CONF-781146--15

MASTER

NUCLEAR PIN SIMULATION ANALYSIS*

Presented at the

SIXTH WATER REACTOR SAFETY RESEARCH INFORMATION MEETING

November 6-9, 1978

by

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PWR-BDHT Analysis Group
Oak Ridge National Laboratory

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NUCLEAR PIN SIMULATION ANALYSIS

The PINSIM-MOD1 computer code has been developed and is being used at ORNL to investigate the relationships between thermal-hydraulic transients involving nuclear fuel pins and similar transients involving electrically-heated fuel pin simulators. PINSIM-MOD1 is currently being used to (1) predict the thermal response of specified nuclear and/or electric pin models to power and/or hydraulic transients; (2) determine transient electric pin power required to simulate a nuclear pin transient; (3) analyze and evaluate electric pin simulator transients; and (4) optimize the design and operation of electric pin simulators.

This presentation discusses some differences between electric and nuclear pins, provides an overview of the PINSIM-MOD1 computer code, and presents some typical results from three types of PINSIM-MOD1 problems.

Differences between nuclear fuel pins and electric pin simulators arise because the two are constructed of different materials. Included in the presentation are plots, for each type of pin, of typical radial temperature distributions, radial stored energy distributions, and radial variations in thermal diffusivity.

PINSIM-MOD1 is described in the presentation as a modular computer code. Simplified overall major module interaction is diagrammed and each of the five major modules is briefly described.

The first type of PINSIM-MOD1 problems presented had as its objective predicting the thermal response of an idealized nuclear pin model to a hydraulic transient similar to that of a typical THTF test. The problem is briefly described, and a problem model diagram is presented. Examples of PINSIM-MOD1 results (temperature distributions, surface heat flux, and heat transfer coefficient transients) are presented.

An electric pin power programming problem is presented as the second type of PINSIM-MOD1 problem. The problem is briefly described, and example results are presented. The results illustrate the ideal power program, compare the desired surface heat flux transient with the predicted surface heat flux, and present the corresponding internal electric pin temperature distributions. Also discussed is a scheme by which PINSIM-MOD1 results are processed to meet THTF power programming requirements.

A third type of problem solved by PINSIM-MOD1 is presented in a discussion of evaluation of electric pin transients. Analysis in this area is intended to provide information which will assist in determining whether a specified electric pin transient has simulated, or will simulate, a conceivable nuclear pin transient. Several types of PINSIM-MOD1 problems generate information which addresses this question; several of these problems are discussed in the presentation. Each problem is briefly described, and sample results are presented. The problems discussed include those which were intended to (1) determine the nuclear system transient which is equivalent to an electric pin transient defined by surface temperature and surface heat flux transients; (2) determine the corresponding "closest typical" nuclear system transient; and (3) contrast the predicted nuclear pin response with the corresponding electric pin thermal response.

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PROGRAM

NUCLEAR PIN SIMULATION ANALYSIS

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PRESENTED AT

SIXTH WATER REACTOR SAFETY RESEARCH
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GENERAL AREA OF ANALYSIS

THE RELATIONSHIPS BETWEEN THERMAL-HYDRAULIC TRANSIENTS INVOLVING NUCLEAR FUEL PINS AND SIMILAR TRANSIENTS INVOLVING ELECTRICALLY-HEATED PIN SIMULATORS

PRIMARY ANALYSIS TOOL

THE PINSIM–MOD1 COMPUTER CODE

~~[illegible]~~ 8620

2

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THE PINSIM-MOD1 COMPUTER CODE HAS BEEN DEVELOPED AND IS BEING USED AT ORNL TO ADDRESS QUESTIONS WHICH ARISE WHEN ELECTRICALLY-HEATED PINS ARE USED TO SIMULATE NUCLEAR FUEL PINS DURING HYDRAULIC TRANSIENTS

- HOW AND WHY DO THE TRANSIENT RESPONSES OF NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS DIFFER?
- HOW CAN AN ELECTRICALLY-HEATED PIN BE USED TO APPROXIMATE THE THERMAL RESPONSE OF THE NUCLEAR FUEL PIN?
- HOW WELL HAVE ELECTRIC PIN SIMULATOR TRANSIENTS ACTUALLY SIMULATED CONCEIVABLE NUCLEAR FUEL PIN TRANSIENTS?

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GENERAL TASKS IN NUCLEAR PIN SIMULATION ANALYSIS

- PREDICTING THE THERMAL RESPONSE OF SPECIFIED NUCLEAR FUEL PIN AND ELECTRIC PIN SIMULATORS TO POWER AND/OR HYDRAULIC TRANSIENTS
- PROGRAMMING OF TRANSIENT ELECTRIC PIN SIMULATOR POWER
- ANALYSIS AND EVALUATION OF ELECTRIC PIN SIMULATOR TRANSIENTS
- OPTIMIZATION OF ELECTRIC PIN SIMULATOR DESIGN AND OPERATION

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NUCLEAR PIN SIMULATION ANALYSIS: TOPICS

DIFFERENCES BETWEEN NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS

DESCRIPTION OF PINSIM-MOD1

PRINCIPAL APPLICATIONS OF PINSIM-MOD1

- PIN/CHANNEL SIMULATION
- ELECTRIC PIN POWER PROGRAMMING
- EVALUATION OF ELECTRIC PIN TRANSIENTS

71.5

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NUCLEAR PIN SIMULATION ANALYSIS: TOPICS

DIFFERENCES BETWEEN NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS

DESCRIPTION OF PINSIM-MOD1

PRINCIPAL APPLICATIONS OF PINSIM-MOD1

- PIN/CHANNEL SIMULATION
- ELECTRIC PIN POWER PROGRAMMING
- EVALUATION OF ELECTRIC PIN TRANSIENTS

71.5%

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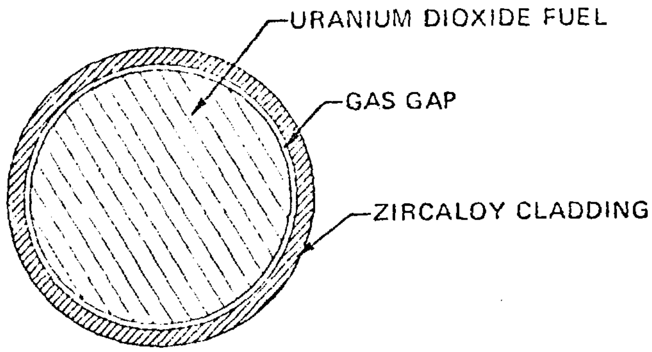
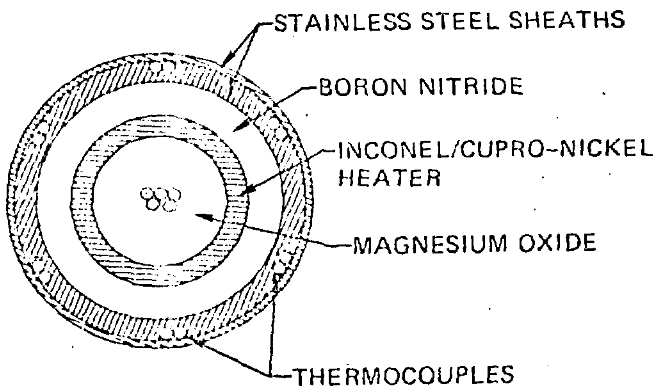
NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS ARE CONSTRUCTED OF DIFFERENT MATERIALS

NUCLEAR FUEL PIN



ELECTRIC PIN SIMULATOR



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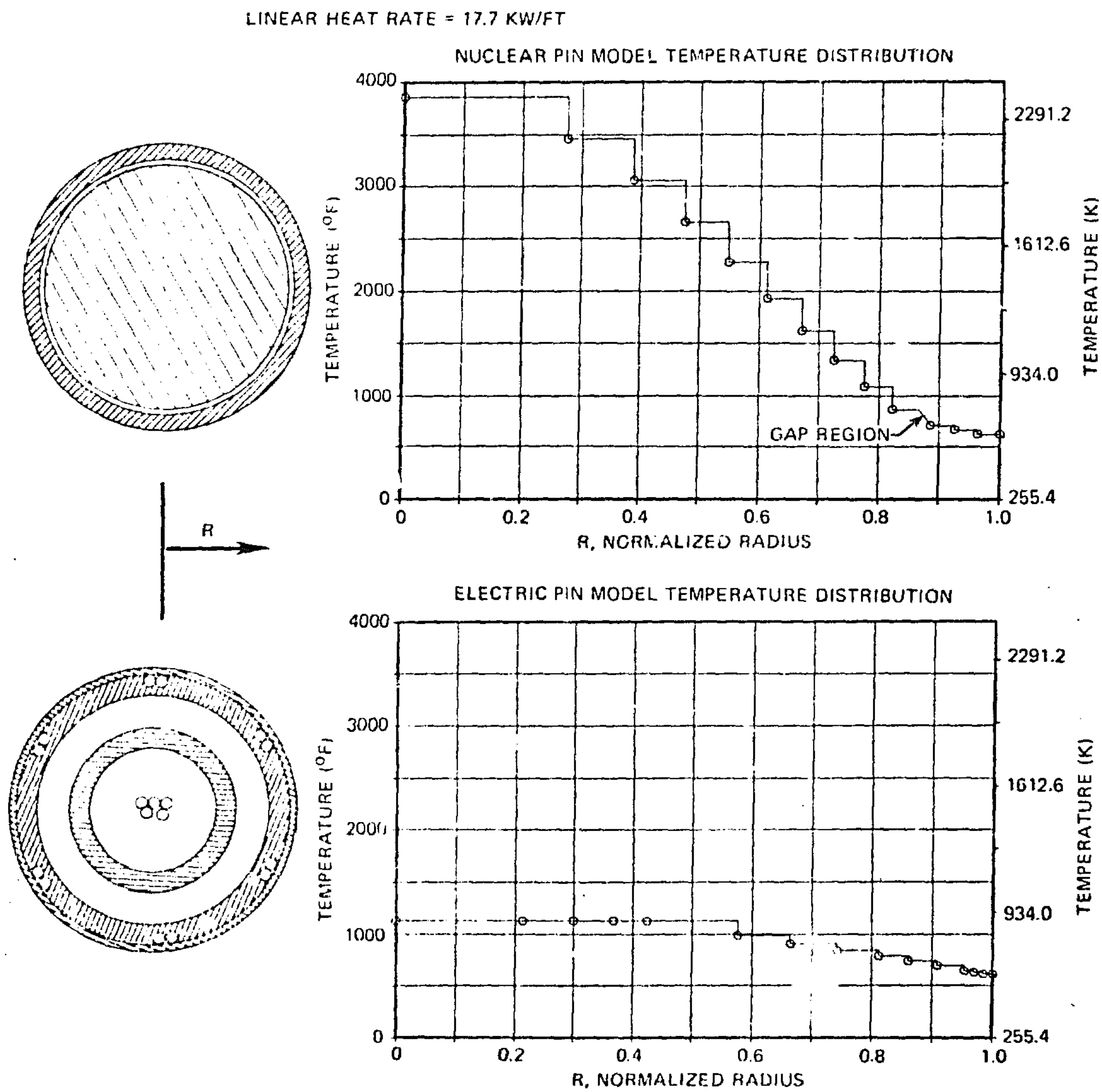
AT STEADY STATE, A NUCLEAR FUEL PIN OPERATES AT A HIGHER TEMPERATURE THAN DOES AN ELECTRIC PIN SIMULATOR



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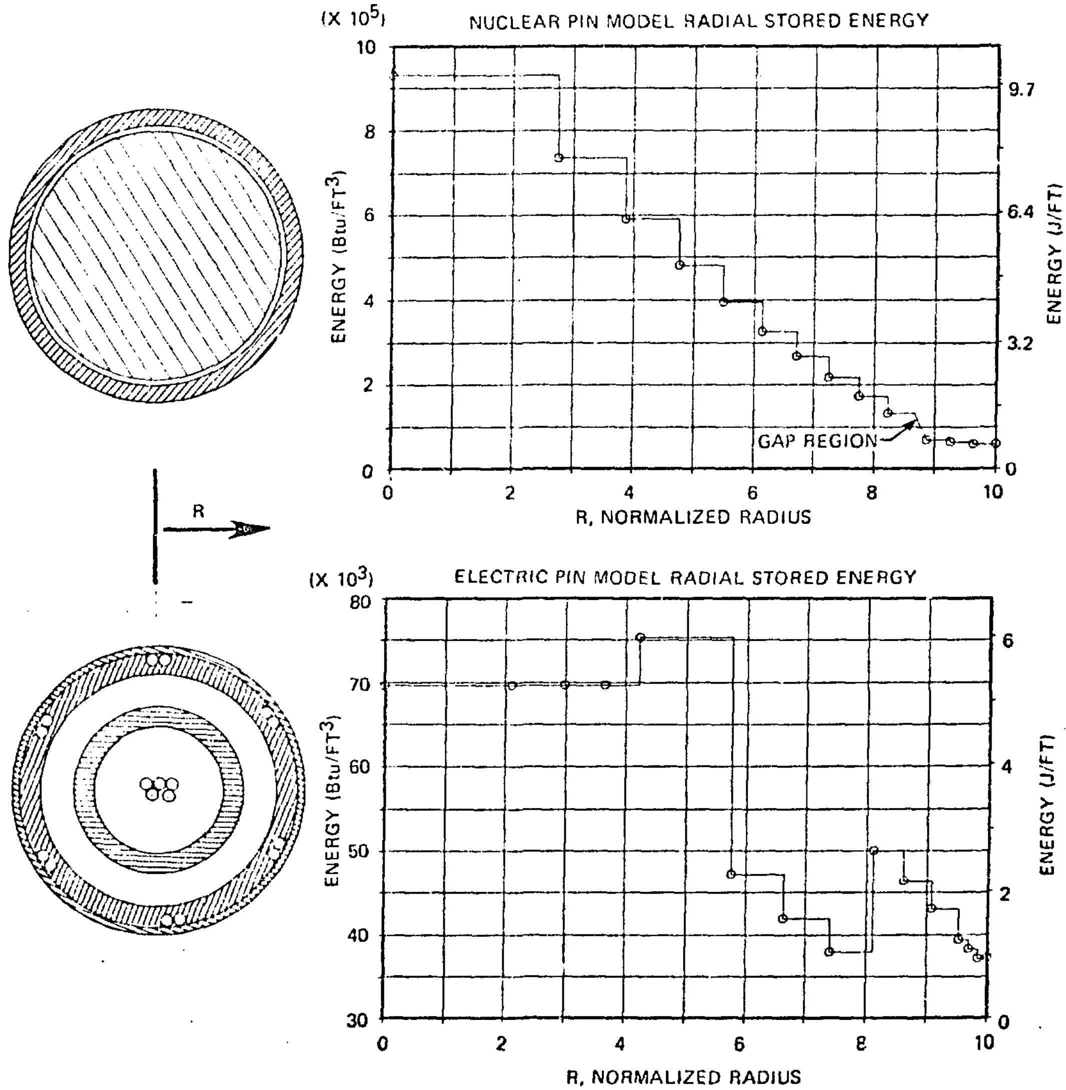
AT STEADY STATE, A NUCLEAR FUEL PIN CONTAINS MORE STORED ENERGY ($\rho C_p T$) THAN DOES AN ELECTRIC PIN SIMULATOR

LINEAR HEAT RATE = 17.7 KW/FT



50%, then [illegible] 96% of that

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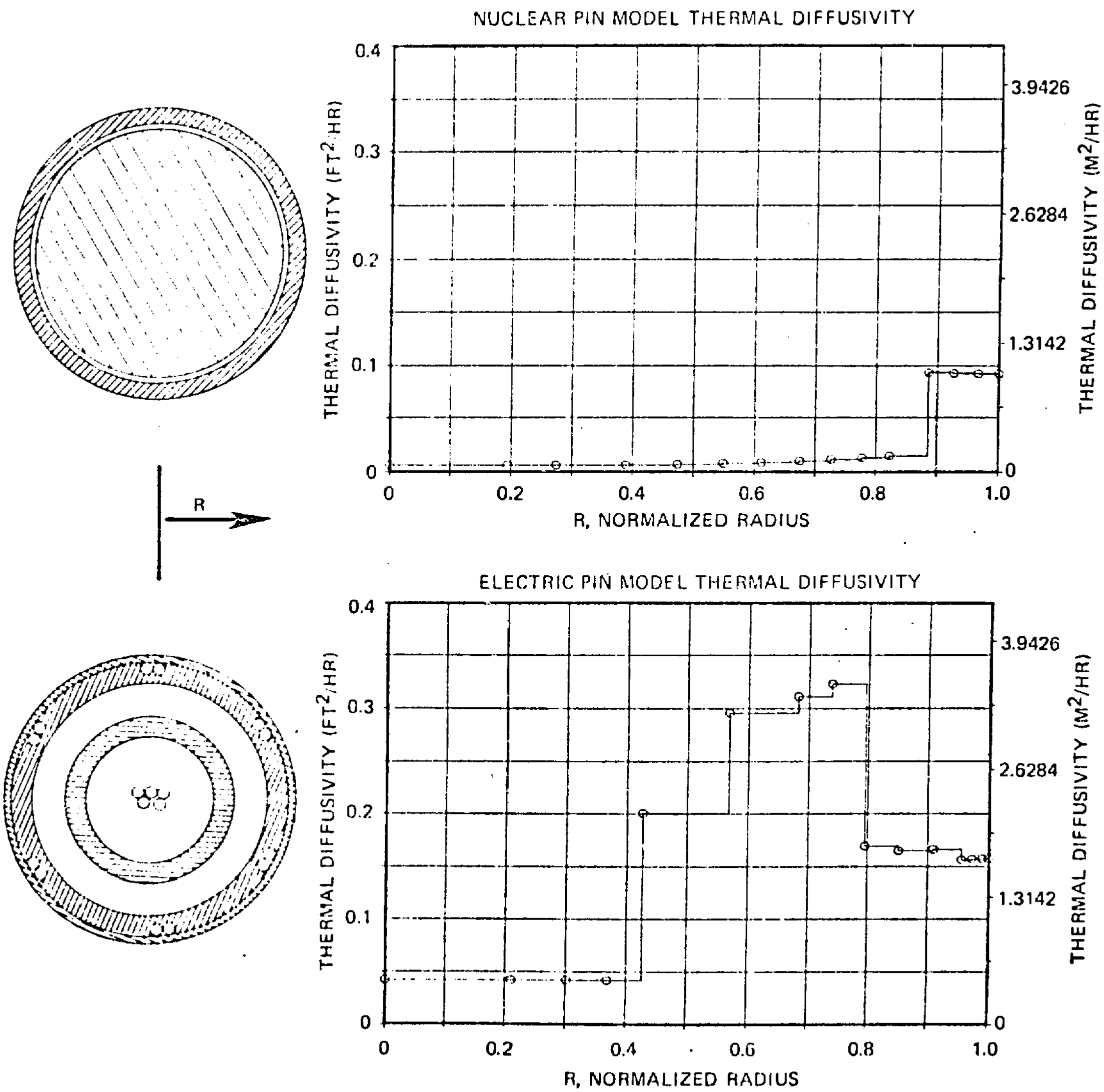
THE TRANSIENT THERMAL RESPONSES OF NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS DIFFER, IN PART BECAUSE OF DIFFERENT RADIAL "THERMAL DIFFUSIVITY ($K/\rho C_p$) DISTRIBUTIONS"



93% of that

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NUCLEAR PIN SIMULATION ANALYSIS TOPICS

DIFFERENCES BETWEEN NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS

DESCRIPTION OF PINSIM-MOD1

PRINCIPAL APPLICATIONS OF PINSIM-MOD1

- PIN/CHANNEL SIMULATION
- ELECTRIC PIN POWER PROGRAMMING
- EVALUATION OF ELECTRIC PIN TRANSIENTS

71.5%

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PINSIM-MOD1 CAN BE DESCRIBED AS A MODULAR COMPUTER CODE. MAJOR CODE MODULES INCLUDE:

– PIN MODEL HEAT TRANSFER MODULE

– COOLANT HYDRAULICS AND WATER PROPERTIES MODULES

– SYSTEM POWER AND ASSOCIATED MODULES

– MATERIAL PROPERTIES MODULE

– INPUT/OUTPUT MODULES

PINSIM-MOD1 WAS DEVELOPED AND IS OPERATIONAL ON AN IBM360/195.

