amount calculated for equipment drift and the resulting number is the Allowable Value (AV). This Allowable Value also becomes part of the plant technical specifications and represents the value to which the equipment can drift between calibrations and still be consistent with the Safety Analysis.

Thus the CE setpoint methodology results in an Equipment Setpoint and an Allowable Value which, assuming the equipment operates as designed, assure that the equipment will initiate protective action conservatively relative to the Analysis Setpoint used in the Safety Analysis.

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

2.2 Analysis Setpoint

As a basic requirement, setpoints must be chosen to (1) ensure initiation or protective action as required 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 using 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.

[ ]

This setpoint is called the Nominal Value and represents the approximate value of the final expected setpoint. The Nominal Value is used in the Preliminary Safety Analysis Report (PSAR) which is issued well before the final Safety Analysis is completed and incorporated into the Final Safety Analyses Report (FSAR). The Nominal Value is then 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 in acceptable plant performance.

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 events.

The Analysis Setpoints are used in the Safety Analysis to show acceptable consequences for the events analyzed. In the Safety Analysis, the Analysis Setpoint is the value of the measured parameter at the measurement point at which protection system actuation is assumed to start. The Safety Analysis is described in the Final Safety Analysis Report (FSAR) (Reference 4.3) and is part of the documentation required to receive an operating license. The final Analysis Setpoints used in the Safety Analysis are then used in the setpoint calculation to determine Equipment Setpoints and Allowable Values as described in subsequent sections of this report.

2.3 Equipment Errors

2.3.1 General

Current setpoint requirements and good engineering practice dictate that all factors which can affect the operation of equipment be considered when determining errors in the setpoint calculation. In the CE setpoint methodology, each error component that can have an impact on equipment performance is determined separately and then the individual errors are combined in a statistically valid method to arrive at a total equipment error. 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 calibration error;
2. PPS cabinet periodic test error;
3. Process equipment calibration error;
4. Process equipment periodic test error;
5. Accident environment error;
6. Process error;
7. Dynamic Allowance.

Following this is a description of the method used to combine the individual errors to arrive at a total equipment error.

For means of setpoint calculation, the PPS is divided into two major regions as shown on 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. This is consistent with the surveillance requirements in the plant technical specifications (Reference 4.4) which require a channel functional check (i.e., PPS cabinet) monthly and a channel calibration (i.e., process equipment and PPS cabinet) every 18 months.

2.3.2 Individual Errors

2.3.2.1 PPS Cabinet Calibration Error

This is the error inherent in 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 error is determined for the specific equipment installed in the PPS cabinet from information supplied by the manufacturer and actual calibration requirements on the equipment.

2.3.2.2 PPS Cabinet Periodic Test Error

This error accounts for the expected drift of the PPS cabinet setpoint over the period from when the setpoint is set until the monthly Channel Functional Check is performed to check the setpoint. When determining this error, 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. The component errors are combined to determine the PPS cabinet periodic test error in a manner similar to that described later in Section 2.3.3 for determining total equipment errors. The PPS cabinet periodic test error is calculated using information supplied by the equipment manufacturer and from actual testing of the equipment.

2.3.2.3 Process Equipment Calibration Error

This error is analogous to the PPS calibration error but applies to the process equipment as shown on Figure 3, vice the PPS cabinet. This is the error inherent in 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 calibration error 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 Error

This error is analogous to the PPS cabinet periodic test error but applies to the process equipment. The error accounts for the expected drift of the equipment during the time between channel calibrations, which are performed as a minimum every 18 months as required by the plant technical specifications (Reference 4.4). The same aspects are considered when calculating this error as are considered when determining the PPS cabinet periodic test error described above and the components are combined in a similar manner.

2.3.2.5 Accident Environment Error

During certain analyzed events the atmosphere in the containment is affected, and/or seismic events are considered to occur simultaneously. This change in environment introduces 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 effect, pressure effect, reference leg effects, seismic effects and radiation effects. The individual errors are then 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 worst case environment calculated or postulated to exist up to the time of the required reactor trip or Engineered Safety Features (ESF) actuation.

This environment can be different for different events analyzed. In most cases of 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 than for those events with little or not 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 (described later in this section) which also become specific.

2.3.2.6 Process Error

This error accounts for the uncertainty of the value of the process parameter (e.g., neutron flux power) 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 part of the setpoint calculation, the process errors are combined with the other equipment errors to determine the total equipment error as described later in this section.

2.3.2.7 Dynamic Allowance

In certain cases it is determined that the actual delay time for the equipment is longer than the time used in the Safety Analysis. In these cases a dynamic allowance may be incorporated into the setpoint to compensate for this time response difference.

Refer to Figure 4 for a simplified representation of the dynamic allowance discussed here. 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 when the Control Element Drive Mechanism (CEDM) coil flux has decayed sufficiently so that the Control Element Assemblies (CEAs) begin to move into the core.

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. As has been stated, in certain cases the actual time delay for the equipment may be longer than that used in the Safety Analysis. The reason for this difference is that the expected dynamic response of the sensor is slower than that originally assumed as input to the Safety Analysis. To assure, then, that a protective action occurs at or before the time assumed in the Safety Analysis, the Equipment Setpoint is altered in a conservative direction to compensate for the sensor response characteristics. [

] This resulting dynamic allowance is then conservative for all transients with a rate of change less than that used in the calculation.

2.3.3 Total Equipment Error

After the individual error components have been determined, they are then combined to arrive at a total equipment error which is used in calculating Equipment Setpoints. 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 combination of a random error component and non-random component. The total equipment error represents the maximum error calculated that could occur at any time during the periodic calibration interval for the limiting event for which the function is required to operate. As discussed previously, in some cases different accident environment errors are calculated for different events analyzed. In these cases different total equipment errors are then calculated using the different accident environment errors. These total equipment errors are event specific and are used as such when determining Equipment Setpoints as discussed in Section 2.4.1.

2.4 Setpoint Determination

2.4.1 General

The plant technical specifications (Reference 4.4) have Equipment Setpoint and Allowable Value requirements for the PPS equipment. The Safety Analysis uses Analysis Setpoint values for the PPS equipment as part of showing acceptable consequences for the events analyzed. Equipment Setpoints, Allowable Values and Analysis Setpoints are tied together in the setpoint determination process of the setpoint calculation.

2.4.2 Equipment Setpoint

As discussed in Section 2.3.3, a total equipment error is determined for each PPS function. This represents the maximum error which must be accommodated to account for all the individual errors which can affect the accuracy of the equipment being used. In some cases, different total equipment errors are calculated for different events analyzed. To accomodate all errors in the setpoint calculation, then, the Analysis Setpoint is changed in a conservative direction by the amount of the total equipment error to arrive at the Equipment Setpoint. When different total equipment errors and different Analysis Setpoints are determined for different analyzed events, the event specific Analysis Setpoints are changed in a conservative direction by the corresponding event specific total equipment errors. The most conservative resulting value is then used as the Equipment Setpoint so that in all cases a conservative setpoint calculation is assured. See Figure 5 for a representation of Equipment Setpoint calculations where different events are analyzed separately.

