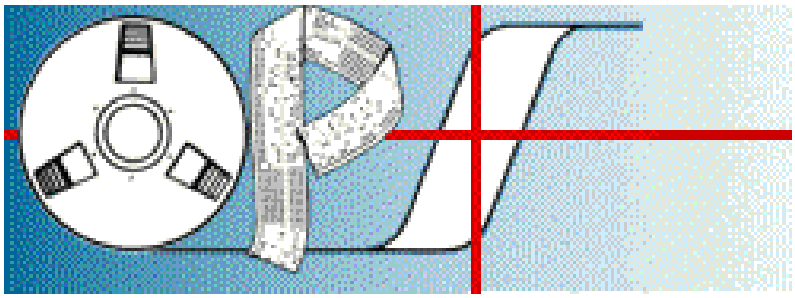
OPTIMIZED PROGRAM SERVICE LLC.



Electro-Magnetic Design Using Advanced Computer Techniques
info@opsprograms.com
opseast@msn.com
440-238-0700

HIREAC

PROGRAM DESCRIPTION AND OPERATING INSTRUCTIONS

I. INTRODUCTION

HIREAC is a program capable of handling a wide range of high reactance transformers which use special arrangements of coils and/or magnetic shunts to achieve precise values of reactance. **HIREAC** is ideally suited to handle current-limiting transformers, ballasts and transformers where precise impedance is to be built into the design. It is intended to be used by experienced transformer designers as an extension to their engineering capabilities and relies on their background for judgement and subjective analysis of the results obtained. The computational power of **HIREAC** enables the designer to examine many alternatives and quickly provides the effects of each decision made during the design process.

HIREAC is an interactive program that allows the user to establish and maintain custom data files containing proprietary material, cost and labor information. This gives the user greater control over a wide range of design considerations. It enables the designer to research more efficient, and most cost effective design solutions, resulting in improved product quality, improved productivity and lower costs.

II. FEATURES

HIREAC INCLUDES THE FOLLOWING NEW FEATURES:

CUSTOM DATABASE – HIREAC operates using a database of materials supplied by the individual user. This feature allows the designer to further control the material types and sizes to be considered. With conductor selection options, the program is limited to selecting components readily available from the user's own inventory of materials. More realistic cost information is provided since the user can submit costs into the database.

II. FEATURES (CONTINUED)

THERMAL MODELING – HIREAC uses sophisticated thermal network modeling techniques to determine temperature rise. The thermal model is developed using a comprehensive nodal circuit analysis routine that considers the effects of the mechanical structure as well as the thermal characteristics of the materials used in the design. This provides more accurate results in the temperature calculations.

ELECTRICAL ANALYSIS – Extended analysis of a fixed design is further enhanced in **HIREAC**. Impedance characteristics expressed as %IR, %IX and %IZ and leakage inductance are provided for each winding using the **EXTENDED ANALYSIS OPTION**.

VARIABLE DUCTING – Many variations of ducting arrangements are available in **HIREAC**. Included are ducts of variable size, ducts on both sides of insulating barriers, and ducts with both blanketed or unblanketed cooling surfaces.

Other enhancements are continuously being made to expand capabilities and to improve the calculations of **HIREAC**.

III. USE

HIREAC is a program used to design high-reactance applications that require side-by-side windings with air space or magnetic shunts between windings; concentric windings with magnetic shunts between coils; or concentric windings with a second gapped core structure.

HIREAC is used to design: lighting Ballasts, current limiting transformers and precise reactance transformers.

IV. INPUT REQUIREMENTS

For entry of design information see **Page 4**.

DISCLAIMER

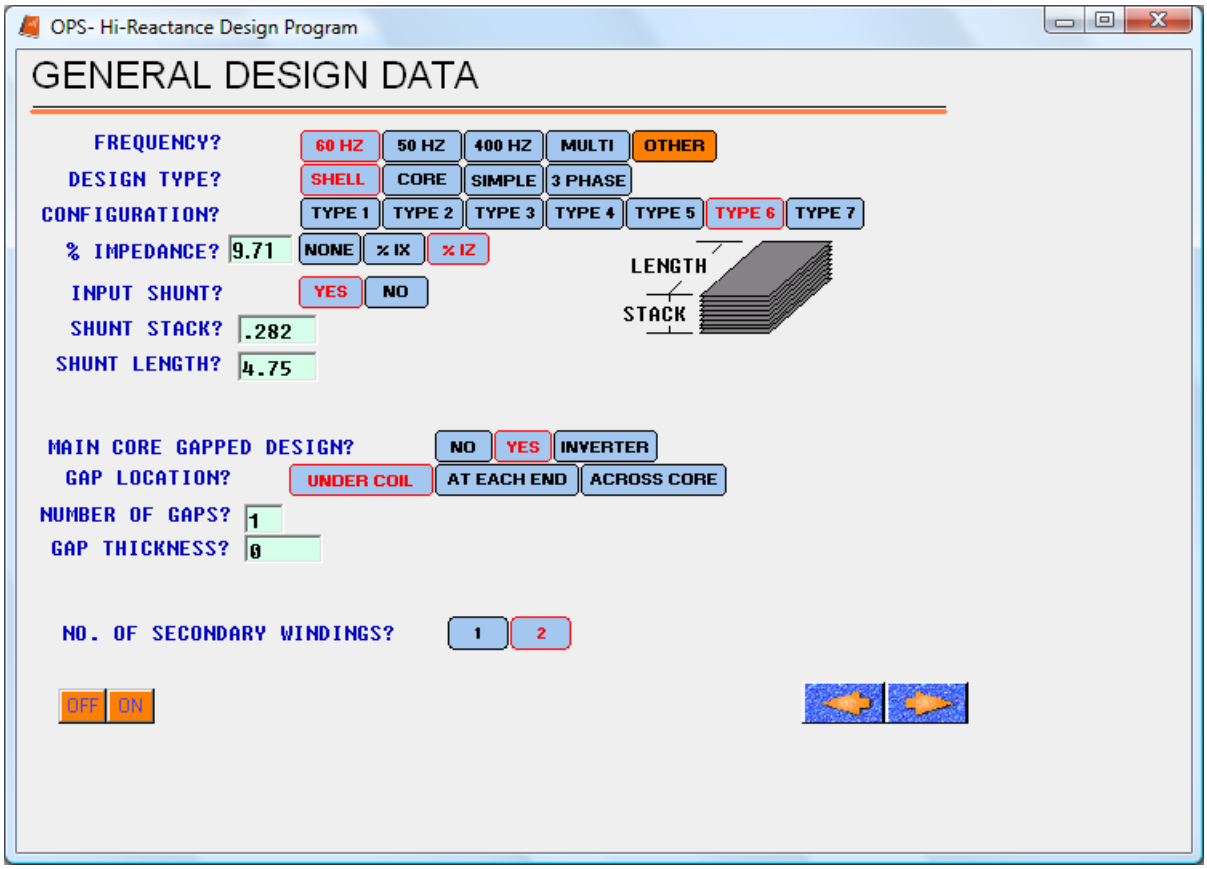
This program and its documentation have been subjected to normal field testing procedures. Optimized Program Service, llc. makes no warranty, expressed or implied, as to the documentation and the performance of the program. Users are expected to make the final evaluation as to the value and correctness of the results obtained for their specific application.

TABLE OF CONTENTS PAGE

MAIN MENU

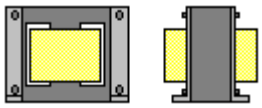
- Select **"BEGIN/REVIEW DESIGN IN ENGLISH UNITS"** to start a design or review current design English units.
- Select **"RETRIEVE DESIGN FILE"** to run program with an existing data file.
- Select **"GENERATE DESIGN PRINTOUT FROM EXISTING DATA"** to print design from existing input data.
- Select **"MODIFY"** to modify existing input data
- **Select** "**TERMINATE**" **to exit the program.**

GENERAL DESIGN DATA

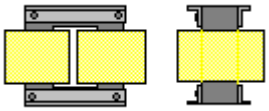


FREQUENCY: Frequency of input voltage in hertz.
(**See 2TRANS Manual Page 34-35** for multiple frequencies.)

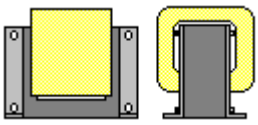
DESIGN TYPE:



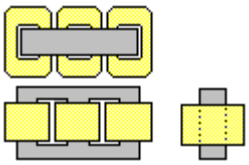
SHELL



CORE TYPE

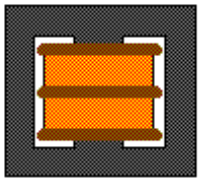


SIMPLE



THREE PHASE
THREE-LEGGED

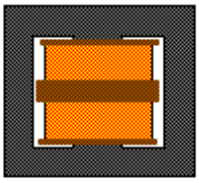
CONFIGURATION



TYPE 1

Split bobbin with center-flange the SAME THICKNESS as outer flanges.

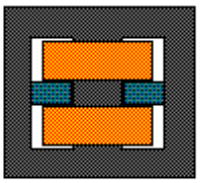
SINGLE PHASE



TYPE 2

Split bobbin with center-flange or space between coils GREATER THAN outer flanges or margins.

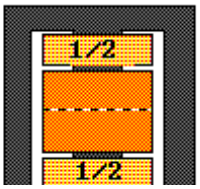
SINGLE PHASE



TYPE 3

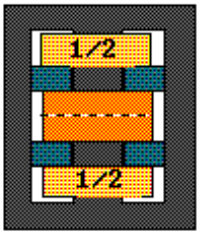
Side-by-side windings with magnetic SHUNT in space between coils.

SINGLE PHASE



TYPE 4

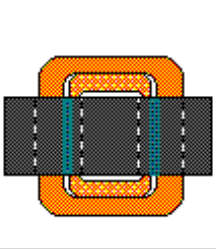
Interleaved coils where primary and secondary can be one coil or two part coils. User can select arrangement of these coils.

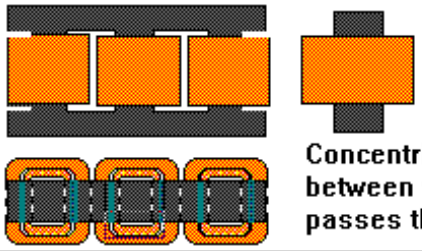


TYPE 5

Interleaved coils where primary and secondary can be one coil or two part coils. Magnetic SHUNTS in space between coils. User can select arr

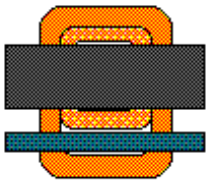
SINGLE PHASE or THREE

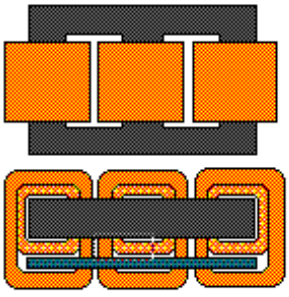


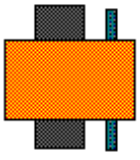


TYPE 6

Concentric coils with SHUNT placed between windings where coil passes through the CORE WINDOW.





