PROPOSED CHANGE NO. 1

FOR THE

SOUTHWEST EXPERIMENTAL FAST OXIDE REACTOR

Re: LICENSE DR-15

DOCKET 50-231

GENERAL ELECTRIC COMPANY

310 DeGuigne Drive

Sunnyvale, California 94086

Proposed Change No. 1

for the

Southwest Experimental Fast Oxide Reactor

I. Introduction

Under the authority of License DR-15, General Electric operates the Southwest Experimental Fast Oxide Reactor at a site near Strickler, Arkansas.

A revision of the current Technical Specifications is desired as described herein. The applicable revised pages of the Technical Specifications are also included as Attachment A.

II. Purpose of the Proposed Change

The purpose of the proposed change is to permit use of substitute thermocouples installed in a new location to monitor reflector region temperatures as required by Section 2.2 of the Technical Specifications. A large percentage of the thermocouples originally installed to monitor these temperatures have failed and are not accessible for repair or replacement. Consequently, the availability of a sufficient number of these thermocouples for the expected duration of plant operation can not be assured. The substitute thermocouples are replaceable and will provide equivalent assurance of adequate cooling for the reflector region.

III. Proposed Changes

Pursuant to the provisions of 10 CFR 50.59, General Electric requests that the Technical Specifications be changed by substituting the pages, numbered 2.2-2, 2.2-3, 2.2-4, and 2.2-5, in Attachment A of this document, for pages 2.2-2, 2.2-3, and 2.2-4, of the current Technical Specifications. The proposed changes to the current Technical Specifications are indicated by brackets in the margin on the enclosed pages. The description of the substitute thermocouple design is given in Section IV of this request, and the safety analysis is given in Section V.

IV. Thermocouple Design

A. Introduction

The SEFOR reactor is controlled by ten movable reflector segments which are located outside the reactor vessel. These reflector segments are actuated by hydraulic control rod drives located in a drive cell below the vessel. The segments are guided by guide rails installed in the annular aluminum guide structure. The arrangement of the reflector control system guide structure lower shield and control drive cell is shown in Figure 1. Additional supplemental design information relative to the control drive system is reported in Reference 1.

Thermocouples are installed within the guide structure and the reflector segments to monitor thermal conditions in this area. A total of 50 thermocouples were originally installed in the guide structure, and ten of these were connected to the reactor safety system.[(2)] Failure of a substantial number of these thermocouples has necessitated development of replaceable instrumentation designed to obtain reliable temperature information from the reflector region.

B. Existing Guide Structure and Segment Thermocouples

The fifty thermocouples installed in the upper portion of the guide structure are distributed to monitor both the temperature of the gas and the temperature of the structure. This instrumentation was designed to confirm the predicted heat generation and cooling characteristics of the system and to protect the system against overtemperature conditions. The left side of Figure 1 illustrates typical thermocouple installations and routing of lead wire for the guide structure thermocouples. These are grounded thermocouples, enclosed in a 1/16" sheath, and imbedded in the aluminum guide structure. The sheathed portion extends out of the high temperature region and terminates in the lower shield region with a connection to the glass insulated thermocouple leads. The

thermocouple lead wire is routed out of the guide structure in bundles to connectors located in the nitrogen cooling supply plenum in the reflector drive cell. The lead wire bundles are supported at intervals with clips affixed to the guide structure. Approximately 60% of these thermocouples have failed.

In addition to the thermocouples located in the guide structure, a total of 18 thermocouples, similar to those used in the guide structure, were originally installed in three of the reflector segments. These thermocouples are imbedded in the nickel at six locations in each of these three segments. The thermocouple leads are routed down the fluted portion of the segment, then down through the hollow extension shaft to a point just above the extension rod coupling in the reflector drive cell. These thermocouples are sheathed along a major portion of their length and then connected to lead wire with glass insulation at a point located in the hollow extension shaft. The leads are brought out of the shaft near the coupling nut, coiled around a supporting member, and terminate in a connector located near the drive mechanism. No failures have occurred in these thermocouples.