61%

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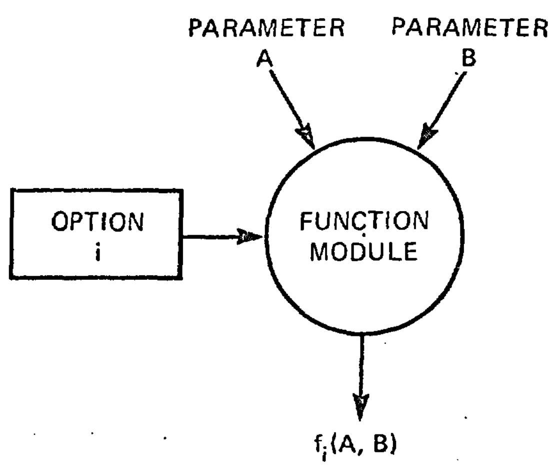
A MODULE IS A SECTION OF THE CODE WHICH OPERATES ON SPECIFIED PARAMETERS



57%

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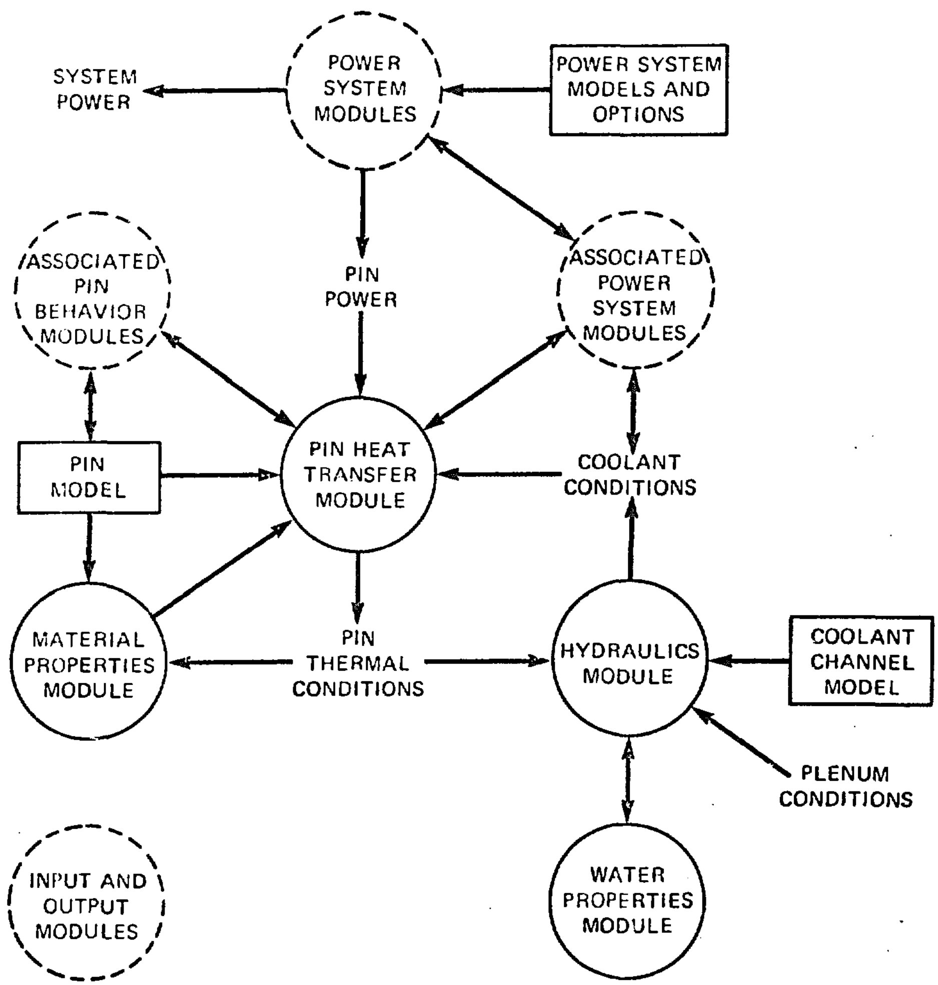
PINSIM-MOD1 SIMPLIFIED MODULE INTERACTION



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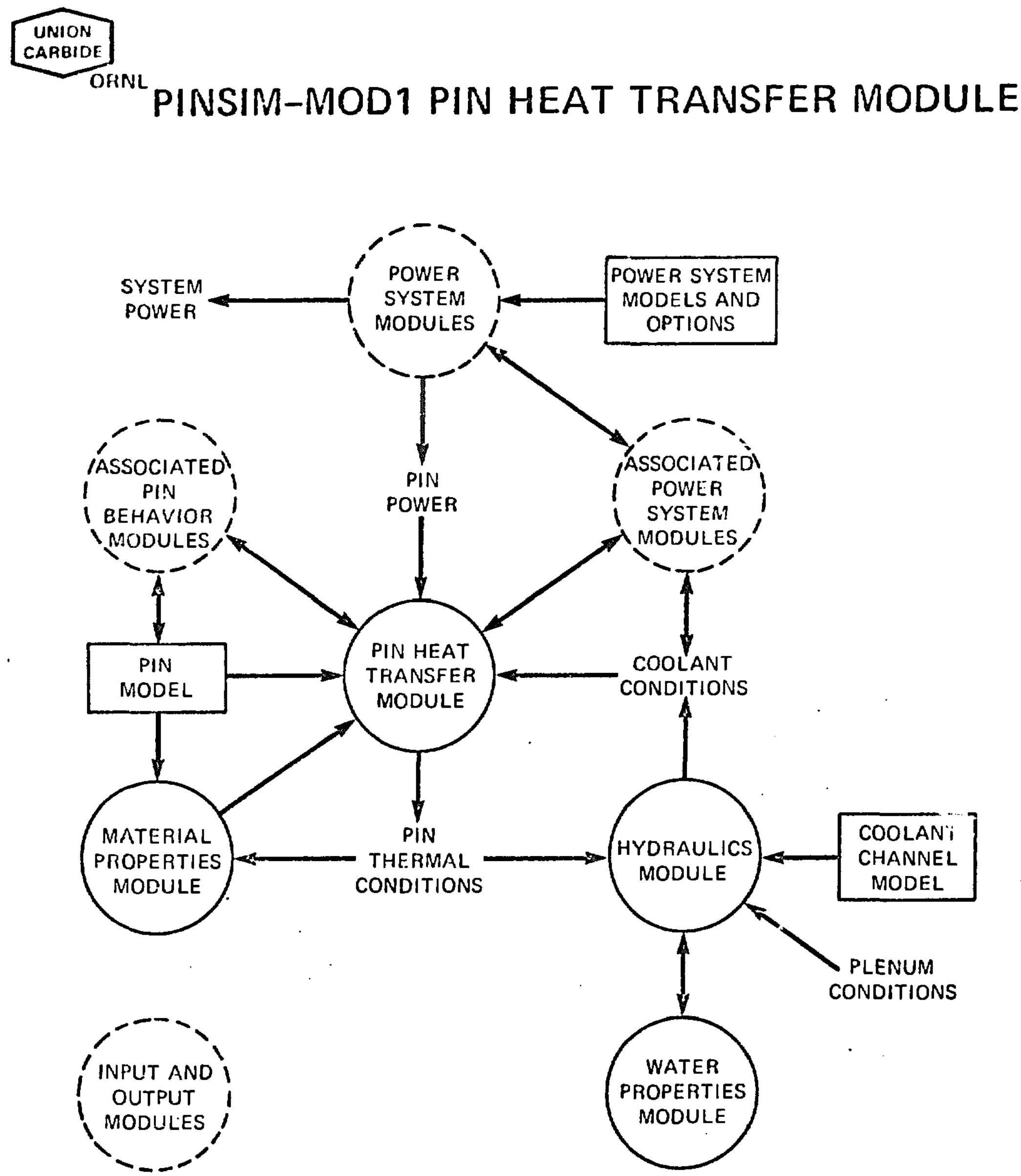
PINSIM-MOD1 PIN HEAT TRANSFER MODULE



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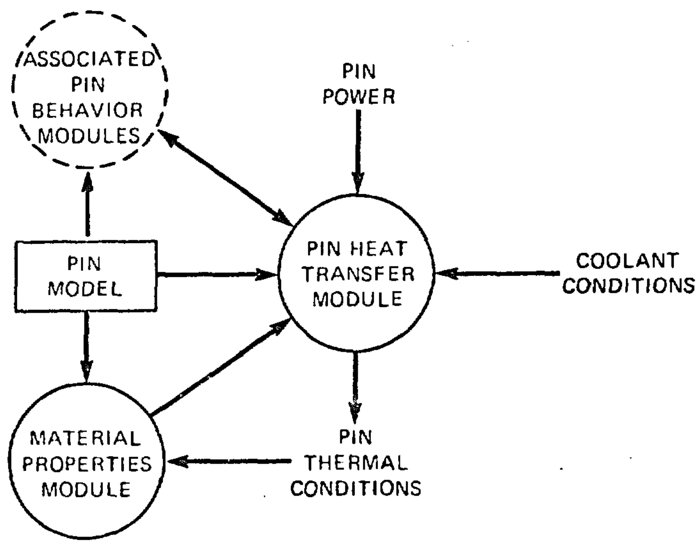
THE PIN HEAT TRANSFER MODULE SOLVES THE TRANSIENT, ONE-DIMENSIONAL CONDUCTION EQUATION



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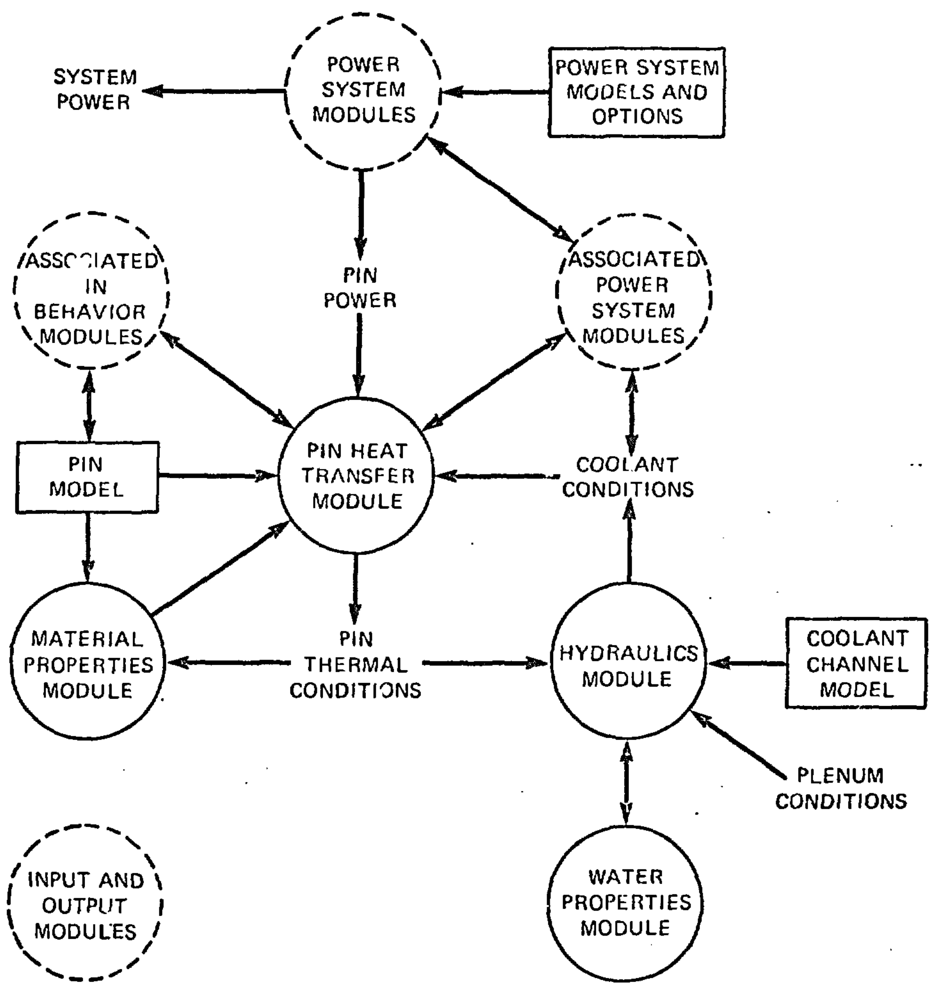
PINSIM-MOD1 PIN MATERIAL PROPERTIES MODULE



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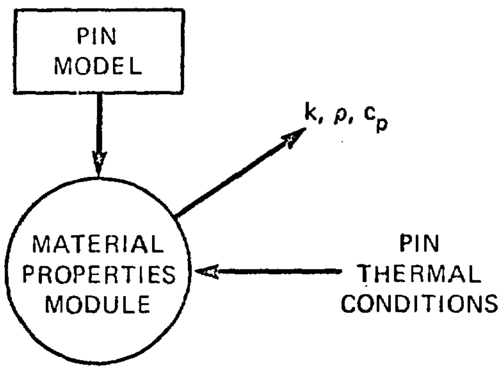
THE MATERIAL PROPERTIES MODULE DETERMINES PIN MODEL THERMO-PHYSICAL PROPERTIES (k, ρ, c_p), BASED ON PIN THERMAL CONDITIONS, FOR USE BY THE PIN HEAT TRANSFER MODULE



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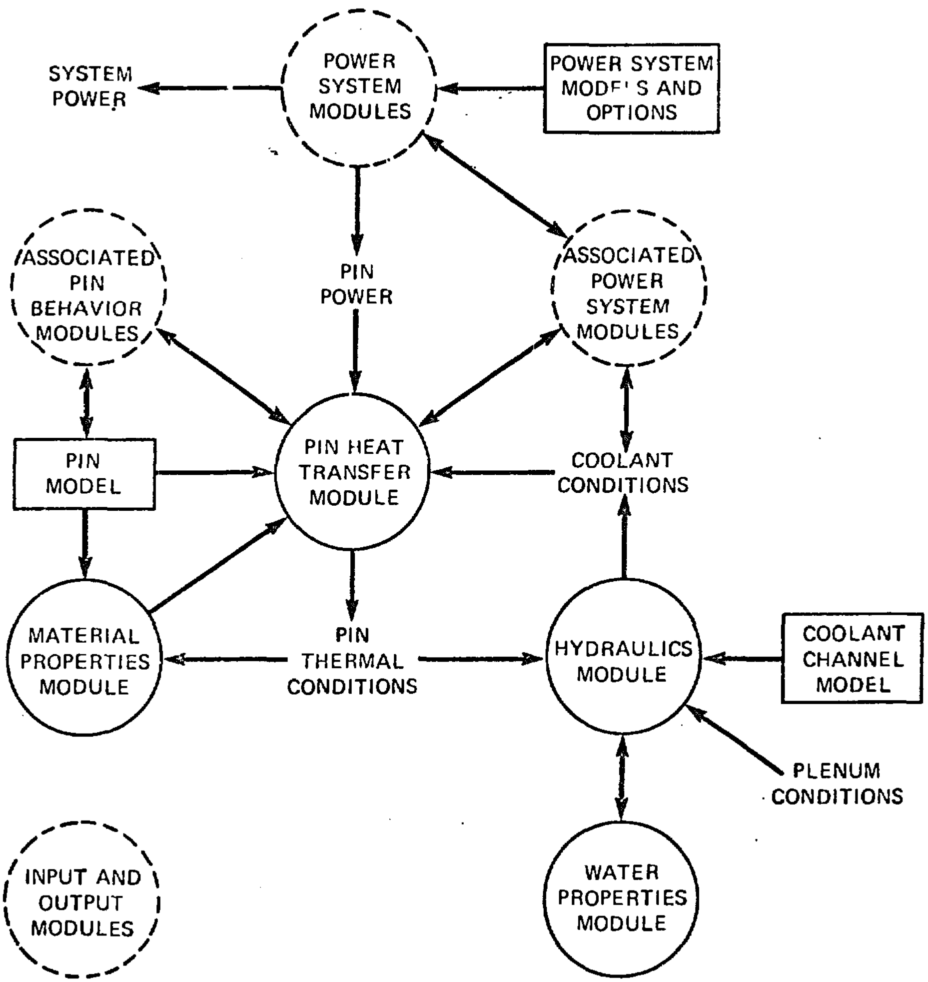
PINSIM-MOD1 HYDRAULICS AND WATER PROPERTIES MODULES



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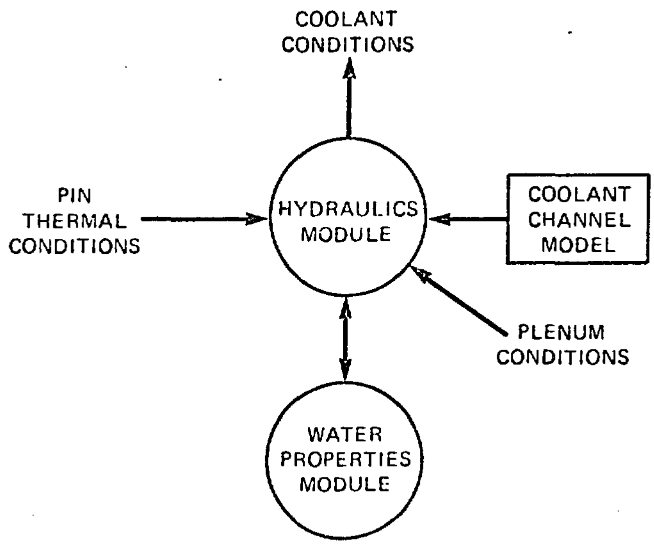
THE HYDRAULICS MODULE SOLVES THE EQUATIONS OF CONSERVATION OF MASS, ENERGY, AND MOMENTUM TO DETERMINE LOCAL FLUID CONDITIONS