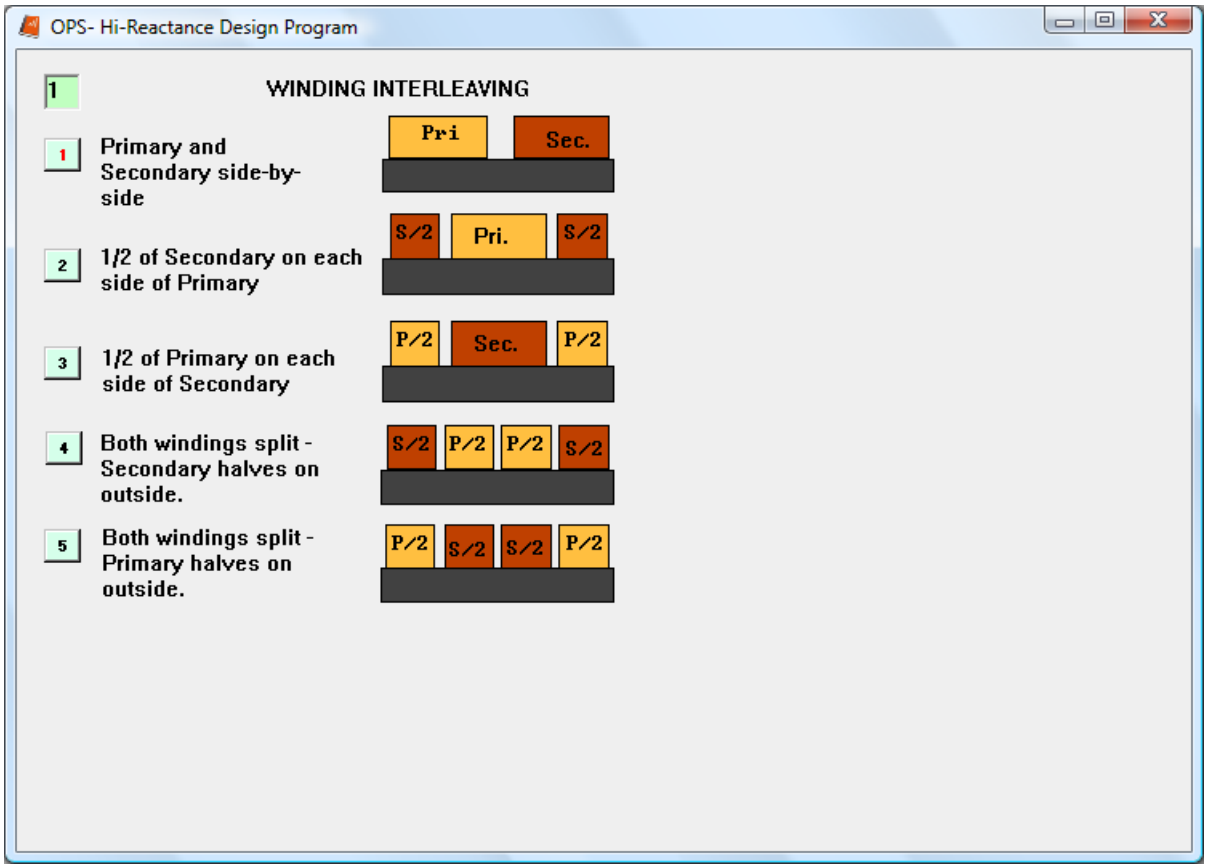


TYPE 7

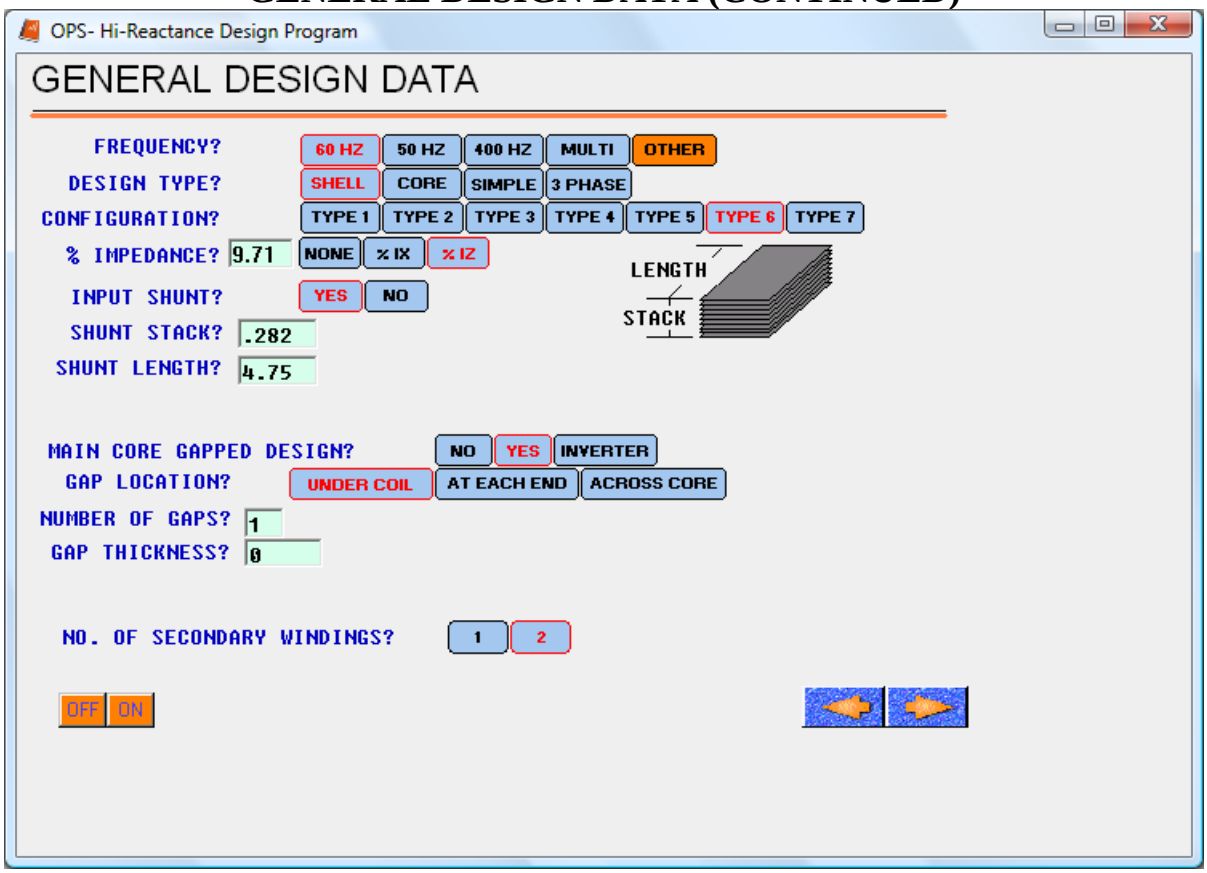
Concentric windings with SHUNT as SEPARATE CORE with 1 or more AIR GAPS.

WINDING INTERLEAVING

WINDING ARRANGEMENTS for Types 4 and 5.



GENERAL DESIGN DATA (CONTINUED)



IMPEDANCE: For types 4-7 only. Enter required impedence as either % IX or % IZ.
INPUT SHUNT: For Types 3 and 5 only. Enter **YES** if shunt is being entered.
SHUNT STACK: Enter stack dimension of the shunt.
SHUNT LENGTH: Enter the length of the shunt. Program will determine shunt gap.

GAPPED DESIGN: Air gap is to be present in the core leg.

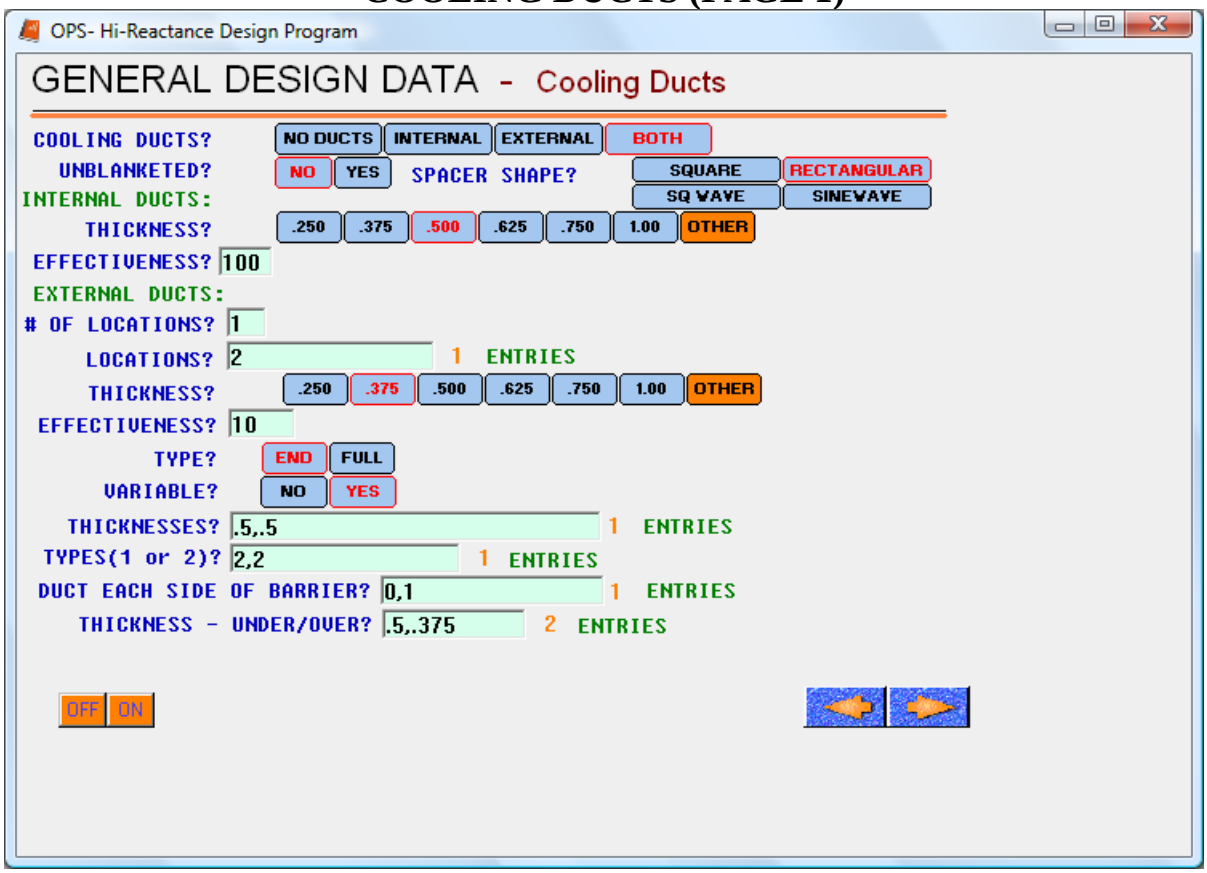
NO: No gap is used.
YES: Enter total length of the air gap to appear across the core.
INVERTER: Primary voltage is alternating D.C.

GAP LOCATION: Select one -

UNDER COIL: Gap appears in center-leg under the coil,
AT EACH END: Gap appears at each end of center-leg
ACROSS CORE: Gap is across core.
NUMBER OF GAPS: Number of gaps to be used.
GAP THICKNESS: Total thickness of gap in inches.

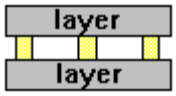
NO. OF SECONDARY WINDINGS: Enter number of secondary (output) windings. Two (2) are permitted.

COOLING DUCTS (PAGE 1)



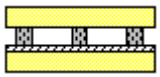
COOLING DUCTS: Spaces in coils that permit air or oil to flow parallel to the coil axis.

INTERNAL DUCTS:
Ducts are placed within windings only



EXTERNAL DUCTS:
Ducts are placed between winding only

BOTH: Ducts both within and between windings.



UNBLANKETED: No insulation in ducted area.

UNBLANKETED **BLANKETED**

SPACER SHAPE: Shape of actual duct spacer.

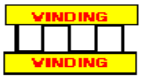
SQUARE: Both dimensions of spacer are the same.

RECTANGULAR: Width of spacer can be different than thickness.

CORRUGATED DUCT SPACER SHAPE: **(**METAL **Spacers only).**

Square wave or Sine wave -

SINE WAVE CORROGATED DUCT.

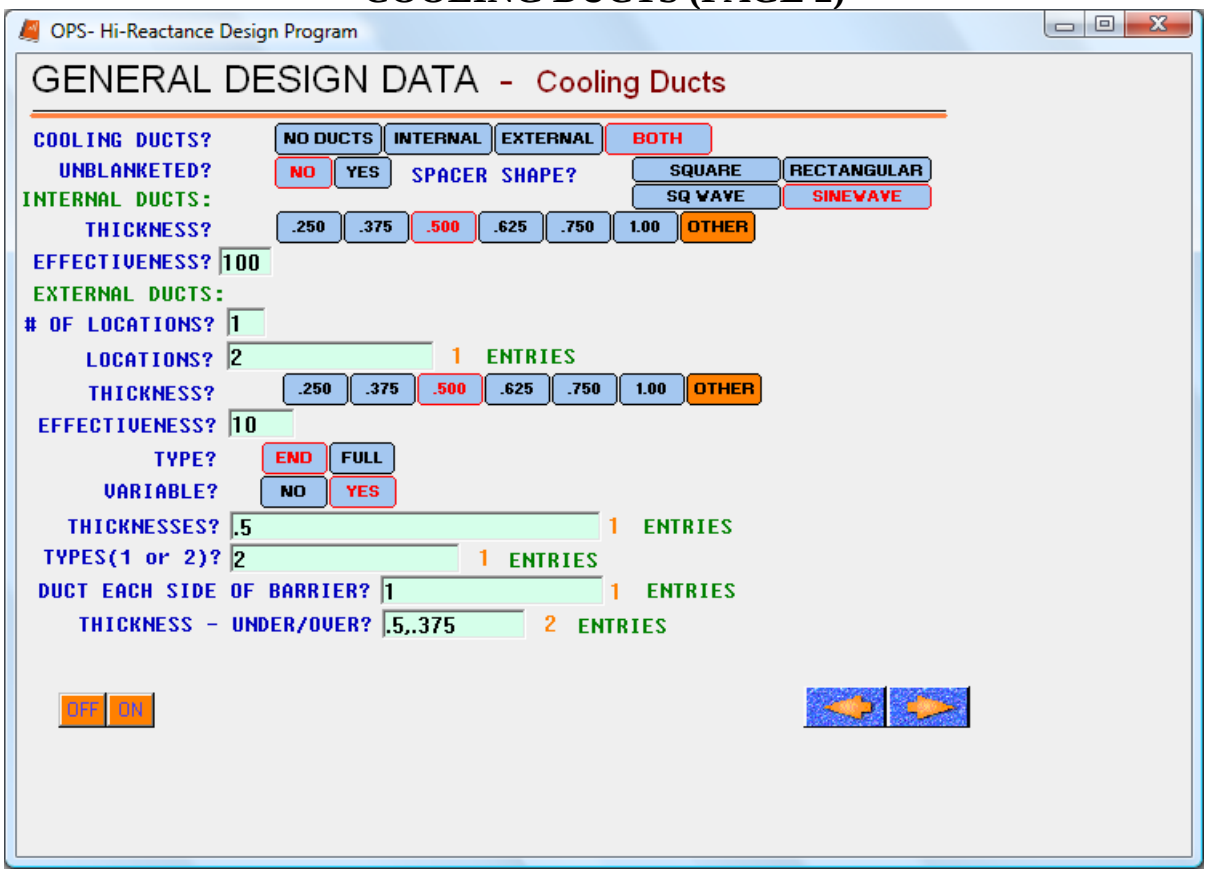


SQUARE WAVE CORROGATED DUCT.