The calculated Equipment Setpoint for each PPS function becomes part of the plant technical specifications (Reference 4.4) and represents the value set into the equipment during calibration. The PPS cabinet equipment, like all analog equipment of this type, cannot be set exactly at a specified value. There are errors inherent in the bistable itself, and in the power supplies and voltmeter used to set and check the setpoint. These errors have been included in the total equipment error as the PPS cabinet calibration error discussed in Section 2.3.2.1. To be consistent with the STS format [

] Equipment Setpoints shown in the plant technical specifications (Reference 4.4) are all prefaced with a $\leq$ or $\geq$, depending on whether the setpoint is above or below the normal operating range, respectively. This limits setting the Equipment Setpoints to no less conservative than the value shown in the technical specifications. [

[ ]

2.4.3 Allowable Value

As discussed in Section 2.3.2.2, the PPS cabinet periodic test error represents the maximum anticipated drift of the PPS cabinet equipment during the specified period of time between calibrations. This error was used when calculating the total equipment error which was used to determine the Equipment Setpoint. The Equipment Setpoint is now adjusted toward the Analysis Setpoint by the amount of the calculated PPS cabinet periodic test error. The resulting value is the Allowable Value listed in the plant technical specifications (Reference 4.4). As required by the technical specifications, 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 actual setpoints which are inconsistent with the Safety Analysis and the setpoint calculation is virtually eliminated.

2.4.4 Technical Specifications

For each PPS function, the Equipment Setpoints and Allowable Values which have been calculated to assure that the equipment will operate as assumed in the Safety Analysis are then incorporated into the plant technical specifications.

As part of the setpoint calculation to arrive at the Equipment 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. The equipment calibration procedure assures that the assumptions used in the setpoint calculation are verified.

2.5 Core Protection Calculator Setpoints

2.5.1 General

The ANO-2 Reactor Protection System uses a Core Protection Calculator (CPC) to generate two of the eleven 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 RPS inputs and trip functions are shown in Figure 6. The CPC is a digital calculator system which uses a method which differs in some important aspects from the method used for the other trip functions to ensure that all equipment uncertainties are accommodated in the decision to initiate a reactor trip. Methods of incorporating uncertainty compensation into the CPC have been addressed in detail in documents previously submitted to the NRC (References 4.3, 4.5, 4.6, 4.7, 4.8, 4.9, and 4.10). 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 now given.

2.5.2.1 Measurement Uncertainties

Measurement uncertainties are the effect on the CPC response due to sensor and measurement channel characteristics. As shown in Figure 6, 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 nuclear flux;

6. CEA position.

A measurement uncertainty is calculated for each of the above CPC inputs (and factored into the CPC algorithms, as will be described in Section 2.5.3). The uncertainties calculated for the CPC measured inputs are based on manufacturer's instrument specification, 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 7 shows in block diagram where the CPC fits into the ANO-2 PPS and what portions of the PPS 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 calibration error;

2. Process equipment periodic test error;

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 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 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 constants in the algorithm. 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 and can consist of both random and non-random components.

2.5.2.4 CPC Processing Uncertainty

The CPC processing uncertainty is attributable to CPC (computer) processing and addresses the effects that scaling, round-off and bit manipulation have on the CPC computed result. Testing of the CPCs and calculations provide the information needed to determine this uncertainty. Comparison of actual CPC resonse 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 transient 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 ANO-2 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 constants is performed similar to the method described in Section 2.3.3 for combining errors in the non-CPC portion of the protection system.

The CPC trips are low DNBR and high Local Power Density (LDP). Constants are determined for use in the DNBR calculation and separate constants are determined for use in the LPD calculation. The following sections discuss the constants used in the DNBR and LPD calculations, respectively.

2.5.3.2 DNBR Uncertainty Constants

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

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

2. Power uncertainty factor used in the DNBR calculation (B_{ERR1}). Region-dependent algorithm uncertainty allowance (E(J)).

2.5.3.2.1 Uncertainty Bias for Power used in the DNBR calculation (B_{ERR2}).

The uncertainty bias for power used in the DNBR calculation accounts for the uncertainty inherent in the inputs to the power calculation in 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 uncertainty bias for power used in the DNBR calculation is added to the calculated power level as:

$$POWER_{DNB} = POWER_{CALC} + B_{ERR2}$$

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

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

B_{ERR2} = Uncertainty bias for power used in the DNBR calculation.

2.5.3.2.2 Power Uncertainty Factor Used in the DNBR Calculation (B_{ERR1}). Region-dependent Algorithm Uncertainty Allowance (E(J)).

These factors account for the uncertainties not accounted for by the previous constant. These two factors are discussed as one because they are determined together and they are applied together in the CPC algorithm, as shown below. For enhanced operating flexibility, the operating space in which the DNBR is calculated is divided into nine different regions depending on inlet coolant temperature, coolant pressure, axial shape index, and integrated radial peaking factor. The region-dependent algorithm uncertainty allowance is also determined separately for each region and nine separate uncertainty allowances result, which are then used in the DNBR calculation. The method of combining the individual uncertainty components to determine the actual values used for these constants is similar to the method described in Section 2.3.3 of this report. The 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:

$$POWER_{DNB\ ADJ} = POWER_{DNB} \cdot B_{ERR1} \cdot (1+E(J))$$

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

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

$E(J)$ = Region-dependent algorithm uncertainty allowance.

OR:

$$POWER_{DNB\ ADJ} = (POWER_{CALC} + B_{BERR2}) \cdot B_{ERR1} \cdot (1+E(J))$$

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 bias 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 bais for power used in the DNBR calculation. Thus, the value of the two constants are the same and they are applied in an identical manner. 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 measurements 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 measurements. This is analogous to the DNBR constants B_{ERR1} and E(J) described in Section 2.5.3.2.3. Unlike the DNBR constants, however, one analysis is performed for the entire LPD operating space. Thus only one power uncertainty factor is used in the LPD calculation results for the entire region. 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 level used in the LPD calculation, as:

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

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 Tech Spec (Ref. 4.4) and in Table 5 of this report, the Analysis Setpoint, Equipment 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 Equipment 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 Equipment Setpoint and Allowable Value are identical for each CPC trip function.

2.6 Equipment Calibration

2.6.1 Basic Description

The CE "explicit" setpoint methodology determines Equipment Setpoints and Allowable Values for the PPS trip functions. These numbers then become part of the plant technical specifications (Ref. 4.4). 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 setpoint procedure is an input to these requirements in the plant technical specifications. This ensures that the specific data in the requirements is consistent with the assumptions used in the setpoint process. To ensure, then, that the protection system equipment continues to operate in a manner consistent with the setpoint calculation, the plant staff maintains the equipment in accordance with the requirements set forth in the plant technical specifications.

