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Monterey, California

PERFORMANCE RATING OF ENHANCED

MARINE CONDENSERS

by

R.H. Nunn
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Report for period ending 30 September 1982

Prepared for:

David Taylor Naval Ship R&D Center
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NAVAL POSTGRADUATE SCHOOL
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This report describes a computer code of moderate complexity

that is suitable for predicting the relative merits of the use of enhanced tubes in radial-flow condensers. The code accounts for vapor shear effects, condensate inundation, and noncondensible gases, and predicts the local steam-side conditions at intermediate locations within the condenser bundle.

Several computer experiments are described in which the impacts of enhanced-tube designs on overall condenser performance are investigated. The results serve to illustrate the importance of internal detail in such analyses and, in addition, they show that judicious use of enhanced tubes can lead to considerable improvements in condenser performance as well as the realization of heretofore unattainable design options.

SUMMARY

Condenser tubes with enhanced surfaces show promise for use in advanced marine condenser designs. In order to adequately predict the performance of enhanced tubes when operating in a condenser-bundle environment, considerable improvement in analytical method is necessary beyond the standard approaches recommended for use with conventional designs.

This report describes a computer code of moderate complexity that is suitable for predicting the relative merits of the use of enhanced tubes in radial-flow condensers. The code accounts for vapor shear effects, condensate inundation, and noncondensible gases, and predicts the local steam-side conditions at intermediate locations within the condenser bundle.

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PERFORMANCE RATING OF ENHANCED MARINE CONDENSERS

INTRODUCTION

Since the early days of naval steam propulsion, the surface condenser has evolved into a very reliable component of the steam propulsion machinery plant. This reliability has been achieved by providing generous design margins to insure thermal performance at full power. The penalties for this overdesign, however, are additional weight and volume (which must be carried around for the life of the ship) and crowded machinery rooms with poor accessibility. Although surface vessels and submarines have different design constraints, both types of vessels can benefit from a more compact condenser design through improved heat transfer. The actual dimensions of the condenser may have an impact on vessel size and displacement, the location of the propulsion machinery aboard the vessel, and even on vessel performance and cost. In addition, the future development of compact steam systems, both for main propulsion and secondary heat recovery purposes, will require the application of advanced technology to all system components, including the condenser.

At the Naval Postgraduate School, the relative benefits of such advanced condenser designs have been analyzed using a modified, radial flow computer code (MORCON) to model the

heat transfer and fluid flow phenomena which occur within this type of heat exchanger. Refinements to this code and improvements in the models used to predict two phase heat transfer and pressure drop are continuing.

Based upon the work accomplished to date, it is clear that present day smooth-tube steam condensers, when operating under typical conditions, are limited in thermal performance due to a large thermal resistance which occurs on the seawater side (tube side) of the condenser. This resistance, on the average, is larger than the thermal resistances which occur on the steam side and in the tube wall, and those due to seawater fouling and noncondensible gas buildup in the vicinity of the tube. Consequently, in present-day conventional condenser designs, what happens on the steam side does not have to be modeled too accurately to arrive at reasonable designs.[1] When using enhanced tubes, however, the enhancement on the seawater side can increase the inside heat transfer coefficient by 100 to 200 percent over the smooth-tube case. The outside heat transfer coefficient, on the other hand, is increased by only 10 to 50 percent. In this situation, the thermal resistances on the inside and outside of the tube can be approximately equal. As a consequence, it becomes essential to understand and accurately model the detailed mechanisms which occur when steam condenses on these enhanced surfaces.

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[1] It should be noted that, even with conventional designs, there can be locations within a condenser bundle where the steam side resistance is largest due to low vapor velocities and noncondensible gas pockets.

Heat transfer on the steam side of Naval condensers often occurs in the presence of high vapor velocities and with severe condensate inundation from neighboring tubes in the bundle. It is also important to predict the resulting two phase pressure drop in order to trace the steam flow path through the condenser bundle and minimize losses in the saturation pressure and temperature across the bundle. Since comprehensive test data on this subject are virtually non-existent, and since advanced computer codes will depend strongly upon good steam-side models, additional experimental work is necessary.

In spite of the tentative nature of existing theoretical steam-side heat transfer models, it has proved to be useful to conduct computer-based condenser performance calculations in order to provide comparative information regarding the relative costs and benefits of enhanced-tube condensers. In addition, the present theoretical basis is adequate to permit the identification of condenser tube-bundle regions that should be particularly sensitive to the introduction of internal and/or external enhancement.

This report documents these computer-based calculations. Since steam-side conditions are especially important in such calculations, some preliminary discussion is devoted to this subject. This is followed by a brief general description of computer modelling of surface condensers. The computer code

used at NPS is then described and several case-studies are provided to illustrate the use of the code and to give some insights concerning the impact of enhanced-tube technology on condenser design.

EFFECTS OF LOCAL STEAM-SIDE CONDITIONS

Single-tube theories and experiments have shown, not surprisingly, that the thermal performance of a condensing tube may be dramatically affected by the thermo-fluid state of the surrounding two-phase multi-component flow. Thus the condensate loading and velocity of the vapor, its temperature, and its non-condensible gas content all have important influences on the thermal resistance on the steam side of the tube. These influences lead to further complications in the analysis of condenser tubes performing in a bundle environment and the overall bundle performance is strongly coupled to the bundle inlet conditions, individual tube performance, and the general nature of the tube distribution within the bundle. Several of the main factors that are likely to be significant in bundle performance are discussed in the following paragraphs.

LOCAL STEAM-SIDE PRESSURE VARIATIONS

Frictional pressure losses on the steam side of a condenser bundle are detrimental from a system point of view

because these losses are directly chargeable against the thermal efficiency of the power system. In addition, the vapor temperature, which is a major factor in the heat transfer process that accompanies condensation, is strongly dependent upon the pressure in the vapor. This dependency is accentuated at low condensing pressures, varying from about 7^{o}F/in. Hg at 6 in. Hg condensing pressure to 12^{o}F/in. Hg at 3 in. Hg. (In other words, at about 3 psia a loss of 0.1 psia in pressure will lead to a 1.3^{o}F loss in vapor temperature and at 1.5 psia the loss would be about 2.4^{o}F.) Consequently, when condenser tubes are closely packed in a bundle the resulting high vapor velocities and correspondingly high pressure losses can severely limit the bundle performance.

VAPOR VELOCITY EFFECTS ON STEAM-SIDE THERMAL RESISTANCE

High vapor velocities can have at least one effect that is beneficial. This is the shearing force that the vapor exerts on the condensate film which, at relatively high vapor velocities, can be significant. A number of investigators [1, 2, 3, 4] have contributed to the understanding of the effects of vapor shear. In particular, Fujii, et al. [1] have recently proposed experimental correlations of the form

$$\frac{Nu_m}{Nu_o} = C_1 \, Nu_o^{(4a - 1)} \, Re_L^{(.5 - 2a)} \qquad (1)$$

where Nu_m is the mean Nusselt number, Re_L is the "two-phase" Reynolds number (based on vapor velocity, tube outside diameter, and kinematic viscosity of the condensate), and Nu_o is the standard Nusselt number for the ideal (zero shear) case. The empirical constants C_1 and a are in the ranges

$$1.13 < C_1 < 1.24$$

$$.195 < a < .2$$

depending upon whether the tube thermal conditions are most appropriately described by constant temperature or constant heat flux conditions. The larger values are for the constant heat flux case. According to Fujii, et al., Eq. (1) is valid in the range $3.3 > Re_L/Nu_o > 0.28$. For smaller values of this parameter, they recommend the use of a slightly reduced value of the standard Nusselt number that is given by

$$Nu_m = 0.96\ Nu_o$$

In a typical naval condenser, vapor velocities well above 100 ft/s are not uncommon and two-phase Reynolds numbers on the order of 10^6 are typical. For a nominal Nusselt number value of $Nu_o = 400$, the resulting vapor shear effect is given by $Nu_m/Nu_o \simeq 1.5$. Thus, the vapor shear effect is clearly important in the range of operation of naval condensers, and, when enhancements of various kinds are applied, this effect may become a dominant factor in overall condenser performance predictions.

Correlations of the form of Eq. (1) appear to be adequate for the prediction of shell-side film coefficients in horizontal and downward vapor flow without condensate inundation. For upward vapor flow, however, the effects of vapor shear on film thickness appear to be much larger, and at very high velocities the shell-side film coefficient, normally low due to poor condensate removal, can be significantly increased - even to the extent that the influence of gravity is overcome by vapor shear effects.