THICKNESS: Thickness of duct opening.

EFFECTIVENESS: Percent of duct free from obstruction , such as leads.

COOLING DUCTS (PAGE 2)



EXTERNAL DUCT -

 # OF LOCATIONS: Enter number of required duct locations.

LOCATIONS: Enter number of winding **UNDER** which duct is to be located. (2 indicates duct under second winding, etc.)

THICKNESS: Radial thickness of duct opening.

EFFECTIVENESS: Percent of duct free from obstruction.

END DUCTS

FULL DUCTS

TYPE -

END: Ducts on ends of coils outside core window

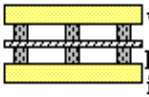
FULL: Duct around coil.

VARIABLE- YES: If all external ducts are of different size or type or if duct is to be on each side of the barrier.

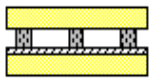
THICKNESS: Enter thickness for each external duct.

TYPE: Enter (1) for End or (2) for Full for each external duct.

DUCT EACH SIDE OF BARRIER : Enter (1) for **YES** or (0) for **NO** for each external duct.



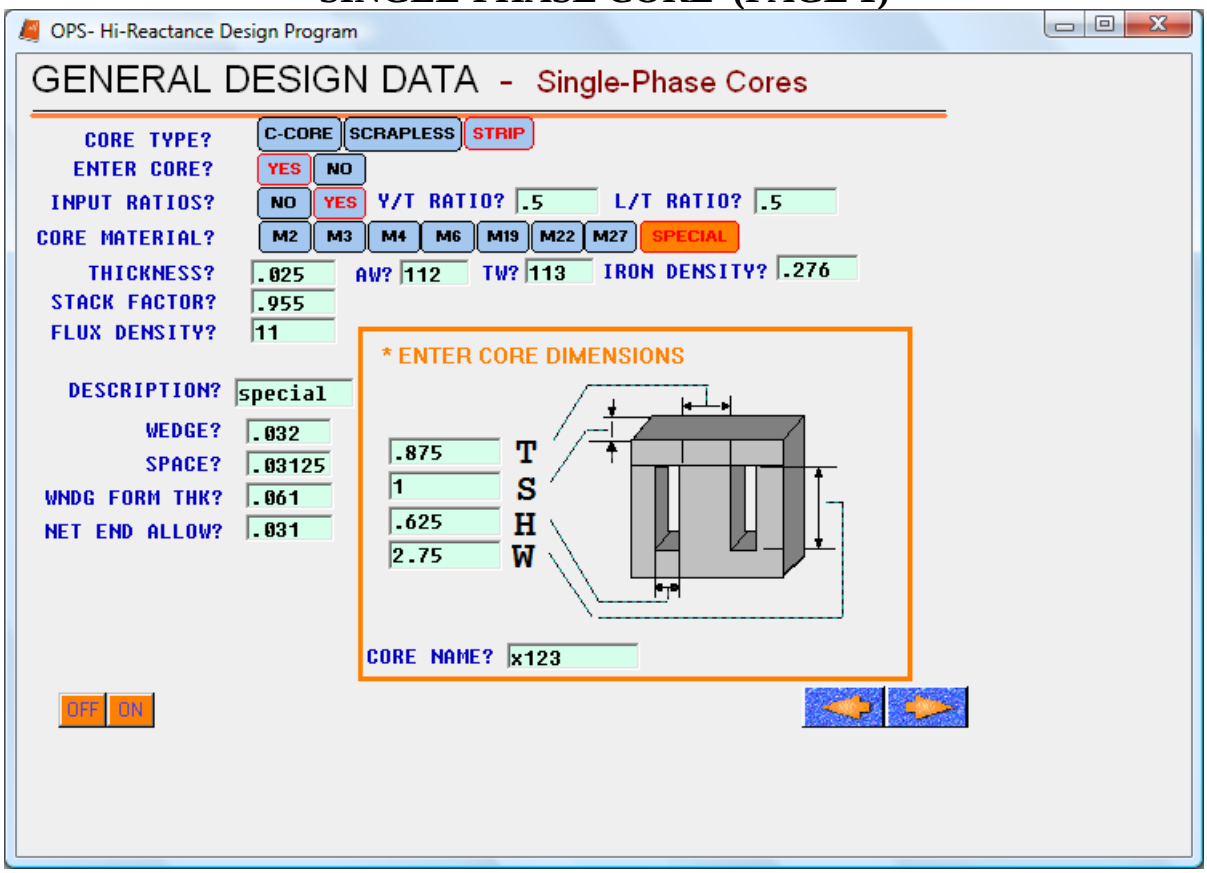
YES, a duct will be placed on each side of insulation barrier.



No, the duct will be placed over the section insulation of the previous winding.

THICKNESS UNDER/OVER: Enter thickness for duct under and over the barrier.

SINGLE-PHASE CORE (PAGE 1)



CORE TYPE: Type of core structure.

C-CORE: Wound cut cores.

SCRAPLESS: Tool made laminations.

STRIP: Core made with sheared strips.

ENTER CORE -

YES: Core dimensions must be entered on next page.

NO: Core will be selected by **HIREAC** for C-Core, Scrapless and Strip only.

INPUT RATIOS -

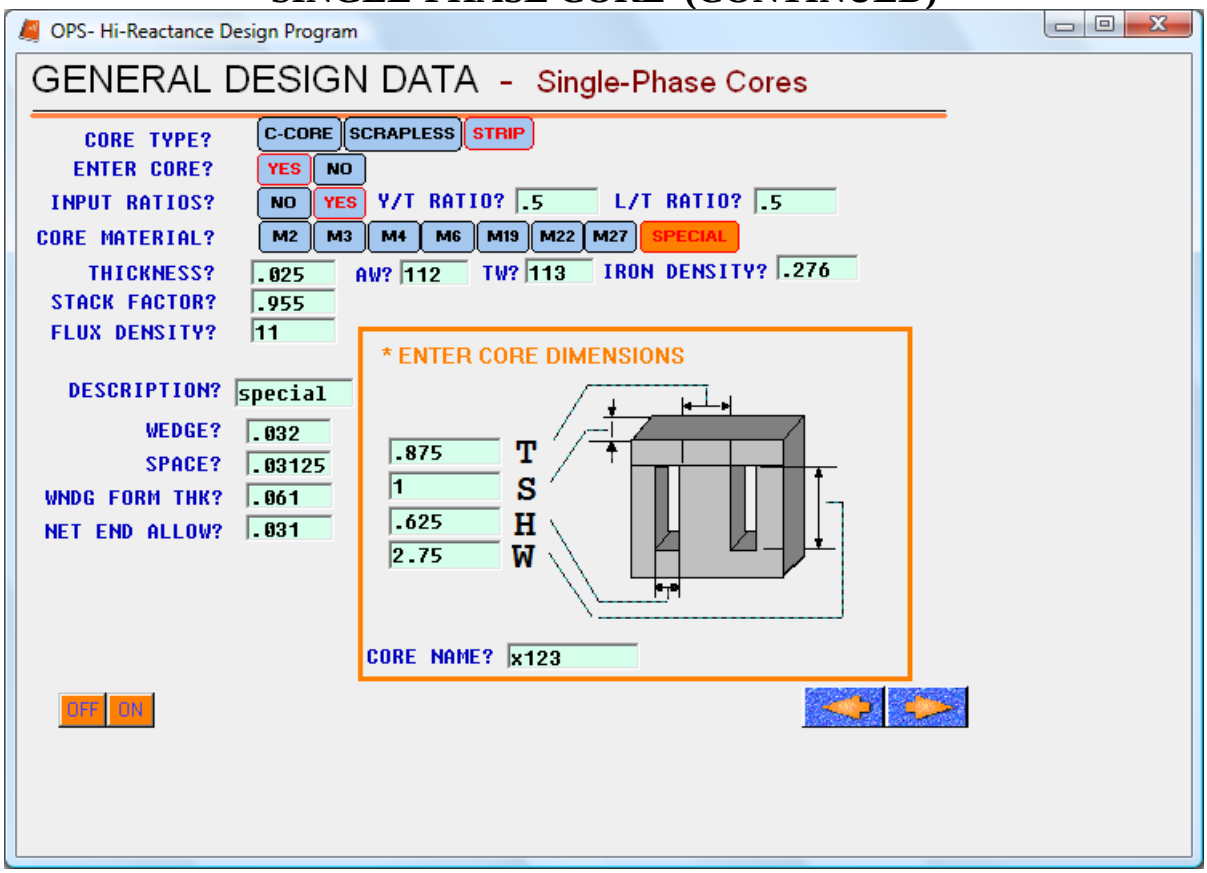
NO: Normal ratios to give uniform cross-section throughout the core structure are assumed.

Default values are:

For single phase (Shell Type)	Leg/Tongue = .5	Yoke/Tongue = .5
For three-phase (Three-Leg)	Leg/Tongue = 1	Yoke/Tongue = 1
For three-phase (Five-Leg)	Leg/Tongue = .5	Yoke/Tongue = .6

YES: Yoke/Tongue and Leg/Tongue must be entered.

SINGLE-PHASE CORE (CONTINUED)



Y/T RATIO: Of the width of strip in core ends to the core leg strip width.

L/T RATIO: Of width of strip in outside core legs to width of strip in core center leg. For shell type core only.

CORE MATERIAL-

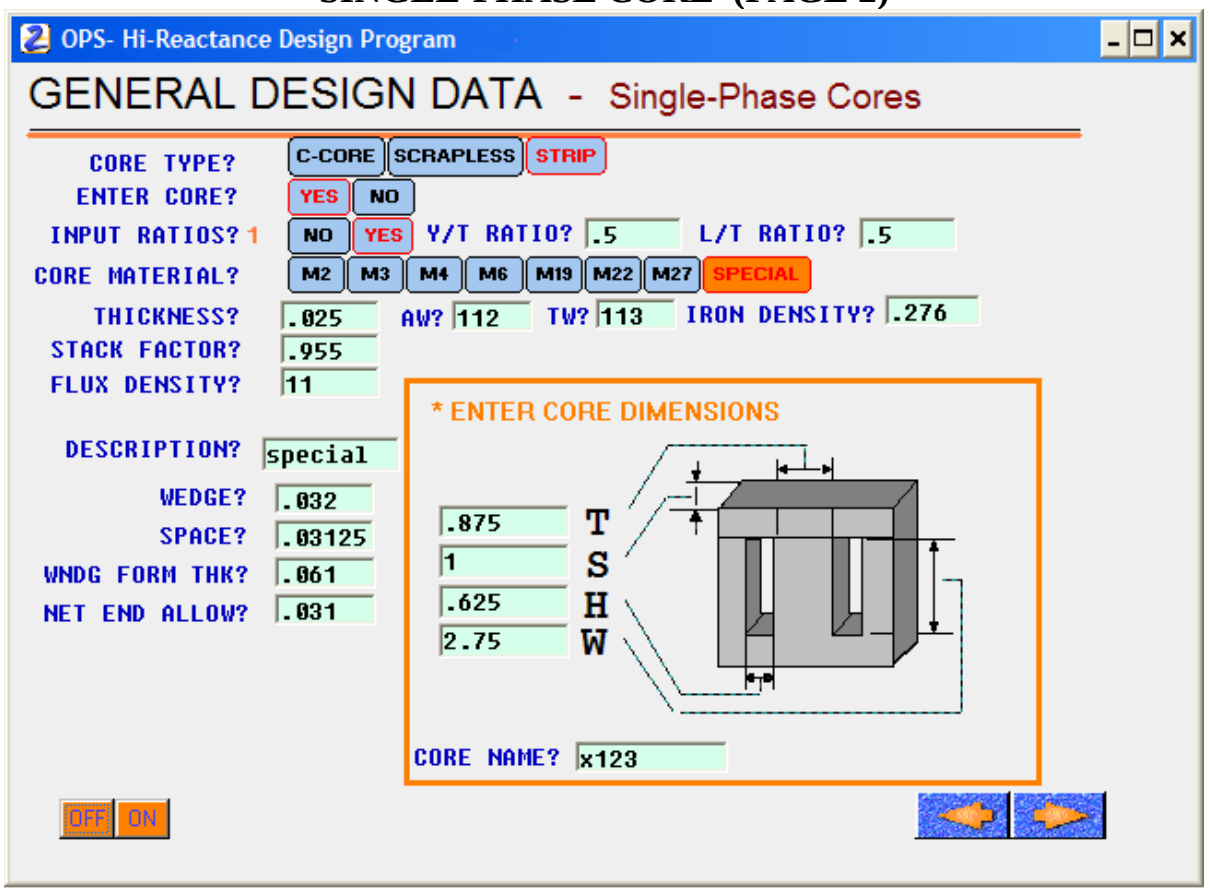
M GRADE: ASTM material grade designation (M6, etc.)
For stamped lamination cores – 6, 15, 19, 22, 27, 36, 45, 50, 54, 55
For strip or cruciform cores – 2, 3, 4, 6, 19, 22, 27

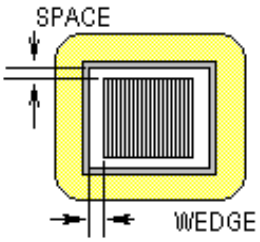
THICKNESS: Thickness of individual lamination.