2.6.2 CPC Calibration

2.6.2.1 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 actuation 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 in 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 7. 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. These will now be discussed individually.

2.6.2.2 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 7). Except for the A/D, this is identical to the non-CCP 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. That is: 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.

2.6.2.3 CPC Computer System Calibration

The remainder of the CPC portion of the protection system is the CPC computer system itself. This is different from the rest of the RPS trip decision logic in that the CPC is a digital computer. As such the CPC trip setpoint is not subject to drift and thus bistable drift was not considered as part of the CPC uncertainty calculation discussed in Section 2.5. However there are numerous similarities between the CPC and the non-CPC portions of the protection system concerning equipment calibration and the majority of the preceding discussion applies to the CPCs.

When determining equipment uncertainties for the CPCs (see Section 2.5.2), certain assumptions are made that require verification to ensure the CPC method of accommodating uncertainties remain 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. Because the CPC is a digital computer system, the algorithm is not subject to drift. As such, the monthly Channel Functional Test required by the technical specification is different from the tests performed on the non-CPC channels. For the CPCs this involves such things as verifying, one-for-one, that the information stored in protected memory agrees with the data on the test disc, and putting in test inputs and checking the CPC outputs to ensure they are correct.

3.0 DETAILED SETPOINT DATA

3.1 NRC Request

On March 22, 1977, the NRC sent a letter of the subject "Arkansas Nuclear One - Unit 2 Instrument Setpoints" to AP&L (Ref. 4.1). 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 ESF 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.

Additionally, on September 1, 1978, the NRC issued Amendment 1 to the ANO-2 operating license (OL) (Reference 4.2). In the OL the the NRC also requested explicit setpoint related information for incorporation into the technical specifications. The three items requested in the OL are identical to items 3-5, respectively, of the above list.

As can be seen, the information requested is purely numerical data. This report has explained the CE "explicit" setpoint methodology so that the data, when presented, will be more easily understood. Tables 1-7 contain the required data. The remainder of Section 3.0 is an explanation of these tables and ties the data presented with the CE setpoint methodology previously discussed.

3.2 Explanation of Tables

3.2.1 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 4.1 and 4.2. 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 ($\pm$) and a non-random (+) component. For the non-random components, as used in this report, the + signifies that the uncertainty is one-sided in the non-conservative direction and included in the setpoint calculation.

The following Sections 3.2.2 - 3.2.6 provide an explanation of the columns of data contained in Tables 1 - 7. Section 3.2.7 discusses additional items by PPS function where further clarification is helpful.

3.2.2 Table 1

Table 1 contains the Equipment Setpoint, Allowable Value and the Drift Allowance for each discussed PPS function. The Equipment Setpoint and the Allowable Value data is obtained directly from the plant technical specifications (Ref. 4.4). The Equipment Setpoint is the value of the trip setpoint actually set into the PPS cabinet during calibration, and corresponds to the data requested in item 1 of the NRC letter (see Section 3.1). 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 a trip 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 contains the Drift Allowance and corresponds to item 3 of the NRC request and item 1 of the ANO-2 OL. This is the difference between the Equipment Setpoint and the Allowable Value and represents the equipment drift calculated that may occur between technical specification surveillance tests.

3.2.3 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 and item 2 of the ANO-2 OL. 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 calibration and periodic testing is listed. The calibration uncertainty accounts for basic inaccuracies in the equipment used during calibration and in the equipment being calibrated. The periodic testing procedure uses the same test equipment as during calibration. Therefore, the calibration uncertainty is included in the calculation of the periodic test uncertainty in addition to the other components, as discussed in Section 2.3. As a result, the calibration uncertainty data contained in Table 2 is not explicitly included, again, in the total error calculation.

The PPS cabinet periodic test error in Table 2 is used indirectly to determine the Drift Allowance data given in Table 1. The random and non-random components of the periodic test error are combined to determine the calculated equipment drift between calibrations. This is applied to the Equipment Setpoint toward the Analysis Setpoint to give the Allowable Value. Because of mathematical round-off in non-significant figures, the Drift Allowance and the PPS periodic test error are not identical in every case. Some Drift Allowances are larger than th PPS periodic test error in the third decimal place; an apparent non-conservative result, as this would seem to allow the actual setpoint to come too close to the Analysis Setpoint. Figure 8 explains how this can result in the setpoint calculation and still be a conservative result.

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

3.2.4 Table 4

Table 4 contains the Analysis Setpoint data and the margin between the Analysis Setpoint and the Equipment 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 Equipment Setpoint is the mathematical difference between the two values. This corresponds to item 5 of the NRC request and item 3 of the ANO-2 OL. In all cases this margin is larger than 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.

3.2.5 Table 5

Table 5 contains the Equipment 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 Equipment Setpoint and Allowable Value are identical, the instrument drift allowance for the CPCs - item 3 of the NRC request and item 1 of the ANO-2 OL - is zero. The reason for the identical values is explained in Section 2.5.3.4.

Since the CPC is a digital computer system, it is not subject to drift. Because the Equipment Setpoint and Analysis Setpoint are identical, the margin between these two values - item 5 of the NRC request and item 3 of the ANO-2 OL - 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.

3.2.6 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 and item 2 of the ANO-2 OL. 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.

3.2.7 Additonal Notes

1. High Logrithmic 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. Low Steam Generator Water Level - RPS/EFAS: Two different Analysis Setpoints and two corresponding uncertainty calculations were performed. One calculation was performed specifically for the asymmetric steam generator transients. Where two values are given, the first is applicable to the is applicable for all other analyzed events. Where only one value is given, it is applicable to both setpoint calculations.

4. 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.

5. 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 Equipment Setpoint allows a range for setting, consistent with the calibration uncertainties.

6. 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.

4.0 References

4.1 Nuclear Regulatory Commission, "Arkansas Nuclear One - Unit 2 Instrumentation Setpoints", letter to Arkansas Power & Light Company, Docket No. 50-368, March 22, 1977.

4.2 Nuclear Regulatory Commission, "Arkansas Power and Light Company, Docket No. 50-368, Arkansas Nuclear One, Unit 2, Faciltiy Operating License", Amendment No. 1, License No. NPF-6, September 1, 1978.

4.3 Arkansas Power & Light Company, "Arkansas Nuclear One - Unit 2 Final Safety Analysis Report".

4.4 Arkansas Power & Light Company, "Arkansas Nuclear One - Unit 2 Technical Specifications".

4.5 Arkansas Power & Light Company, "Arkansas Nuclear One - Unit 2 Final Safety Analysis Report, Chapter 7A, Proprietary Version".