From the point of view of enhancement, simple reasoning would lead to the expectation that improvements in heat transfer due to vapor shear will be less significant at high external enhancement conditions. This follows from the argument that enhanced tubes will carry thinner faster-moving condensate films (other conditions being equal) that are less sensitive to shearing effects acting at the vapor interface. Equation (1) reflects this effect in that (since $a < .25$ in all known cases) the ratio Nu_m/Nu_o varies inversely with Nu_o. The vapor shear effect might also be reduced by some of the previously-mentioned external enhancement schemes employing extended surfaces that would trap or otherwise "protect" the condensate. With high levels of internal enhancement, on the other hand, failure to provide for adequate condensate removal will be somewhat compensated by the shearing of the relatively thick condensate film at high vapor velocities.

Other vapor velocity effects, such as rippling, inducement of turbulence and stripping of the condensate film, are relatively poorly understood. A particularly important area in need of further research is the consideration of the entrainment of condensate droplets in fast-moving vapor flows. As will be discussed in the subsequent section, condensate droplets as they traverse the condenser can have a profound effect upon the performance of downstream tubes. To the extent that the paths of these droplets and the vapor flow are coupled through viscosity, an additional dependency upon vapor velocity must be considered.

CONDENSATE INUNDATION

The true behavior of the condensate generated within a tube bundle is far from the ideal model of vertically-dropping laminar sheets hypothesized by Nusselt. In fact, the condensate in most condenser environments will be in many forms (droplets, rivulets, sheets, sprays) and will flow in many directions. It is highly unlikely that any quantity of condensate will traverse a condenser without losing its identity by impinging upon other tubes in the bundle. The effect of this impingement is referred to here as condensate "inundation" or "rain" and it is probable that a true theoretical model of the phenomenon would of necessity be stochastic in nature. In the absence of such analytical sophistication, a

number of empirical models have been developed that are useful when applied within their range of credibility.

Strict application of the classical Nusselt theory, together with its restrictive assumption of a laminar film falling under the influence of gravity alone, leads to the conclusion that the average condensate film heat transfer coefficient for a vertical row of n tubes, $\bar{h}_n$, is given by [5]

$$\frac{\bar{h}_n}{\bar{h}_o} = n^{-0.25} \tag{2}$$

where h_o is the single-tube film coefficient. Numerous investigators have compared this simple expression with experimental results [6, 7, 8, 9, 10, 11] and it has become clear that in reality the results obtained from Eq. (2) reflect an overprediction of the detrimental effects of inundation. In fact, a modified form of Eq. (2) may be written as

$$\frac{\bar{h}_n}{\bar{h}_o} = n^{-s} \tag{3}$$

where empirical evaluation of s has led to values in the range $.07 < s < .25$ [7]. Within this range, for example, a column of 30 tubes may be judged to have an average film coefficient that is 79% to 43% of the single-tube value. It should be noted further that the actual film coefficient for the n-th tube in a column, h_n, may be found using Eq. (3) with the result that

$$\frac{h_n}{h_o} = n^{(1-s)} - (n-1)^{(1-s)} \qquad (4)$$

The range of s leads to a range in h_n of from 75% to 32% of h_o: clearly the range of uncertainty in s is unacceptable.

Among the chief discrepancies in the assumed constancy in s in Eqs. (3) and (4) are:

1. The effect of inundation is definitely dependent upon the vapor velocity and direction.
2. Bundle tube layout (tube spacing and pattern) will influence condensate inundation.

Thus, even if the functional relationship given in Eq. (3) is authentic, the exponent s must show the dependency

s = fct (steam velocity vector, bundle geometry).

The first of these is indicated nicely by Brickell [11] in which a general decrease in s with steam velocity is shown. These results are reproduced here in Fig. 1. It is also apparent that at low steam velocities the exponent s is larger (more inundation effect) for both upward and downward steam flow than it is for horizontal steamflow. This directional effect is less noticeable at high steam velocities. The influence of tube separation upon inundation effects is not clearly discernable from available data, largely because of the coupling of vapor shear effects with those due to inundation. It is possible to speculate with some confidence, however, that closely-spaced tubes are more influenced by inundation than are the tubes in relatively disperse bundles.

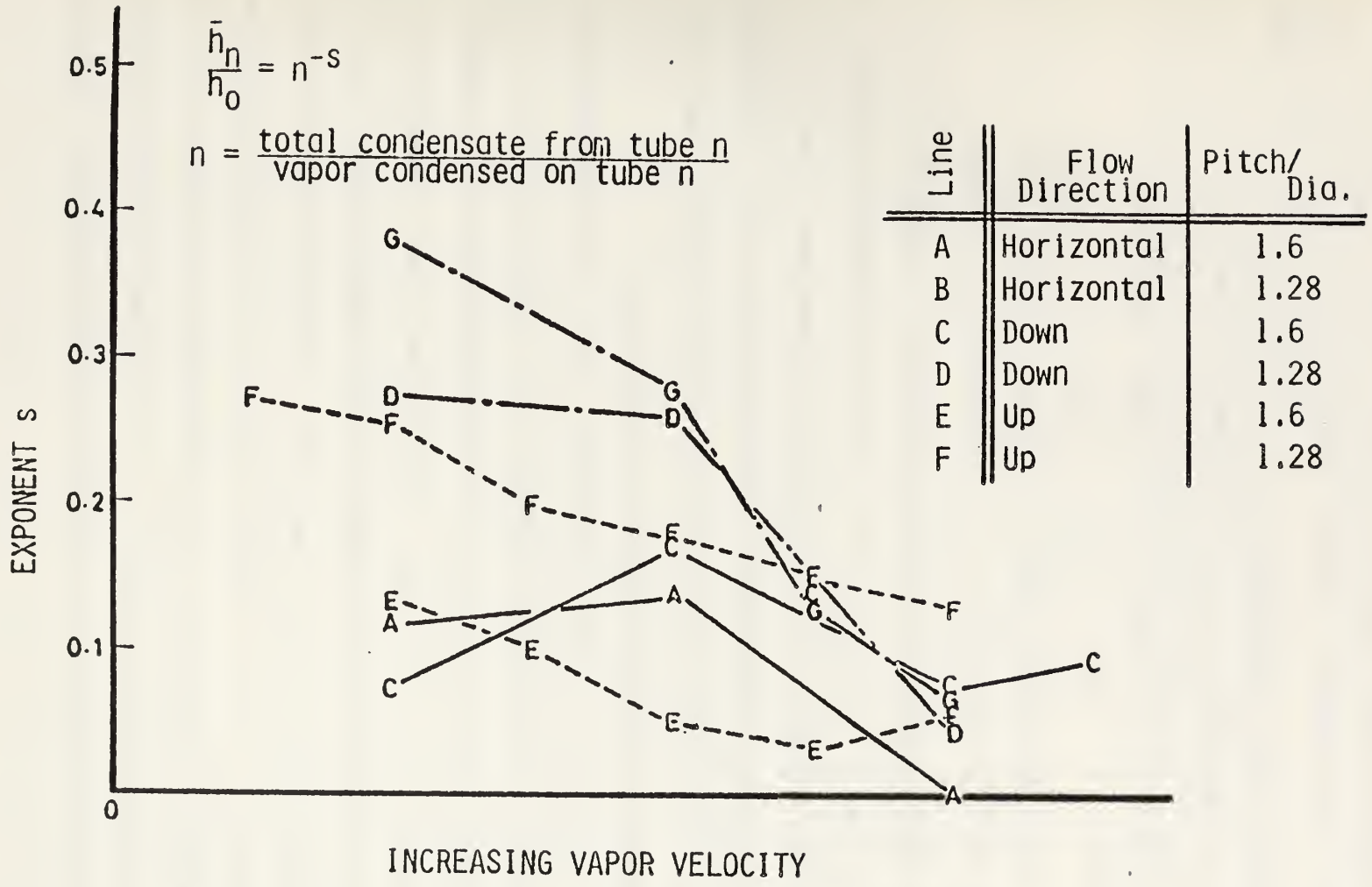


Figure 1. Effects of vapor velocity, flow direction, and tube spacing on tube performance in bundles[11].

One important influence of tube spacing in low velocity steam flow is that of side-drainage whereby condensate generated from above may, due to surface tension effects, proceeds laterally to adjacent tubes rather than directly downward. Eissenberg [7] has contributed a means of quantifying this effect with the result that Eq. (3) may be modified as follows:

$$\frac{\bar{h}_n}{h_o} = (1 - F_d) n^{-s} + F_d[0.6 + 1/2\ (2n)^{-s}] \qquad (5)$$

where F_d depends upon tube spacing and approaches unity for densely-packed staggered tube banks and zero for disperse tube layouts. Equation (5) represents the state-of-the-art in the prediction of condensate inundation effects and its effectiveness in doing so is, of course, highly dependent upon the selection of correct values for s and F_d.