STACKING FACTOR: Proportion of core stack that is actually iron.

FLUX DENSITY: Induction in core (in kilo-gausses).

SINGLE-PHASE CORE (PAGE 2)





WEDGE: Thickness allowed at each end of the core stack (S).

SPACE: Thickness allowed on each side of the core tongue (T).

WNDG. FORM THK: Total thickness of winding tube, bobbin, or insulation under the first layer of wire.

NET END ALLOW: Net difference between the coil length and the wide dimension (W) of the core window.

SEC. PROPORTION: Enter proportion of net winding space to be allocated to secondary. (Asked for Types 1 through 5).

CORE DIMENSIONS -

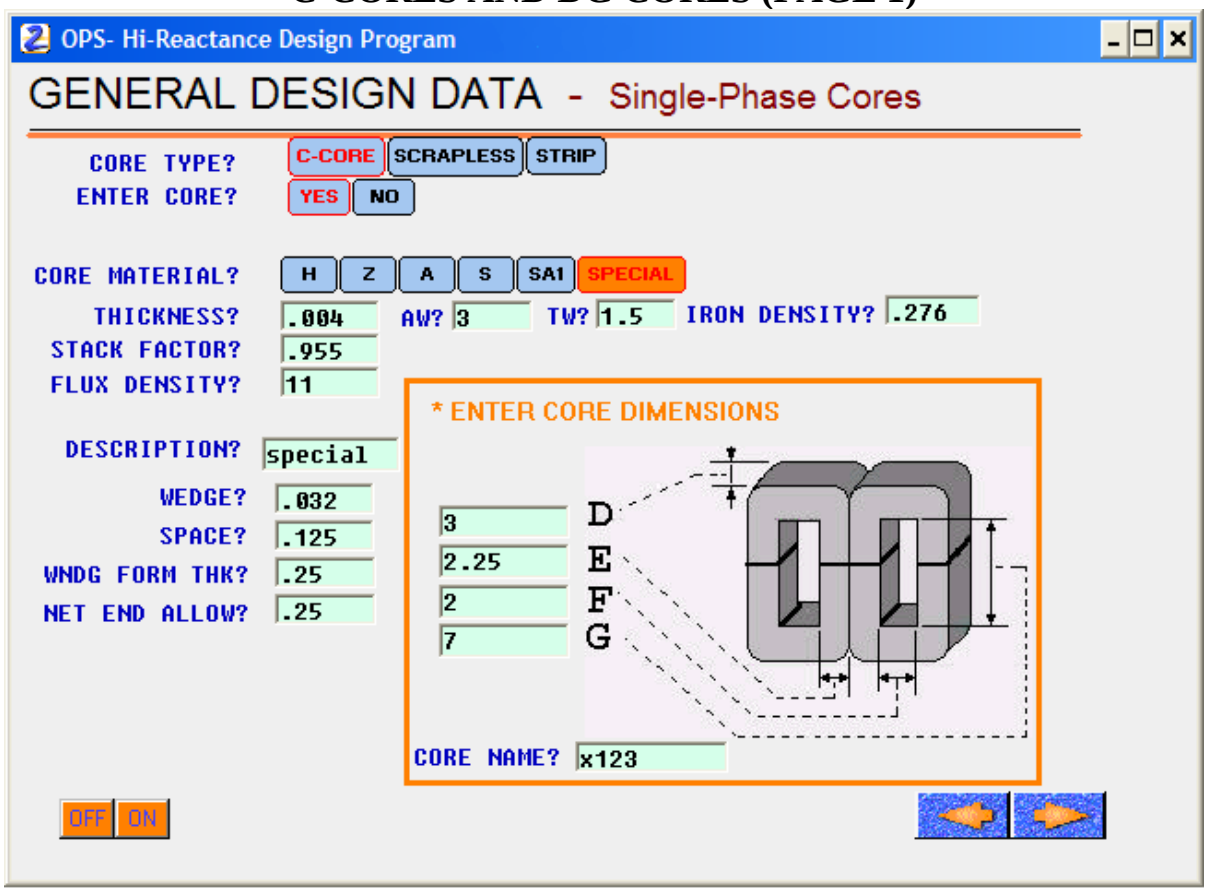
T: Strip width of core center leg.

S: Stack of laminations.

H: Narrow dimensions of core window.

W: Wide dimension of core window.

C-CORES AND DG CORES (PAGE 1)



CORE TYPE -

C-CORE: Wound cut core

SCRAPLESS: Tool made laminations.

STRIP: Core made with sheared strips.

ENTER CORE -

YES: Core dimensions must be entered on next page.

NO: Program selects core from file for C-Cores in the database.
DG core dimensions must always be entered.

CORE MATERIAL: For C-CORES:

H: 4 mil oriented silicon

Z: 4 mil super-oriented silicon

A: 12 mil oriented silicon

S: 4 mil supermendur

SAI: Amorphous metal

SPECIAL: If none of the above, the enter the following-

AW: Excitation loss in VA/Pound (VA/Kilograms for SI units)

TW: Core loss in Watts/Pound (Watts/Kilograms for SI units)

IRON DENSITY: Core material weight in pounds/cubic inch. (Grams/mm^3 for SI units)

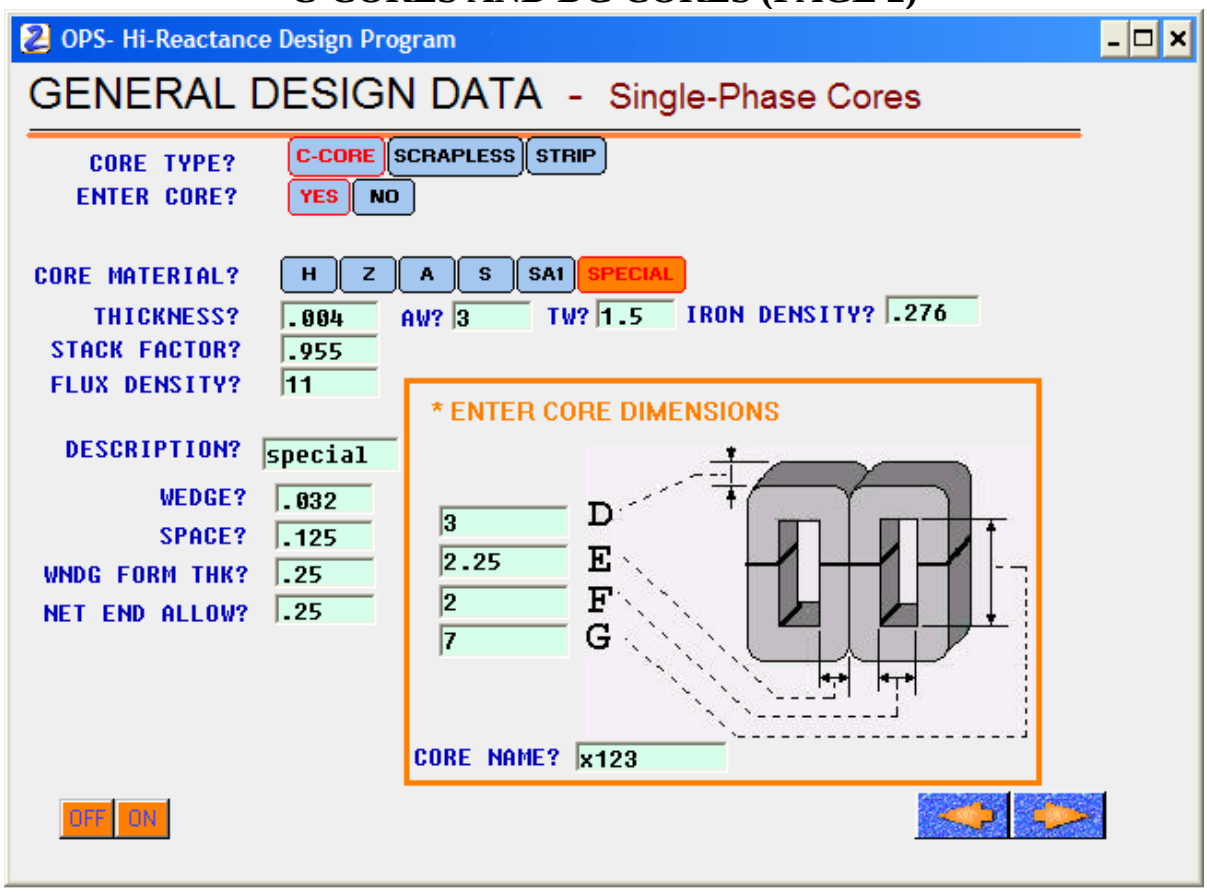
DESCRIPTION: Name of core material.

THICKNESS: Thickness of individual lamination.

STACK FACTOR: Proportion of core leg that is actually iron.

FLUX DENSITY: Induction in core (in kilo-gausses).

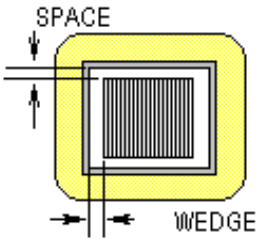
C-CORES AND DG CORES (PAGE 2)



CORE DIMENSIONS -

D: Strip width of wound core.
E: Build-up of strip.
F: Narrow dimension of core window.
G: Wide dimension of core window.

CORE NAME: Core identifier when core is entered.



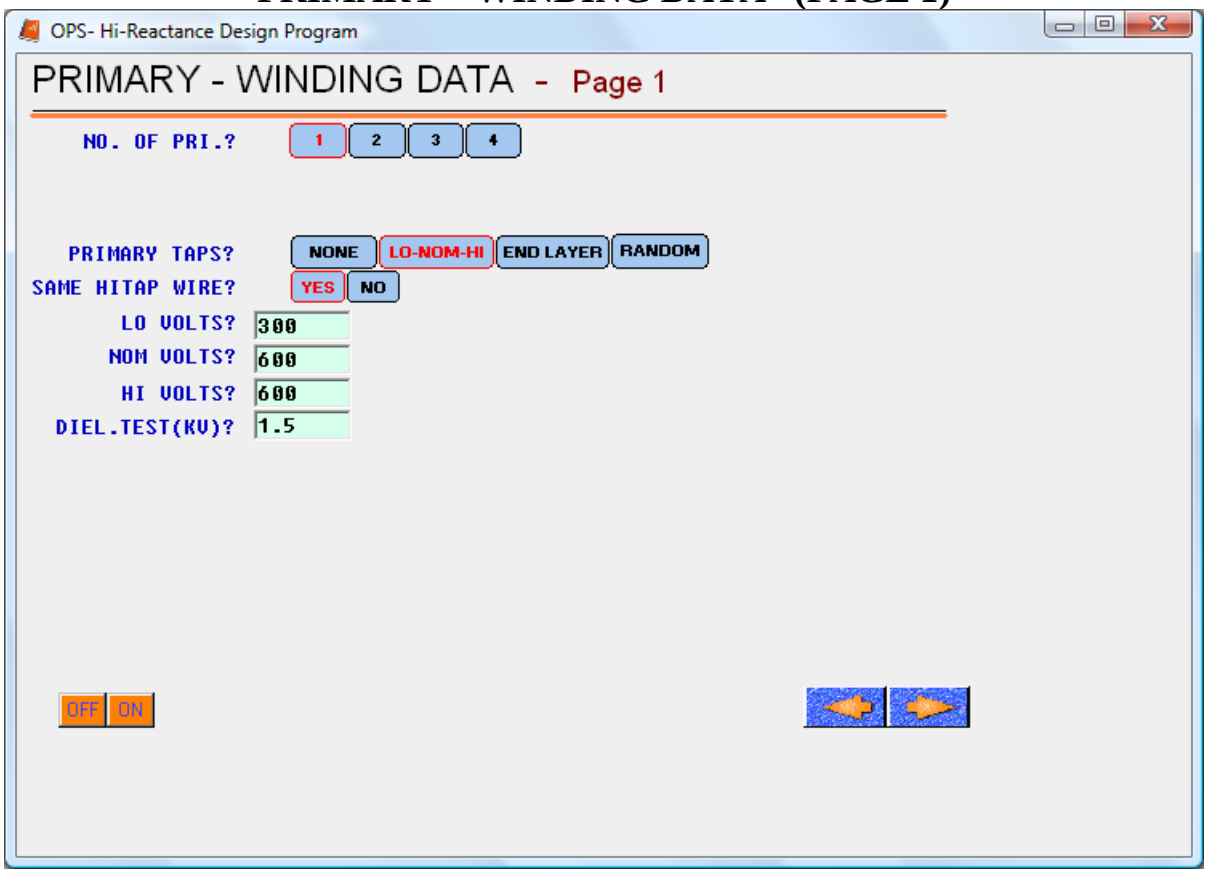
WEDGE: Clearance allowed at each side of "**D**" dimension.