C. Substitute Thermocouples

The new thermocouples being proposed for use in the safety system are installed in the lower end of each reflector segment, as shown on the right side of Figure 1. The new thermocouples are commercially available standard instrumentation. They are ungrounded, with magnesium oxide insulation and a 1/16 inch diameter 304 SS sheath. There are no sharp bends in the sheathed portion of the thermocouple, and all of the glass insulated lead wire is accessible for inspection and repair, if required. The thermocouples can be replaced if necessary. However, three thermocouples are installed in each segment to provide two spares for each segment, which will reduce the need for cell entry to replace failed thermocouples.

The sheathed portion of these thermocouples extends down through a guide tube in the hollow extension shaft to a connector just above the coupling nut on the drive shaft. The guide tube is continuous from the nickel segment to the shaft coupling nut, so that the thermocouples can be replaced if necessary. In order to provide this feature, it was necessary to fabricate replacement extension shafts for each of the ten segments. Manufacturing and quality control procedures used for the original shafts were followed for the replacement shafts.

Modifications made to the replacement shaft consisted of (1) changing the cooling holes at the to~ of the shaft to a slot (Figure 1, View B) to permit passage of the thermocouple guide tube; (2) adding a similar slot at the bottom of the lower extension shaft; and (3) increasing the inside diameter of the lower section of the extension shaft to 0.896 inch to permit installation of the thermocouple guide tube. A design review of these changes showed that the load carrying capability of the shaft was not affected. The predicted buckling load for the replacement shaft is identical to that of the original shaft. The maximum stress in the upper shaft occurs in a section which was not changed. The maximum stress in the lower shaft was increased 23% due to the increased inside diameter, but these stresses are well below the allowable values.[3] Buckling of the thermocouple guide tube will not be a problem since the buckling load is about eight times the maximum applied load.

The substitute thermocouples are installed by inserting the sheathed thermocouple into the lower end of the guide tube. It is then pushed up until it bottoms out in a 3-1/2" deep hole in the bottom of the nickel segment. The position of the lower end of the thermocouple sheath will also be checked to verify the position of the thermocouple in the segment. An immersion depth of three inches is adequate to assure a thermocouple temperature within 10°F of the nickel temperature, without requiring physical contact between the thermocouple and the nickel. (See Section VA.) The thermocouple is clamped securely at its lower end where it leaves the drive shaft. At this point a connection is made to glass insulated lead wire.

Flexible leads are provided for the substitute thermocouples to accommodate drive shaft motion during reactor operation and during scram actuation. The design of these flexible leads is identical to that used for the original 18-segment thermocouples which have operated without failure. The leads are wound upward in a spiral fashion around a supporting member to allow for the required flexibility. (See Figure 1.) The leads are then brought outside the reflector drive cell through penetrations.

Mockup and prototype assemblies were fabricated to verify the adequacy of the design. Complete thermocouple guide tube assemblies were fabricated and thermocouple insertion and installation procedures were established and checked out.

V. Safety Evaluation

A. Thermal-Hydraulic Analyses

Installation of the substitute thermocouples to monitor reflector system temperatures required the choice of a location which would be accessible for installation and possible replacement and which would provide proper thermal response to changes in reactor power and reflector cooling. The methods described in Reference 4 were used to calculate component temperatures for several combinations of reactor power and reflector coolant flow rate. Significant results of these calculations are shown in Figures 2, 3, 4 and 5, and are described below.

The new thermocouples are installed in the lower end of each reflector segment. (See Section IV, above.) The 3-1/2 inch depth of insertion into the segment was chosen so that the thermocouple temperature would be within 10°F of the nickel temperature at that location, without requiring physical contact between the thermocouple and the nickel. Results from calculations performed using the TGR-V heat transfer code show that a minimum depth of 3 inches satisfies this requirement. (See Figure 2.)

Figure 3 shows the reflector segment temperature at the thermocouple location for two values of reactor power. The proposed Limiting Safety System Setting (LSSS) of 450°F, marked on these curves, would cause a reactor scram if the reflector cooling flow were reduced to 62% of the design flow for 20 MW operation. At 10 MW, the trip would occur at 29% flow, which is 58% of the design flow for 10 MW operation. Thus, at all power levels, the LSSS would cause reactor scram at about 60% of the nominal cooling flow rate for that power level.

Figure 4 shows similar curves for the maximum temperature in the aluminum guide structure. The proposed LSSS would correspond to a maximum aluminum temperature of 300°F at 20 MW and 315°F at 10 MW, as indicated by these curves.