The extent to which enhanced tubes are susceptible or resistant to inundation effects is a matter that is far from settled. (Indeed, the issue is unresolved as far as smooth tubes are concerned, when bundle effects are taken into account.) There are some experimental results [12] that indicate that smooth tubes operating in the dropwise mode of condensation are not greatly affected by inundation. (This observation was made at very low vapor velocities.) Preliminary indications are likewise encouraging for film condensation on enhanced tubes where single-tube experiments [13] have indicated values of s [Eq. (3)] in the range of 0.04 to 0.10.

NON-CONDENSIBLE GASES

The effects of non-condensible gases can be classified into one of two categories:

1. The introduction of an additional local thermal resistance due to the propagation of gases towards a condensing tube surface under the influence of a gradient in partial pressure, and
2. The cumulative effect of gas blanketing where uneven rates of condensation in a condenser bundle eventually lead to regions where tubes are inoperative in a condensing role.

In naval condensers [14] as well as in shore-based power condensers [8], non-condensible gases contained in the inlet flow are usually on the order of 100-200 weight-parts-per-million. This ratio increases in the condenser, as steam is extracted, but even at a worst-case condition (20,000 wppm, say) the local overall heat transfer coefficient will be reduced by only about 15% and this in a very small region of the condenser. Thus, although a number of theories are available to account for the local effects of non-condensible gases [15] in naval condensers, there appears to be little need for extreme precision in the calculation.

The effect of non-condensible gases on the external resistance of enhanced tubes is a matter of considerable uncertainty. Cunningham [16] has recently reported on single-tube

experiments in which fine-finned tubes were found to be less affected by non-condensible gases than were smooth tubes under corresponding conditions. In any event, it is expected that because of the low concentrations of non-condensible gases under naval condenser conditions their effect will be small unless their presence in some way affects the enhancement process itself.

The more-important aspect of non-condensible gas effects, crucial in all condenser applications, is the design of tube bundles such that non-condensible gases do not accumulate. In large tube bundles it is often necessary to incorporate special inlet baffling and steam lanes that allow the steam to penetrate deep into all parts of the tube nest in order to avoid gas blanketing. The compensation of condenser bundle designs for this purpose has often been experimental in nature, involving large-scale and extremely expensive tests, and is probably a major reason why condenser cross-sections do not seem to change drastically from generation to generation.

In recent years, however, the ascendancy of computational capabilities has led to the feasibility of the comprehensive computer codes necessary for the prediction and alleviation of gas blanketing. One such computer code has been developed in the UK (such codes are not, in our experience, available to the public) and has been used to great advantage in the design and improvement of shore-based power condensers [8].

SUMMARY

The performance of a condenser tube within a tube bundle is strongly influenced by the history of the vapor/gas mixture prior to arrival at the tube in question. Conversely, the performance of any given tube can have a profound effect upon the thermal behavior of tubes located downstream. The complexity of these interactions may lead to a degree of depression in the mind of the researcher who would predict overall bundle performance. On the other hand, these inadequacies in understanding may be viewed as challenges and, even in our present state of ignorance, we can answer questions in a relative way. For instance, qualitative trends due to augmentation may be identified and relative improvements due to augmentation may be quantified within a precision of perhaps 10-20%.

Just as a condenser is larger and more complex than a single tube, it is to be expected that the necessary computational and experimental scales will be larger for condensers than they are for single tubes. To justify such investments, and to guide the efficient allocation of resources, it is necessary to use what tools we have at hand to investigate potential payoffs and pacing problems. The following sections describe some preliminary results obtained from computer models of condenser bundles.

COMPUTER MODELING

Analytical models for the estimation of condenser performance may be classed as follows:

1. Standard methods of the "black-box" type that are used for preliminary - and sometimes, it is suspected for final - design purposes. These methods include those recommended by the Heat Exchange Institute (HEI [17]) and British Electrical and Allied Manufacturers' Association (BEAMA [18]).
2. Intermediate computer codes that, to varying extents, include the details of tube-to-tube flow within the condenser. For purposes of classification, these codes are restricted to the analysis of condenser designs in which the vapor/gas mixture may be presumed to flow in a fixed direction (such as radial, horizontal, upwards, or downwards). The code MORCON is of this class and is described in some detail below.
3. Multi-dimensional codes utilizing finite element or finite difference methods for the solution of the governing conservation equations. Because codes in this category are proprietary (in all cases, to our knowledge), little is known concerning the extent to which they exist and work. The CERL code mentioned above [8] appears to be quite successful in application

and there are some indications [19] that U.S. manufacturers possess a similar capability.

The black-box methods are extremely limited to their application to all but the most standard condenser designs. In essence, only the overall heat transfer coefficient, U, is predicted by these methods and even this is subject to considerable uncertainty (HEI predictions of U have been observed to differ from measured values by from 100% on the high side to 50% on the low side [20]. These methods of prediction are based upon the assumption that the overall thermal resistance is dominated by the internal (tubeside) resistance - they are limited to cases of moderate cooling water velocity - and the allowances for fouling are subject to considerable criticism on physical bases. No means are provided for accounting for the distribution of thermal resistances across individual tube sections or between tubes in a bundle. It is clear that major advances in condenser designs cannot be based on these black-box methods.

At the other extreme of the spectrum of sophistication lie the multi-dimensional computer-based methods. The basic computational difficulties in the development of these comprehensive computer codes are largely ones of scale. It is quite difficult, yet most important to include two-dimensional capabilities that allow calculations in the plane of flow normal to the axis of the condenser. The third dimension,

steam/gas flow in the direction of the tube axis, may be obtained with reasonable accuracy by combining two-dimensional slices. Even so, the complexity of the two-dimensional calculation is sufficient unto itself in that it is often necessary to compute the two-phase multi-component flow in the passages between thousands of tubes. As a result, it is common to combine groups of tubes into "mini-bundles". Within these mini-bundles the equations of mass, momentum, and energy are satisfied by means of finite-difference expressions for the convective, conductive, and source effects. The source terms in these expressions require much of the approximation necessary in less-complicated codes in terms of interaction effects such as vapor shear and condensate inundation. Thus, the extension to multi-dimensional computations does not obviate the need for additional insights into the various bundle interactions mentioned in the previous section. The chief benefit of such extensions appears to be the ability to predict the performance of poorly designed condenser bundles especially with respect to air-blanketing.

Multi-dimensional computer codes can be extremely valuable for condenser performance predictions and may even be essential to the development of truly optimized condensers. Large resource investments are required for the development of such codes and questions inevitably arise concerning their cost-effectiveness. This issue is not developed further here except to say that, because of it, our emphasis has been at the

intermediate level of analytical sophistication where codes such as MORCON are found.

THE MORCON COMPUTER CODE

MORCON (Modified Oak Ridge Condenser) is a modified version of the ORCON1 code developed at the Oak Ridge National Laboratories [21]. Some of the features and limitations of MORCON are summarized below:

a. MORCON allows the calculation of radial flow in circular bundles. (Other unmodified versions of ORCON1 have been developed for downward and horizontal-flows.)

b. Correction of the condensate film coefficient for the effects of rain, including side drainage, is accomplished by the means previously described. As has been pointed out, the correction only accounts for the distribution of condensate rain upon lower tubes in a gravity-dominated flow and does not account for the interaction of vapor shear effects with those due to inundation.

c. Non-condensible gases (up to four species) are taken into account by the use of the Colburn analogy [22] together with an empirical correlation credited to Eissenberg in [21].

d. MORCON allows for the effects of heat transfer enhancement of the inner and/or outer film coefficients. The influence of enhancement on tubeside and shell-side pressure drops is also included.

e. MORCON, as in all other known cases, includes fouling effects only as a constant resistance term.

f. All tube-side and shell-side fluid properties are continuously calculated as they change with pressure and temperature throughout the condenser. The latter quantities vary due to inlet, outlet, and tube-to-tube flow cross-section variations, as well as viscous losses.

g. Bundles can be segmented into as many as six computational sectors. Steam flow entering each sector is adjusted until the shell-side pressures at the exits of each sector (which is also the air cooler inlet) are matched within a specified limit. The sector arrangement for the circular bundle with radial flow is illustrated in Fig. 2.

h. The overall heat transfer coefficient for each row in each sector is calculated on the basis of an "average" tube. This is a basic limitation of the code that is somewhat relieved by the ability to calculate performance by sectors.

i. Vapor shear effects are included in the manner previously described. To the extent that the Fujii correlation does not include the interaction of vapor velocity with condensate inundation, the results are suspect for other than gravity-dominated (low vapor velocity) flow.