SPACE: Clearance allowed at each side of "**E**" dimension.

WNDG FORM THK: Total thickness of winding tube, bobbin, or insulation under the first layer of wire.

NET END ALLOW: Net difference between coil length and window "**G**" dimension.

PRIMARY – WINDING DATA (PAGE 1)



NO. OF PRI: Number of Primary windings.
Select 1 for single primary winding
Select 2 for two identical primaries
Select 3 or 4 for extended primaries **(See 2TRANS Manual Page 37-43).**

THREE PHASE -

WYE: One end of each three-phase winding is connected to a common point. (neutral)

WYE

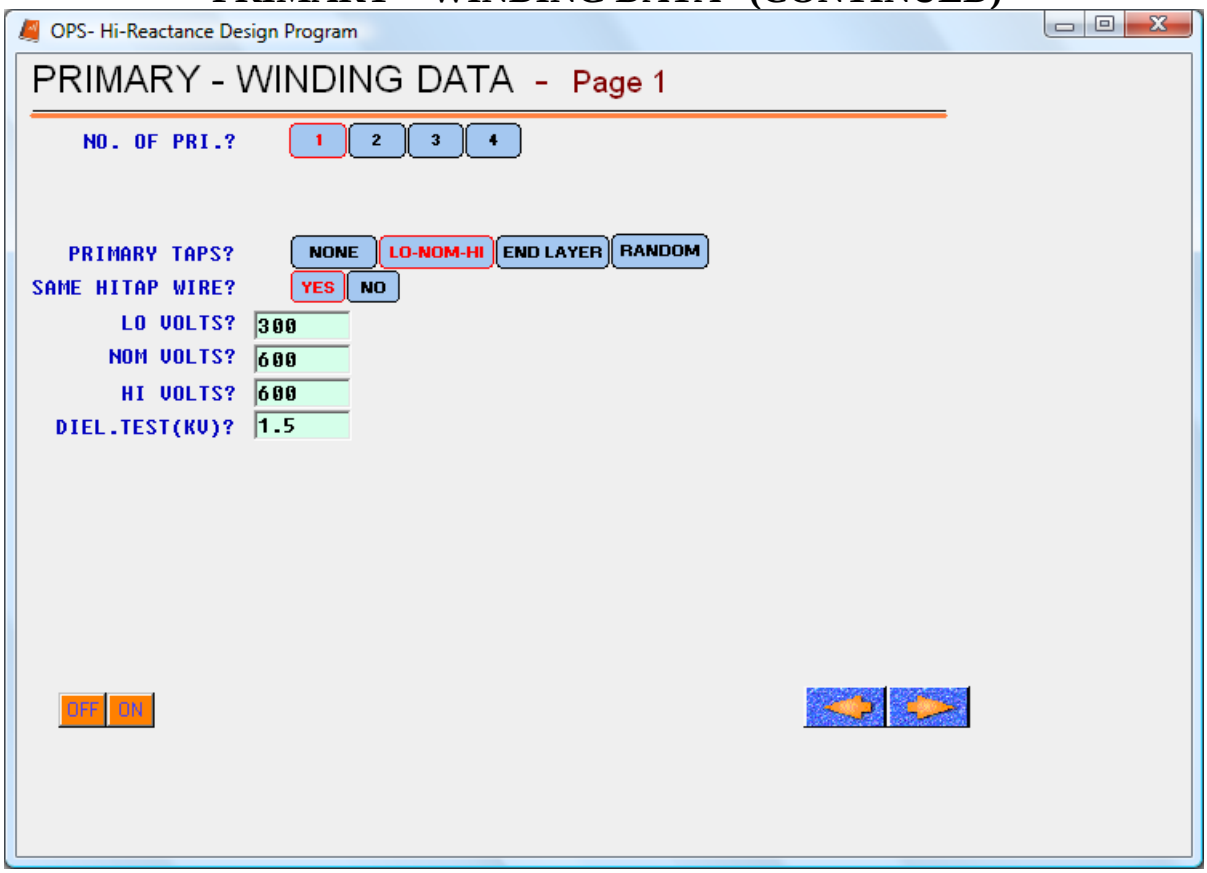
DELTA: Three-phase windings are connected in series for a closed circuit.

DELTA

PRIMARY TAPS -

NONE: No Taps.
LO –NOM – HI: Tap below nominal and above nominal in primary only.
END LAYER: Up to 6 taps permitted in each winding with all taps exiting at end of layers.
RANDOM: Up to 6 taps permitted in each winding with taps exiting the coil wherever they occur.

PRIMARY – WINDING DATA (CONTINUED)



SAME HITAP WIRE -

YES: Entire primary is wound with the same wire.

NO: Portion of primary above the nominal is wound with a different wire.

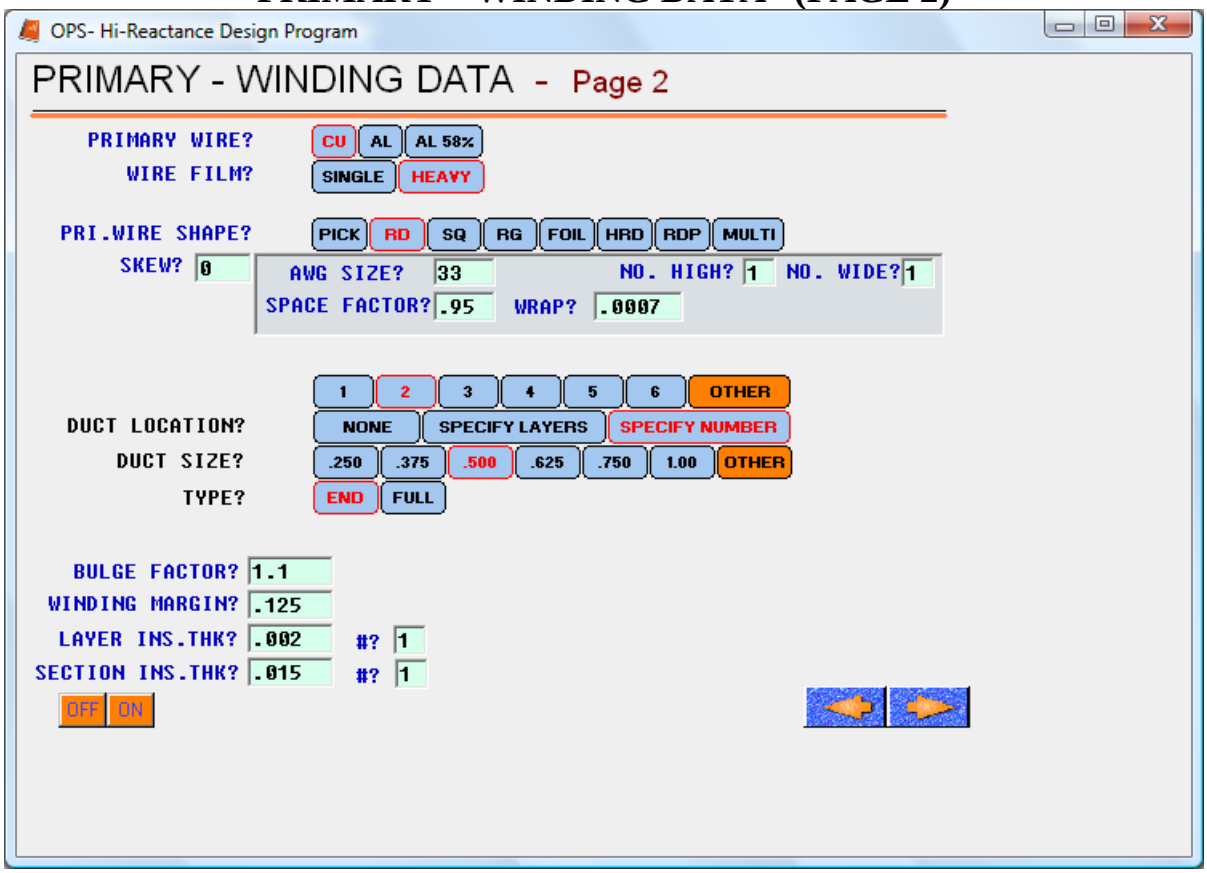
LO VOLTS: Lowest voltage tap on the primary.

NOM VOLTS: Nominal voltage tap on the primary.

HI VOLTS: Highest voltage tap on the primary.

DIEL. TEST (KV): Test voltage in kilo-volts usually applied for 1 minute.

PRIMARY – WINDING DATA (PAGE 2)



PRIMARY WIRE: Select Copper (CU) or Aluminum (AL).

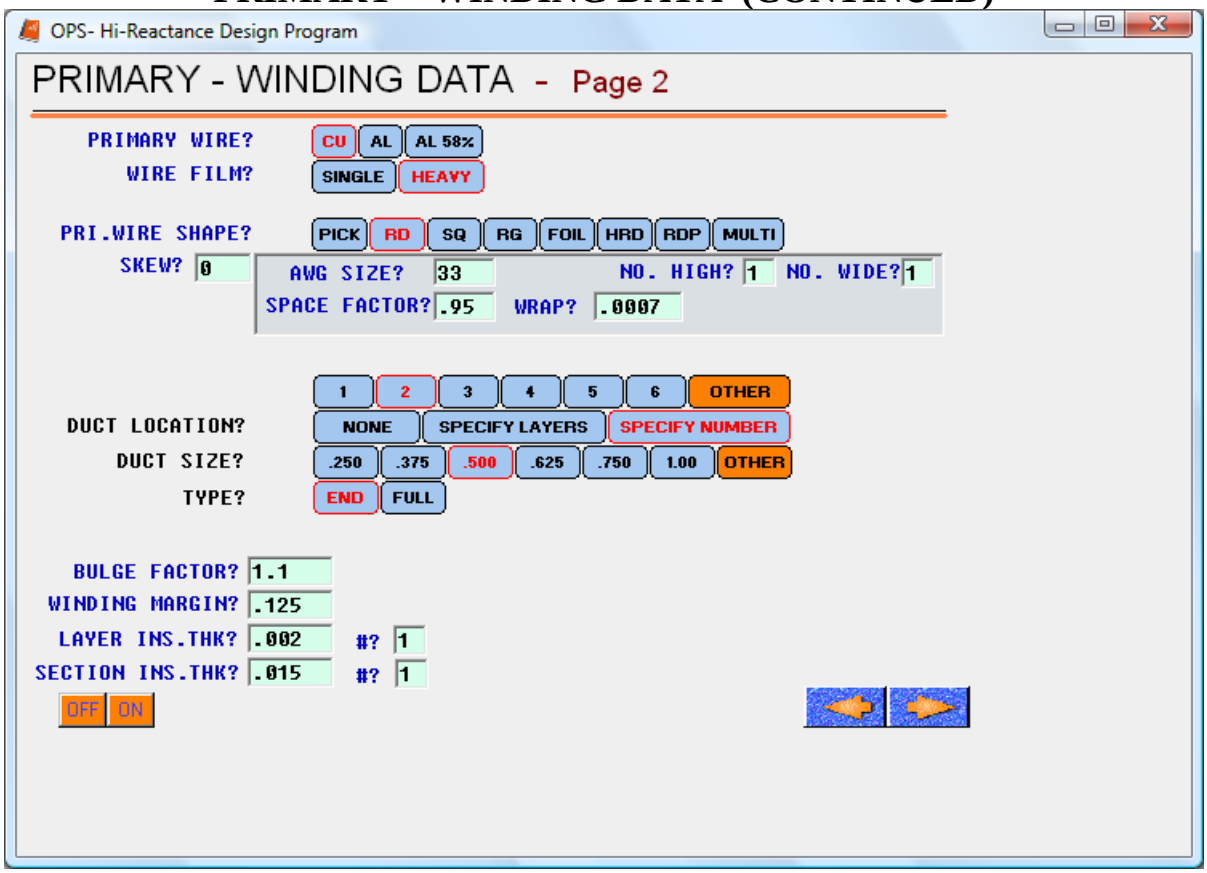
WIRE FILM: Select Single Film or Heavy Film.