Figure 5 shows the variation of component temperatures with axial position (elevation) for 20 MW operation at 100% and at 50% of the design coolant flow rate.

B. Comparison of Protection and Margins

1. Maximum Aluminum Temperature

The existing LSSS for the guide structure thermocouples on the inner cylinder limits the maximum aluminum temperature to 350°F to provide assurance that the temperature of the guide structure will not reach the range where the mechanical properties begin to decrease rapidly. A value of 400°F is specified[5] as a reasonable upper limit for aluminum, although somewhat higher temperatures could be justified. The proposed LSSS of 450°F for the segment thermocouples limits the maximum aluminum temperature to about 315°F. This additional margin with respect to the present LSSS of 350°F provides adequate margin for uncertainties in the calculated values of guide structure temperature. Therefore,

the proposed LSSS of 450°F for the reflector segment thermocouples provides at least equivalent protection against excessive guide structure temperatures to that provided by the existing system.

2. Thermal Distortion and Bowing

Calculations have been made to show that stresses and deflections due to thermal distortion and mechanical tolerances are acceptable for the design condition.(6) Extrapolation of these calculations to conditions for a cooling flow reduction of 50% show that the stresses and deflections are also acceptable for this condition. At 50% coolant flow, the relative expansion between the reflector segment and guide structure would cause less than 60 mils compression of the T-pad springs in the reflector segment, which is well within the demonstrated capability of the system.(7)

3. General Undercooling

The proposed LSSS of 450°F for segment thermocouples will cause a trip at a flow rate of 60% of normal, while the previous LSSS of 350°F for guide structure thermocouples would cause a trip at about 50% of normal cooling flow. Thus, the margin in coolant flow rate is improved slightly for the LSSS based on segment thermocouples.

4. Local Undercooling

Changes in the flow distribution around a particular segment due to cooling gap tolerances are shown to be of no concern in Reference 4. The cooling flow to each bay is supplied through an axial gap in the inner shroud of the guide structure, and no mechanism has been identified by which coolant flow reduction to a single reflector bay could occur. However,

it is possible that small variations in flow rate might occur, so that some reflector bays would be slightly hotter or colder than the average bay. In order to assure that a safety system trip will occur at the earliest indication of an overtemperature condition, one thermocouple from either the guide structure or reflector segment in each reflector bay is chosen to make up the ten thermocouples used by the safety system.

5. Segment Position

One or more of the reflector segments may be partially or fully lowered during reactor operation, depending on reactor power and coolant temperature conditions. The temperature of such a segment at the location of the substitute thermocouple will be reduced below the values shown in Figure 3, and there will be a corresponding reduction in the coolant flow rate at which this thermocouple will reach the trip level. However, thermocouples on the guide structure or on the other segments which are in the full up position will still cause reactor scram at about 60% of the normal coolant flow rate, as discussed above. Thus, equivalent protection against reflector region undercooling will remain in effect for all reactor operating conditions.

6. Neutron Monitor Cooling

Adequate cooling of the neutron monitors in the bottom shield is assured by the proposed LSSS. The calculated coolant temperature rise in the bottom shield region is only 7°F at 20 MW. A reduction in cooling flow to 50% of the normal value would increase the outlet temperature by only 7°F, so the effect on the temperature of the neutron monitors would be negligible. The proposed LSSS will cause a scram at about 60% of the normal value, and therefore assures adequate cooling for the neutron detectors.

C. Safety System Thermocouples

The safety system uses ten thermocouples to monitor the reflector region, with two high temperature signals required to scram the reactor.[2] The trip levels can be set individually for each of the ten thermocouples. Thermocouples from either the guide structure or the lower end of the reflector segment will be used to monitor each of the ten reflector bays. However, if the present failure rate for guide structure thermocouples persists, all of the guide structure thermocouples may eventually fail. In that event, a thermocouple from each of the ten reflector segments will be used for the safety system.

D. Review by Site Safety Committee

The Site Safety Committee has reviewed the proposed changes and has found that they do not reduce plant safety margins. The procedures used to make the proposed modifications include previously used maintenance procedures. These procedures have been carefully reviewed and approved with necessary revisions which assure that the reflector control system will not be damaged and that proper measures will be taken to provide safe control of core reactivity, radiation exposure to personnel, and contamination while performing the required modifications.