4.6 CE 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.

4.7 CE Power Systems, Combustion Engineering, Inc., "CPC - Assessment of the Accuracy of PWR Safety System Actuation as Performed by the Core Protection Calculators", CENPD-170 Supplement 1-P, November, 1975.

4.8 Nuclear Power Systems, Combustion Engineering, Inc., "Arkansas Nuclear One - Unit 2, Docket 50-368, Final Safety Analysis Report, Proprietary Verisons of Responses to Core Protection Calculator System Questions 222.59-222.80 and 222.101-222.164", CEN-35(A)-P, July 26, 1976.

4.9 Nuclear Power Systems, Combustion Engineering, Inc., "Core Protection Calculator System Phase I Design Qualification Test Report", CEN-72(A)-P, October, 1977.

4.10 Nuclear Power Systems, Combustion Engineering, Inc., "Core Protection Calculator Functional Description", CEN-44(A)-P, January, 1977; Supplement 1(P), May, 1977; Supplement 2(P), September, 1977; and Supplement 3(P), September, 1977.

TABLE 1

PPS EQUIPMENT SETPOINTS, ALLOWABLE VALUES AND DRIFT ALLOWANCES

PPS FUNCTION	EQUIPMENT SETPOINT	ALLOWABLE VALUE	DRIFT ALLOWANCE
High Logarithmic Power Level - RPS	$\leq$0.75% of rated thermal power	$\leq$0.819% of rated thermal power	0.069% of rated thermal power
High Linear Power Level - RPS	$\leq$123% of rated thermal power	$\leq$123.712% of rated thermal power	0.712% of rated thermal power
High Pressurizer Pressure - RPS	$\leq$2368 psia	$\leq$2376.887 psia	8.887 psi
Low Pressurizer Pressure RPS/CCAS/SIAS	$\geq$1740 psia	$\geq$1686.75 psia	53.25 psi
High Steam Generator Water Level - RPS	$\leq$93.6% Water Level	$\leq$94.489% Water Level	0.889% Water Level
Low Steam Generator Water Level RPS/EFAS	$\geq$46.5% Water Level	$\geq$45.61% Water Level	0.89% Water Level
Low Steam Generator Press-RPS/MSIS/EFAS	$\geq$728 psia	$\geq$706.6 psia	21.4 psi
High Steam Generator Delta Press-EFAS	$\leq$39 psid	$\leq$48.35 psid	9.35 psi
High Containment Press-RPS/CCAS/SIAS/CIAS	$\leq$18.4 psia	$\leq$19.024 psia	0.624 psi
High High Containment Press-CSAS	$\leq$23.3 psia	$\leq$23.624 psia	0.324 psi
Low Refueling Water Tank Level - RAS	6 $\pm$ 0.5% Indicated Level	$\geq$5.111%, $\leq$6.889% Indicated Level	0.889% Indicated Level

TABLE 2

PPS INSTRUMENT BIAS COMPONENTS

PPS FUNCTION
High Logarithmic Power Level - RPS
High Linear Power Level - RPS
High Pressurizer Pressure - RPS
Low Pressurizer Pressure-RPS/CCAS/SIAS
High Steam Generator Water Level - RPS
Low Steam Generator Water Level-RPS/EFAS
Low Steam Generator Press-RPS/MSIS/EFAS
High Steam Generator Delta Press - EFAS
High Containment Press-RPS/CCAS/SIAS CIAS
High High Containment Press - CSAS
Low Refueling Water Tank Level - RAS

TABLE 3

PPS INSTRUMENT BIAS COMPONENTS, CONTINUED

PPS FUNCTION
High Logarithmic Power Level - RPS
High Linear Power Level - RPS
High Pressurizer Pressure - RPS
Low Pressurizer Pressure-RPS/CCAS/SIAS
High Steam Generator Water Level - RPS
Low Steam Generator Water Level-RPS/EFAS
Low Steam Generator Press-RPS/MSIS/EFAS
High Steam Generator Delta Press-EFAS
High Containment Press-RPS/CCAS/SIAS/CIAS
High High Containment PRESS - CSAS
Low Refueling Water Tank Level-RAS

TABLE 4

PPS ANALYSIS SETPOINTS AND SETPOINT MARGINS

PPS FUNCTION	ANALYSIS SETPOINT	MARGIN BETWEEN ANALYSIS SETPOINT & EQUIPMENT SETPOINT
High Logarithmic Power LEVEL-RPS	2% of Rated Thermal Power	≥1.25% of Rated Thermal Power
High Linear Power Level-RPS	129% of Rated Thermal Power	≥6% of Rated Thermal Power
High Pressurizer Pressure-RPS	2422 psia	≥ 54 psi
Low Pressurizer Pressure-RPS/CCAS/SIAS	1625 psia	≥ 115 psia
High Steam Generator Water Level-RPS	96% Water Level	≥ 2.4% Water Level
Low Steam Generator Water Level RPS/EFAS	45% & 5% Water Level	≥1.5 & ≥41.5% Water Level
Low Steam Generator Press-RPS/MSIS/ERAS	678 psia	≥ 50 psi
High Steam Generator Delta Press-EFAS	100 psid	≥ 61 psi
High Containment Press-RPS/CCAS/SIAS/CIAS	20.7 psia	≥2.3 psi
High High Containment Press-CSAS	25.7 psia	≥2.4 psi
Low Refueling Water Tank Level-RAS	1.5 & 10.5% Indicated Level	≥4.3 & ≥4.5% Indicated Level

TABLE 5

PPS CORE PROTECTION CALCULATOR TRIP SETPOINT DATA

PPS FUNCTION	EQUIPMENT SETPOINT	ALLOWABLE VALUE	ANALYSIS SETPOINT
Low DNBR-RPS	1.3 DNBR	1.3 DNBR	1.3 DNBR
High Local Power Density-RPS	20.3 kw/ft	20.3 kw/ft	20.3 kw/ft