PRI. WIRE SHAPE -

PICK: Program selects from wire file.
RD: Round wire: Enter as AWG wire size.
SQ: Square wire: Enter as AWG wire size.
RG: Rectangular wire: Enter as thickness and width.
FOIL: Foil or Strip: Enter as thickness and width.
HRD: Round half AWG size wire.
RDP: Round wire precision wound.
MULTI: Wire consisting of more than one size. **(See 2TRANS Manual Page 36).**

SKEW: Portion of a turn width subtracted from the winding space because of skew in the winding. A value of (1) means 1 turn width subtracted.
AWG SIZE: Standard American wire gauge sizes for round and square wires.
NO HIGH: Number of wire strands high in a multi-stranded wire.
NO. WIDE: Number of wire strands wide in a multi-stranded wire.

PRIMARY – WINDING DATA (CONTINUED)



SPACE FACTOR: Proportion of space occupied by wire that is actually wire.

WRAP: Thickness of wrap on a conductor. If (0) the program uses designated film thickness.

DUCT LOCATION-

NONE: No ducts

SPECIFY LAYERS: Select number of layers desired between internal ducts in this winding.

*****NOTE: See 2TRANS Manual Page 55 for other entries permitted for ducting in single phase Core-Type Transformers.**

BULGE FACTOR: Factor applied to winding build when calculating the winding mean turn. Default value is 1.1

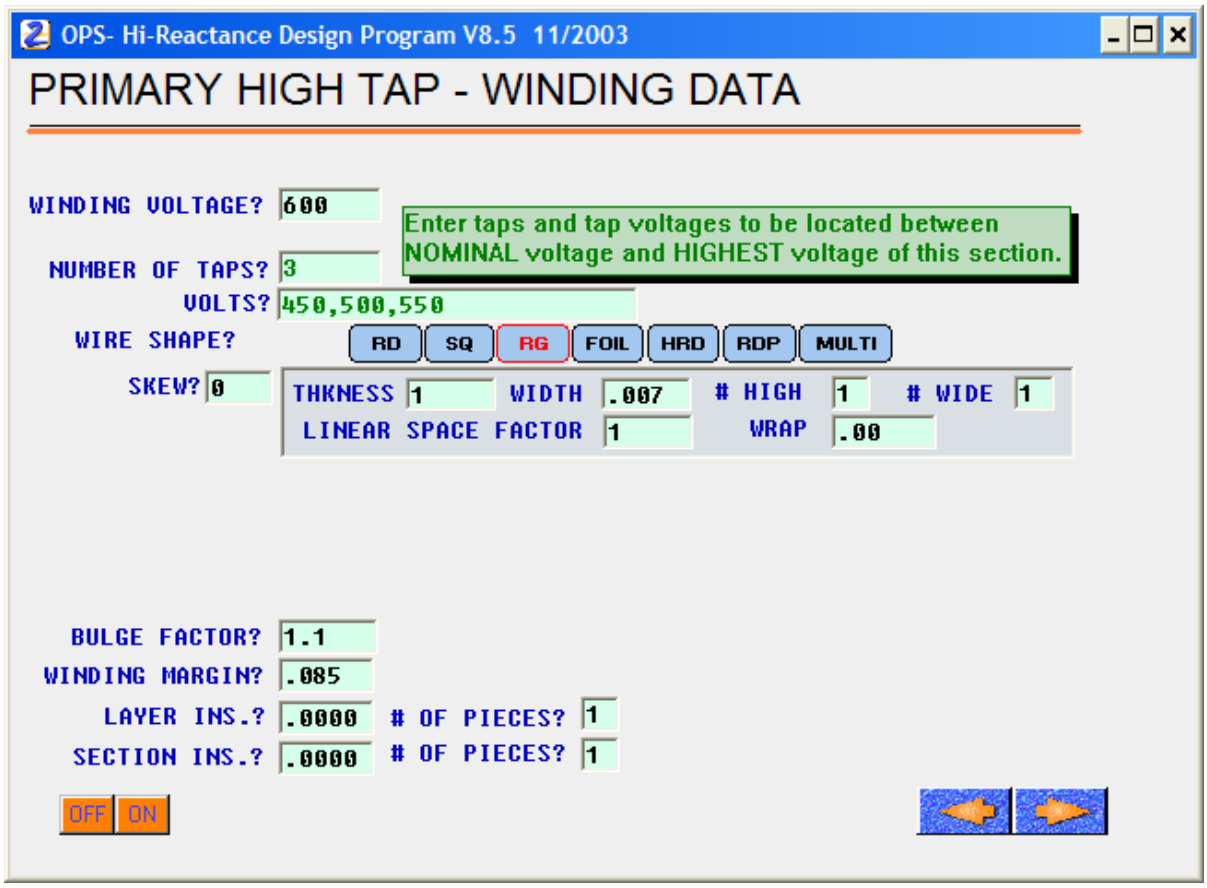
WINDING MARGIN: Distance from each end of the coil from where winding is to begin. (For bobbins, enter flange thickness.)

LAYER INS. THK: Thickness and number of thickness between layers of wire.

*****NOTE: If program is to select insulation, enter voltage stress in volts/per mil. Value must be greater than 9. For SI units enter as volts/mm. Value must be greater than 356.**

SECTION INS. THK: Enter as thickness and number of thicknesses.

HIGH TAP – WINDING DATA

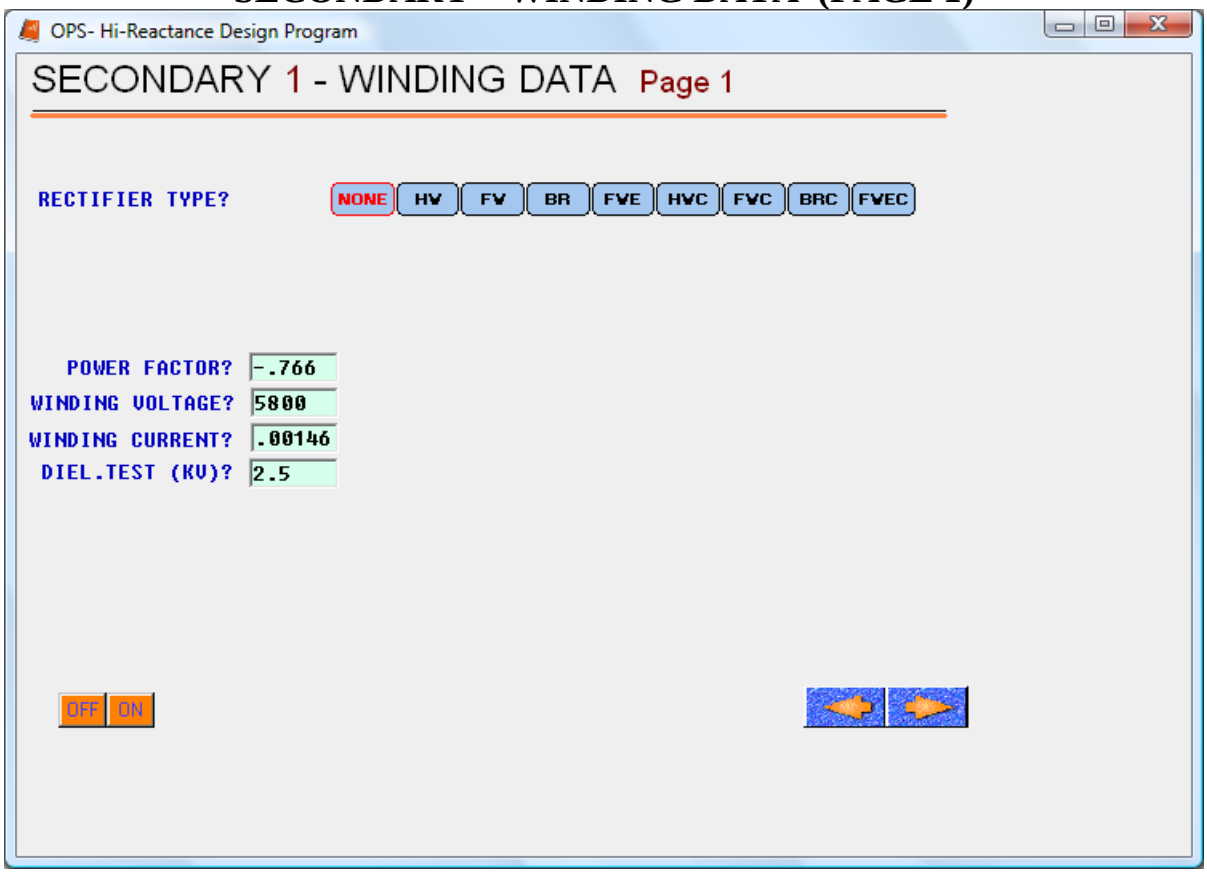


WINDING VOLTAGE: Total voltage of the primary nominal voltage plus the high tap section.

NUMBER OF TAPS: Up to 6 permitted.

TAP VOLTS: Entered as values between the nominal primary voltage and the value shown in the winding voltage (highest voltage of the section).

SECONDARY – WINDING DATA (PAGE 1)



RECTIFIER TYPE -

NONE: Output is not rectified. For Rectified Windings **See 2TRANS Manual Page 51-53.**

THREE PHASE -

WYE: One end of each three-phase winding is connected to a common point. (neutral)

WYE

DELTA: Three-phase windings are connected in series for a closed circuit.

DELTA

POWER FACTOR: Enter as cosine of load power factor angle or as negative (-) if leading

WINDING VOLTAGE: For single phase enter as winding RMS voltage. For three phase Enter as line – to –line voltage.

WINDING CURRENT: For single phase enter as winding RMS current for three phase Enter as line current.

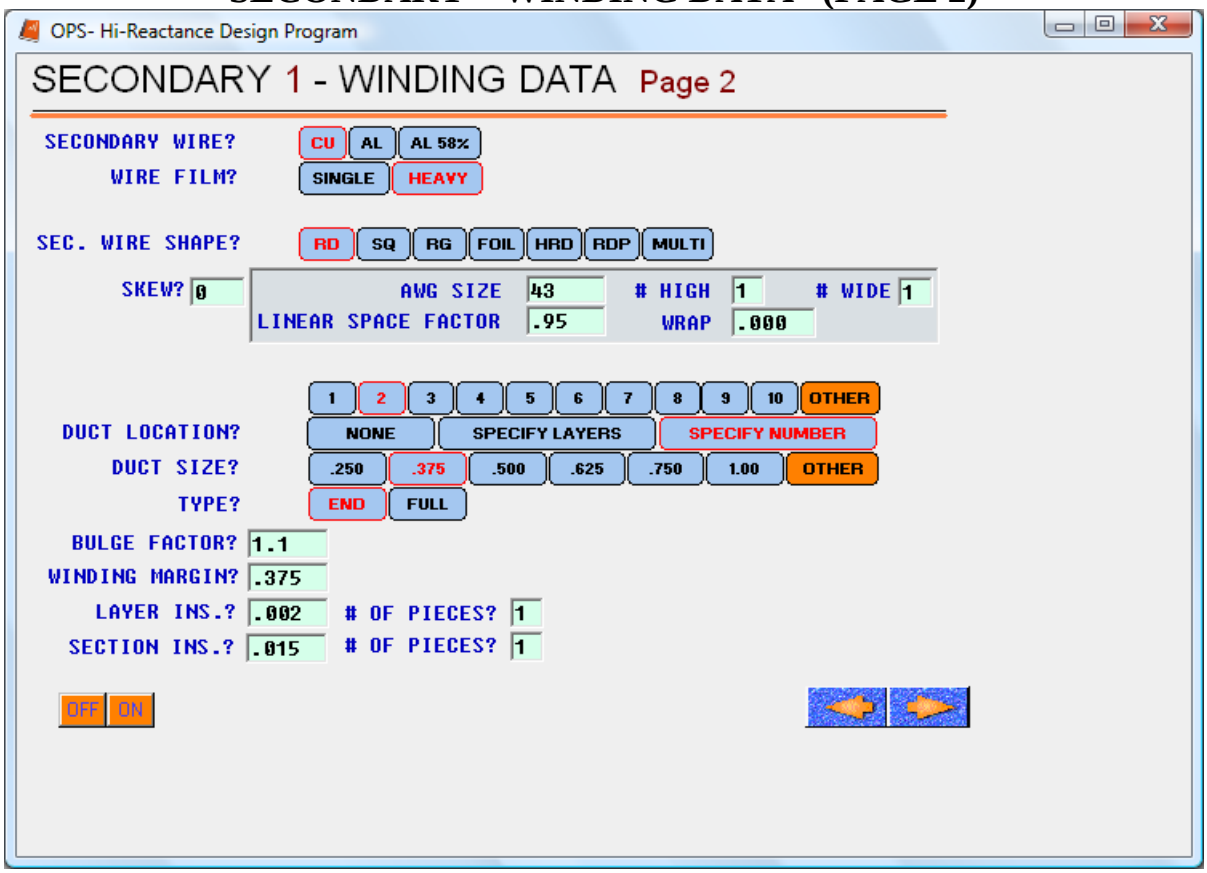
SHORT CIRCUIT CURRENT: Current achieved when first secondary (only)is shorted.

DIEL. TEST (KV): Enter winding test volts in KV.

NUMBER OF TAPS: Up to 6 taps are permitted below the rated secondary voltage.

