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12.2 CONTROL ELEMENT ASSEMBLY CALCULATORS (CEACs)

Learning Objectives:

1. State the purpose of the control element assembly calculators (CEACs).
2. Explain why the CEACs are included in the reactor protection system (RPS) design.

12.2.1 Introduction

The CEACs sense the position of each of the control element assemblies (CEAs), determine CEA misalignment, and transmit misalignment information (in the form of penalty factors) to the core protection calculators (CPCs). The CEACs are required because each CPC receives CEA position from only one core quadrant and cannot sense misalignments that would affect local power density (LPD) and departure from nucleate boiling ratio (DNBR). In addition to supplying information to the CPCs, the CEACs provide CEA position indication.

12.2.2 CEAC Inputs

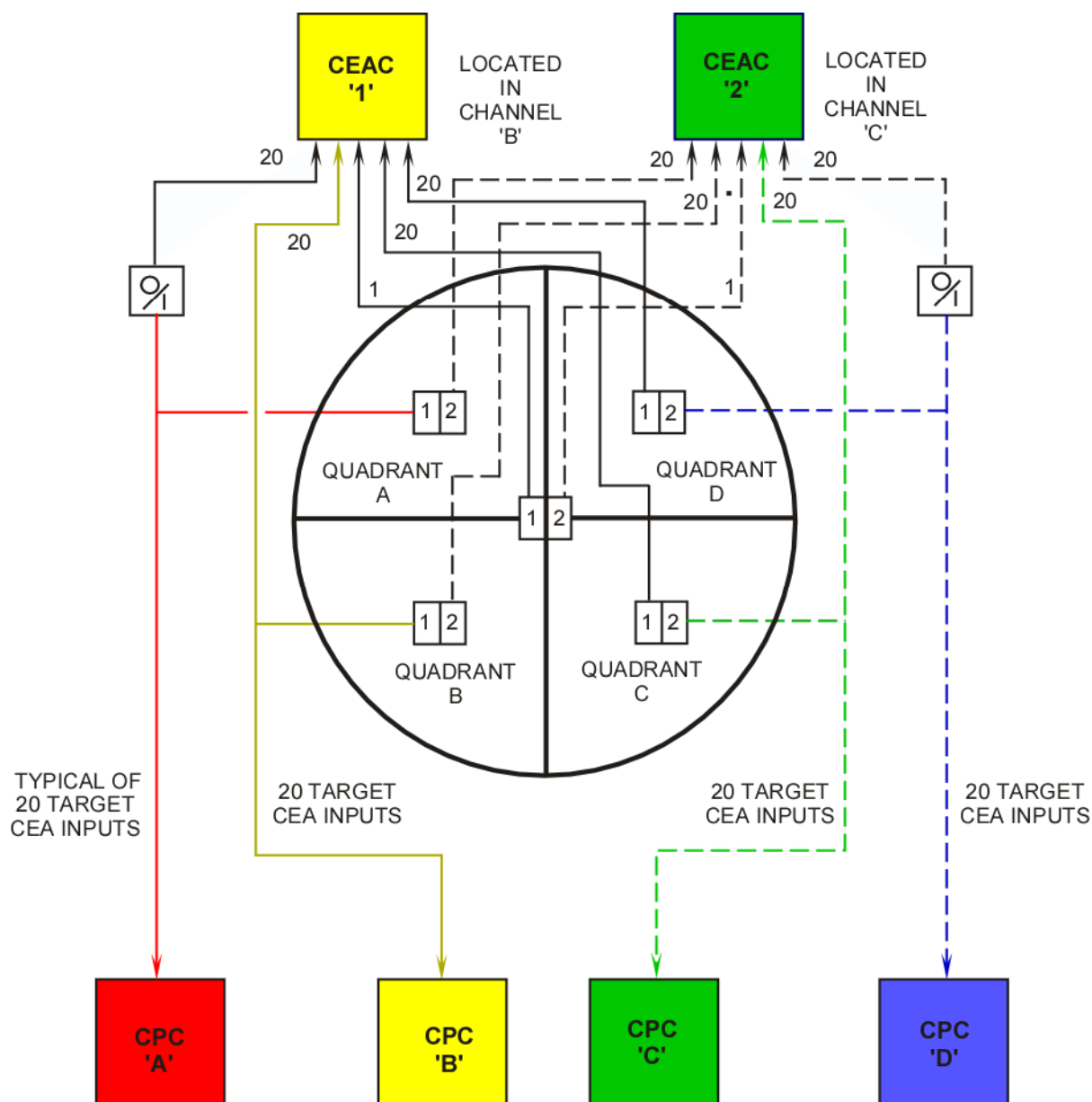


Figure 12.2-1 CEAC Inputs

Each CEA's position is sensed by redundant Reed Switch Position Transmitters (RSPTs). These RSPTs must supply target CEA positions for the CPC and supply position information to the CEACs.

The CEAC 1 inputs are as listed below:

1. 20 inputs from the CEAs that serve as target CEA inputs to CPC "B".