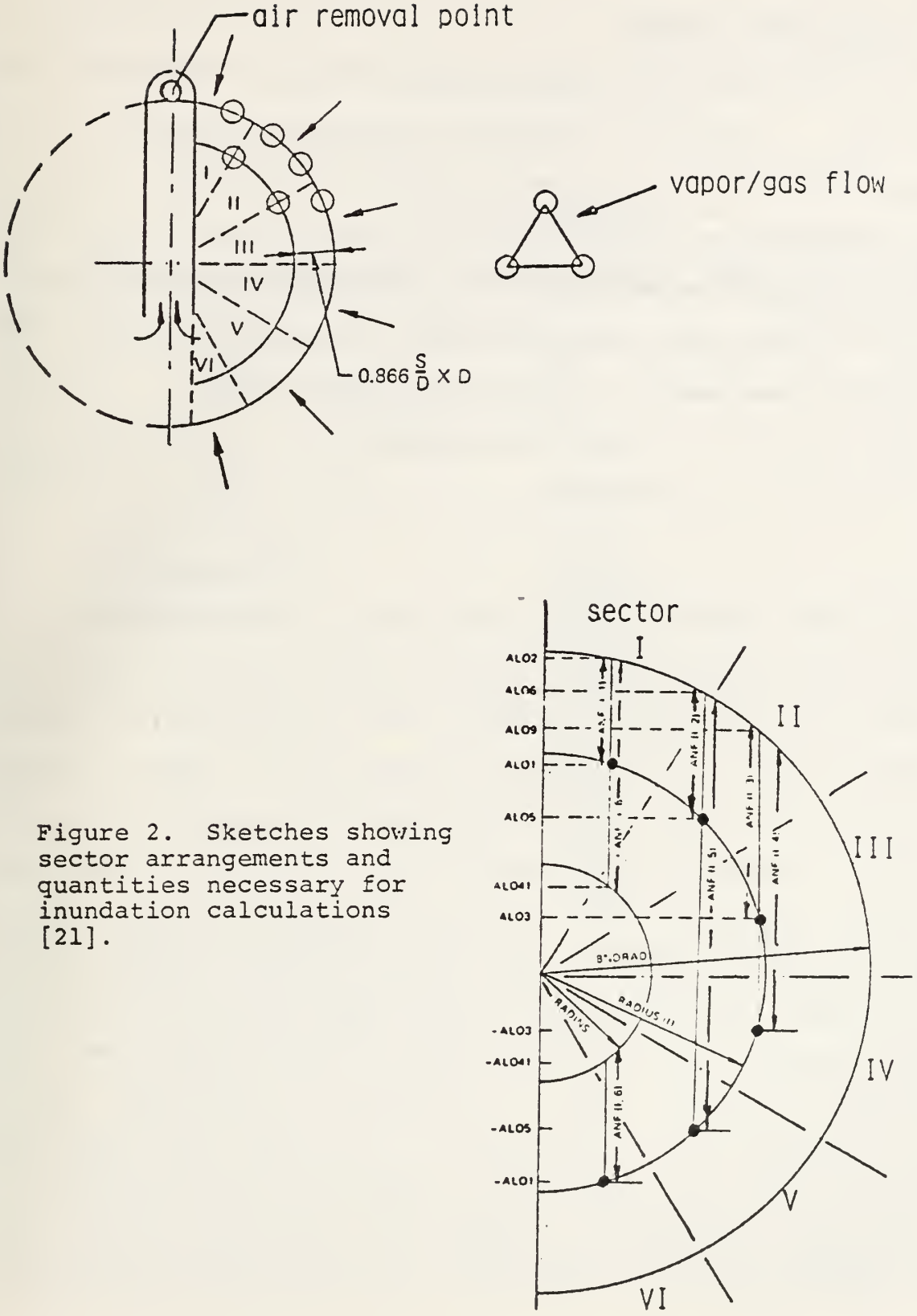


Figure 2. Sketches showing sector arrangements and quantities necessary for inundation calculations [21].

DESCRIPTIVE SUMMARY

In this section the organization and flow of MORCON are described. A listing of the code is provided in Appendix A. Because MORCON is in large part identical to the ORCON1 code, the treatment here will be brief with details confined to the few modifications made to ORCON 1. For a more complete description of the basic code, the reader is referred to [21]. The subroutines contained in the code are listed below:

MAIN (not labeled)

SECALC

COOLEX

HETTRN

ADJUST

PRSRDP

DFSVTY

INPUT

OUTP1

ZERO

Subroutine DFSVTY computes the mutual diffusivity of the vapor/gas mixture. Various function subroutines are included to calculate specific heats, thermal conductivities, viscosities, and densities of the gas, vapor, and condensate as required. Function subroutines are also provided to calculate vapor saturation pressures and temperatures and the latent heat of vaporization. The purposes of subroutines INPUT, OUTP1, and ZERO are indicated

by their names and these will receive no further discussion here. The subroutine calling protocol is indicated in Table I, below.

Table I. Subroutine Calling Protocol

Calling Sub-Routine	Called Subroutine							
	SECALC	COOLEX	HETTRN	ADJUST	DFSVTY	PRSDRP	INPUT	OUTP1
MAIN	X	X		X			X	X
SECALC			X			X		
COOLEX			X			X		
HETTRN					X			

Subroutine MAIN

Subroutine MAIN is the main control program. Input values are taken into this subroutine and the tube bundle cross-sectional geometry is determined. This geometry is defined by the specified number of tubes, their outside diameter, and the spacing between them. The tubes are arranged radially such that the outer row of the bundle is complete. The tube array is staggered with the radial spacing between rows equal to $(\sqrt{3}/2)$ times the specified circumferential spacing between tubes. The void diameter is determined by the space necessary to accommodate the number of tubes that are insufficient to complete an outer row. With the tube sheet entirely filled (zero void diameter), the specification of additional tubes will result in the removal of a number of tubes from the void sufficient to complete an additional outer row. (Because of the difference in performance of inner and outer-row

tubes, this method of allocating tube cites leads to highly non-linear and sometimes confusing results when tube count is used as an independent design variable.)

Bundle symmetry is assumed about the vertical centerline of the circular bundle and the remaining semi-circular tube array is divided into six sectors. Each partial row in each sector is defined by the central tube in that string and the program calculates the number of tubes in a vertical row above this "mean" tube. This is needed to provide for inundation calculations.

Following these preliminary arrangements, subroutine SECALC is called. The return information is the condition of the vapor/gas mixture as it leaves the main condenser bundle and enters the air cooler. The performance of the cooler is then computed by means of a call to subroutine COOLEX.

The final overall vapor/gas conditions, as returned from COOLEX, are transmitted to subroutine ADJUST. If the exit fraction of the current design is equal to the input specification (within five percent error) the return from ADJUST is followed by final output actions. If the specified exit fraction is not obtained, the code will adjust either the inlet steam flow or the tube (bundle) length, as selected by the user. The updated design is then returned to SECALC for evaluation and the above procedure is repeated until convergence is obtained or the iteration limit (set to 10) is exceeded.

Figure 3, below, summarizes the function of subroutine MAIN.