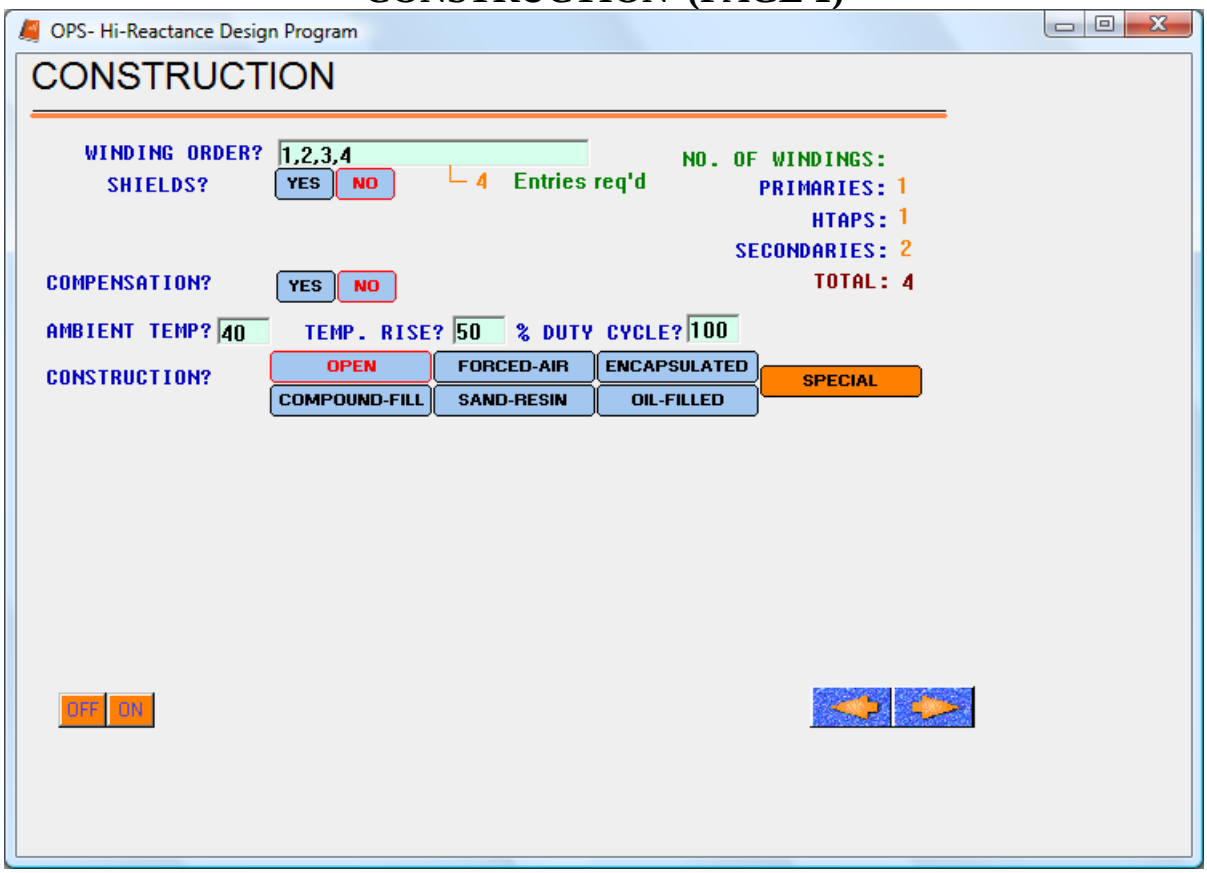
TAP VOLTS: Enter a voltage for each tap specified above.

SECONDARY – WINDING DATA (PAGE 2)

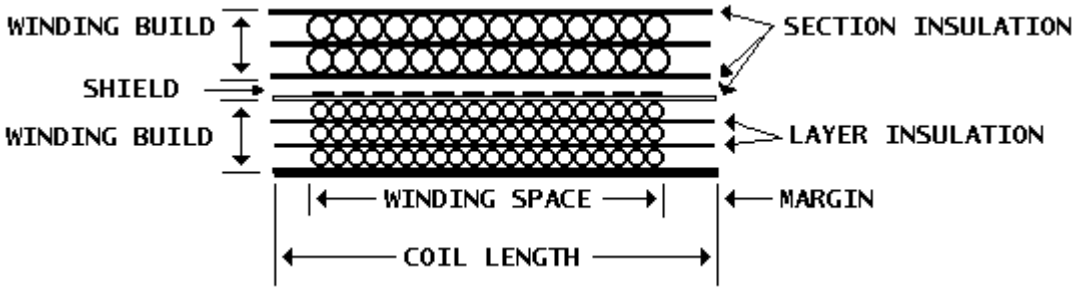


******NOTE: Definitions for all items above are shown on Primary Page 18**.

CONSTRUCTION (PAGE 1)



WINDING ORDER: Data for windings has been entered in the order of P1, P2, S1, S2, etc. Enter a number for each winding indicating the order it is to be wound.



SHIELDS -

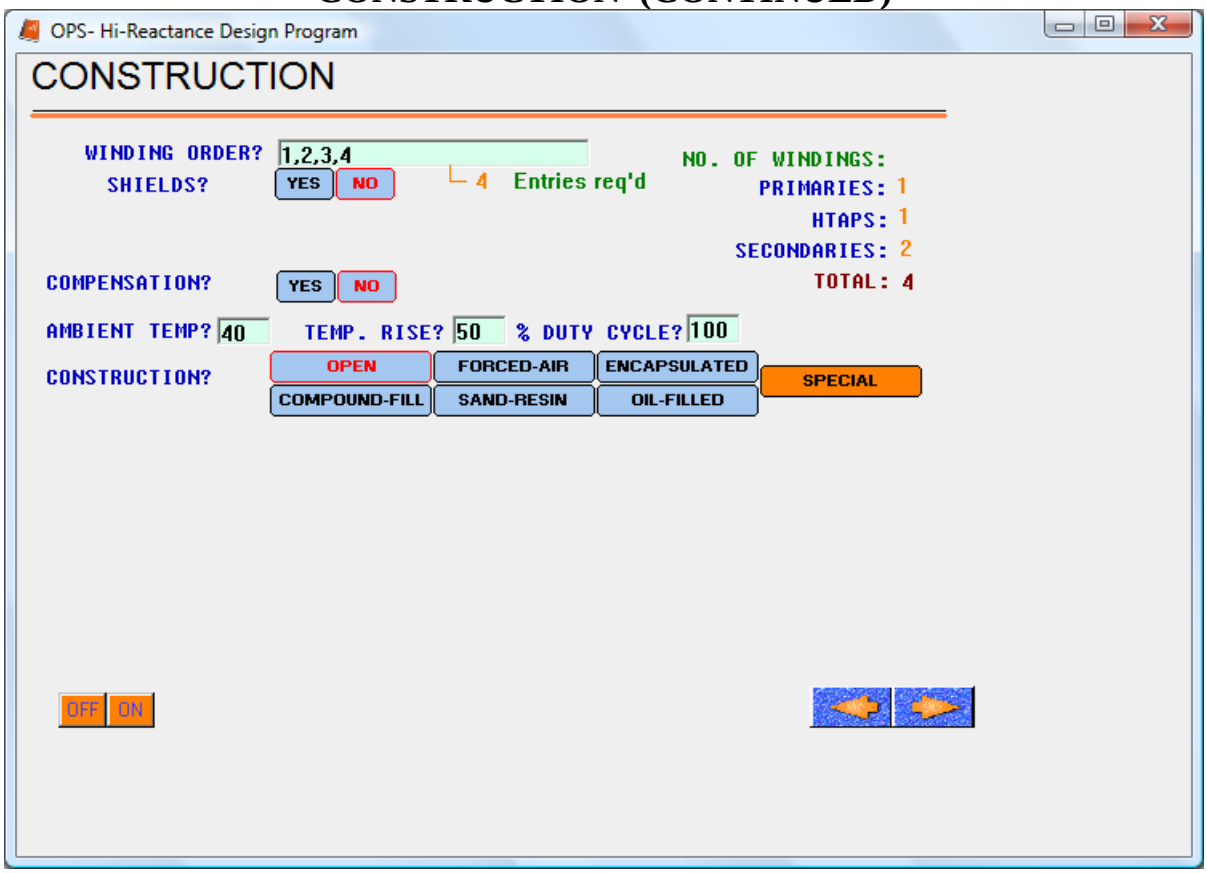
YES: Transformer is to have electro-static shields between some windings.

NO: No shields are to be used.

NUMBER OF SHIELDS: Enter total number of shields.

POSITION: Enter number of the winding under which a shield is to be located. Quantity of entries must correspond to the number of shields.

CONSTRUCTION (CONTINUED)



SHIELD TYPE -

WIRE: A layer of wire corresponding to the smallest wire in the windings adjacent to the shield will be used.

FOIL: A foil will be used for the shield. Enter the thickness of the foil.

INSULATION: Enter the thickness of insulation to be wound over the shield.

COMPENSATION -

YES: Secondary turns will be adjusted to achieve the voltage entered at full load and at operating temperature.

NO: Secondary turns will be determined from the primary/secondary voltage ratio and will not be adjusted for voltage drops.

% REGULATION: Enter output voltage change from no load to full load, as a percentage of full load output volts

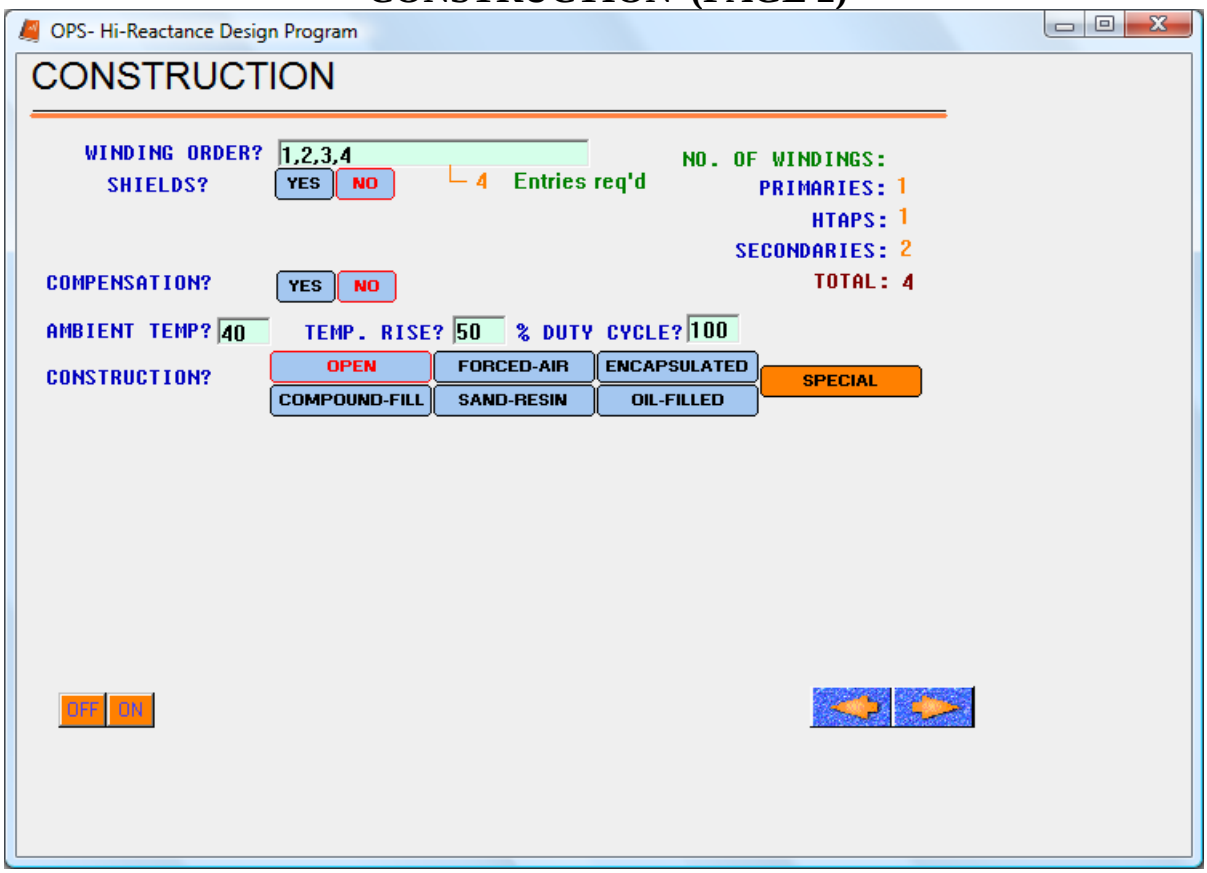
% BUILD: Percentage of the core narrow window dimension actually filled by wire, full ducts, insulation, winding form thickness, and clearance (space).

AMBIENT TEMP: Temperature in degrees C of surrounding air in which the transformer is operating.

TEMP. RISE: Temperature rise permitted in the hottest winding, above the ambient temperature.