61020

20

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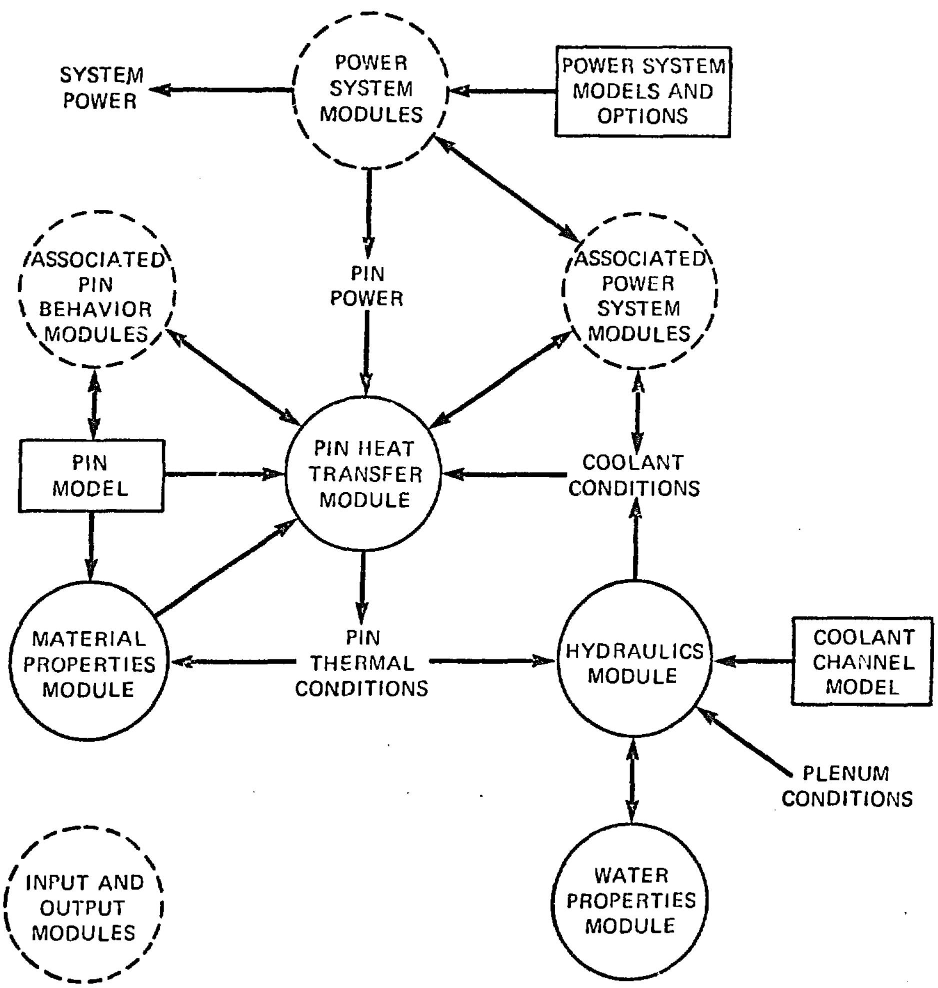
PINSIM-MOD1 POWER SYSTEMS MODULES



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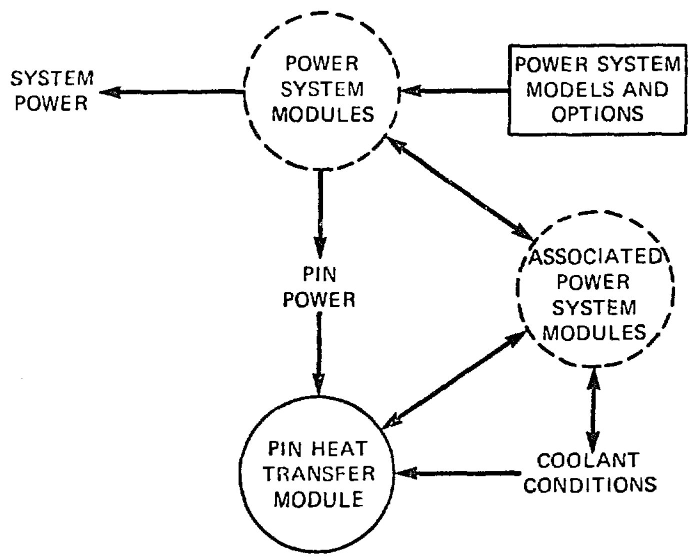
THE POWER SYSTEMS MODULES DETERMINE SYSTEM POWER AND PIN MODEL POWER IN CONJUNCTION WITH THE PIN HEAT TRANSFER MODULE



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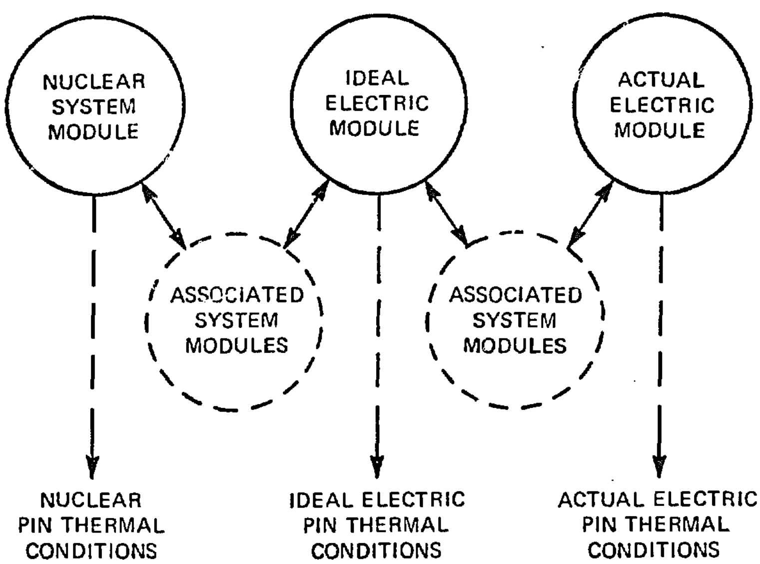
PINSIM–MOD1 INCLUDES 3 SEPARATE POWER SYSTEM MODULES



67.5%

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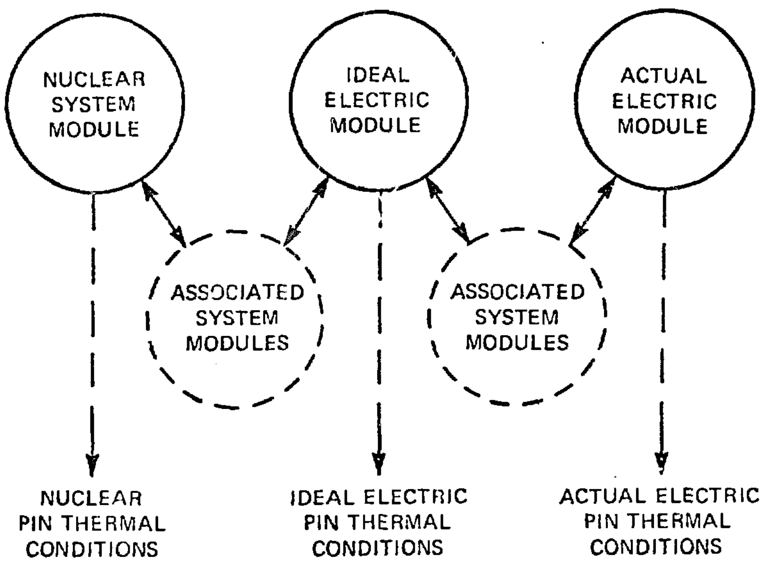
PINSIM-MOD1 INCLUDES 3 SEPARATE POWER SYSTEM MODULES



67.5%

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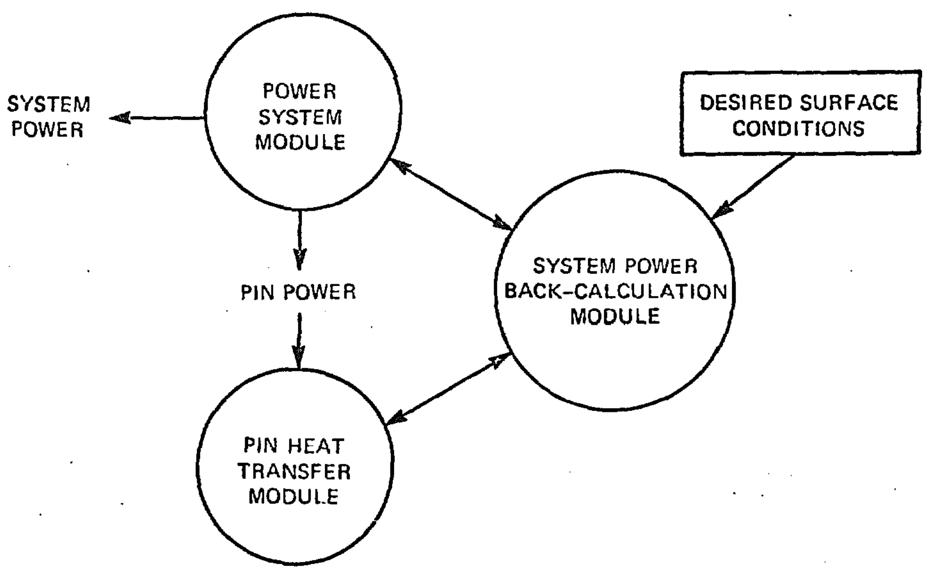
EITHER NUCLEAR AND/OR IDEAL ELECTRIC SYSTEM POWER MAY BE BACK-CALCULATED FROM DESIRED PIN SURFACE CONDITIONS



63.5%

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SYSTEM POWER IS BACK-CALCULATED FROM DESIRED SURFACE CONDITIONS USING THE ASSUMPTIONS THAT:

- THE USER-SUPPLIED NORMALIZED RADIAL POWER DISTRIBUTION IS FIXED
- THE USER-SUPPLIED NORMALIZED AXIAL POWER DISTRIBUTION IS FIXED
- THE SYSTEM POWER IS A FIXED, USER-SUPPLIED MULTIPLE OF THE PIN MODEL POWER

THUS, CALCULATED CHANGES IN LOCAL POWER ARE REFLECTED IN CORRESPONDING PROPORTIONAL CHANGES IN SYSTEM POWER

Hagar 25

100%

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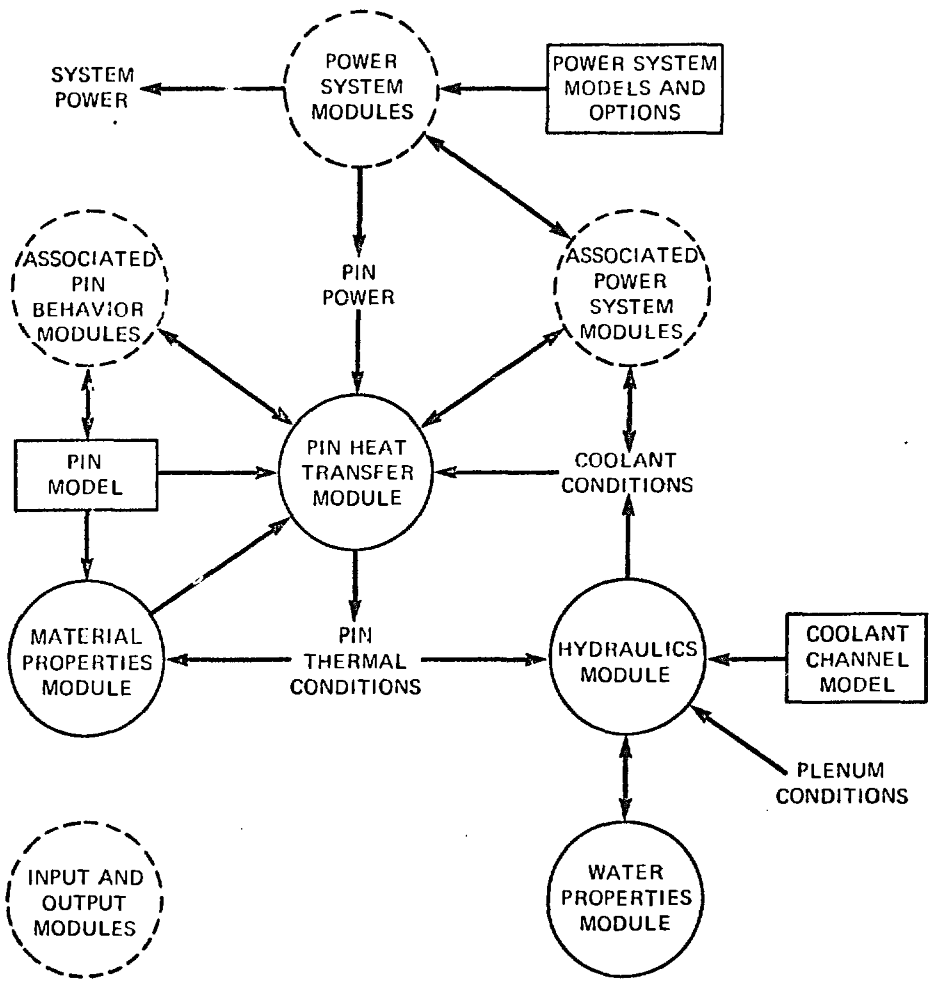
PINSIM–MOD1 INPUT/OUTPUT MODULES



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PINSIM-MOD1 PRODUCES OUTPUT IN FOUR AREAS. THESE ARE:

- MAJOR EDITS
- MINOR EDITS
- PLOT/RESTART RECORD OUTPUT
- DEBUG OUTPUT

THE FREQUENCY AND EXTENT OF ALL OUTPUT ARE USER-SPECIFIED.

115%

27

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NUCLEAR PIN SIMULATION: TOPICS

DIFFERENCES BETWEEN NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS

DESCRIPTION OF PINSIM-MOD1

PRINCIPAL APPLICATIONS OF PINSIM-MOD1

- PIN/CHANNEL SIMULATION
- ELECTRIC PIN POWER PROGRAMMING
- EVALUATION OF ELECTRIC PIN TRANSIENTS

70%

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NUCLEAR PIN SIMULATION: TOPICS

DIFFERENCES BETWEEN NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS

DESCRIPTION OF PINSIM-MOD1

PRINCIPAL APPLICATIONS OF PINSIM-MOD1

- PIN/CHANNEL SIMULATION
- ELECTRIC PIN POWER PROGRAMMING
- EVALUATION OF ELECTRIC PIN TRANSIENTS

7070

29

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PIN/CHANNEL SIMULATION SAMPLE PROBLEM

OBJECTIVE: PREDICT THE THERMAL RESPONSE OF AN IDEALIZED NUCLEAR PIN MODEL TO A HYDRAULIC TRANSIENT SIMILAR TO THAT OF A TYPICAL THTF TEST

MODELS: IDEALIZED NUCLEAR PIN SIMILAR TO THAT DESCRIBED IN THE WESTINGHOUSE RESAR-1 AT B.O.L.

COOLANT CHANNEL MODEL REPRESENTATIVE OF A COOLANT CHANNEL IN THE THTF

BOUNDARY CONDITIONS: NUCLEAR SYSTEM POWER SUPPLIED AS A TABLE; STANDARD POWER DECAY CURVE IS DEFINED

COOLANT CHANNEL INLET AND OUTLET CONDITIONS ARE THOSE PREDICTED BY RELAP4/MOD5 TO HAVE OCCURRED IN THE THTF

59.5%

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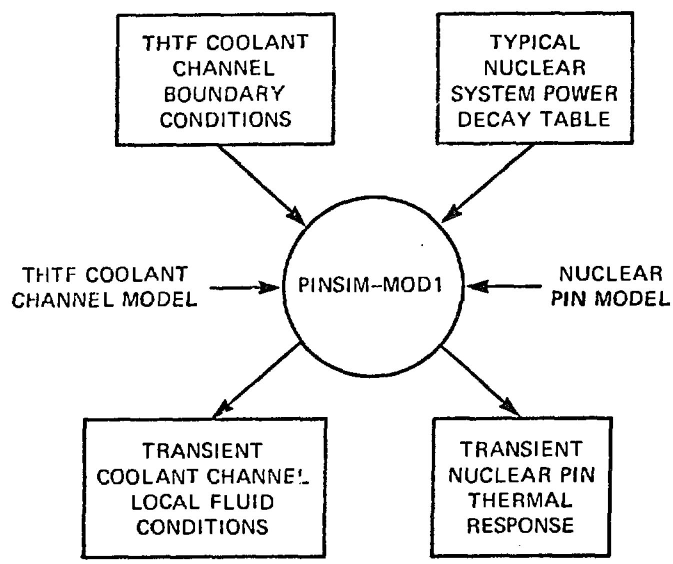
PIN/CHANNEL SIMULATION PROBLEM MODULAR REPRESENTATION



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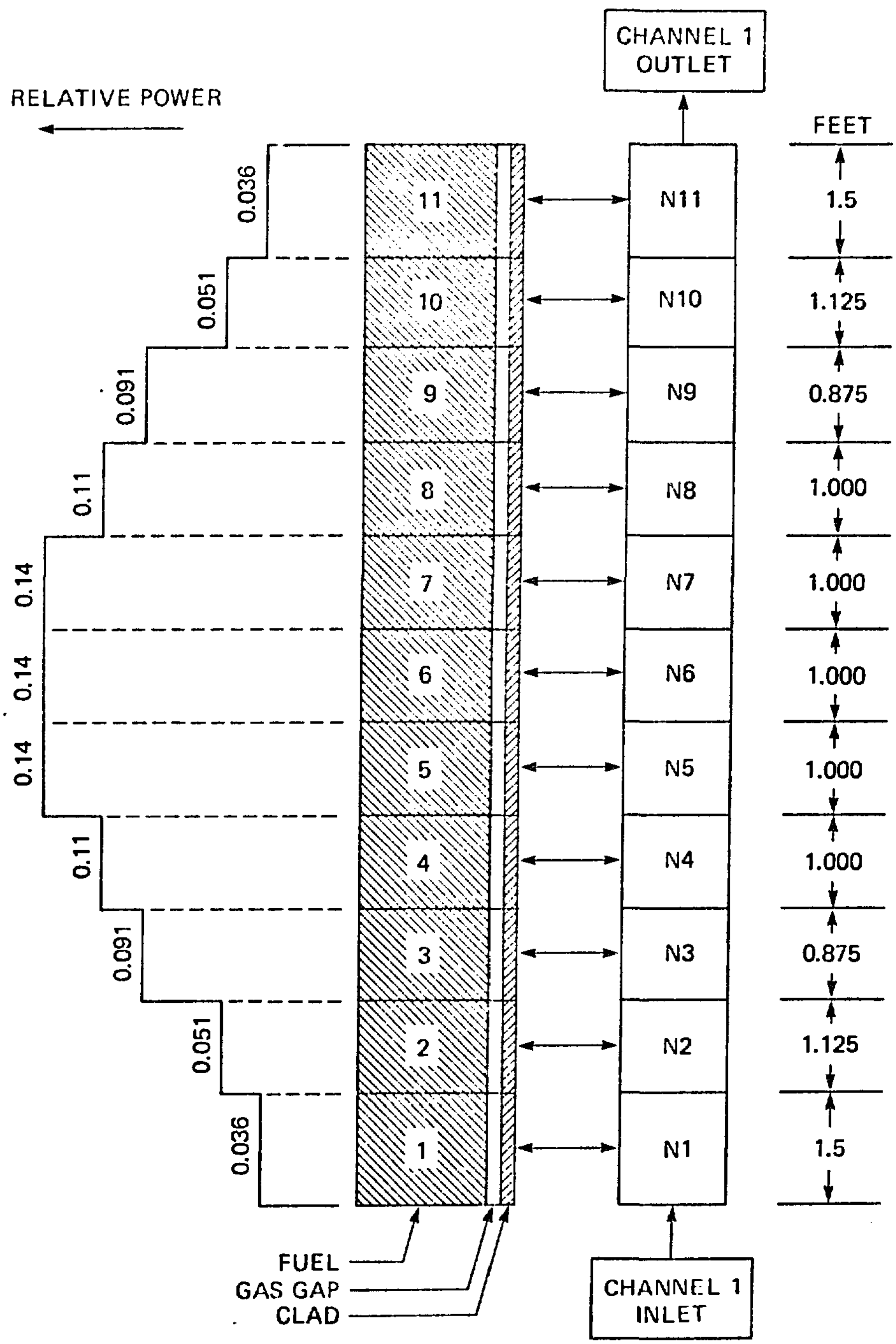
PIN/CHANNEL SIMULATION PROBLEM MODELS