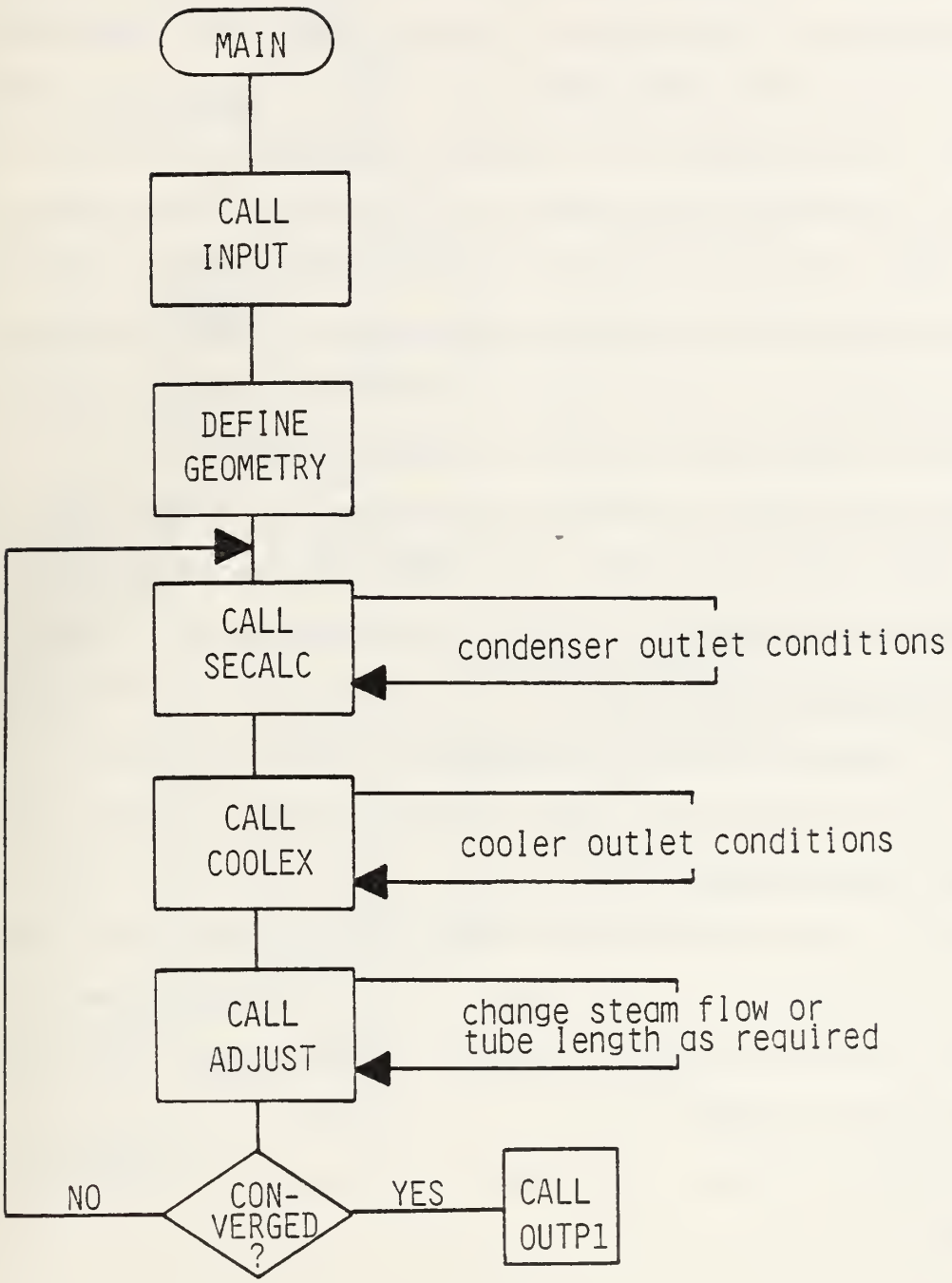


Figure 3. Simplified flow diagram of main calling subroutine.

Subroutine SECALC

Subroutine SECALC, with calls to subroutine HETTRN, determines the sector-by-sector and row-by-row performance of the condenser. Calculation is begun in the first (uppermost) sector at the first (outermost) row. Using the central tube of this and subsequent row segments, subroutine HETTRN is called to determine the thermal performance of the current "man" tube. With information returned from HETTRN, subroutine PRSDRP is called to determine the pressure of the vapor/gas mixture entering the next row and the steam quantity and conditions for this next row are returned to HETTRN.

The outer loop in SECALC covers the six sectors while the inner loop covers the rows (the number of rows is determined by the input geometry). Following the completion of both loops, the steam-side pressures at the outlet of each sector are each compared with the mean of the outlet pressures. The total inlet steam flow is then adjusted so that sectors with excessive steam-side pressure drop receive less flow and conversely for those sectors with relatively higher outlet pressures. The calculation is then repeated in its entirety (all sectors, all rows) until the bundle outlet pressure is uniform to within one percent.

Figure 4, below, illustrates the function of subroutine SECALC.

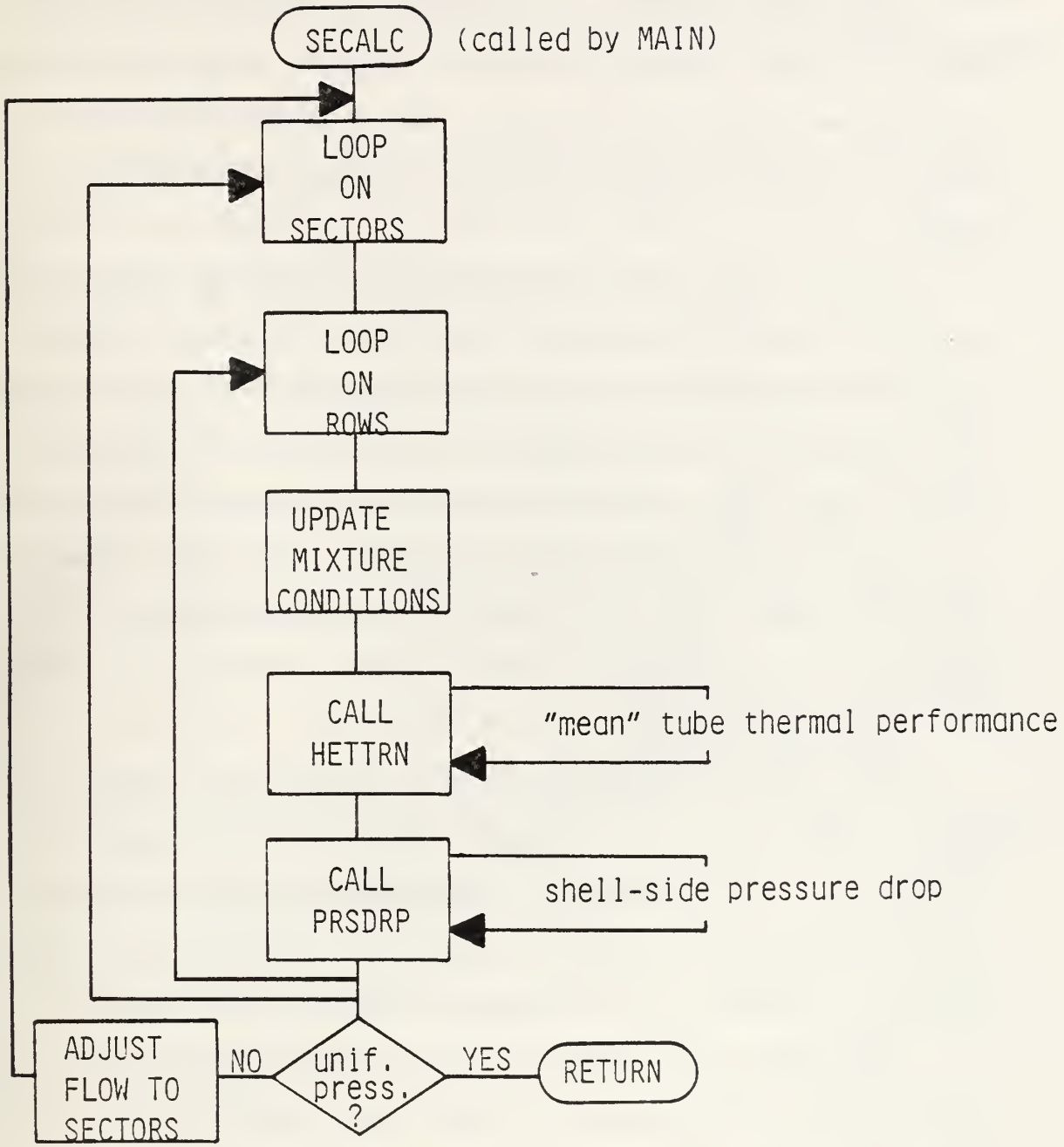


Figure 4. Simplified flow diagram for subroutine SECALC.

Subroutine COOLEX

Subroutine COOLEX is a simplified version of subroutine SECALC in which calls to HETTRN are used to obtain row-by-row performance of the cooler tubes. No steam-side pressure balance (such as that performed in SECALC) is attempted in COOLEX.

The user specifies the percentage of the total number of condensing tubes to be used in the cooler section. These tubes are allocated to a vertical staggered array with cross-flow dimension initially equal to the bundle void diameter. If this tube cite allocation results in crowding of the cooler tubes (as indicated by vapor/gas mixture velocities in excess of 150 ft/s) the cooler is widened (and proportionately shortened) as necessary.

Subroutine HETTRN

This program contains the basic heat transfer algorithms and, as noted above, is called by SECALC for each mean tube in each row of each sector. Following a summary of the procedures followed in HETTRN, a few of the more-important heat transfer algorithms are discussed in some detail below.