% DUTY CYCLE: Percent of on-time where a full rated load is present in a repetitive on-off cycle. (Full load continuous is 100%.)

CONSTRUCTION (PAGE 2)



CONSTRUCTION -

OPEN: Open core-coil

FORCED AIR: Open core-coil with blower driven air.

ENCAPSULATED: Transformer covered with conformal coating.

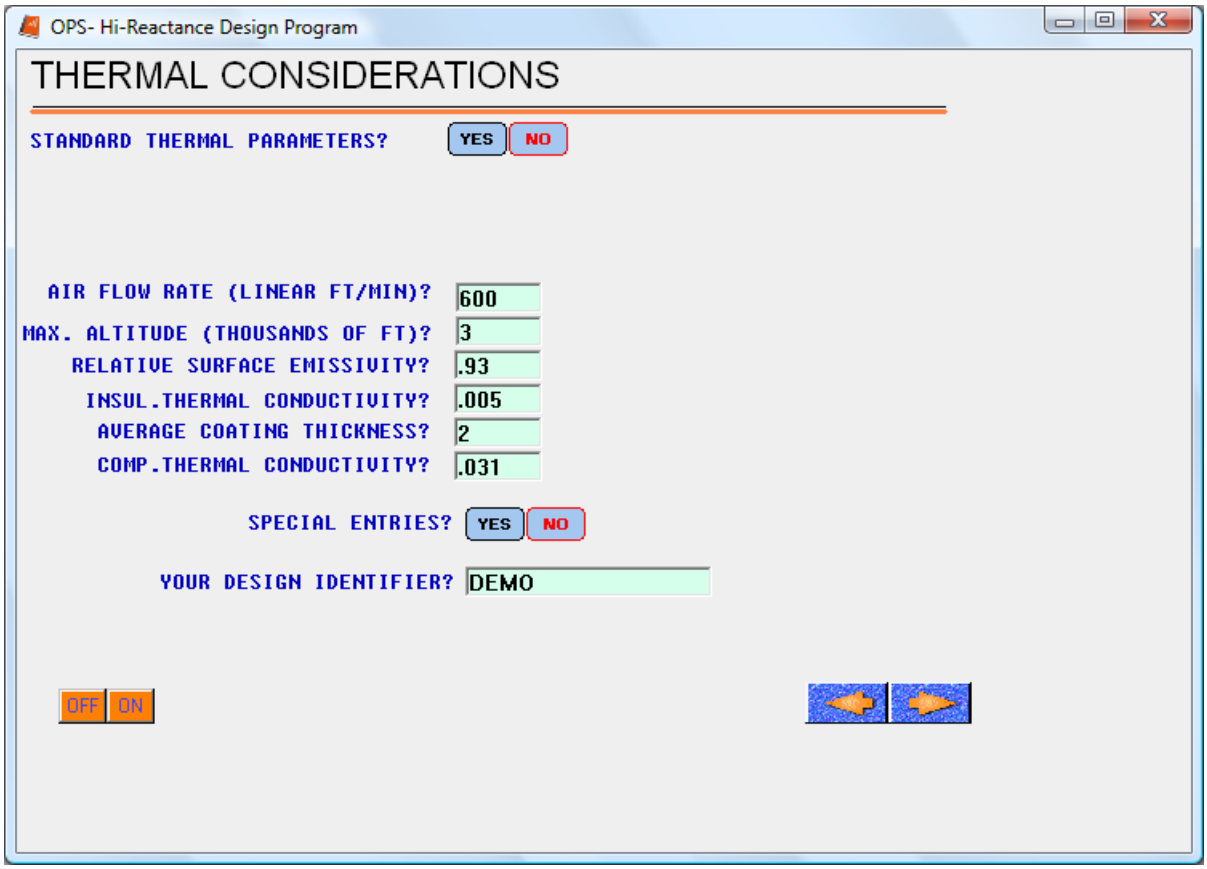
COMPOUND FILLED: Transformer embedded in material filling an enclosure.

SAND RESIN: Transformer embedded in a mixture of sand and resin in an enclosure.

OIL FILLED: Liquid filled enclosure using oil as an insulator and as a cooling medium.

SPECIAL: Special thermal routines. **(See 2TRANS Manual Page 30-31).**

THERMAL CONSIDERATIONS



STANDARD THERMAL PARAMETERS -

YES: **HIREAC** uses default values for altitude, surface emissivity, and thermal conductivity.

NO: User enters values.

AIR FLOW RATE: For forced air designs enter air flow rate in linear feet per minute.

MAX. ALTITUDE: Enter altitude in thousands of feet. Default value is 3.3.

RELATIVE SURFACE EMISSIVITY: A relative measure of surface emissivity used in calculation of radiation coefficient. Default is 0.93.

INSULATION THERMAL CONDUCTIVITY: Average conductivity of layer and section insulation in watt-inches per inch per degree celsius. Default value is .005.

COMP. THERMAL CONDUCTIVITY: Conductivity of material surrounding core-coil.

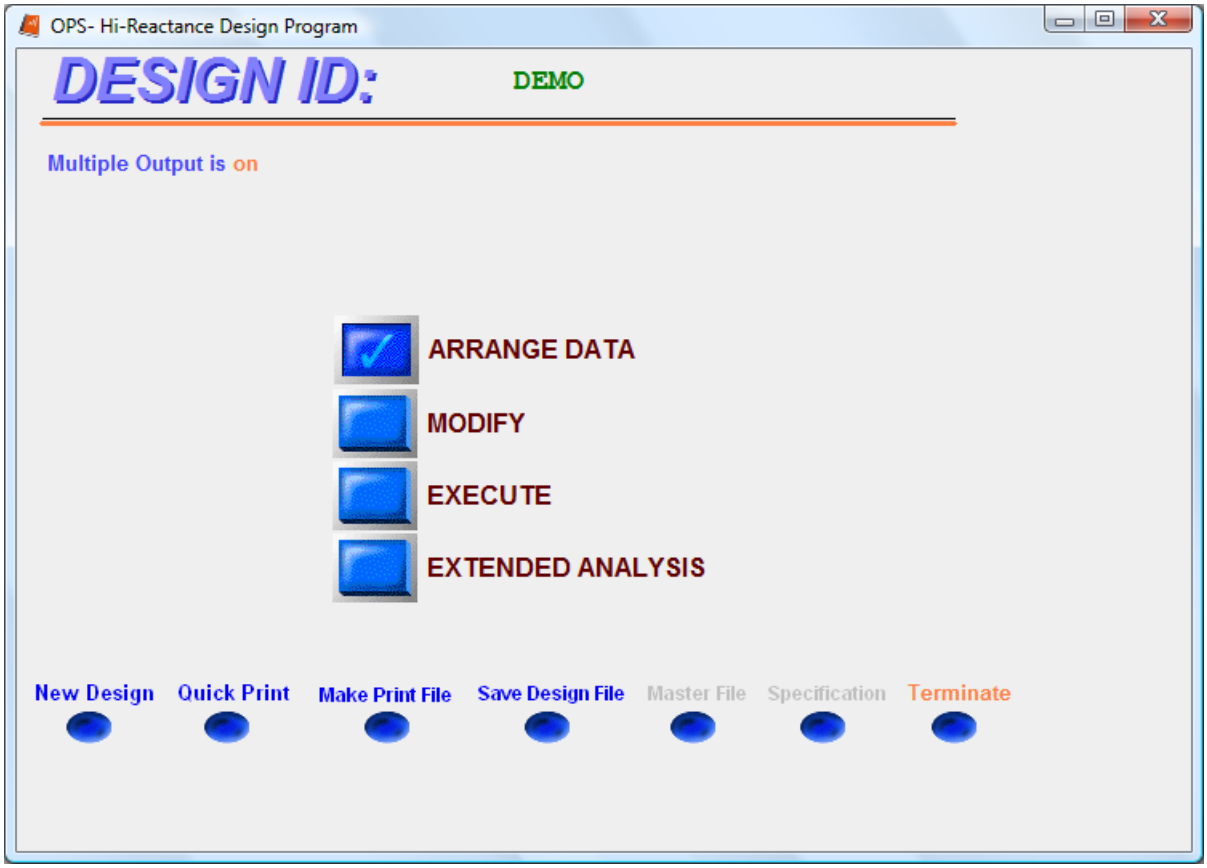
AVERAGE COATING THICKNESS: Average thickness of encapsulating material, compound, or sand-resin embedment.

SPECIAL ENTRIES -

YES: A group of special entry options appears. **(See Page 28).**

NO: No special entries are used.

YOUR DESIGN IDENTIFIER: Used to identify the print-out. Enter any combinations of letters and numbers up to 16 characters.

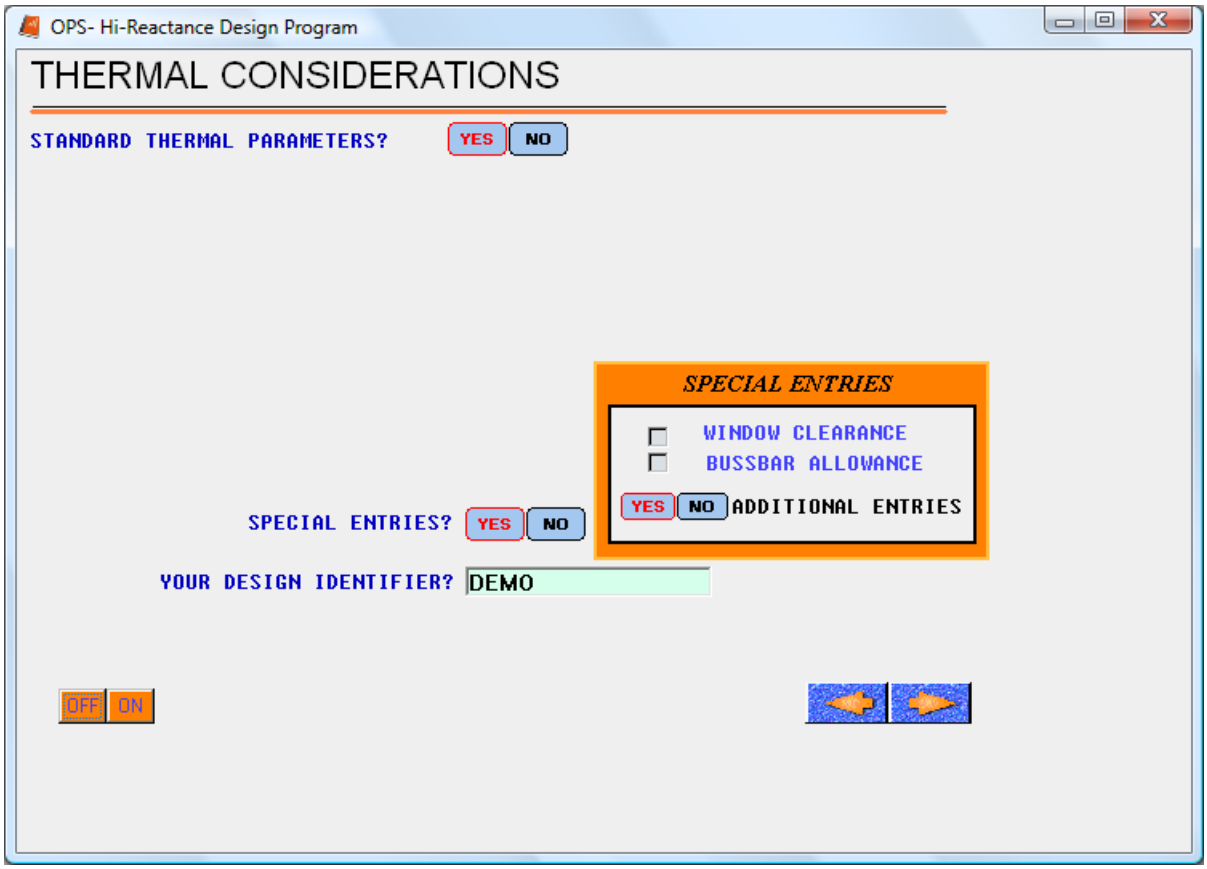


- Select **"ARRANGE DATA"** to read input data into the program.
- Select **"MODIFY"** to modify input data.
- Select **"EXECUTE"** to run the design.
- Select **"EXTENDED ANALYSIS"** to run Extended Analysis Program
  (Only accessible after running a design.)

Navigational Buttons:

New Design- returns to Main Menu page.
Quick Print - writes current design output to notepad
Make Print File - saves print data to text file
Save Design File – creates input data file for current design
Terminate – exits program

SPECIAL ENTRIES



YES Allows user to select special entries.

WINDOW CLEARANCE - Program will prompt for additional clearance in the core window which will be disregarded in the build calculation.

BUSSBAR ALLOWANCE – Program will prompt for additional space in each winding for bussbar or leads.

Appendix

Type3: side-by-side windings with magnetic shunt in space between

$\mathbf{CL_{S1}}$ = (Window width – ShuntLength) x sec. proportion – net end allow

$\mathbf{CL_{P1}}$ = (Window width – ShuntLength) x (1 – sec. proportion) – net end allow