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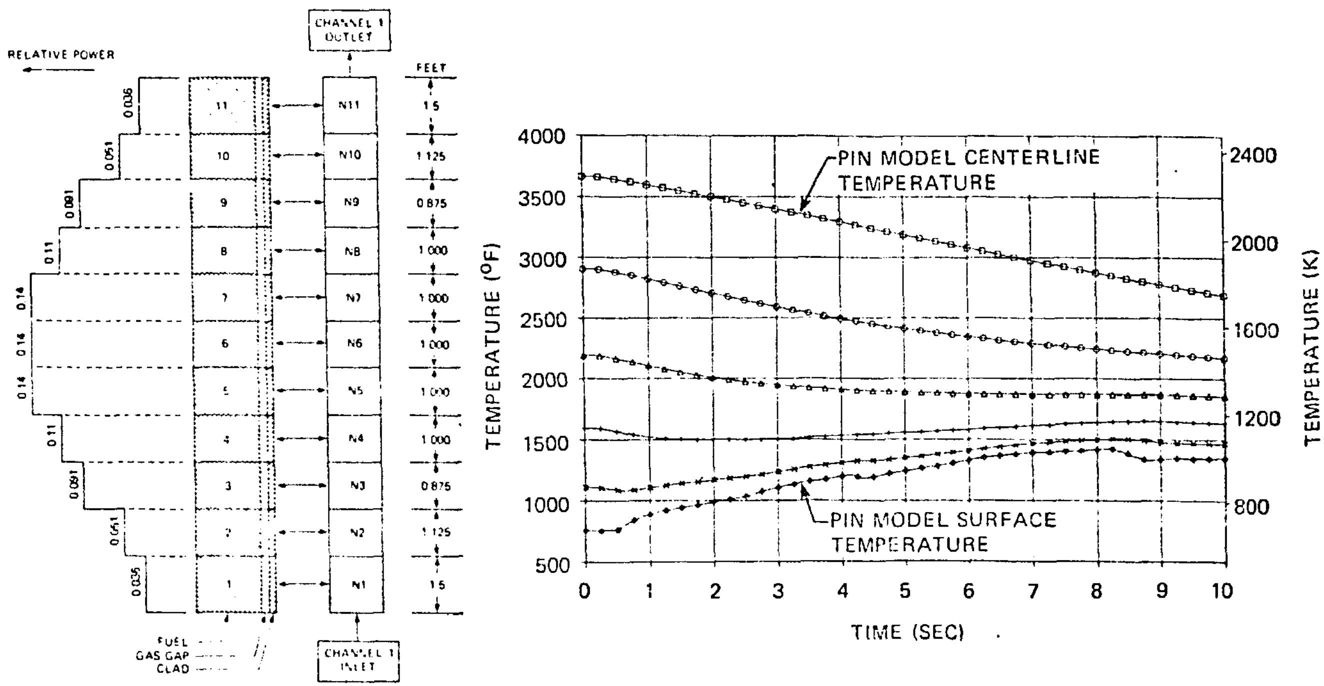
NUCLEAR PIN THERMAL RESPONSE CALCULATED BY PINSIM-MOD1 AT AN AXIAL LEVEL WITHIN THE HIGH-POWERED ZONE INDICATES A MAXIMUM CLADDING SURFACE TEMPERATURE BELOW 1500°F



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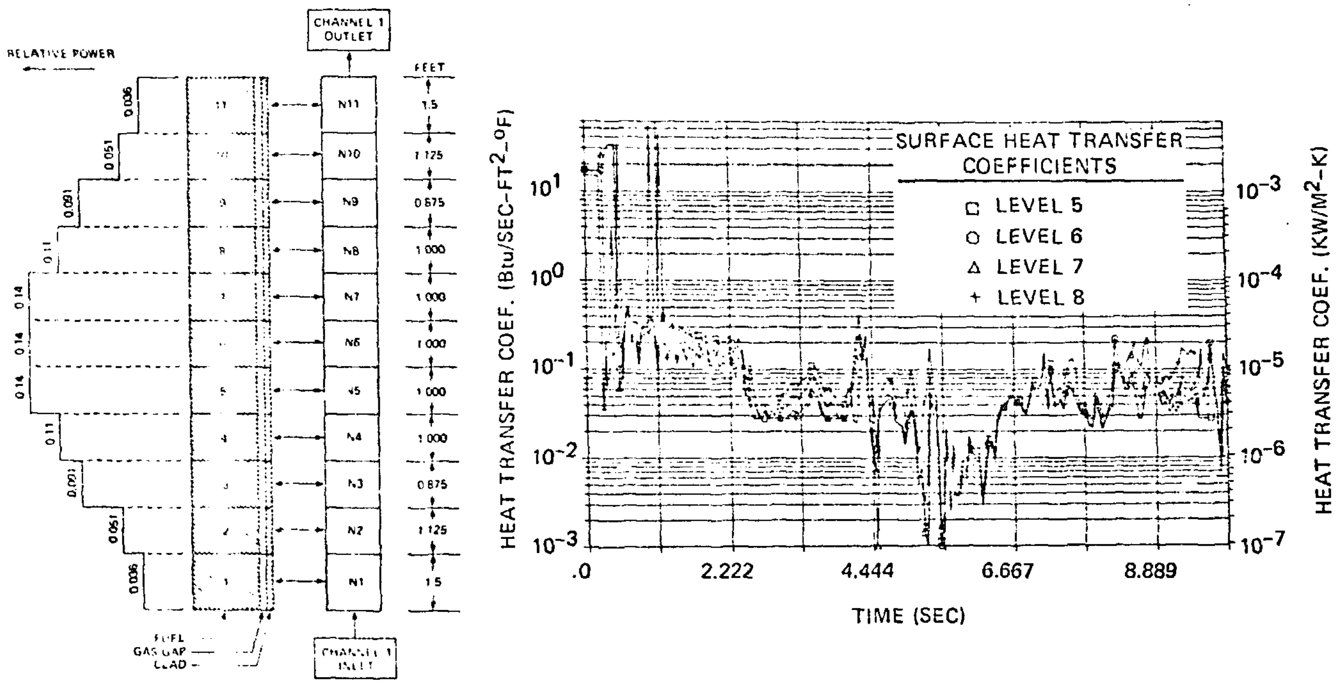
TRANSIENT SURFACE HEAT TRANSFER COEFFICIENTS CALCULATED BY PINSIM-MOD1 SUGGEST NEARLY UNIFORM COOLANT CONDITIONS IN THE HIGH-POWERED ZONE



57%

34

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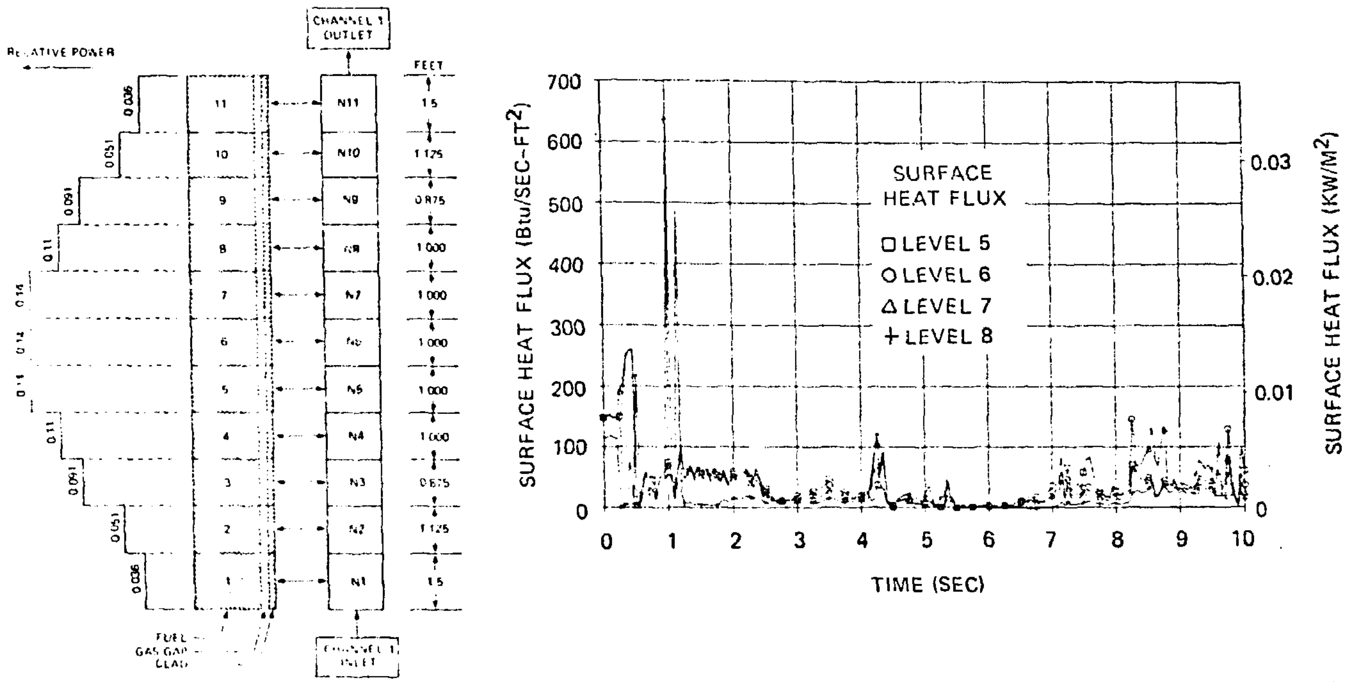
SURFACE HEAT FLUX TRANSIENTS CALCULATED BY PINSIM–MOD1 INDICATE TIMES TO CHF BETWEEN 0.2 AND 0.5 SECONDS WITHIN THE HIGH-POWERED ZONE



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THE PIN/CHANNEL SIMULATION CAPABILITY OF PINSIM-MOD1 IS CURRENTLY LIMITED

– LOCAL FLUID CONDITION PREDICTIONS CAN BE NO MORE ACCURATE THAN THE USER-SUPPLIED PLENUM CONDITIONS

– ONLY IDEALIZED NUCLEAR FUEL PIN THERMAL BEHAVIOR CAN BE PREDICTED

– AXIAL POWER DISTRIBUTIONS WITHIN THE PIN REMAIN FIXED DURING THE TRANSIENT

12270

36

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NUCLEAR PIN SIMULATION: TOPICS

DIFFERENCES BETWEEN NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS

DESCRIPTION OF PINSIM-MOD1

PRINCIPAL APPLICATIONS OF PINSIM-MOD1

– PIN/CHANNEL SIMULATION

– ELECTRIC PIN POWER PROGRAMMING

– EVALUATION OF ELECTRIC PIN TRANSIENTS

54.5%

37

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POWER PROGRAMMING PROBLEM

OBJECTIVE: DETERMINE THE OPTIMUM REALIZABLE TRANSIENT ELECTRIC POWER REOUIRED TO FORCE AN ELECTRIC PIN SIMULATOR TO EXPERIENCE A SPECIFIED SURFACE HEAT FLUX TRANSIENT IN THE THTF

MODEL: ELECTRIC PIN MODEL REPRESENTATIVE OF A TYPICAL THTF ELECTRIC PIN

BOUNDARY CONDITIONS: SURFACE HEAT FLUX TRANSIENT CALCULATED BY RELAP4/MOD5 TO BE REPRESENTATIVE OF A TYPICAL NUCLEAR PIN DURING A LOCA

SURFACE TEMPERATURE TRANSIENT CALCULATED BY RELAP4/MOD5 TO BE REPRESENTATIVE OF A TYPICAL ELECTRIC PIN IN THE THTF DURING A BLOWDOWN EXPERIMENT

1

532 38

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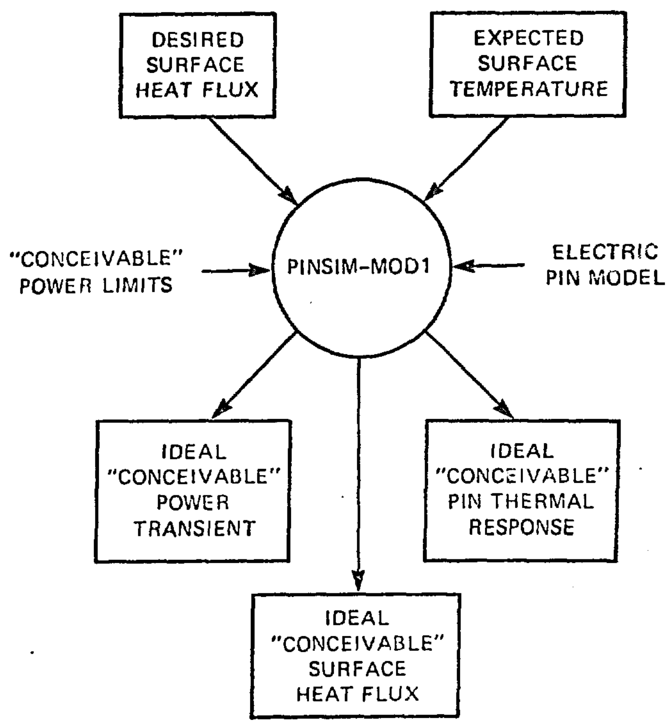
POWER PROGRAMMING PROBLEM: MODULAR REPRESENTATION



50%, then 96.5%

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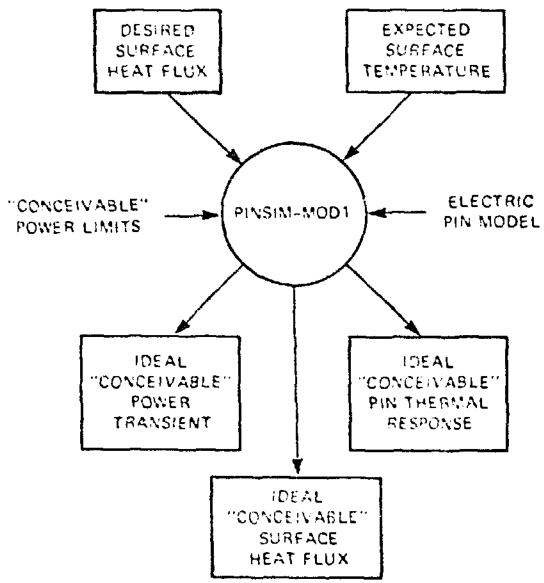
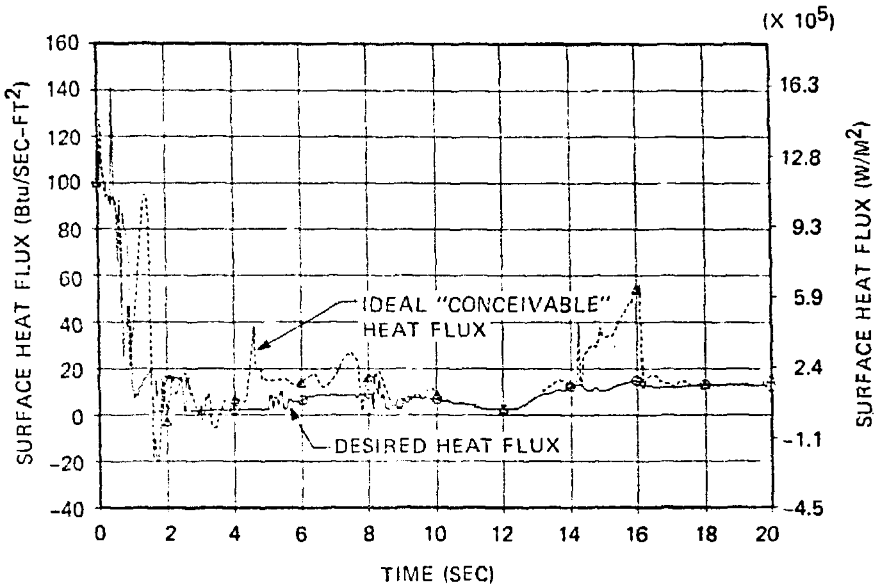
A COMPARISON OF THE DESIRED SURFACE HEAT FLUX TRANSIENT AND THE IDEAL "CONCEIVABLE" HEAT FLUX TRANSIENT CALCULATED BY PINSIM–MOD1





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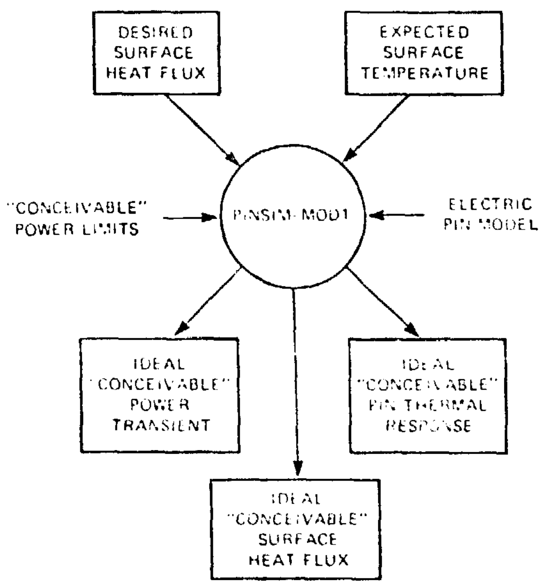
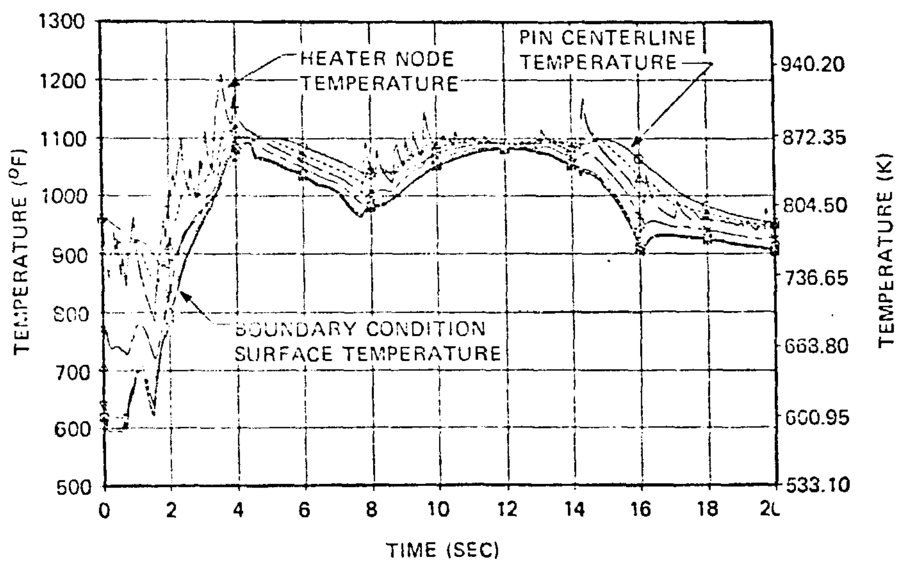
TRANSIENT INTERNAL PIN TEMPERATURES DURING THE IDEAL "CONCEIVABLE" POWER TRANSIENT, CALCULATED BY PINSIM-MOD1