2. 20 inputs, via optical isolation, from the CEAs that serve as target CEA inputs to CPC "A".
3. 40 inputs from the redundant RSPT on the target CEAs for CPC "C" and CPC "D".
4. One direct input from the center CEA.

The inputs for CEAC 2 are as follows:

1. 20 inputs from the CEAs that serve as target CEAs for CPC "C".
2. 20 inputs, via optical isolation, from the CEAs that serve as target CEAs for CPC "D".
3. 40 inputs from the redundant RSPT on the target CEAs for CPC "A" and CPC "B".
4. One direct input from the center CEA.

12.2.3 Signal Processing

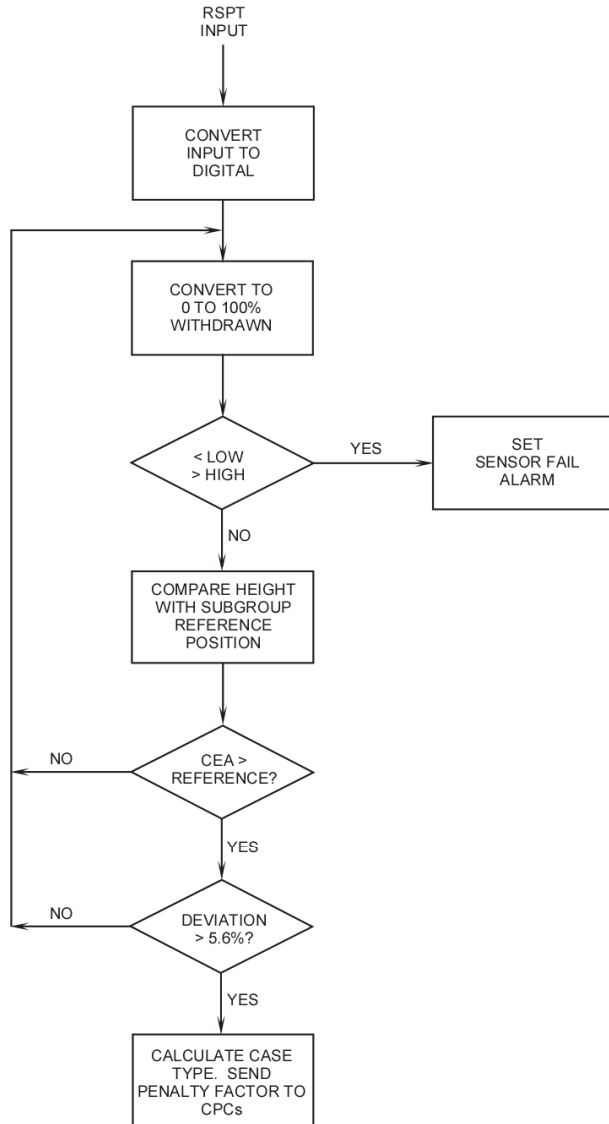


Figure 12.2-2 CEAC Software

The 5 to 10 volt analog input from the RSPT is converted to a digital signal corresponding to 0 to 100% withdrawn. A comparison is made to predetermined high and low limits. If a sensor fails high, the signal is set equal to the 100% withdrawn position, and conversely, if the signal fails low, the signal is set equal to the 0% withdrawn position. In either case, a sensor fail alarm is sent to the CPC/CEAC insert in the control room. Next, the calculator determines the reference position for each subgroup of CEAs by finding the lowest CEA in that subgroup. Each CEA position is compared with the reference position for its subgroup.