TABLE 6

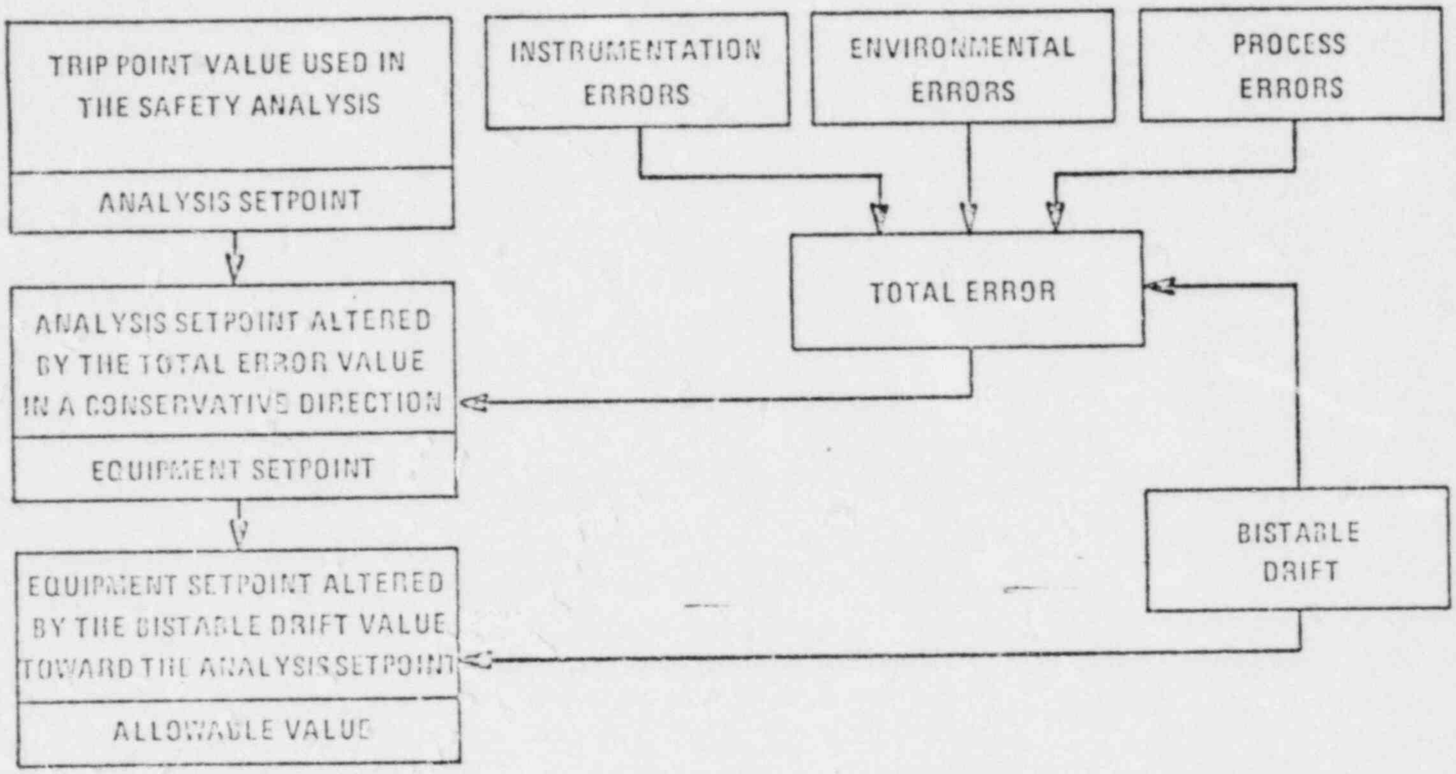
PPS CORE PROTECTION CALCULATOR PROCESS EQUIPMENT BIAS COMPONENTS

	MEASUREMENT CHANNEL		
CPC INPUT FUNCTION	CALIBRATION	PERIODIC TEST	A/D CONVERSION
Pressurizer Pressure			
Hot Leg Temperature			
Cold Leg Temperature			
CEA Position			
Ex-Core Linear Subchannels			
RCP Shaft Speed-28 Inch Disc			
RCP Shaft Speed-16.969 Inch Disc			