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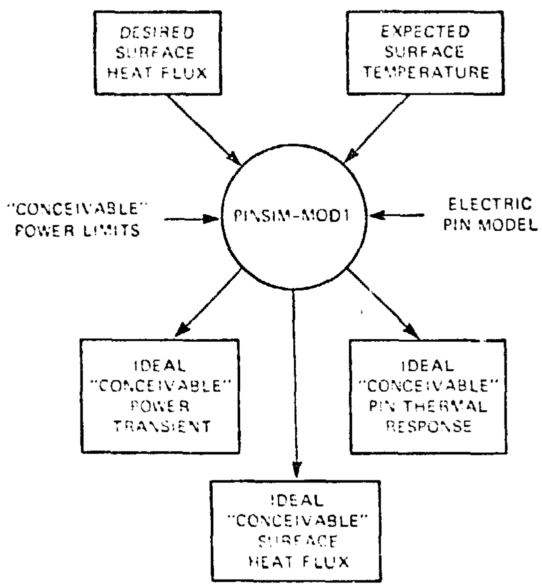
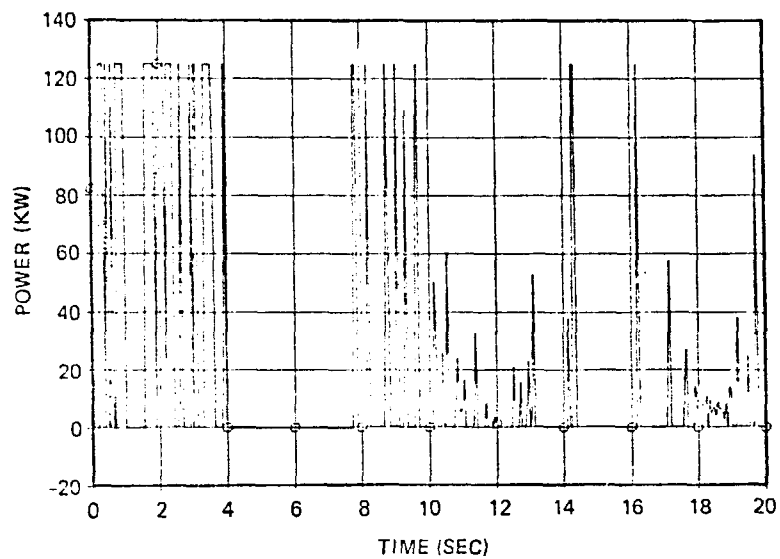
IDEAL "CONCEIVABLE' POWER TRANSIENT DETERMINED BY PINSIM-MOD1





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- THE IDEAL "CONCEIVABLE" POWER TRANSIENT CANNOT BE APPLIED DIRECTLY TO MEET THTF POWER PROGRAMMING REQUIREMENTS
- AN INTEGRATE-SMOOTH-DIFFERENTIATE (ISD) SCHEME IS BEING USED TO PROCESS THE PINSIM-CALCULATED POWER TRANSIENT
- THE ISD PROCESSING OF THE POWER TRANSIENT IS PERFORMED BY A POST-PROCESSING CODE, INDEPENDENT OF PINSIM-MOD1

135%

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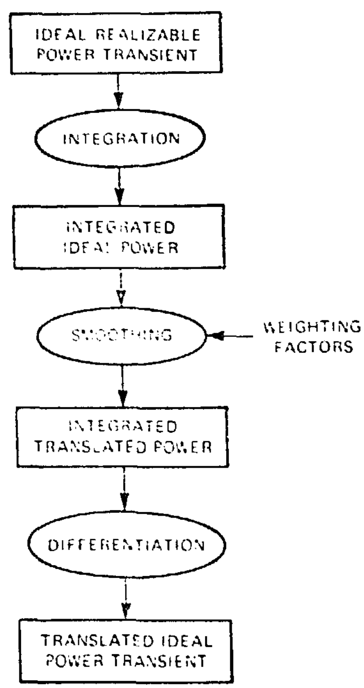
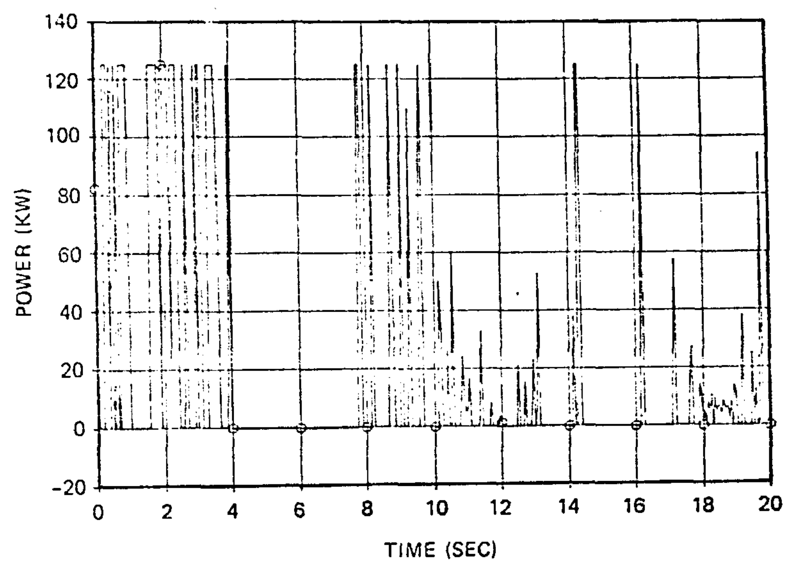
IDEAL REALIZABLE POWER TRANSIENT DETERMINED BY PINSIM-MOD1

INTEGRATE-SMOOTH-DIFFERENTIATE (ISD) SCHEME





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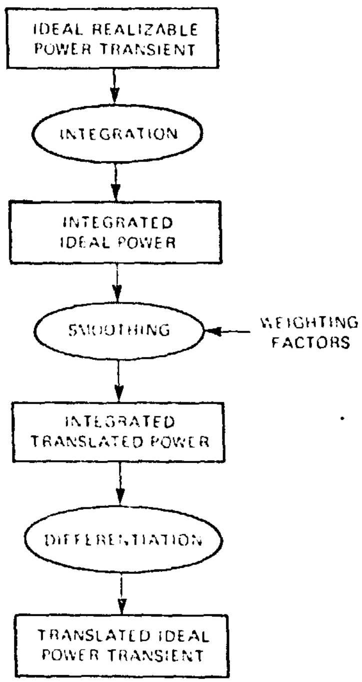
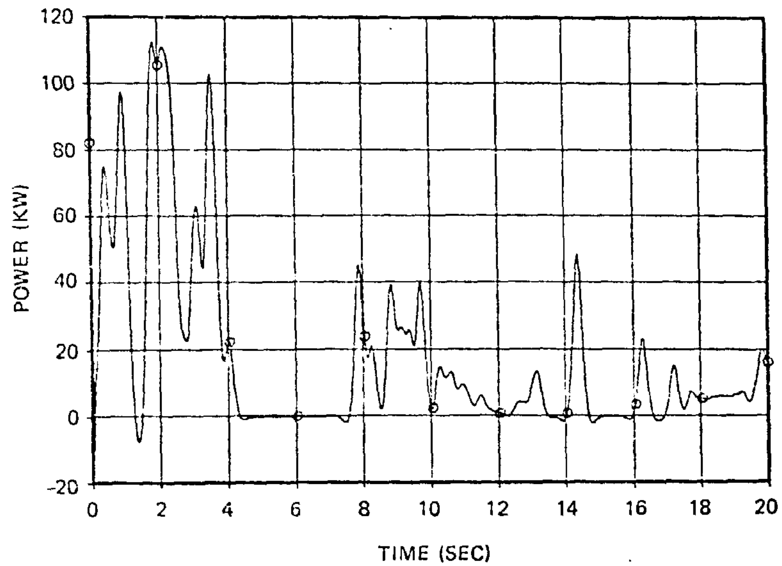
THE "TRANSLATED" IDEAL POWER TRANSIENT

INTEGRATE-SMOOTH-DIFFERENTIATE (ISD) SCHEME





ORNL-WS--1662

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NUCLEAR PIN SIMULATION: TOPICS

DIFFERENCES BETWEEN NUCLEAR FUEL PINS AND ELECTRIC PIN SIMULATORS

DESCRIPTION OF PINSIM-MOD1

PRINCIPAL APPLICATIONS OF PINSIM-MOD1

- PIN/CHANNEL SIMULATION
- ELECTRIC PIN POWER PROGRAMMING
- EVALUATION OF ELECTRIC PIN TRANSIENTS

7002

44

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EVALUATION OF ELECTRIC PIN TRANSIENT

GENERAL OBJECTIVE: PROVIDE INFORMATION WHICH WILL ASSIST IN DETERMINING WHETHER A SPECIFIED ELECTRIC PIN TRANSIENT HAS SIMULATED, OR WILL SIMULATE, A CONCEIVABLE NUCLEAR PIN TRANSIENT

MODELS: NUCLEAR PIN MODEL

BOUNDARY CONDITIONS:

- { ELECTRIC PIN SURFACE HEAT FLUX TRANSIENT; ELECTRIC PIN SURFACE TEMPERATURE TRANSIENT }
- { ELECTRIC PIN SURFACE TEMPERATURE TRANSIENT; NUCLEAR PIN POWER DECAY CURVE }

52.5%

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OPTIONS AVAILABLE IN PINSIM-MOD1 ALLOW THE USER TO GENERATE RESULTS WHICH WILL ADDRESS A VARIETY OF QUESTIONS

- WHAT NUCLEAR PIN TRANSIENT IS EQUIVALENT TO A SPECIFIED ELECTRIC PIN TRANSIENT?
- HOW CLOSE WAS THE ELECTRIC PIN TRANSIENT TO A CONCEIVABLE NUCLEAR PIN TRANSIENT?
- HOW DOES THE ELECTRIC PIN'S THERMAL RESPONSE TO THE HYDRAULIC TRANSIENT COMPARE WITH THE THERMAL RESPONSE OF A NUCLEAR PIN TO A SIMILAR HYDRAULIC TRANSIENT?

75%

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OPTIONS AVAILABLE IN PINSIM–MOD1 ALLOW THE USER TO GENERATE RESULTS WHICH WILL ADDRESS A VARIETY OF QUESTIONS

– WHAT NUCLEAR PIN TRANSIENT IS EQUIVALENT TO A SPECIFIED ELECTRIC PIN TRANSIENT?

– HOW CLOSE WAS THE ELECTRIC PIN TRANSIENT TO A CONCEIVABLE NUCLEAR PIN TRANSIENT?

– HOW DOES THE ELECTRIC PIN'S THERMAL RESPONSE TO THE HYDRAULIC TRANSIENT COMPARE WITH THE THERMAL RESPONSE OF A NUCLEAR PIN TO A SIMILAR HYDRAULIC TRANSIENT?

110%

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OPTIONS AVAILABLE IN PINSIM-MOD1 ALLOW THE USER TO GENERATE RESULTS WHICH WILL ADDRESS A VARIETY OF QUESTIONS

- WHAT NUCLEAR PIN TRANSIENT IS EQUIVALENT TO A SPECIFIED ELECTRIC PIN TRANSIENT?
- HOW CLOSE WAS THE ELECTRIC PIN TRANSIENT TO A CONCEIVABLE NUCLEAR PIN TRANSIENT?
- HOW DOES THE ELECTRIC PIN'S THERMAL RESPONSE TO THE HYDRAULIC TRANSIENT COMPARE WITH THE THERMAL RESPONSE OF A NUCLEAR PIN TO A SIMILAR HYDRAULIC TRANSIENT?

110%

ORNL-WS-1666

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EQUIVALENT NUCLEAR PINS TRANSIENT PROBLEM

OBJECTIVE: DETERMINE THE NUCLEAR PIN TRANSIENT EQUIVALENT TO THE ELECTRIC PIN TRANSIENT OF THTF TEST 105, AXIAL LEVEL F

PIN MODEL: IDEALIZED NUCLEAR PIN SIMILAR TO THAT DESCRIBED IN THE WESTINGHOUSE RESAR-1 AT B.O.L.

BOUNDARY CONDITIONS: REPRESENTATIVE SURFACE TEMPERATURE AND SURFACE HEAT FLUX TRANSIENTS, DETERMINED BY THE ORINC CODE, FOR AXIAL LEVEL F IN THTF TEST 105

105%

50

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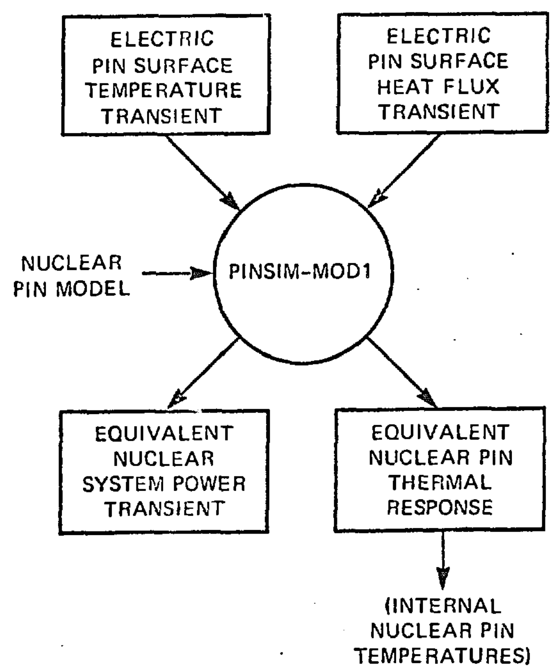
EQUIVALENT TRANSIENT PROBLEM MODULAR REPRESENTATION



98.5%

51

ORNL–DWG 78–19728

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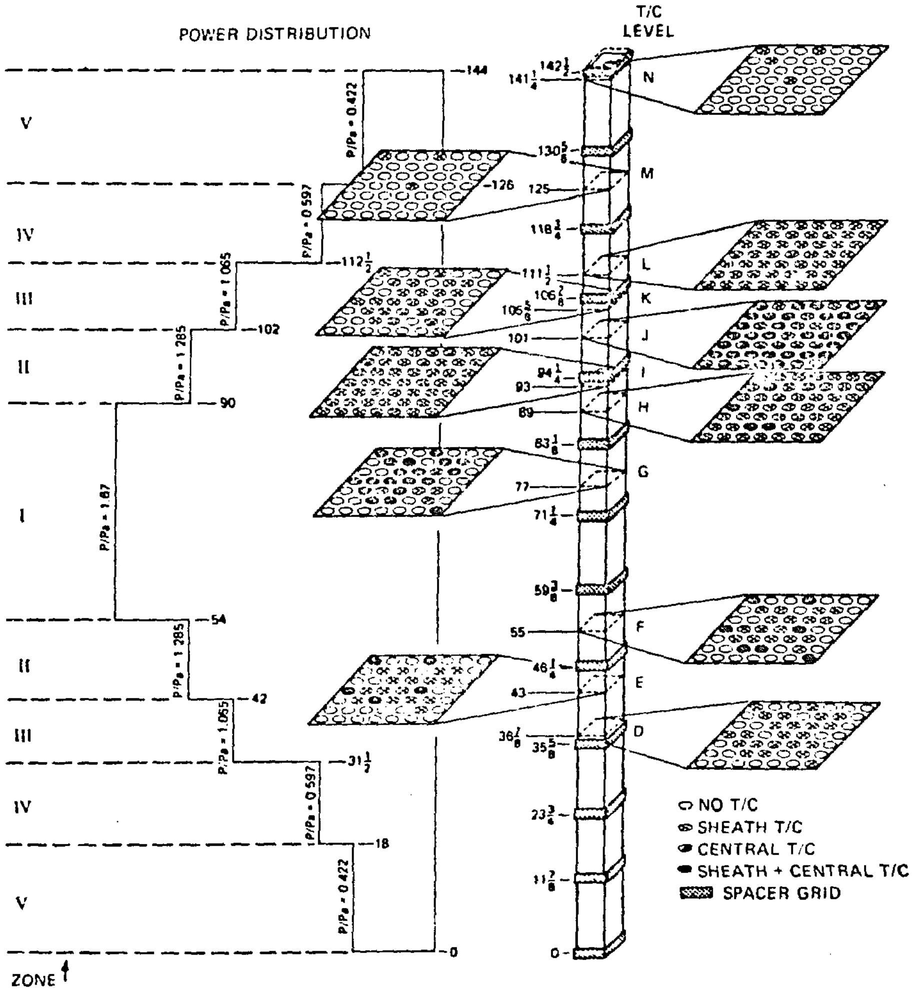
AXIAL LEVEL F IN THTF BUNDLE 1 IS NEAR THE CENTER OF THE BUNDLE, IN A RELATIVELY HIGH-POWERED ZONE



ORNL-DWG 78-15728

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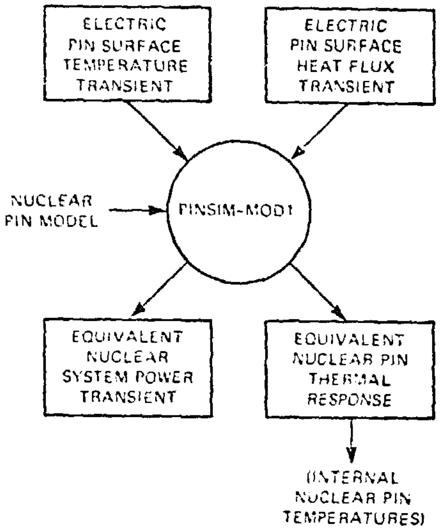
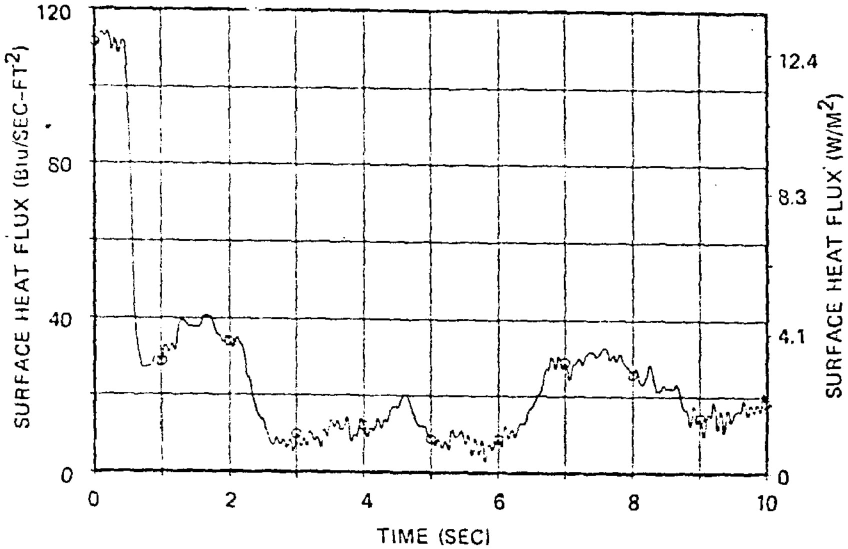
TEST 105 ELECTRIC PIN SURFACE HEAT FLUX, AXIAL LEVEL F