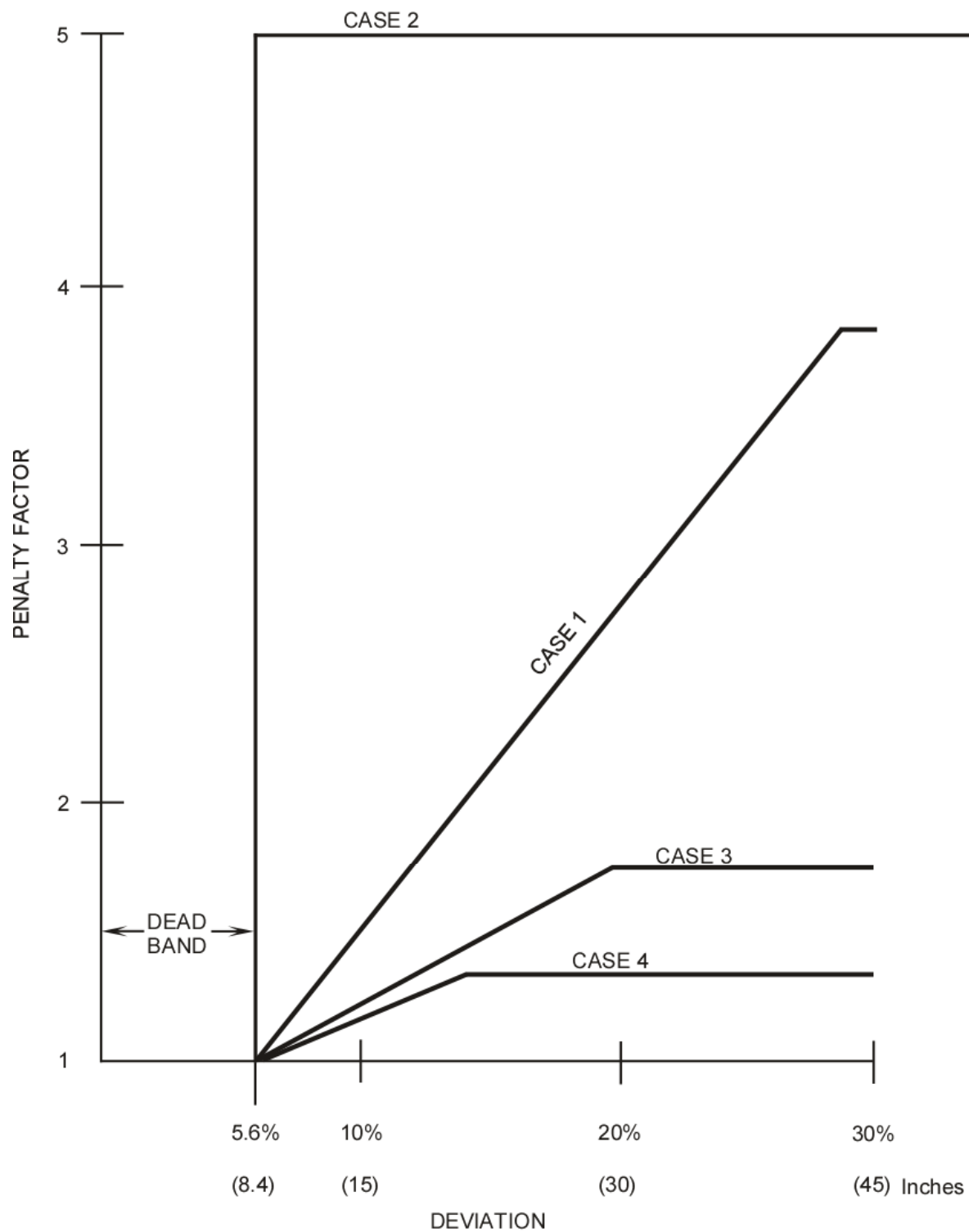
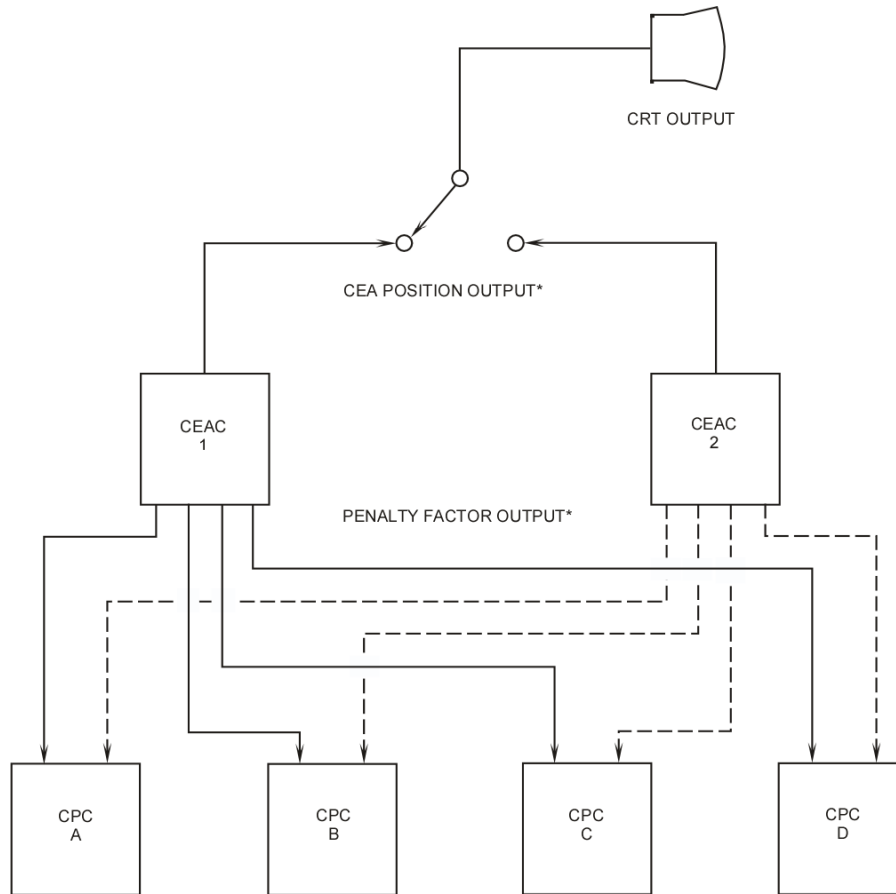