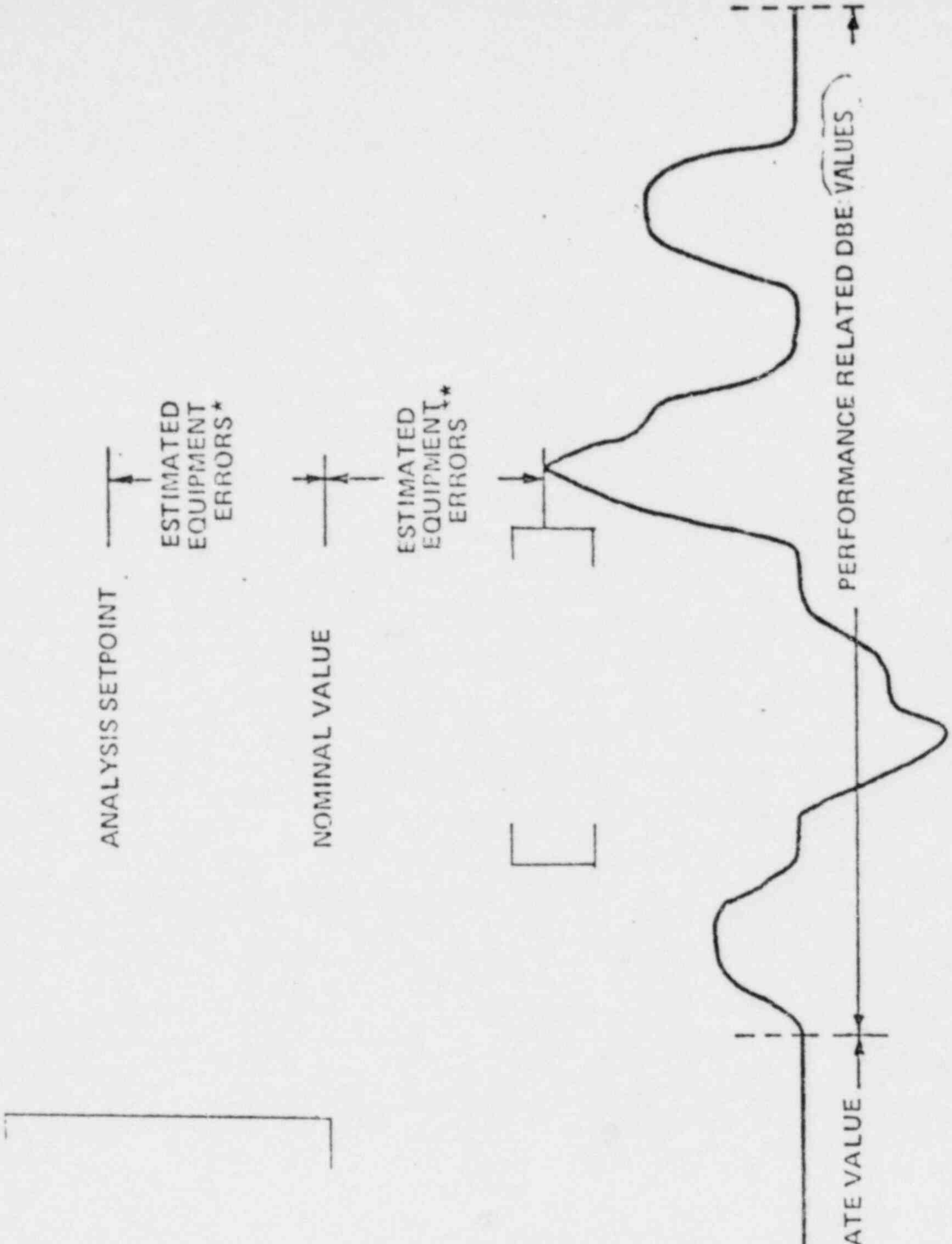
TABLE 7

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

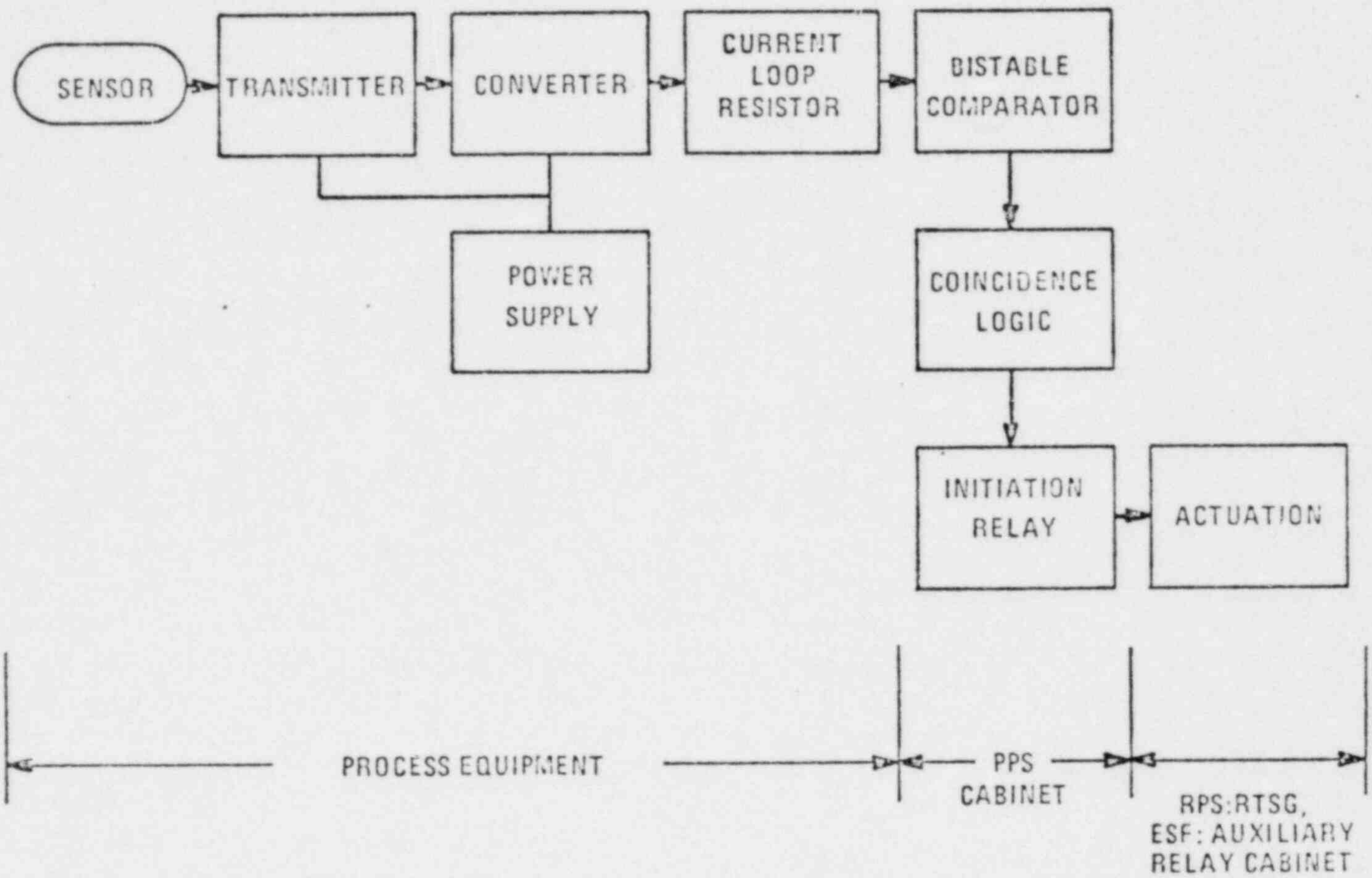
CPC INPUT FUNCTION	ENVIRONMENTAL EFFECTS	SOFTWARE ROUND-OFF	TOTAL ALLOWANCES
Pressurizer Pressure			
Hot Leg Temperature			
Cold Leg Temperature			
CEA Position			
Ex-Core Linear Sub-channels			
RCP Shaft Speed-28 Inch Disc			
RCP Shaft Speed-16.969 Inch Disc			



	SETPOINT CALCULATION METHODOLOGY	Figure 1



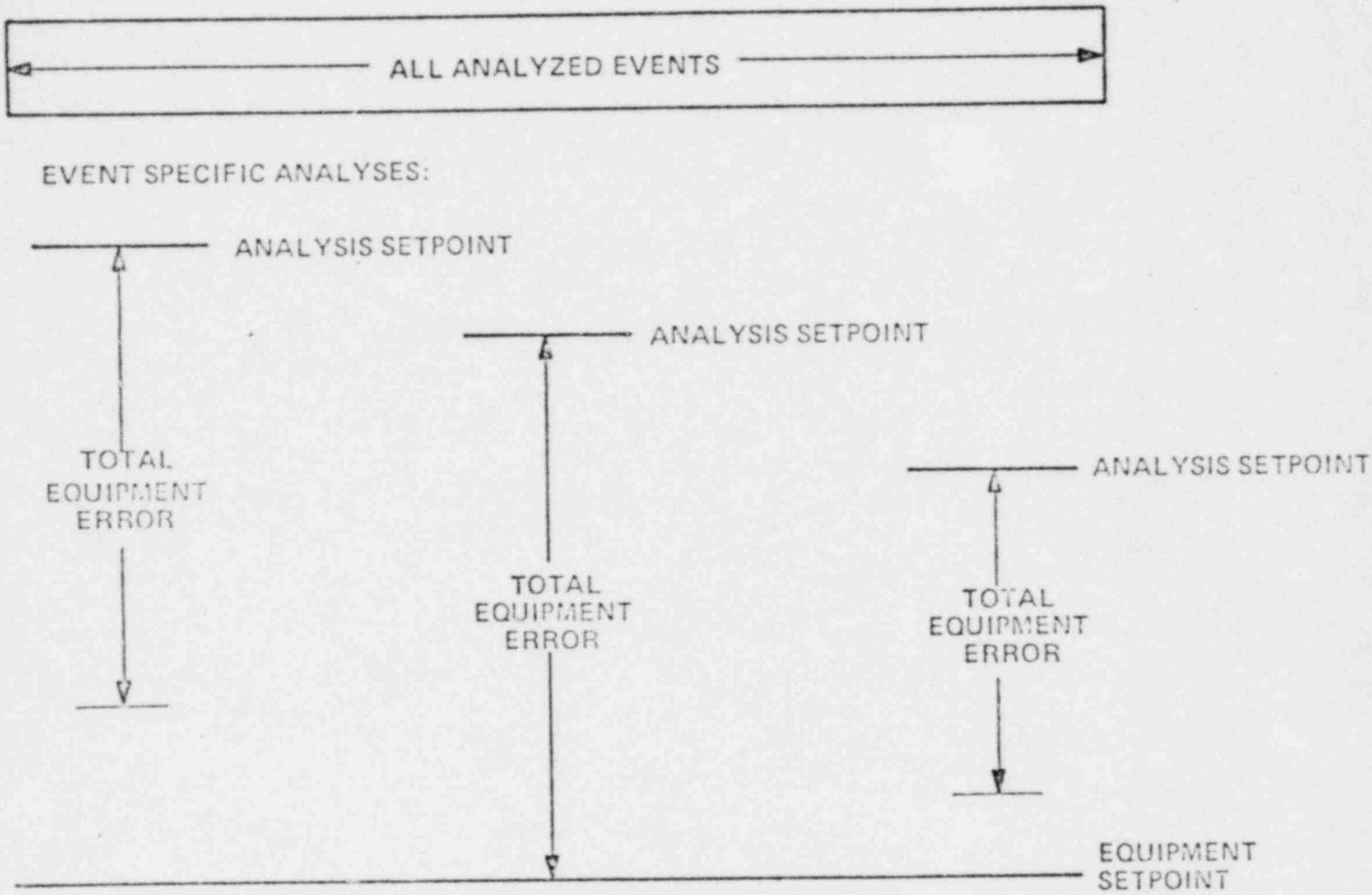
	ANALYSIS SETPOINT INITIAL DETERMINATION	Figure 2