Because the thermodynamic and physical properties of the cooling water are allowed to depend upon temperature in HETTRN, a basic iteration is required to compute the overall heat transfer coefficient. This iteration begins with an estimate from which, with local steam conditions and cooling water inlet

temperature and flow rate, the cooling water outlet temperature is calculated. Cooling water properties are then calculated based upon the mean of the inlet and outlet temperatures of the cooling water.

Following the determination of cooling water properties, HETTRN then computes, in order, the internal thermal resistance (based upon the Dittus-Boelter correlation with internal enhancement taken into account) and the external condensate film thermal resistance based upon the Nusselt correlation (see below). The external resistance is then corrected for vapor shear and condensate rain effects. These resistances, together with tube conduction resistance and a constant fouling resistance (input by the user), are then summed to develop an interim value of total resistance to heat transfer, exclusive of the resistance of the non-condensible gas film. The thermal resistance of the non-condensible gas film is calculated and various key variables for the current iteration are determined. Convergence of the basic loop is based upon agreement between current and previous values of film temperature drops. Agreement to within 0.01 degrees Fahrenheit is required in the case of the liquid film temperature drop and if non-condensible gases are present the iterations continue until the calculation of the gas film temperature drop is steady to within 0.001 degrees Fahrenheit. Following convergence, values are transferred to SECALC and common storage as necessary for future use.

Condensate Film Thermal Resistance

In MORCON the standard Nusselt relationship for the condensate film resistance is corrected for vapor shear effects according to the correlations of Fujii et al. [1]. On the assumption that the thermal resistance on the steam side is relatively small, the constant heat flux case is taken to be most appropriate. (Within experimental uncertainties the two cases - constant heat flux or uniform wall temperature - are not appreciably different.) Eq. (1) becomes

$$\frac{Nu_m}{Nu_o} = 1.24\ Nu_o^{-0.2}\ Re_L^{0.1} \tag{6}$$

where Nu_o is the Nusselt relationship given by

$$Nu_o = 0.725 \left[\frac{g\rho^2 d_o^3 h_{fg}}{K_L \mu_L \Delta T} \right]^{\frac{1}{4}} \tag{7}$$

Following correction of the mean Nusselt number for vapor shear effects, this value is further corrected for condensate inundation. Equation (5) is applied with a value of s = 0.2 so that the average film coefficient for a vertical row of m tubes is given by

$$\frac{\bar{h}_m}{ho} = 0.6F_d + (1 - 0.5647F_d)m^{-0.2} \tag{8}$$

This expression is evaluated for m = n and m = n-1, where n is the number of condensing tubes vertically above the

tube in question, and the heat transfer coefficient for that tube is given by

$$h_n = n\,\bar{h}_n - (n-1)\,\bar{h}_{n-1} \qquad (9)$$

The selection of the exponent s = 0.2 in these calculations is based upon the comparison with experiment shown in Fig. 5 and is also in consonance with the observations of others [7, 11, 23] (see also Fig. 1).

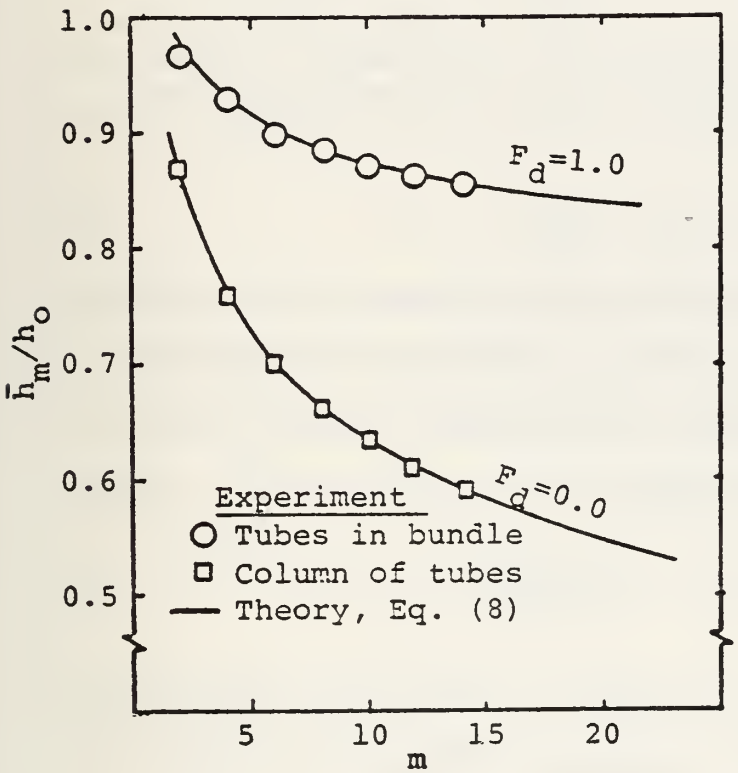


Figure 5. Tubes with inundation and side drainage; comparison of theory with experiment. Data of Ferguson and Oakden ("Heat Transfer Coefficients for Water and Steam in a Surface Condenser," Trans. Chem. Eng. Congress (World Power Conf.), v.3; 640 (1936)) as reported in [7].

Non-Condensible Gas Film Coefficient

The process of heat transfer through the non-condensible portion of the gas/vapor mixture is modelled as one due to mass transfer of the vapor through the gas. Sensible heat

transfer across the gas film (usually about 0.1% or less) is neglected. A mass transfer coefficient, K_G, is defined such that

$$K_G = \frac{h_g \Delta T}{h_{fg} \Delta P_{sf}} = \frac{h_g}{h_{fg}} \left(\frac{\partial T}{\partial P} \right) \tag{10}$$

where ΔP_{sf} is the drop in vapor partial pressure in the film, ΔT is the corresponding temperature change, h_{fg} is the latent heat of vaporization, and h_g is the heat transfer coefficient for the process across the non-condensible film.

The drop in vapor partial pressure across the gas film is taken equal to the rise in gas partial pressure across the film so that

$$\Delta P_{sf} = P_{gc} - P_{gb} \tag{11}$$

where P_{gc} and P_{gb} are the gas partial pressures at the condensate film interface and the external mixture conditions, respectively. Combining Eqs. (10) and (11), the gas film temperature drop may be written:

$$\Delta T = \frac{K_G h_{fg}}{h_g} P_{gc} - P_{gb} \left(\frac{\partial T}{\partial P} \right) \tag{12}$$

The partial pressure P_{gb} is known at each point in the calculation and the rate $(\partial T/\partial P)$ is calculated from the saturated steam line. The condensate interface gas partial pressure is taken from the empirical relationship suggested by Eissenberg and Noritake [24]:

$$P_{gc} = \frac{C_j}{K_G}$$

where

$$C_j = \frac{G}{(S_c)^{2/3}} \quad \exp\ (.54 - .544\ \ln\ Re)$$

with G the local mass velocity, Sc the local Schmidt number, and Re the local vapor Reynolds number. With this correlation, Eq. (13) becomes

$$\Delta T = \frac{C_j h_{fg}}{h_g} - P_{gb}\left(\frac{\partial T}{\partial P}\right) \tag{13}$$

The gas film temperature drop may be further defined in terms of heat transfer coefficients by the following heat balance:

$$h_g \Delta T = U_g \Delta T_m \tag{14}$$

where U_g is the overall heat transfer coefficient belonging to the log-mean temperature difference ΔT_m. That is, if U is the heat transfer coefficient without non-condensible gases (known, at this point in the calculation) then:

$$\frac{1}{U_g} = \frac{1}{h_g} + \frac{1}{U} \tag{15}$$

Combination of Eqs. (13) - (15) with the elimination of ΔT and h_g leads to the following quadratic relationship for the overall heat transfer coefficient:

$$U_g^2 - \left\{ \frac{h_{fg} C_j}{\Delta T_m} + U\left[1 + \frac{P_{gb}}{\Delta T_m}\left(\frac{\partial T}{\partial P}\right)\right]\right\} U_g + \frac{h_{fg} C_j U}{\Delta T_m} = 0 \tag{16}$$

All the quantities necessary to determine the coefficients in this relationship are available (for the current iteration) so that a solution for U_g is forthcoming. Solutions for h_g and ΔT follow according to Eqs. (15) and (14).

Subroutine PRSRDP

As the name implies, the purpose of this subroutine is to compute the pressure drop on the steam side between adjacent rows of tubes. In MORCON (as in ORCON1) the friction factor is given by [24]:

$$f = 0.102 + \frac{52.2}{Re} \tag{17}$$

where f is related to the pressure drop by

$$\frac{4f}{\frac{1}{2}\rho V^2} = \Delta P$$

or

$$\Delta P = \frac{2fG^2}{\rho}$$

The application of the correlation of Eq. (17) is limited to moderate mass velocities ($G < 1500$ lb/hr - ft^2) and, as such, may lead to significant errors when used to predict steam-side pressure drops in some advanced marine condenser designs.