Figure 12.2-3 CEAC Penalty Factors

As an example, assume a four CEA subgroup with one CEA at 50% withdrawn and the remaining CEAs at 60% withdrawn. In this example, the CEAC would determine that three CEAs are misaligned. If the CEA exceeds a misalignment deadband (Figure 12.2-3) then a penalty factor is calculated.

Four different case types each with different penalty factors, are calculated. The first case involves the deviation of one CEA and provides protection for the uncontrolled withdrawal of a single or part length CEA. The second case provides protection for the misalignment of two CEAs within a subgroup. The third case provides protection for the drop of a single CEA while the fourth and final case protects against the drop of a five (5) CEA subgroup. These four cases represent the anticipated operational occurrences (AOOs) involving the CEAs.

12.2.4 CEAC Outputs



*OUTPUTS TRANSMITTED VIA OPTICAL ISOLATION

Figure 12.2-4 CEAC Outputs

The CEAC outputs two types of signals. The first signal is position information and is sent to a CRT display via a selector switch. The selector switch allows either CEAC to display the position of all CEAs. Each CEAC also transmits a penalty factor via optical isolators to each CPC.

In the CPC, the highest penalty factor is selected and applied to the power distribution calculations. Should a single CEAC become inoperable, the CPCs will select the highest signal from either the

operable CEAC or the last valid signal from the inoperable CEAC.