65%

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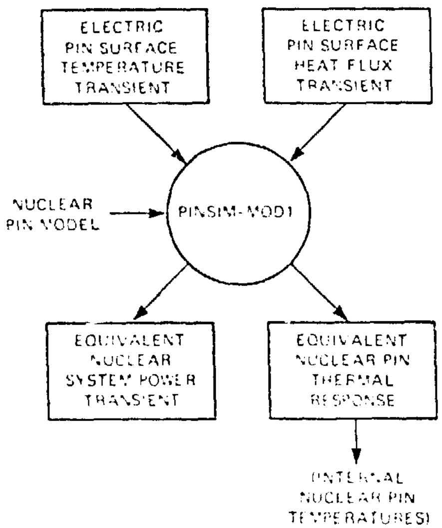
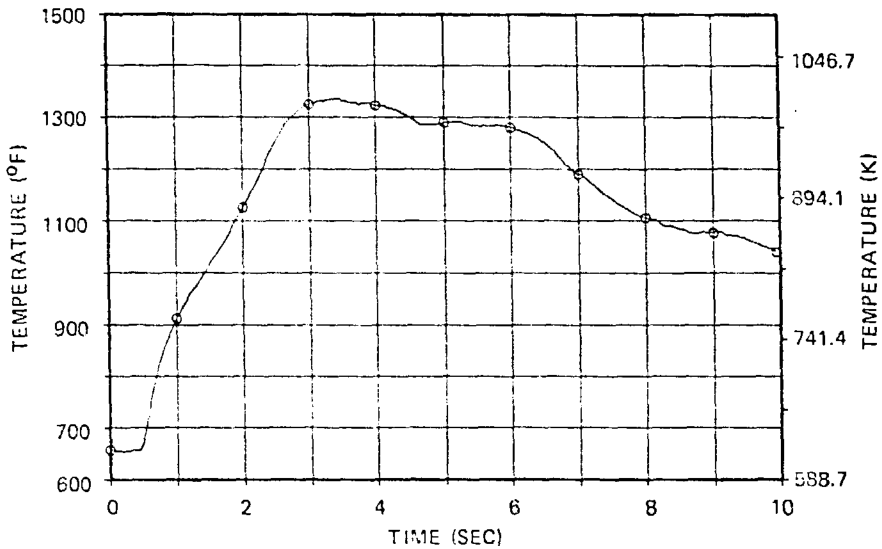
TEST 105 ELECTRIC PIN SURFACE TEMPERATURE, AXIAL LEVEL F





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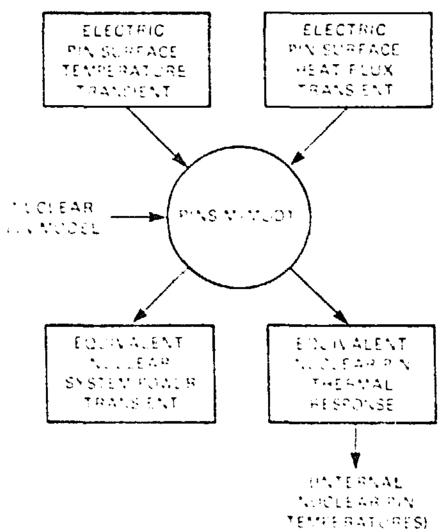
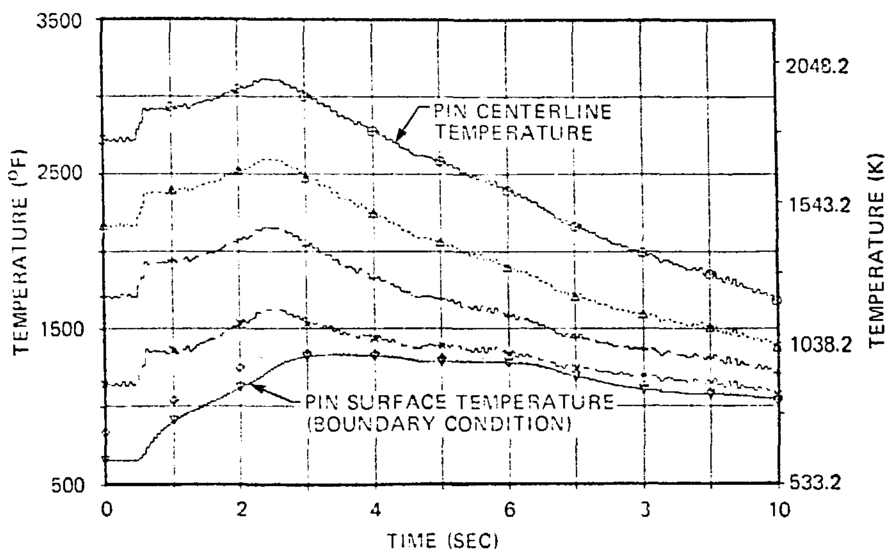
ORNL

TEST 105 EQUIVALENT TRANSIENT NUCLEAR PIN TEMPERATURE DISTRIBUTIONS (AXIAL LEVEL F) CALCULATED BY PINSIM–MOD1





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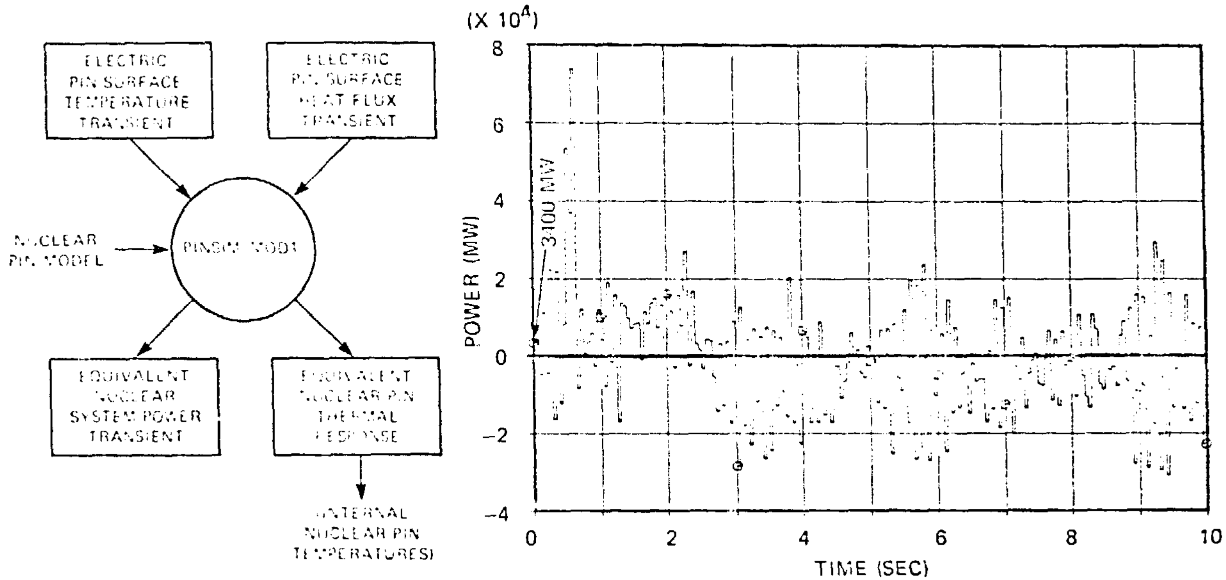
UNION CARBIDE ORNL

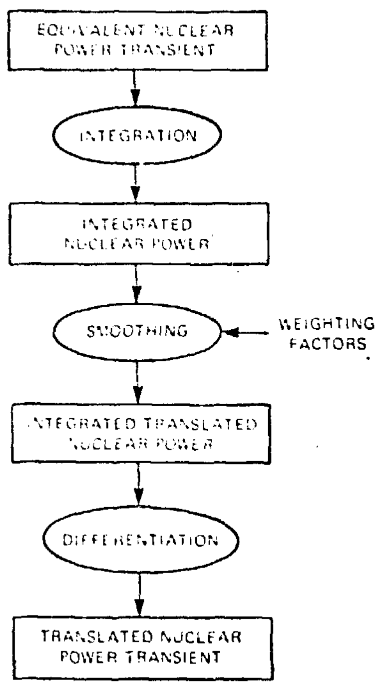
TEST 105 EQUIVALENT NUCLEAR SYSTEM POWER TRANSIENT (AXIAL LEVEL F), DETERMINED BY PINSIM–MOD1

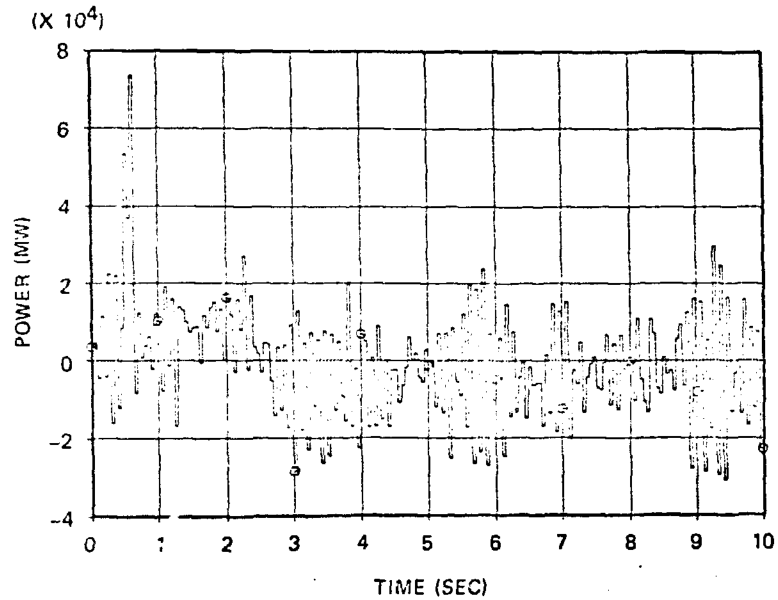


UNION CARBIDE ORNL

TEST 105 EQUIVALENT NUCLEAR SYSTEM POWER (AXIAL LEVEL F), DETERMINED BY PINSIM–MOD1

INTEGRATE-SMOOTH-DIFFERENTIATE (ISD) SCHEME





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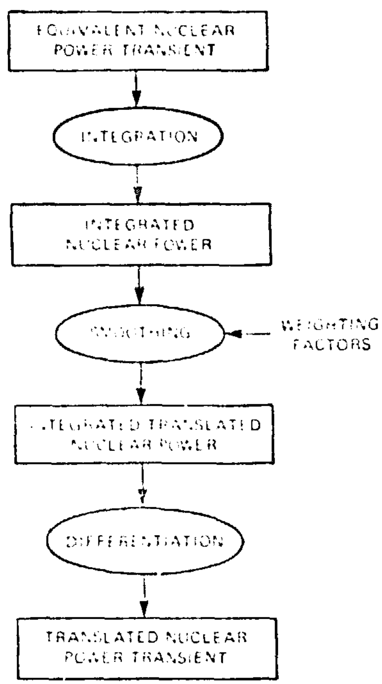
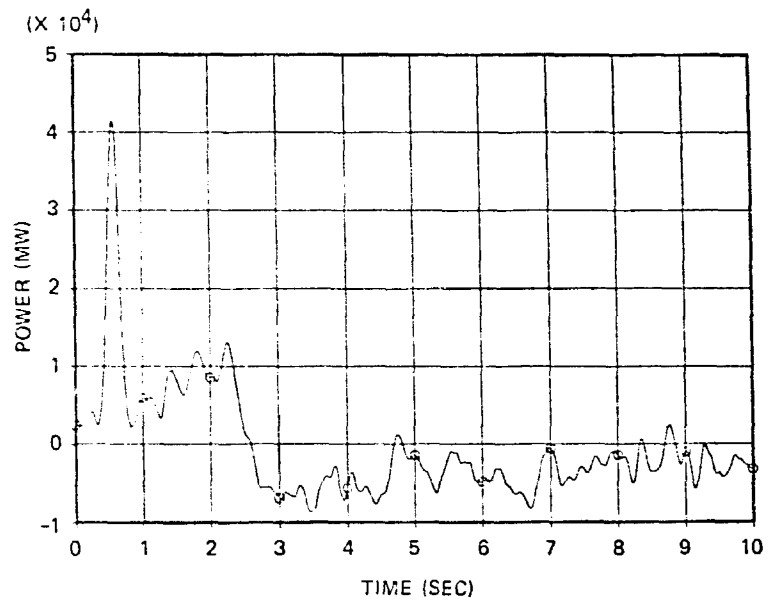
ORNL

A "TRANSLATED" NUCLEAR SYSTEM POWER TRANSIENT FOR THTF TEST 105, AXIAL LEVEL F

INTEGRATE-SMOOTH-DIFFERENTIATE (ISD) SCHEME





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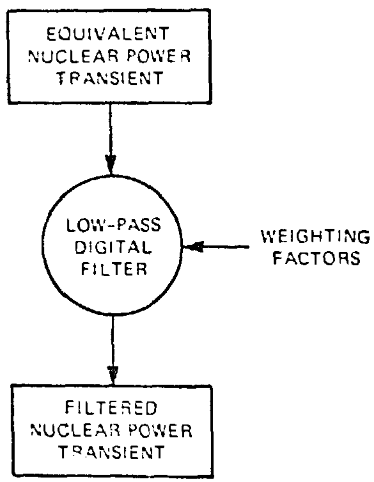
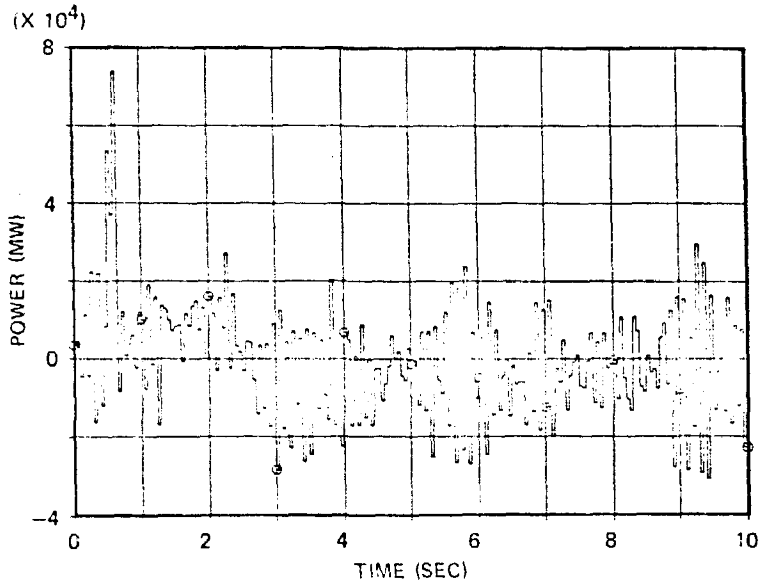
THE UNFILTERED EQUIVALENT NUCLEAR POWER TRANSIENT DETERMINED BY PINSIM-MOD1

DIGITAL FILTERING SCHEME





ORNL-DWG 78-19736

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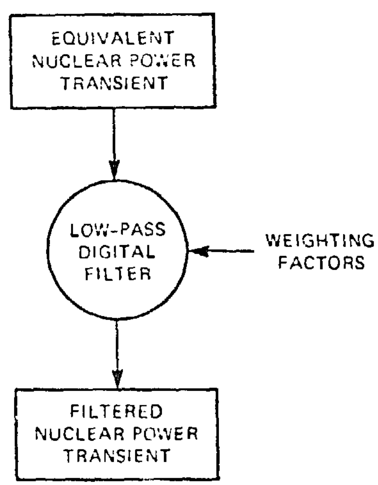
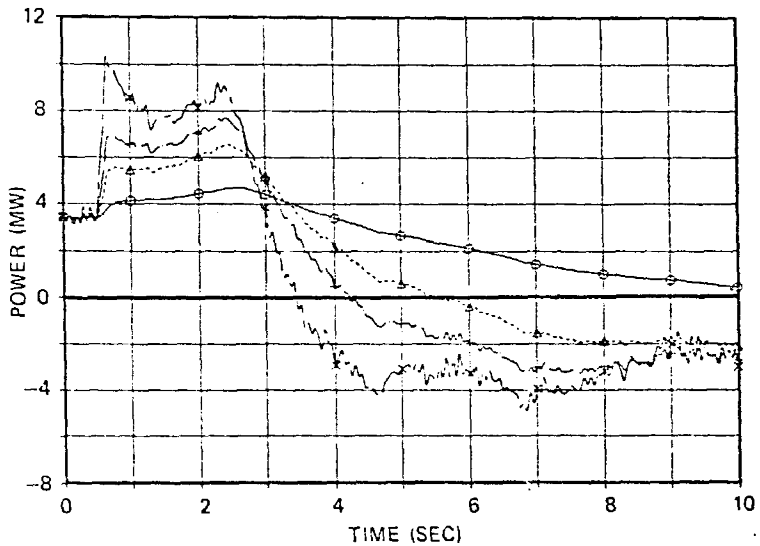
ORNL

RESULTS OF DIGITAL FILTERING OF EQUIVALENT NUCLEAR POWER TRANSIENT, FOR VARIOUS WEIGHTING FACTORS

DIGITAL FILTERING SCHEME





64%

60

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OPTIONS AVAILABLE IN PINSIM-MOD1 ALLOW THE USER TO GENERATE RESULTS WHICH WILL ADDRESS A VARIETY OF QUESTIONS

– WHAT NUCLEAR PIN TRANSIENT IS EQUIVALENT TO A SPECIFIED ELECTRIC PIN TRANSIENT?

– HOW CLOSE WAS THE ELECTRIC PIN TRANSIENT TO A CONCEIVABLE NUCLEAR PIN TRANSIENT?

– HOW DOES THE ELECTRIC PIN'S THERMAL RESPONSE TO THE HYDRAULIC TRANSIENT COMPARE WITH THE THERMAL RESPONSE OF A NUCLEAR PIN TO A SIMILAR HYDRAULIC TRANSIENT?