SAMPLE RUN

In this section a sample run is described in order to illustrate the necessary user procedure and to provide a baseline case for subsequent analysis of the effects of enhancement. The tubesheet layout for the baseline design is shown in Fig. 6.

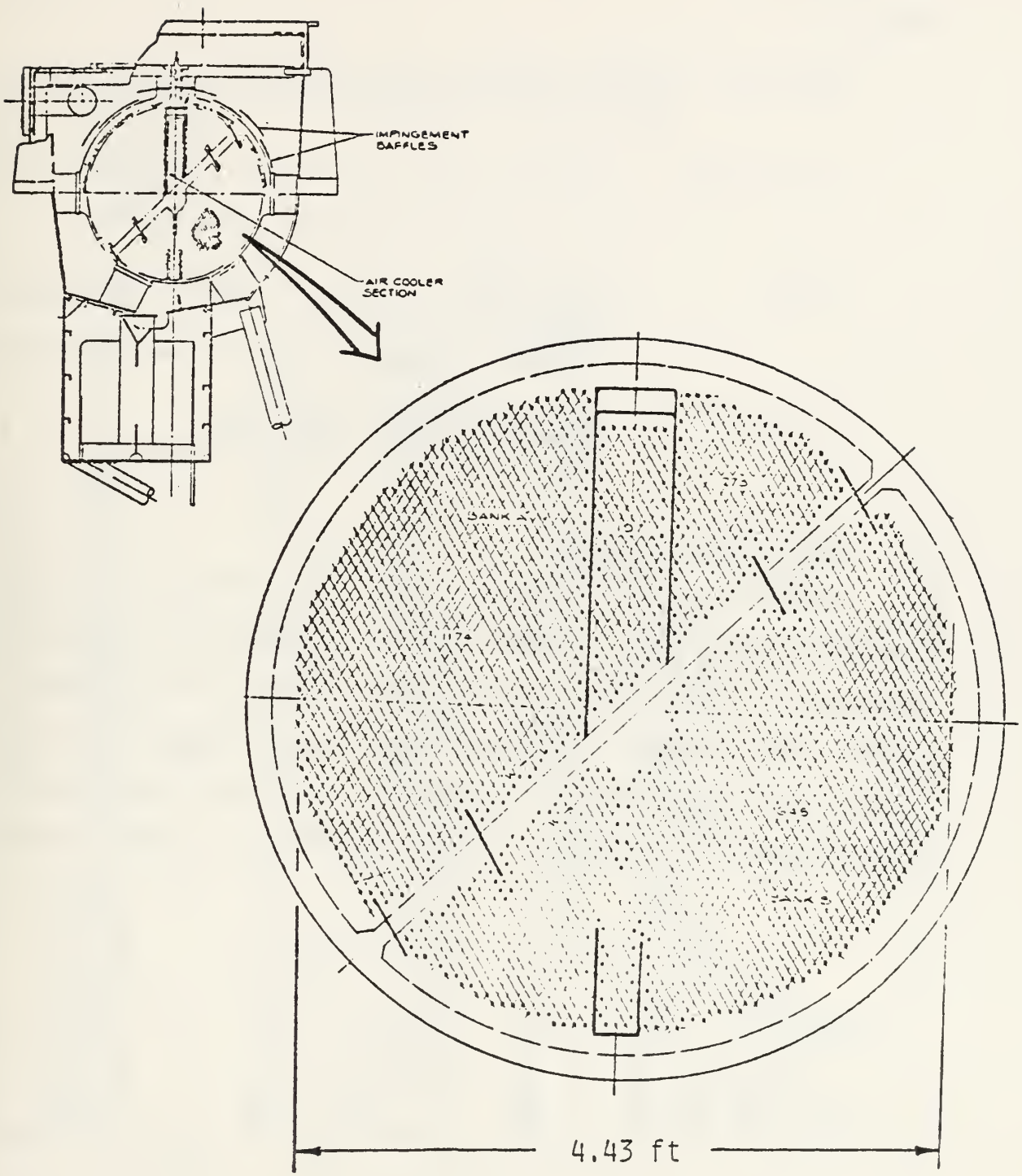


Figure 6. Assembly and tubesheet layout for baseline condenser.

and general specifications for this design are listed in Table II.

Table II. Design and Performance Specifications for the Baseline Condenser

Inlet steam:	189,003 lb_m/hr saturated 5 in.Hg (133.7°F)
	33.7 lb_m/hr noncondensibles (air)
Tubes:	1646 tubes in each of two passes, 6% in cooler 70-30 Cu Ni, 5/8 OD, 16 BWG (0.065 wall) Pitch/OD 1.35 Fouling Resistance 3.3×10^{-4} hr ft^2 °F/Btu
Cooling water:	Inlet temperature 66.1°F Velocity 8 ft/s (7,900 gpm) Salt concentration 3.5% by weight

User Supplied Data

Subroutine INPUT reads, writes, and processes the data provided by the user. These data are supplied via seven cards, as illustrated in Fig. 7. The first five of these cards are identical to those described for ORCON1 [21] but the input nomenclature is repeated here so that the reader may proceed (it is hoped) without reference to that document.

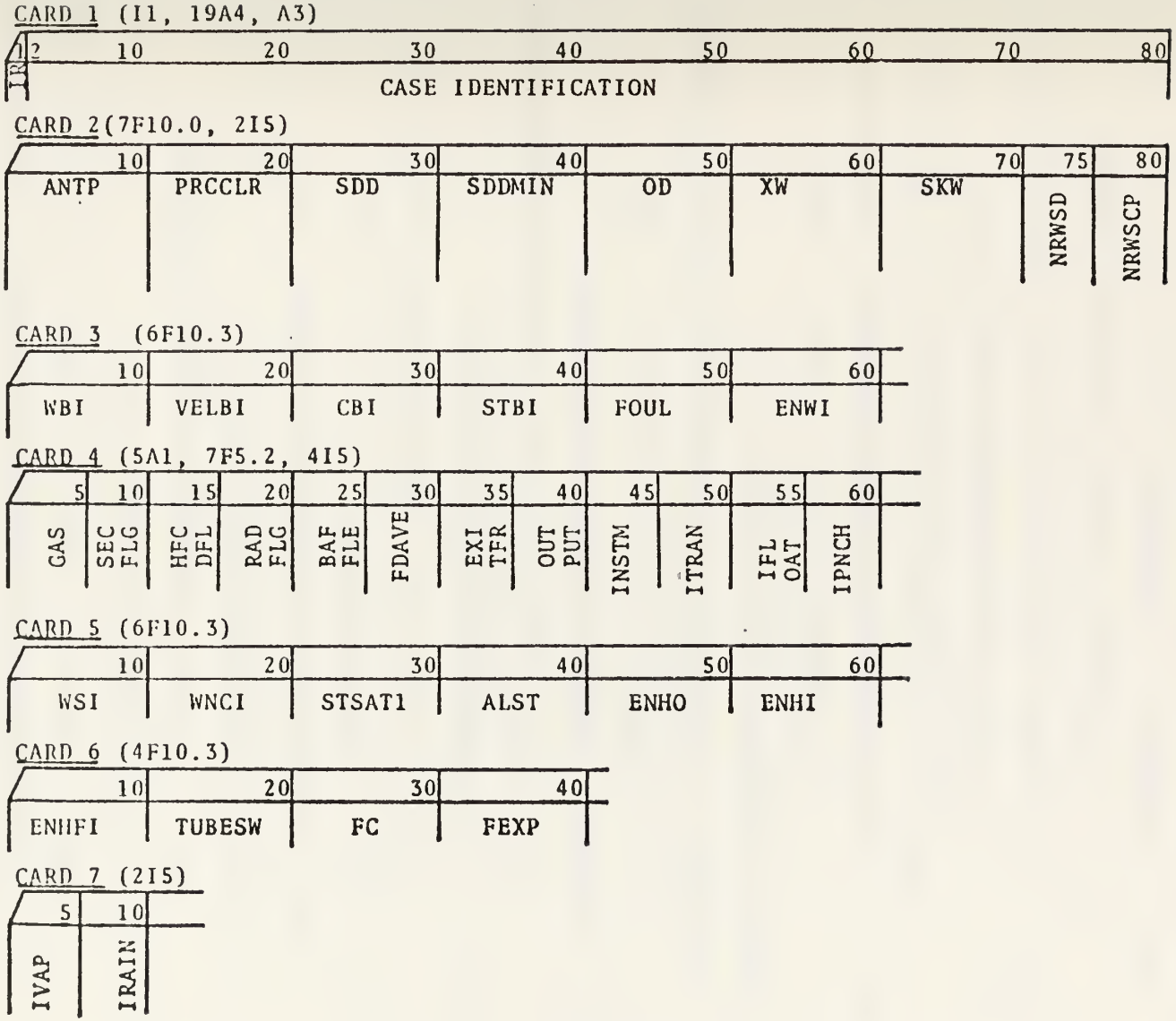


Figure 7. Card deck layout for input data.