The inoperable CEAC may be bypassed by changing an addressable constant in the CPC software. When the CEAC is bypassed, the CPCs use the penalty factor from the operable CEAC. If both CEACs fail, plant operations may continue provided the CEACs are bypassed. Again, the bypass is accomplished by changing addressable constants in the CPCs. In this case, the CPCs use a predetermined conservative penalty factor.

12.2.5 Summary

The CEACs receive CEA position inputs, calculate penalty factors that are applied to the CPC power distribution calculations, and provide CEA position information to the control room display.

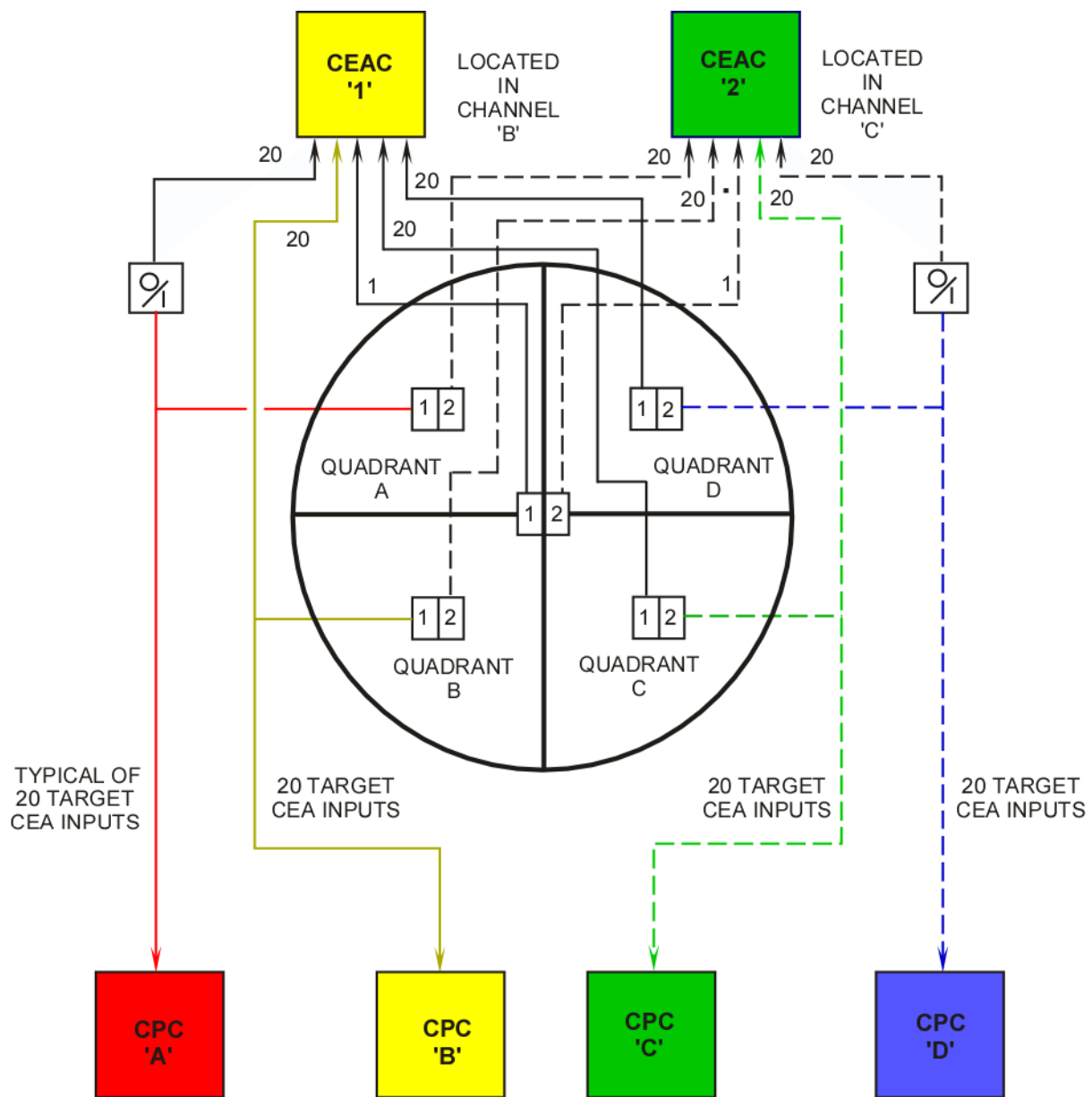


Figure 12.2-1 CEAC Inputs