References

1. FDSAR, Supplement 11
2. FDSAR, Vol. I, p. 10-20
3. FDSAR, Supplement 11, Appendix C
4. FDSAR, Supplement 11, Appendix A
5. Technical Specifications, p 2.2-4
6. FDSAR, Supplement 11, Appendix B
7. FDSAR, Supplement 11, p 7-20

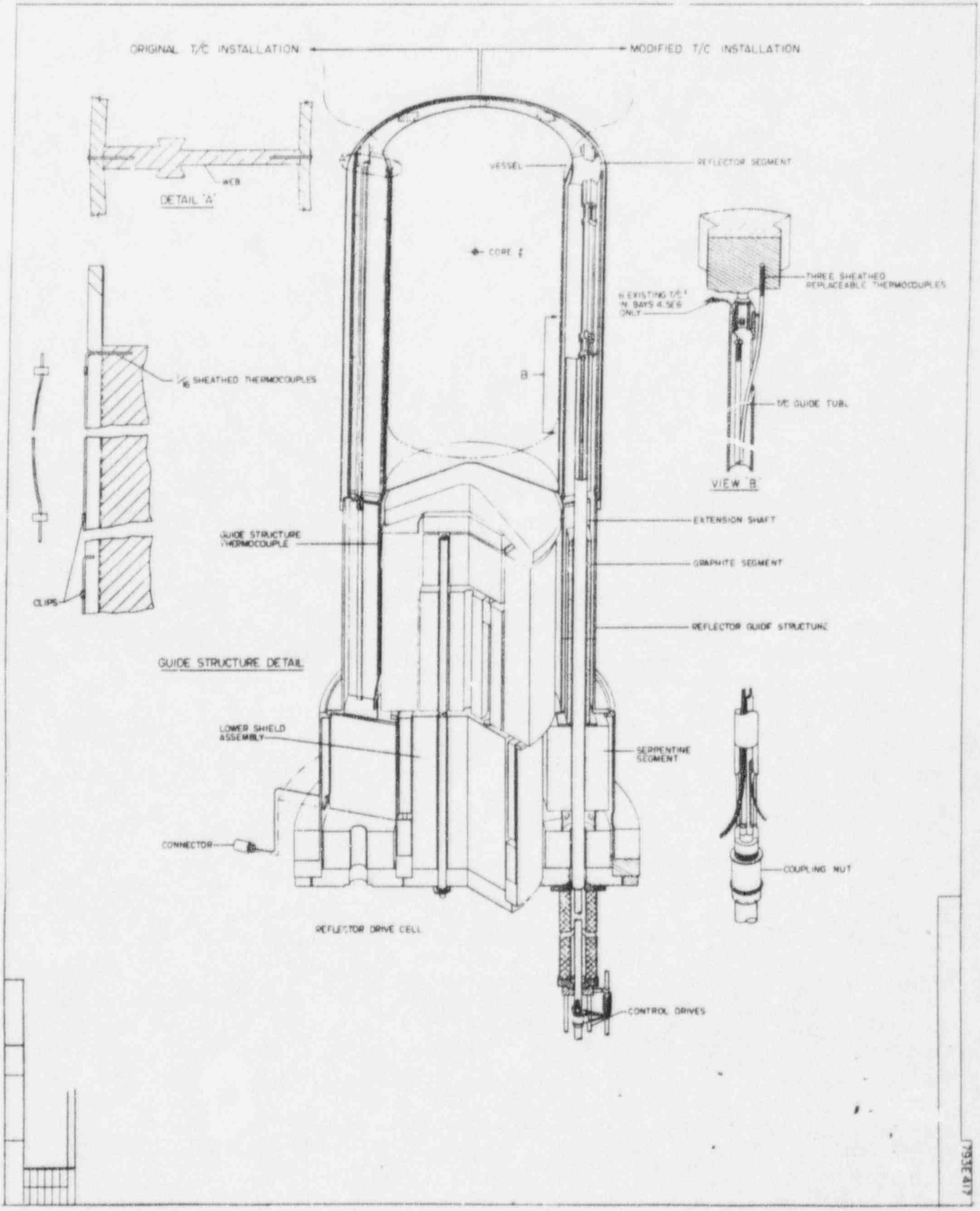
ORIGINAL T/C INSTALLATION
MODIFIED T/C INSTALLATION
WEB
DETAIL 'A'
VESSEL
REFLECTOR SEGMENT
CORE ℄
THREE SHEATHED REPLACEABLE THERMOCOUPLES
6 EXISTING T/C'S IN BAYS 4,5 & 6 ONLY
1/16 SHEATHED THERMOCOUPLES
B
T/C GUIDE TUBE
VIEW 'B'
EXTENSION SHAFT
GUIDE STRUCTURE THERMOCOUPLE
GRAPHITE SEGMENT
CLIPS
REFLECTOR GUIDE STRUCTURE
GUIDE STRUCTURE DETAIL
LOWER SHIELD ASSEMBLY
SERPENTINE SEGMENT
CONNECTOR
COUPLING NUT
REFLECTOR DRIVE CELL
CONTROL DRIVES
793E417