110%

61

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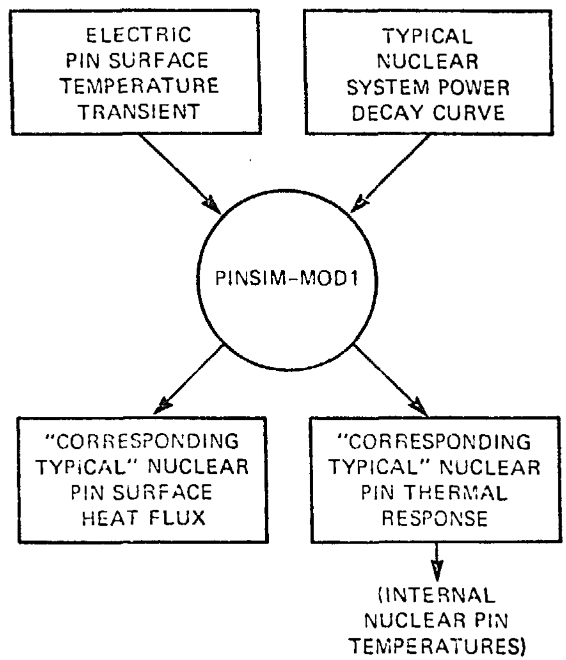
"CORRESPONDING TYPICAL" TRANSIENT PROBLEM MODULAR REPRESENTATION



62

63.5%

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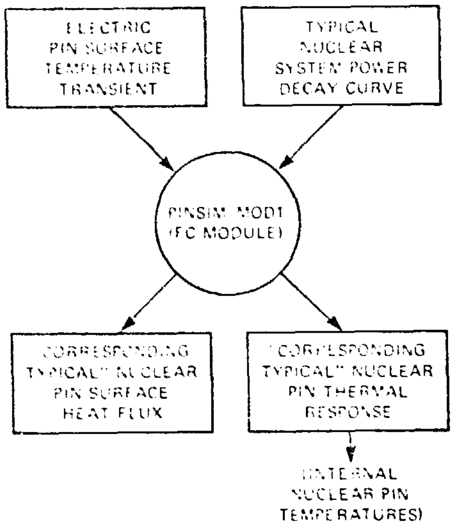
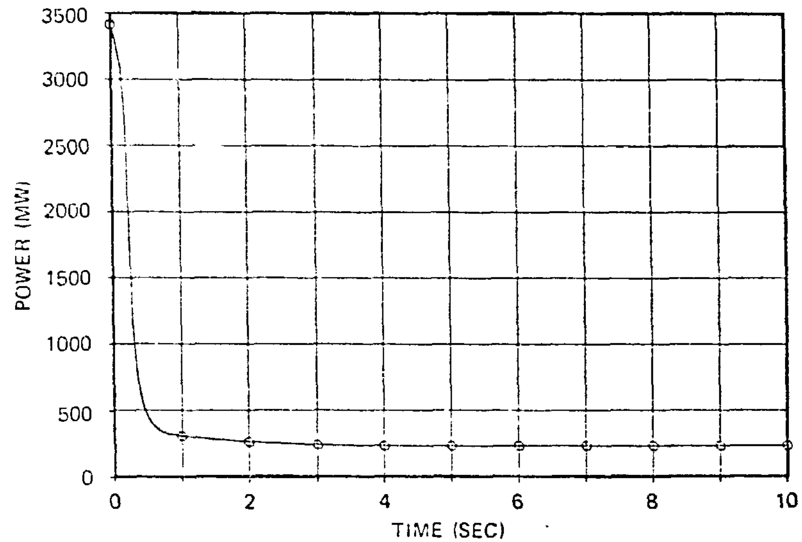
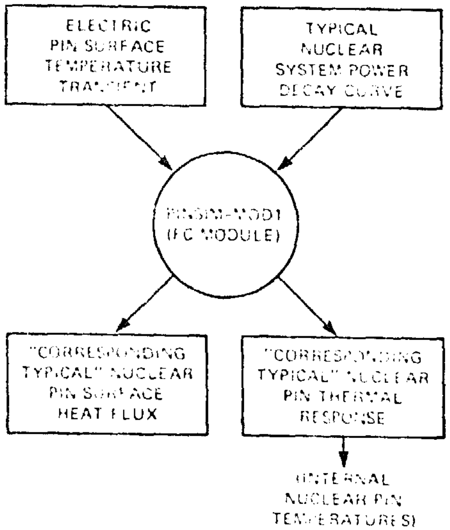
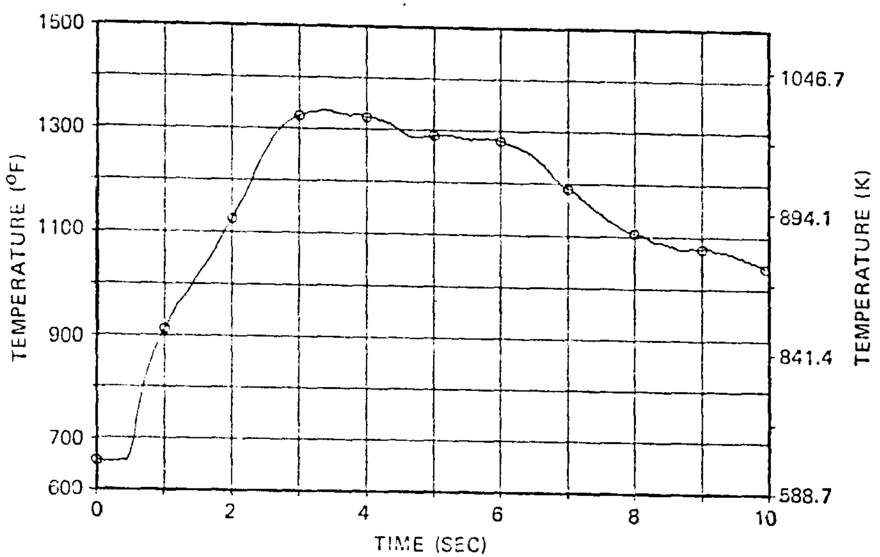
NUCLEAR SYSTEM POWER DECAY CURVE USED TO DETERMINE THE "CORRESPONDING TYPICAL" NUCLEAR PIN TRANSIENT





TEST 105 ELECTRIC PIN SURFACE TEMPERATURE, AXIAL LEVEL F





6 3 . 6

6

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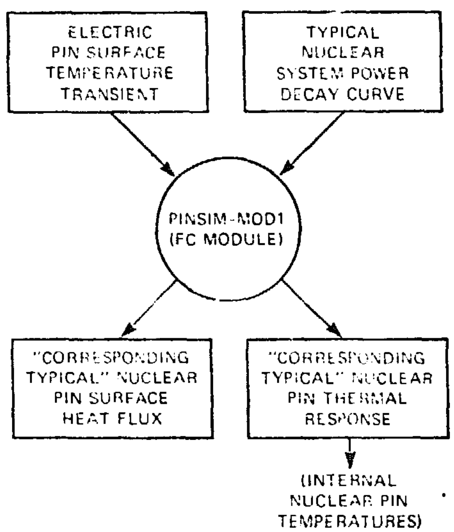
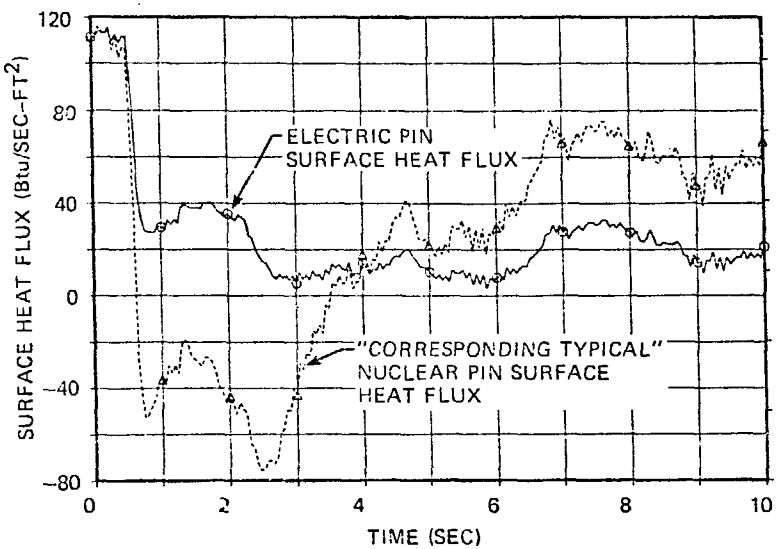
A COMPARISON OF THE ACTUAL ELECTRIC PIN SURFACE HEAT FLUX TRANSIENT IN TEST 105 (AXIAL LEVEL F) AND THE "CORRESPONDING TYPICAL" NUCLEAR PIN SURFACE HEAT FLUX TRANSIENT





60%

65

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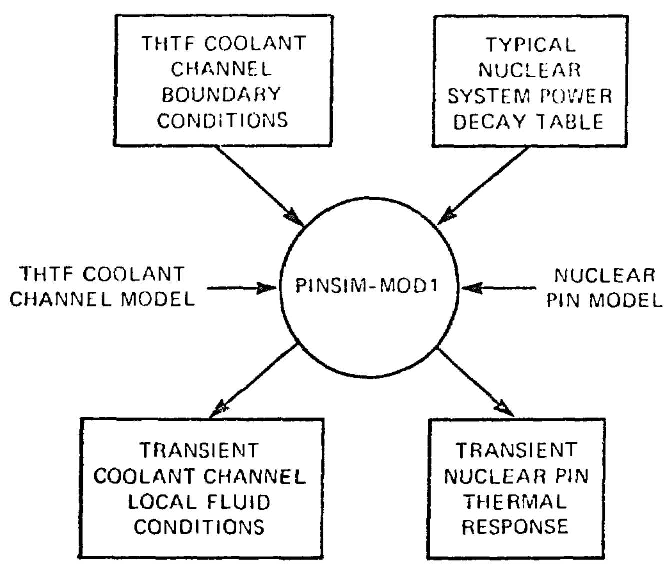
OPTIONS AVAILABLE IN PINSIM-MOD1 ALLOW THE USER TO GENERATE RESULTS WHICH WILL ADDRESS A VARIETY OF QUESTIONS

- WHAT NUCLEAR PIN TRANSIENT IS EQUIVALENT TO A SPECIFIED ELECTRIC PIN TRANSIENT?
- HOW CLOSE WAS THE ELECTRIC PIN TRANSIENT TO A CONCEIVABLE NUCLEAR PIN TRANSIENT?
- HOW DOES THE ELECTRIC PIN'S THERMAL RESPONSE TO THE HYDRAULIC TRANSIENT COMPARE WITH THE THERMAL RESPONSE OF A NUCLEAR PIN TO A SIMILAR HYDRAULIC TRANSIENT?

110%

ORNL-DWG 78-19741

THE PIN/CHANNEL SIMULATION SAMPLE PROBLEM WAS A PINSIM-MOD1 PREDICTION OF THE RESPONSE OF AN IDEALIZED NUCLEAR PIN AND ITS ASSOCIATED COOLANT CHANNEL TO A HYDRAULIC TRANSIENT SIMILAR TO THAT OF THTF TEST 105



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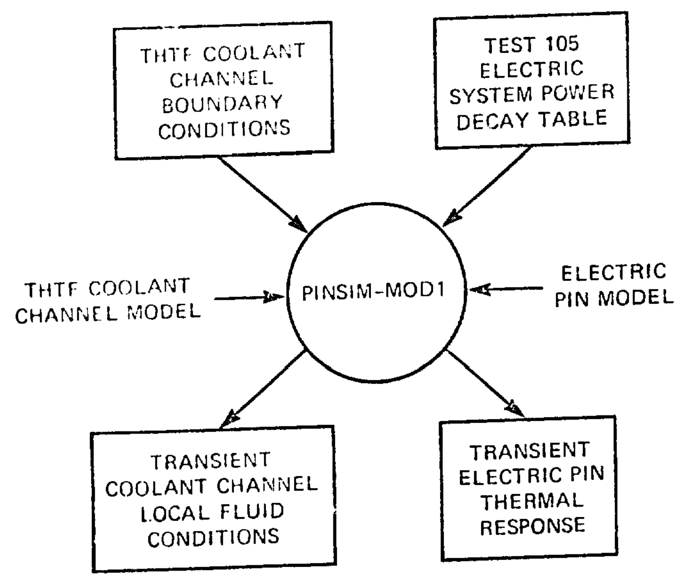
A CORRESPONDING ELECTRIC PIN PROBLEM WOULD USE AN ELECTRIC PIN MODEL AND THE TEST 105 ELECTRIC POWER DECAY CURVE



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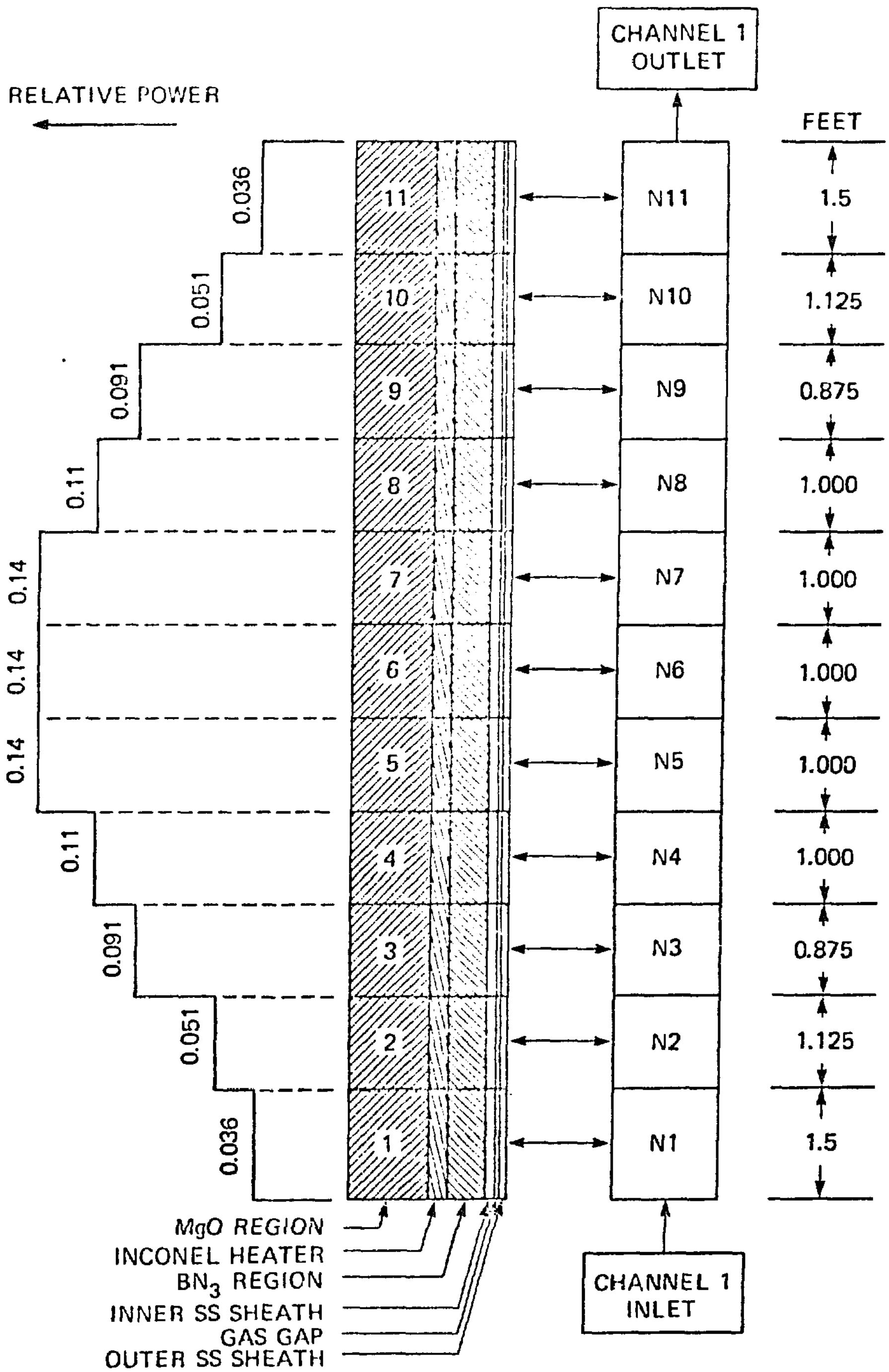
ELECTRIC PIN/CHANNEL SIMULATION PROBLEM MODELS



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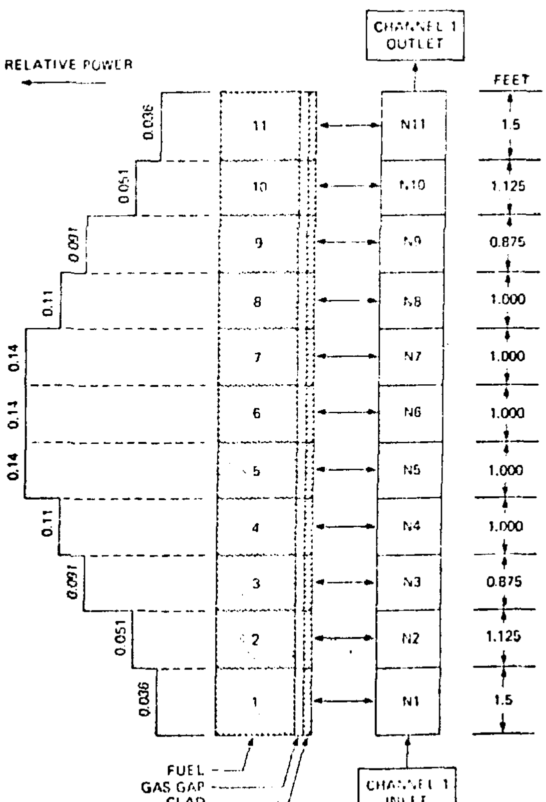
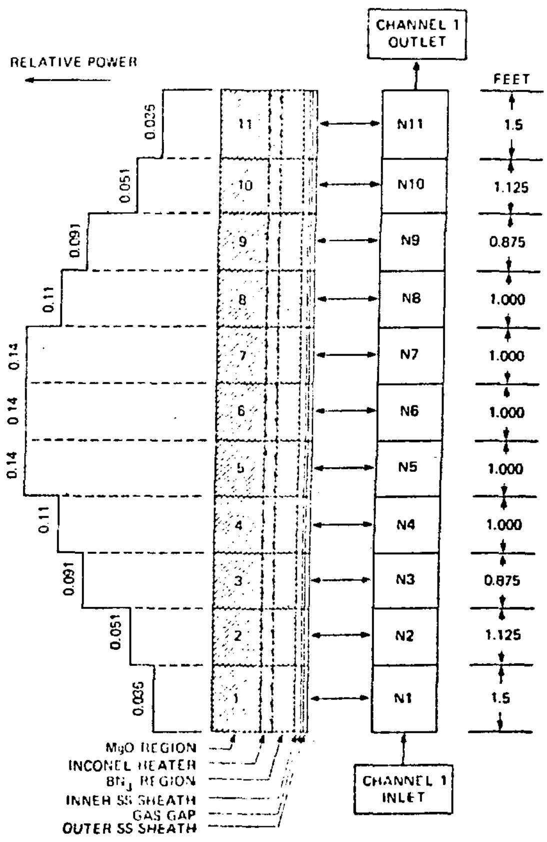
COMPARISONS OF PINSIM-MOD1 PREDICTIONS ALLOW THE THERMAL RESPONSES OF A NUCLEAR PIN MODEL AND AN ELECTRIC PIN MODEL TO BE CONTRASTED