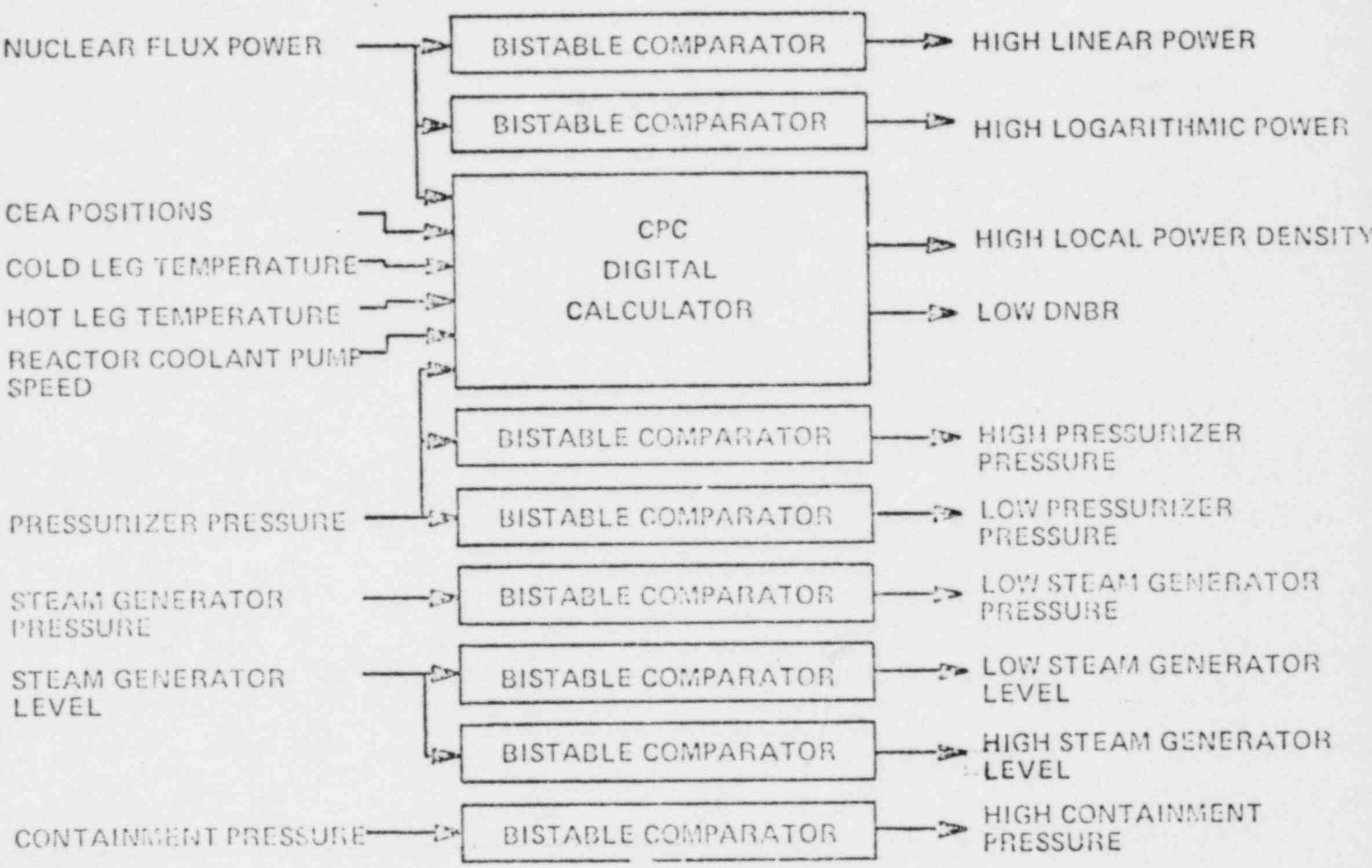
	PLANT PROTECTION SYSTEM BLOCK DIAGRAM	Figure 3