Figure 1

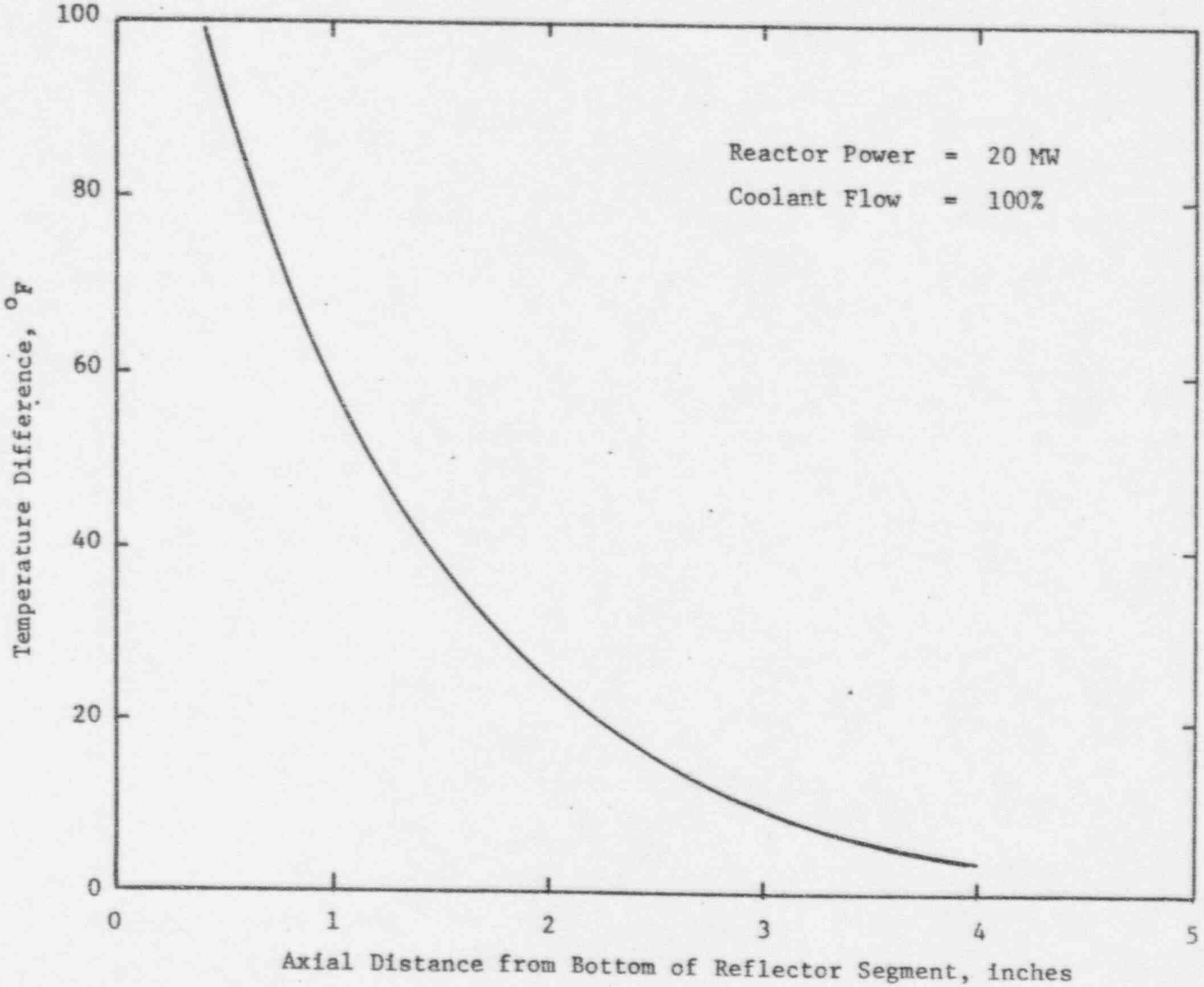

Figure 2: Temperature Difference Between Thermocouple