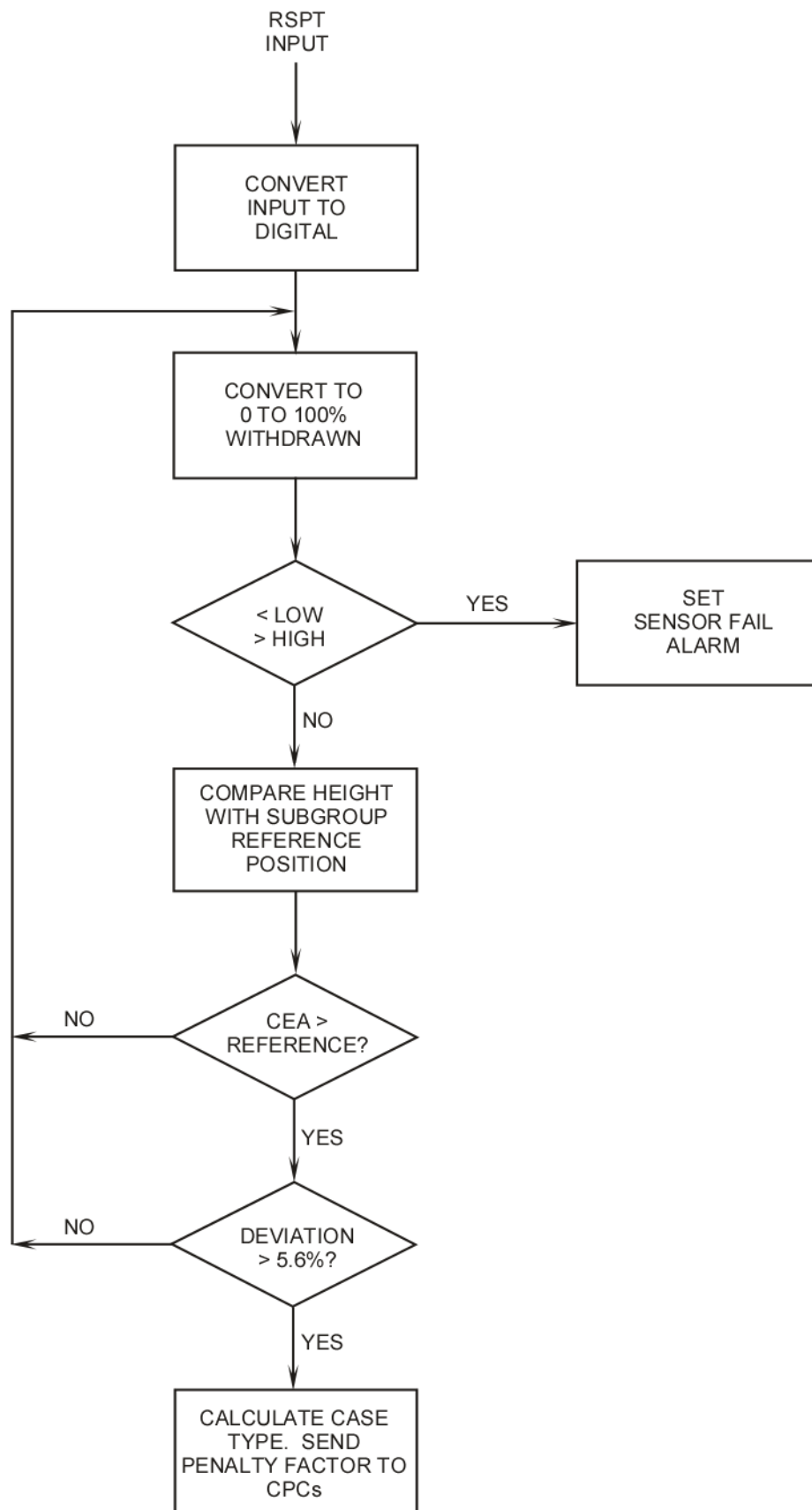


Figure 12.2-2 CEAC Software

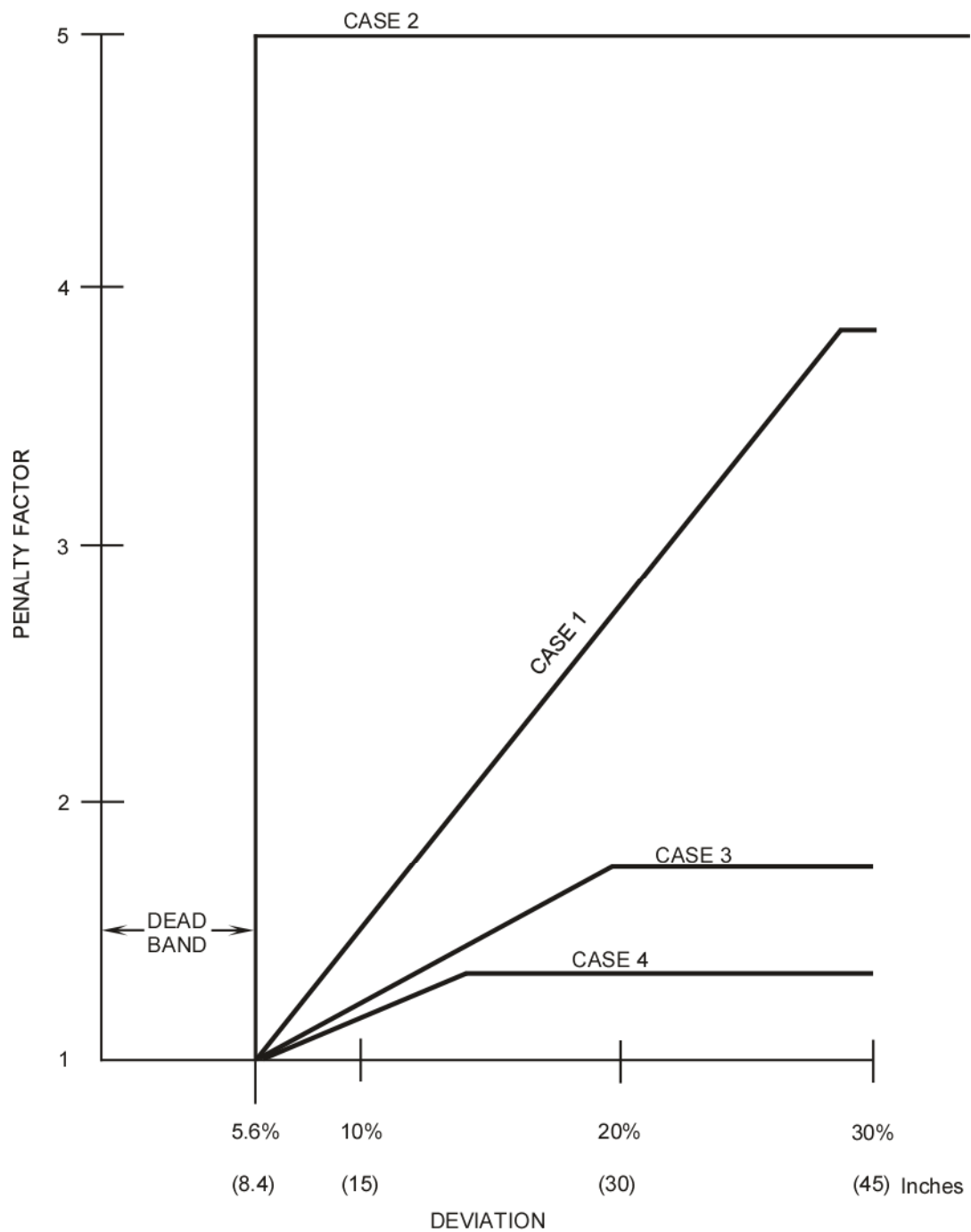


Figure 12.2-3 CEAC Penalty Factors

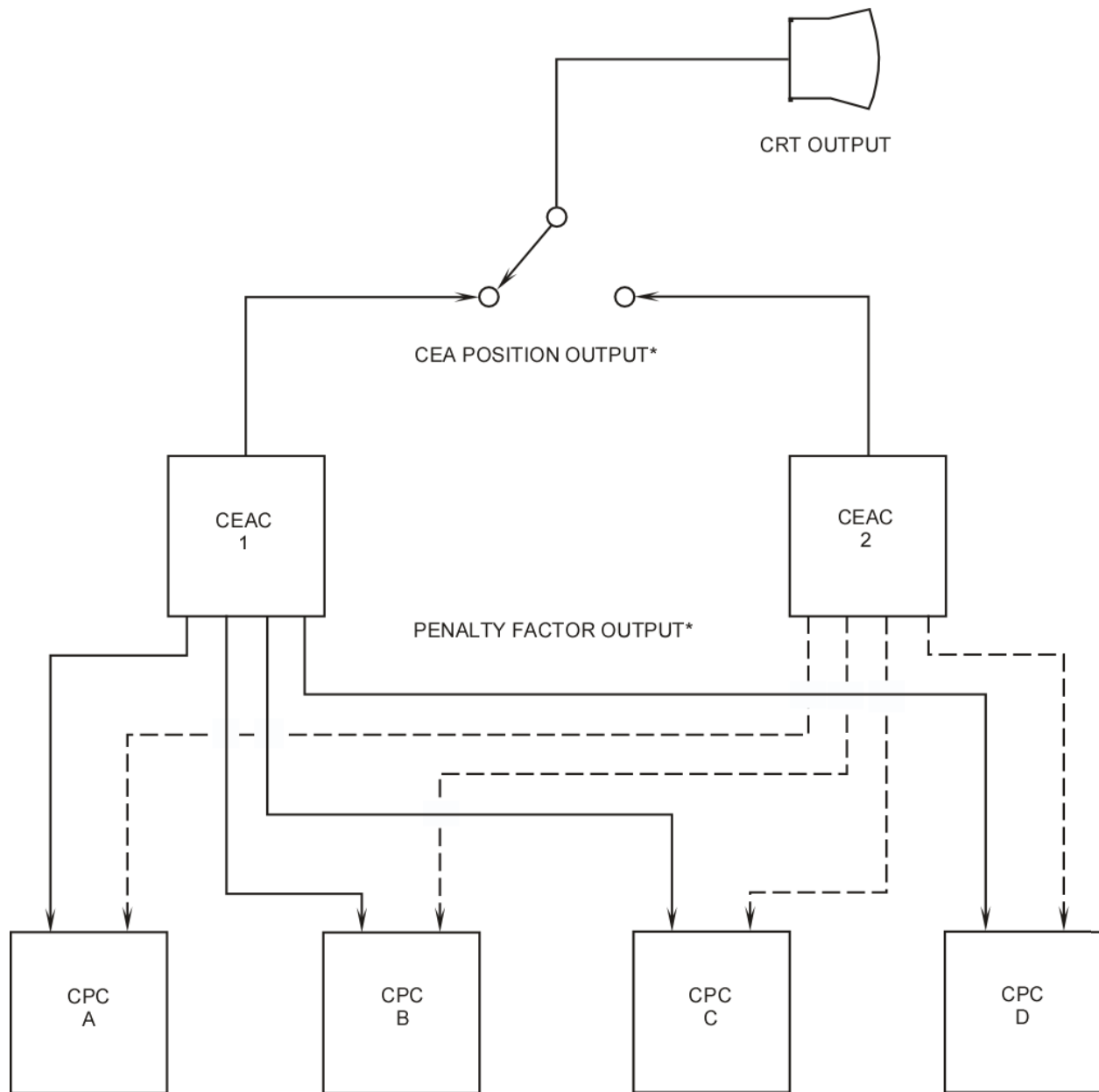


Figure 12.2-4 CEAC Outputs