PLANT PROTECTION SYSTEM TIME DELAY COMPENSATION

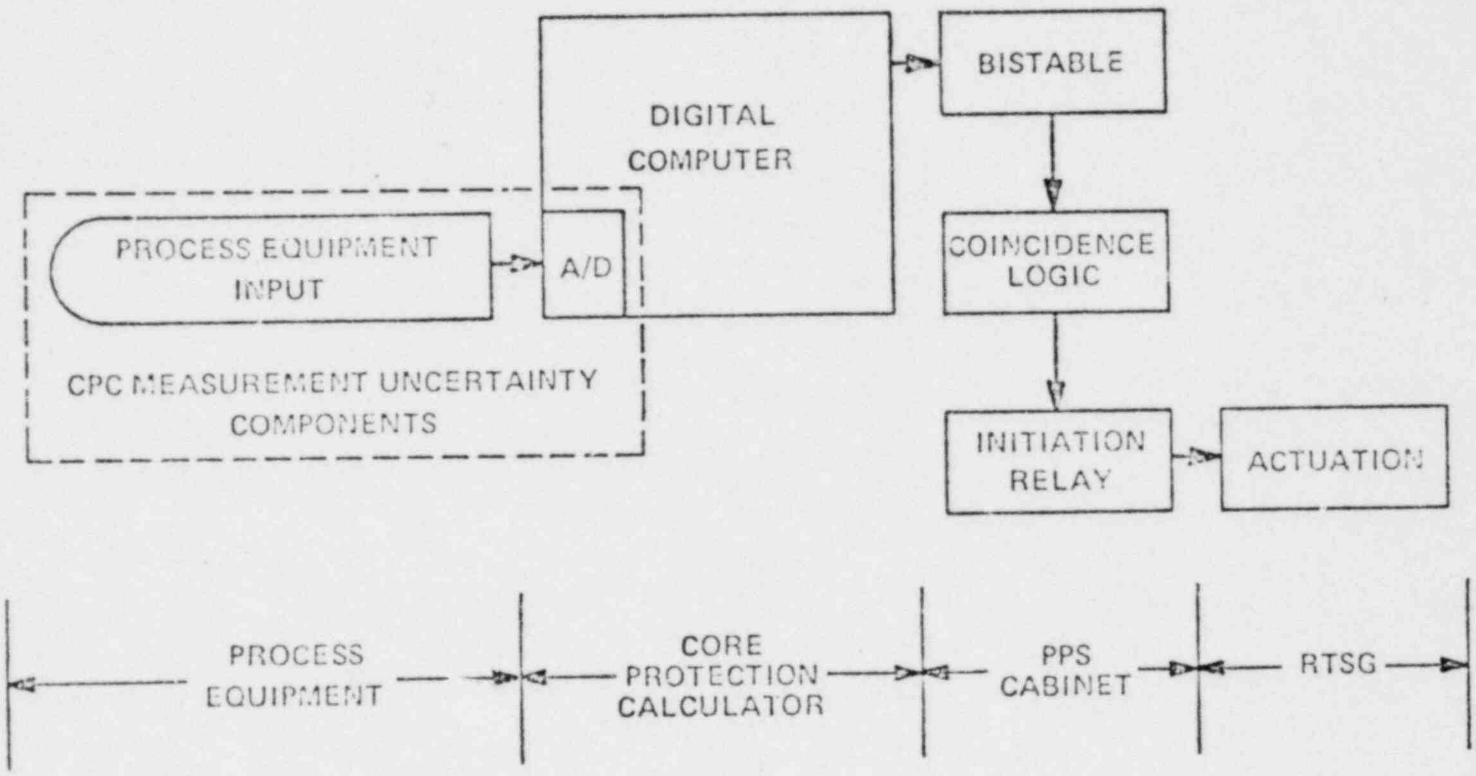
Figure 4



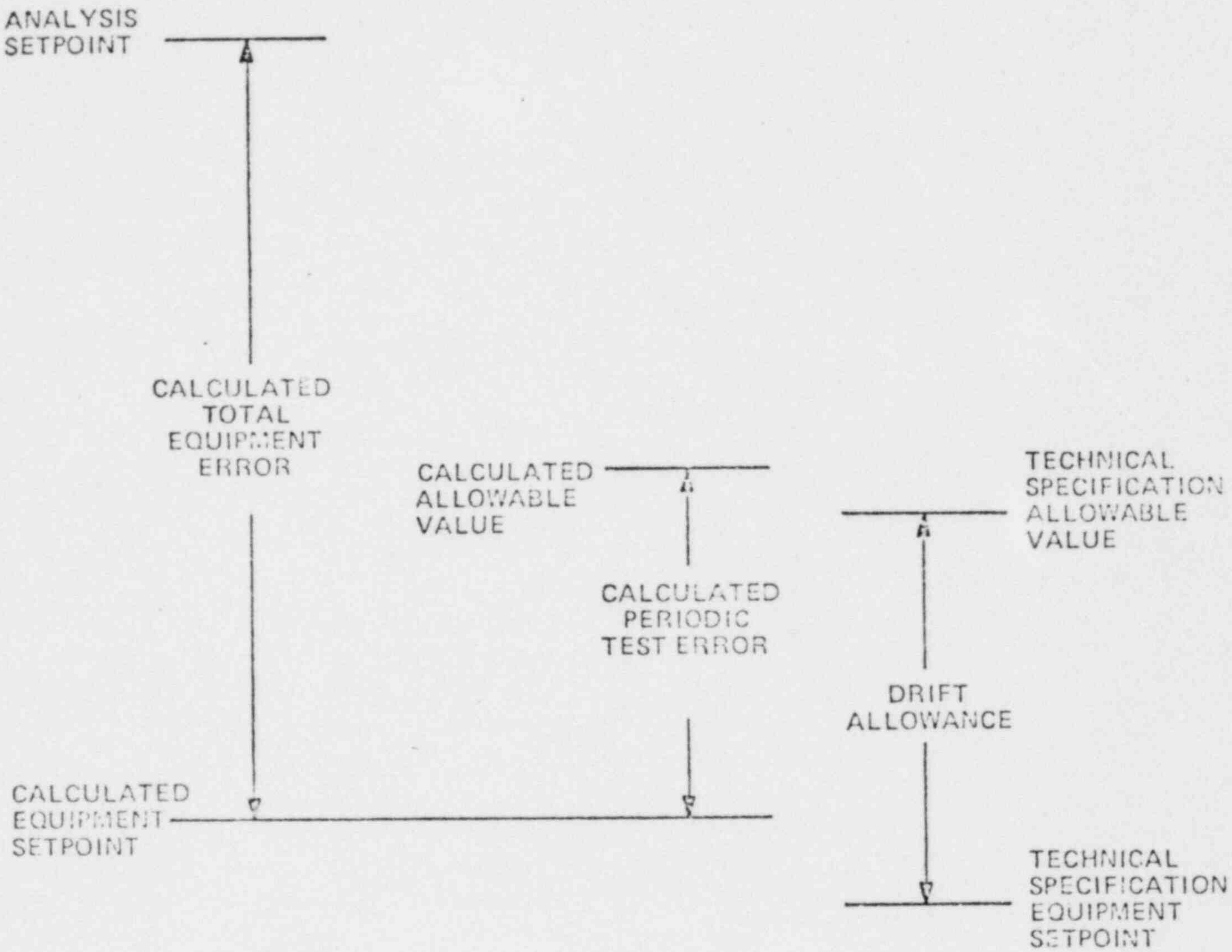
	EQUIPMENT SETPOINT DETERMINATION USING EVENT SPECIFIC DATA	Figure 5



	REACTOR PROTECTION SYSTEM INPUTS AND TRIP FUNCTIONS	Figure 6



	CORE PROTECTION CALCULATOR AS PART OF THE REACTOR PROTECTION SYSTEM	Figure 7



	ROUND-OFF EFFECTS ON EQUIPMENT SETPOINTS AND ALLOWABLE VALUES	Figure 8