and Nickel Segment

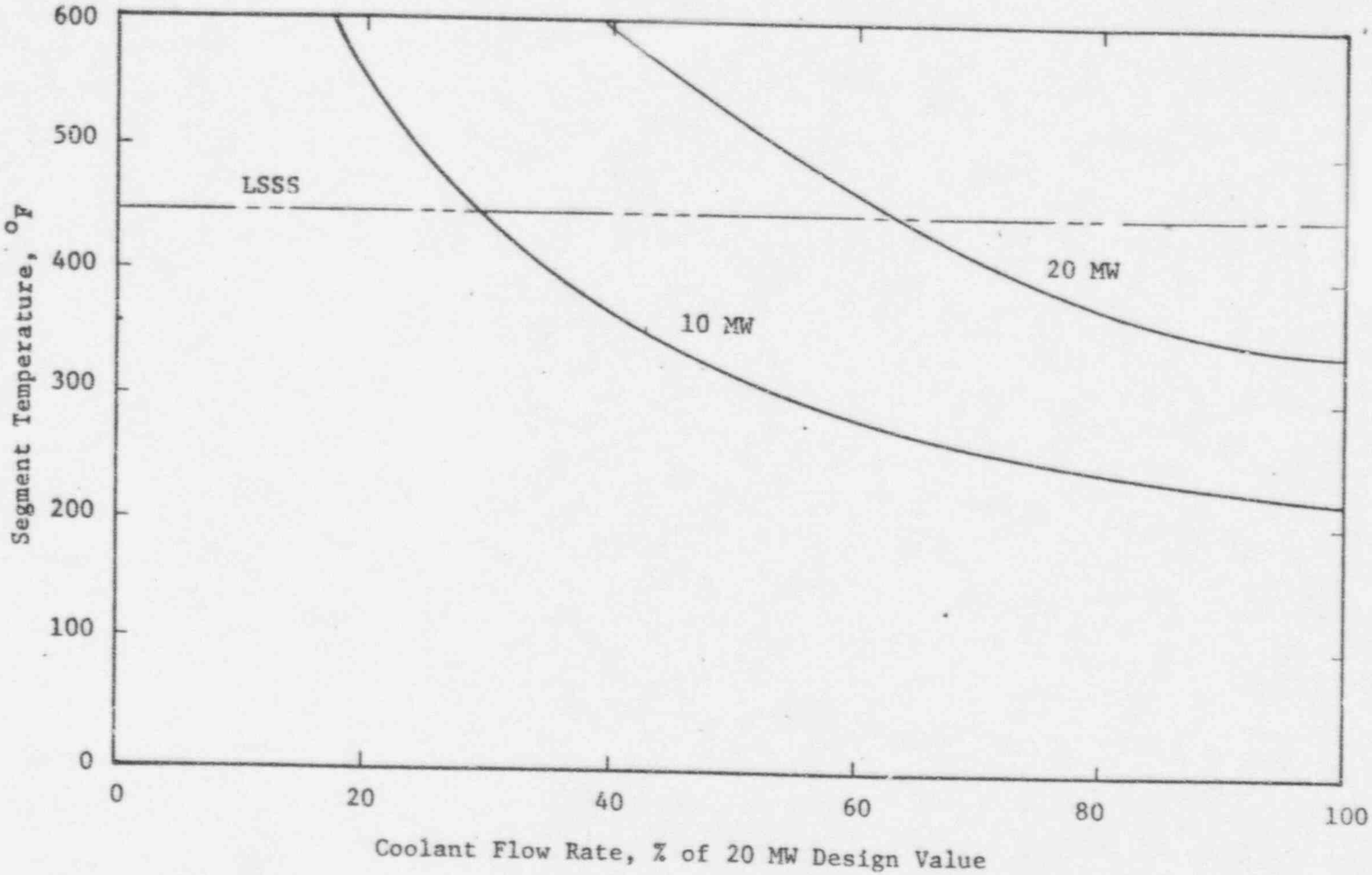

Figure 3: Nickel Segment Temperature at