NUCLEAR PIN/CHANNEL MODEL



ELECTRIC PIN/CHANNEL MODEL



70

50%, then 89%

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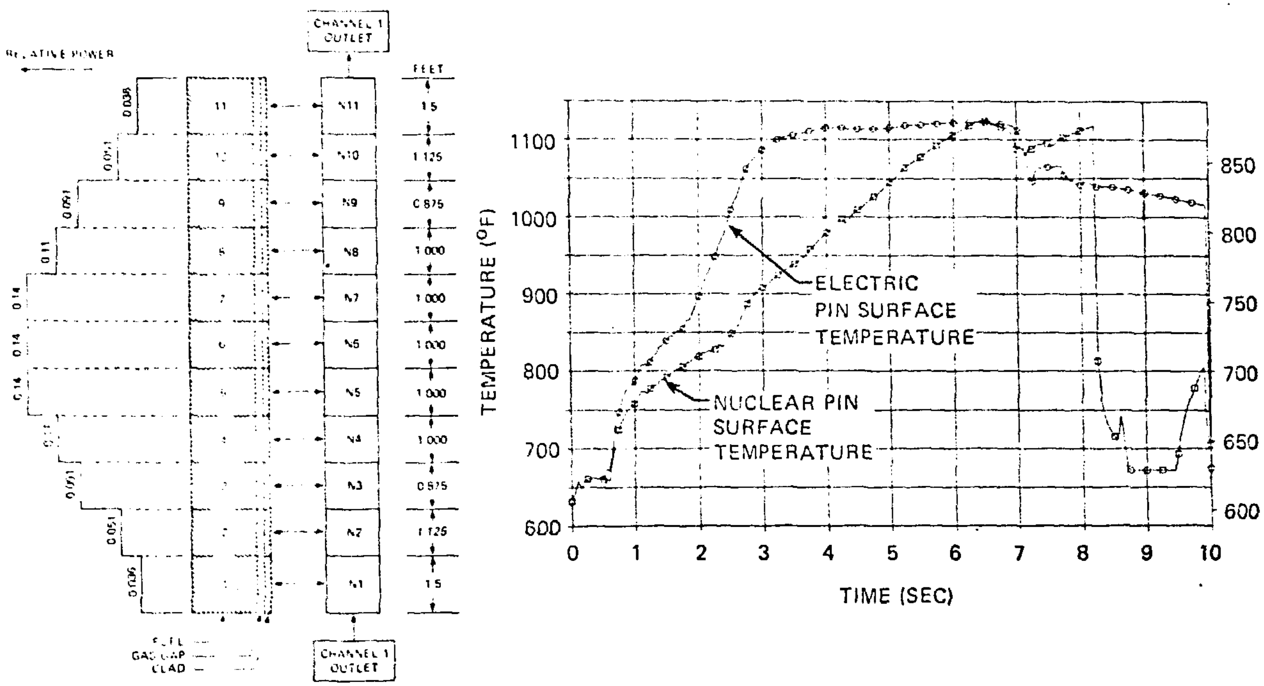
AT AN AXIAL LEVEL BELOW THE MIDPOINT OF THE PIN, PINSIM-MOD1 PREDICTS A MORE RAPID SURFACE TEMPERATURE RISE FOR THE ELECTRIC PIN MODEL THAN FOR THE NUCLEAR PIN MODEL, WITH ESSENTIALLY IDENTICAL TIMES TO CHF



55%

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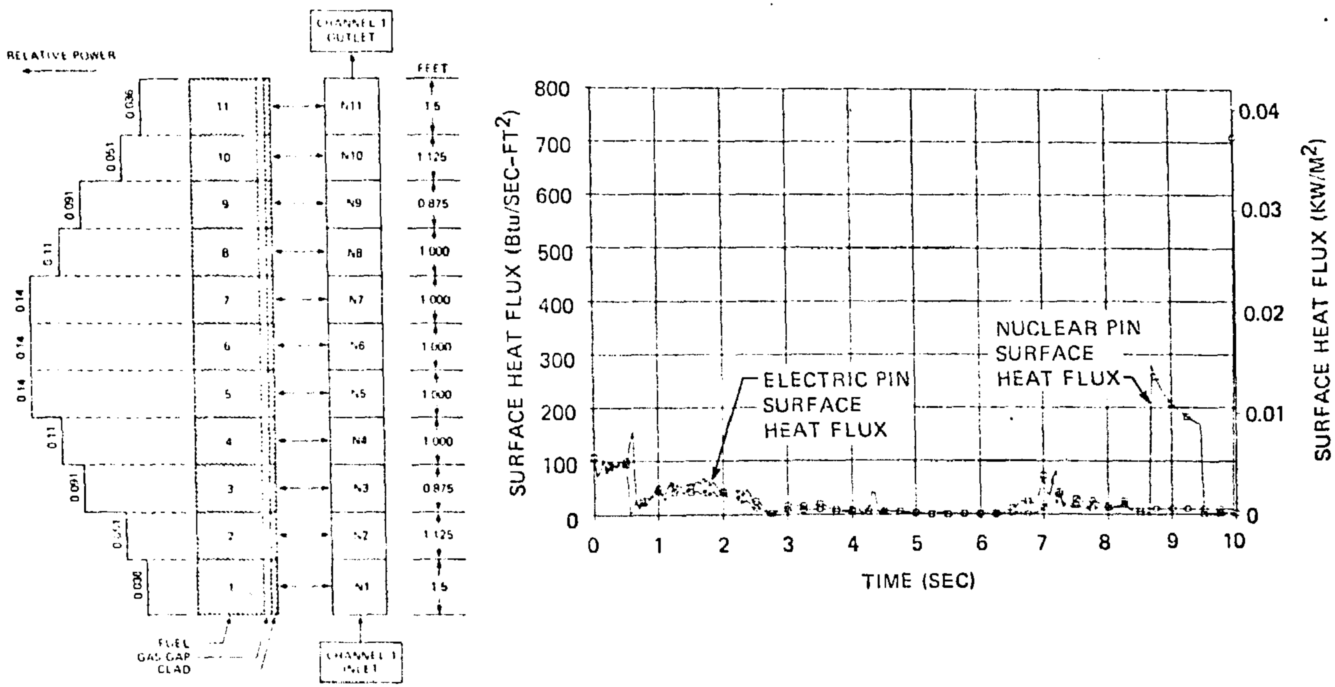
AT AN AXIAL LEVEL BELOW THE MIDPOINT OF THE PIN, PINSIM-MOD1 PREDICTS NEARLY IDENTICAL SURFACE HEAT FLUX TRANSIENTS FOR THE ELECTRIC AND NUCLEAR PIN MODELS



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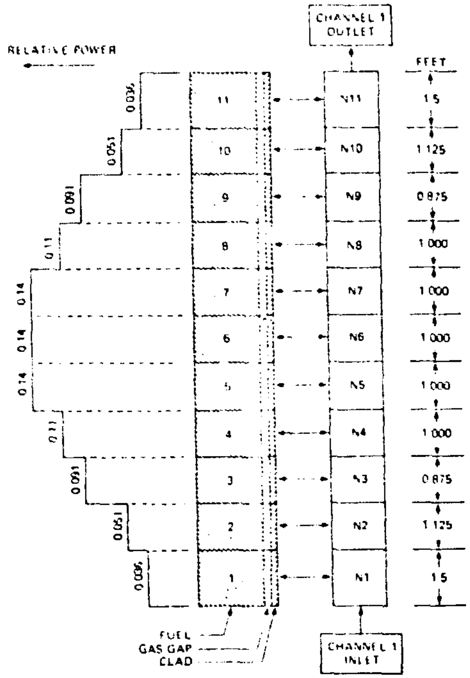
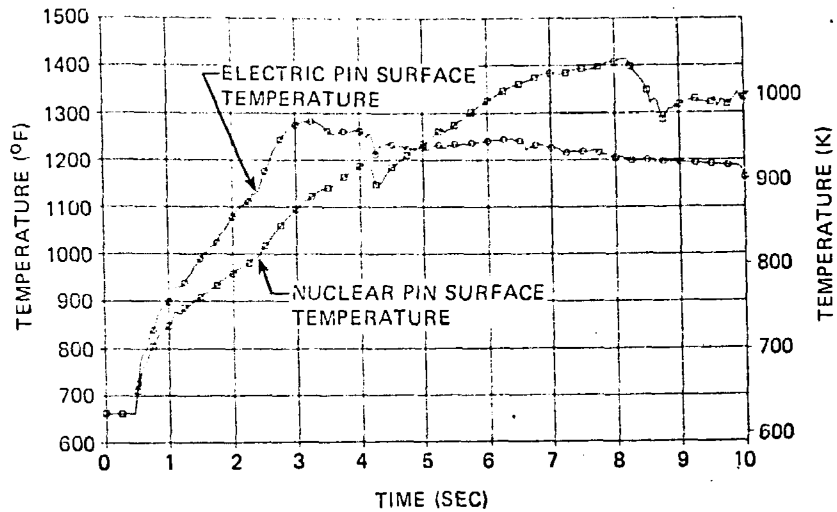
AT AN AXIAL LEVEL NEAR THE MIDPOINT OF THE PIN, PINSIM-MOD1 CALCULATIONS INDICATE DIFFERENT SURFACE TEMPERATURE TRANSIENTS FOR THE ELECTRIC AND NUCLEAR PIN MODELS





73

5770

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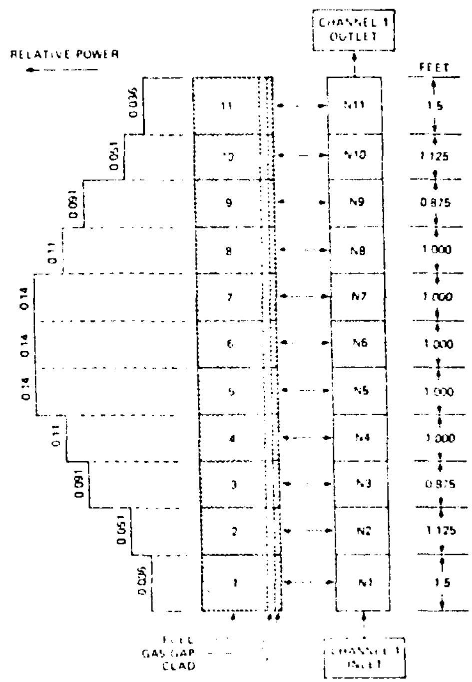
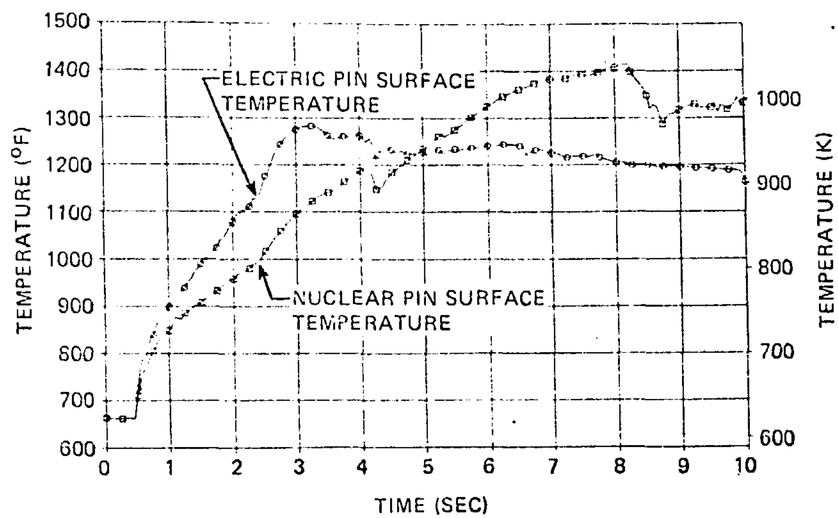
AT AN AXIAL LEVEL NEAR THE MIDPOINT OF THE PIN, PINSIM–MOD1 CALCULATIONS INDICATE DIFFERENT SURFACE TEMPERATURE TRANSIENTS FOR THE ELECTRIC AND NUCLEAR PIN MODELS





73

5770

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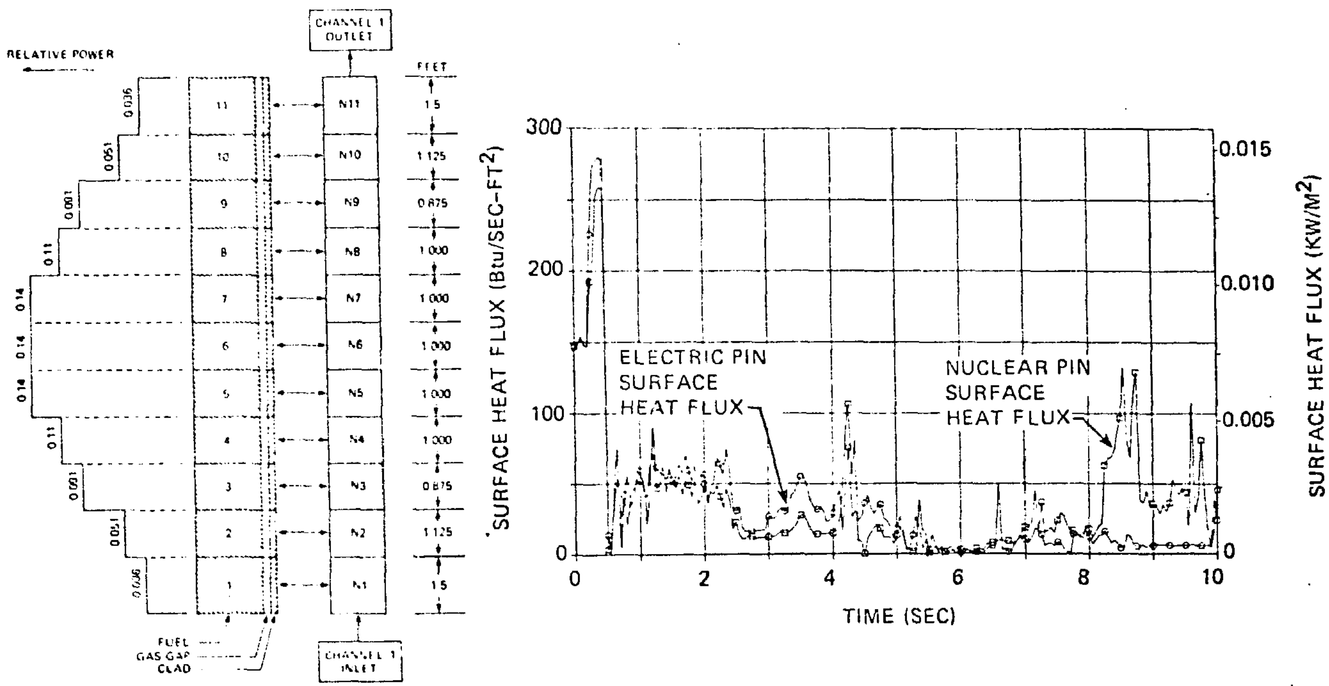
AT AN AXIAL LEVEL NEAR THE MIDPOINT OF THE PIN, PINSIM-MOD1 PREDICTS SIMILAR SURFACE HEAT FLUX TRANSIENTS FOR THE ELECTRIC AND NUCLEAR PIN MODELS



582

74

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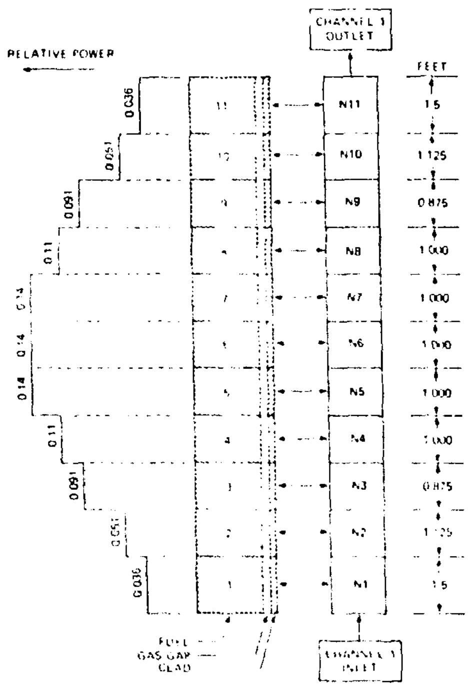
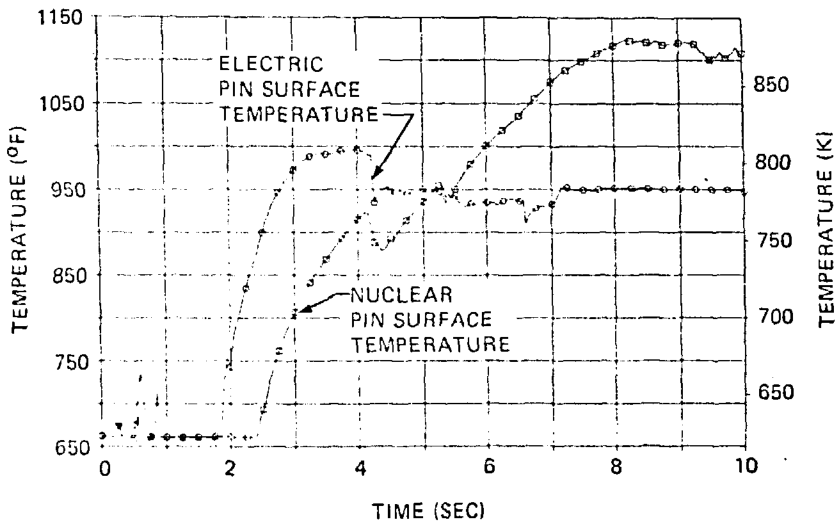
AT AN AXIAL LEVEL ABOVE THE MIDPOINT OF THE PIN, PINSIM-MOD1 PREDICTS A LATER TIME TO CHF FOR THE NUCLEAR PIN MODEL THAN FOR THE ELECTRIC PIN MODEL





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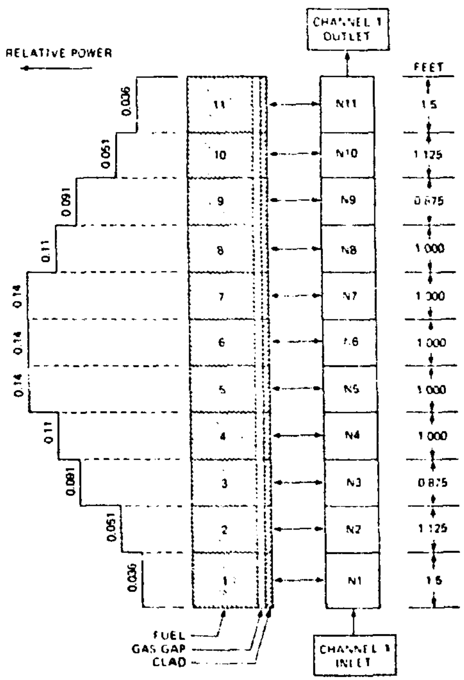
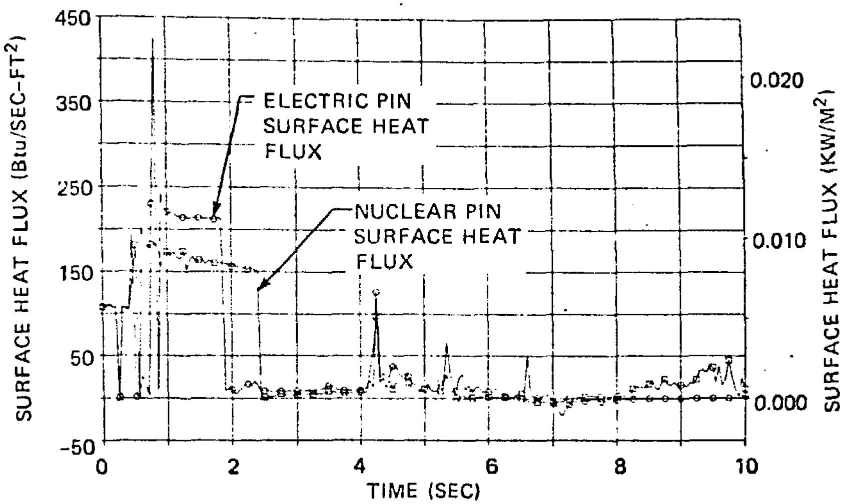
AT AN AXIAL LEVEL ABOVE THE MIDPOINT OF THE PIN, PINSIM-MOD1 PREDICTS SIMILAR POST-CHF HEAT FLUX TRANSIENTS FOR THE ELECTRIC AND NUCLEAR PIN MODELS





5200

76

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DEVELOPMENTAL WORK IS PROCEEDING IN SEVERAL AREAS

– NUCLEAR FUEL PIN MECHANICAL BEHAVIOR

– BACK–CALCULATION FROM FLUID CONDITIONS

– TRANSIENT AXIAL POWER DISTRIBUTIONS

120%

17