the Thermocouple Location

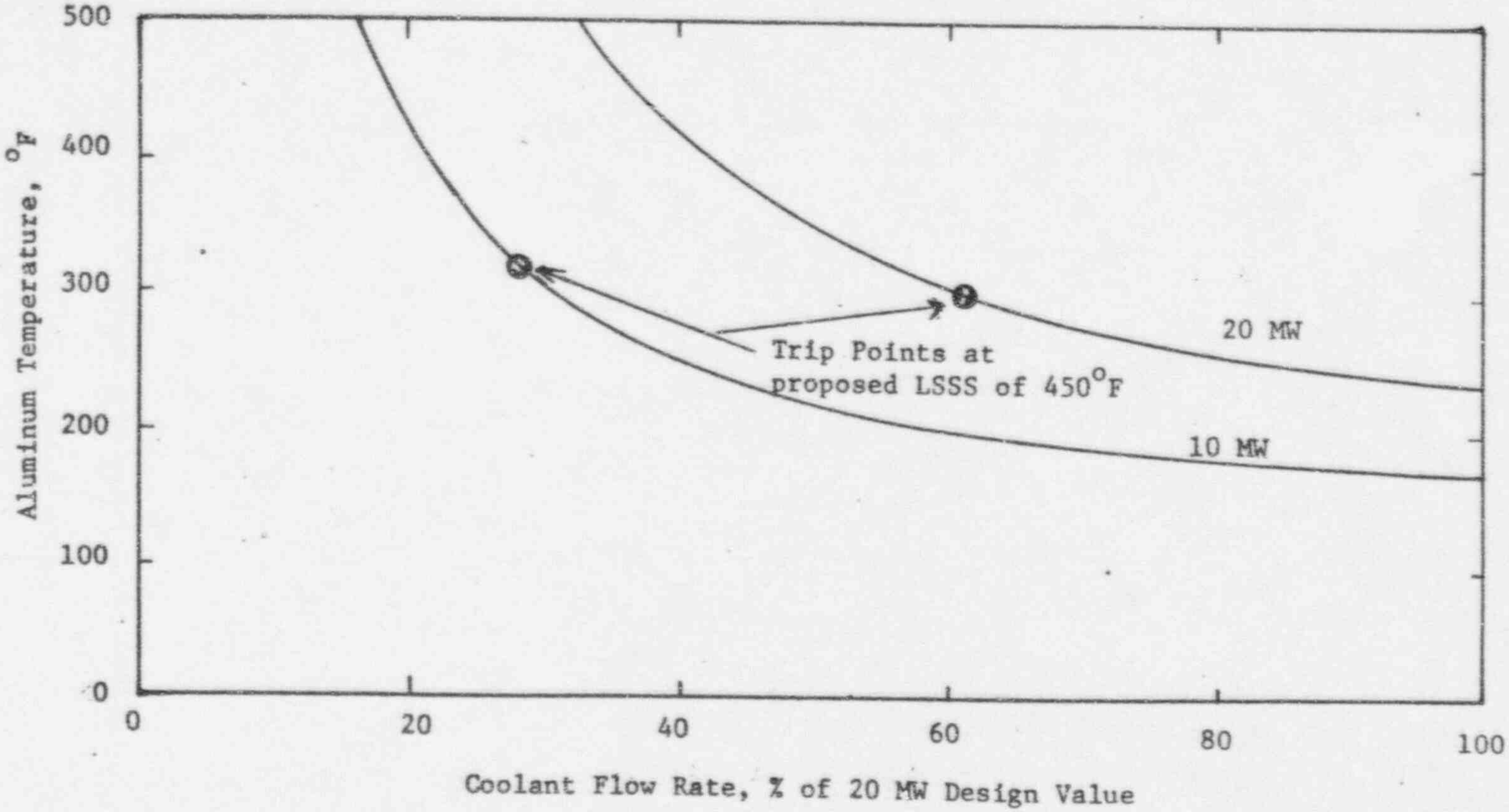

Figure 4: Maximum Temperature in the Guide Structure

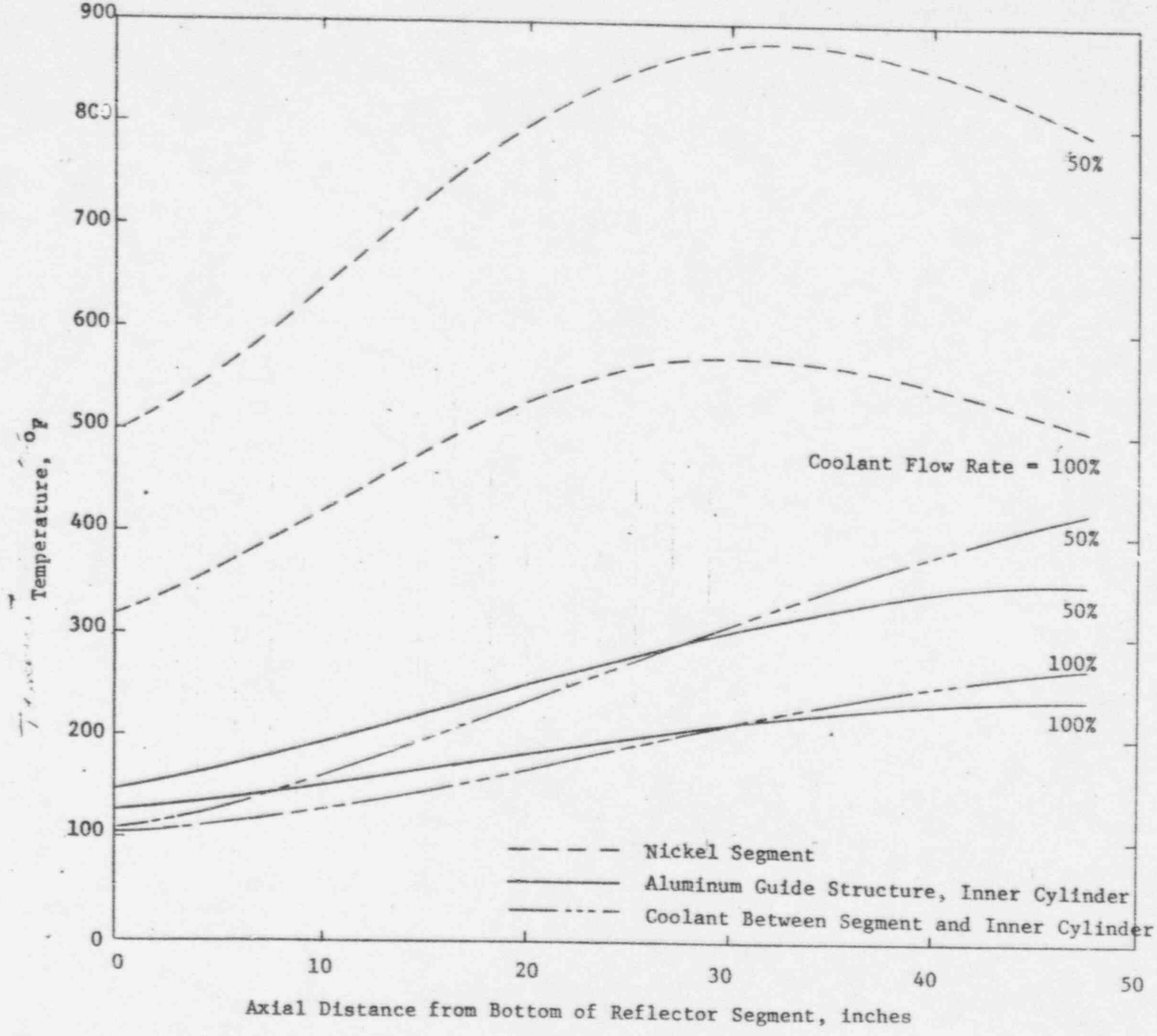

Figure 5: Component Temperatures at 20 MW