Following is a list of definitions of the input parameters. A listing of the input cards for the baseline case is given in Appendix B (compare Table II).

Card 1, (FORMAT: I1, 19A4, A3)

IR — Indicator for cards to be read (column 1 only). If IR = 0, 4, or >5, then all seven cards will be read in proper order.

INDENT — All the remaining columns of the first card are available for identification or notes, 79 columns

Card 2, (FØRMAT: 7F10.0, 215)

ANTP — Total number of tubes in the bundle (includes cooler).

PRCCLR — Percent of tubes in the cooler.

SDD — Ratio of tube circumferential center-to-center spacing to tube diameter

SDDMIN — Ratio of tube spacing to tube diameter for cooler section.

ØD — Outside diameter of all tubes, in.

XW — Wall thickness of tubes, in.

SKW — Thermal conductivity of tube material, $Btu/hr\text{-}ft^2\text{-}^oF/ft$.

NRWSP — Number of rows of condenser coolant inlet temperatures to be read (use only to read punched card inlet coolant temperatures, set = 0 otherwise).

NRWSCP Same as NRWSP except for cooler.

Card 3, (FØRMAT: 8F10.3)

WBI Total coolant flow to condenser (cooler included), lb/hr.

VELBIP Coolant velocity, ft/sec.

(Note: WBI and VELBIP are exclusive variables; one of them should be set to zero. If not, then VELBIP will override WBI).

CBI Coolant salt concentration, fraction by weight.

STBIP Coolant inlet temperature, ^{o}F.

(Note: STBIP is used only if inlet coolant temperatures are not read in or transferred.)

FOUL Tube fouling resistance $hr\text{-}ft^2\text{-}^{o}F/Btu$

ENHI Tube internal heat transfer enhancement factor.

Card 4, (FORMAT: 5A1, 7F5.2, 415)

GAS Type of noncondensible gas, must be one of AIR, CØ2, or MIX.

SECFLG Bundle model indicator, gives number of 30^{o} sectors in one-half of a symmetrical bundle, or total sectors in a semicircular bundle.

HFCDFL Symmetry indicator.

If = 1, model will have symmetry about a vertical centerline

If = 0, model will be a semicircular type.

RADFLG Factor to increase bundle radius beyond that normally calculated by the code (will enlarge center void).

BAFFLE Flag to indicate presence of baffles at 2 and 4 o'clock.

FDAVE Tube spacing parameter. Used in subroutine HETTRN to modify effect of condensate flooding.

EXITFR Target value for vented steam as a percent of input. If EXITFR = 0.0, then program will make a single pass and return the results without any adjustments.

ØUTPUT Control flag to restrict amount of detail printed out.

ØUTPUT = 1.0 gives full detail of all sectors.

ØUTPUT = 0.0 prints only summary.

INSTM Flag to direct program flow when converging on exit fraction (EXITFR) target.

INSTM = 1, inlet steam adjusted.

INSTM = 0, tube length adjusted.

ITRAN Flag to direct code to use outlet coolant temperatures from immediate preceding run (used only when multiple stages are run together) for inlet temperatures of current stage.

ITRAN = 1, use transferred temperatures

ITRAN = 0, do not use transferred temperatures.

IFLØAT Flag to give option of having detail output in floating point form; one gives floating point, zero gives fixed point.

IPNCH Outlet coolant temperatures will be punched for input if IPNCH = 0.

Card 5, (FORMAT: 8F10.3)

WSI Steam flow to condenser, lb/hr.

WNCI Noncondensible gas flow to condenser, lb/hr.

STSAT1 Inlet steam temperature, ^{o}F

ALST Tube length, ft.

ENHØ Tube external thermal enhancement factor for heat transfer.

ENHF Friction factor enhancement factor for use in calculation of pressure drop in the steam.

Card 6, (FORMAT: 4F10.3)

ENHFI Friction factor enhancement factor for cooling water pressure drop

TUBESW Specific weight of tube material, 1 /ft.^{3}

FC Coefficient for enhanced-tube friction factor formula of the form $f_{cw} = FC*(Re_{cw}/10^{5})**FEXP$

FEXP See FC

Card 7, (FORMAT: 2I5)

IVAP, IRAIN Switches to control vapor shear and inundation effects. If set less than one these effects are neglected.

Output

Subroutine OUTP1 handles the principal output from the run. First, an image of the input deck is reproduced followed by an expanded version of this information. There next follows a series of statements defining the progress of the iterations

to achieve the specified exit fraction. In the baseline case (Appendix C) the tube length is successively adjusted until convergence is achieved in the ninth iteration. There follows a table of data describing the condenser, cooler, and overall performance. Next, average inlet and outlet coolant temperatures are calculated for the condenser and the cooler. From these averages overall log mean temperature differences, DTCND2, DTCOL2, and DLTOT2, are calculated for the condenser, cooler and overall, respectively, using inlet steam temperatures. For the appropriate values of heat removed, the overall heat transfer coefficients, UPCOND, UPCOOL, UPAVG, are found for the condenser, cooler, and entire bundle. In addition, during the run, a row-by-row average of the heat transfer coefficients (UBARW, UBARWC, UAVGW, respectively) is made, and the corresponding log mean temperature differences (ADTCND, ADTCLR, ADTOA, respectively) are back calculated.

The option exists to print only the summary of results (OUTPUT = 0), or to have the summary plus two pages of detailed results for each sector (OUTPUT = 1). In the event of an error condition existing when the output subroutine is entered, the above calculations will be omitted and only the detailed output will be printed.

Appendix C contains the summary output as well as the detailed output. In addition, a listing of definitions (not normally included) is inserted to facilitate the analysis of the detailed output. At the bottom of the summary output

(preceding the detailed output) are seven additional quantities. These are defined as follows:

BUNL2P	Tube length for two-pass bundle, ft
BUNVOL	Bundle volume, including tubes and voids, ft^3
BUNWT	Bundle weight, lb
RETUB	Cooling water Reynolds number
FRIFAC	Cooling water friction factor
HDLOSS	Cooling water head loss, ft H_2O
PMPPWR	Cooling water pumping power, hp

RESULTS OF COMPUTER EXPERIMENTS

The following calculations examine applications of the MORCON code to departures from the baseline design. Several computer experiments are described in order to demonstrate some of the effects of internal and external enhancement of tubes contained within bundles. In addition, these examples serve to illustrate some of the influences that tube-to-tube interactions can have upon the performance of tubes in bundles.

Effect of Internal and External Enhancement on Bundle Length

Figures 8a and 8b illustrate the predicted effect of internal and external enhancement in terms of the length of tubes necessary to maintain the baseline heat duty. Constant heat duty is obtained by iteratively varying the tube length to obtain a fixed exit fraction of 0.05% of the baseline inlet

steam flow. Figure 8 includes manufacturer's data for enhancement factors of some commercially available augmented tubes and it is seen that combined internal and external enhancement can be expected to lead to bundle length (and volume and weight) reductions on the order of 35%. Table III gives information describing the augmented tubes used in this study.

Table III. Characteristics of Some Commercially-Available Augmented Tubes[1]

Tube	Groove Geometry		Thermal Enhancement Factors		Head Loss Factor[2]
	Pitch / Dia	Depth / Dia	Internal	External	
KL	0.543	0.025	2.14	1.05	2.03
KM	0.543	0.040	2.51	1.14	3.26
YL1	0.250	0.013	1.44	1.35	1.56
YL2	0.250	0.013	1.44	1.94	1.47
YM1	0.125	0.0215	2.70	1.38	6.02
YM2	0.125	0.0215	2.70	1.94	5.69

Notes:

1. Tubes KL and KM are products of Wolverine Division, UOP Inc. [25]. Tubes YL1, YL2, YM1, and YM2 are products of Yorkshire Imperial Metals, LTD [26].

2. Figures shown are ratios of head loss values to the smooth-tube case for the baseline conditions.

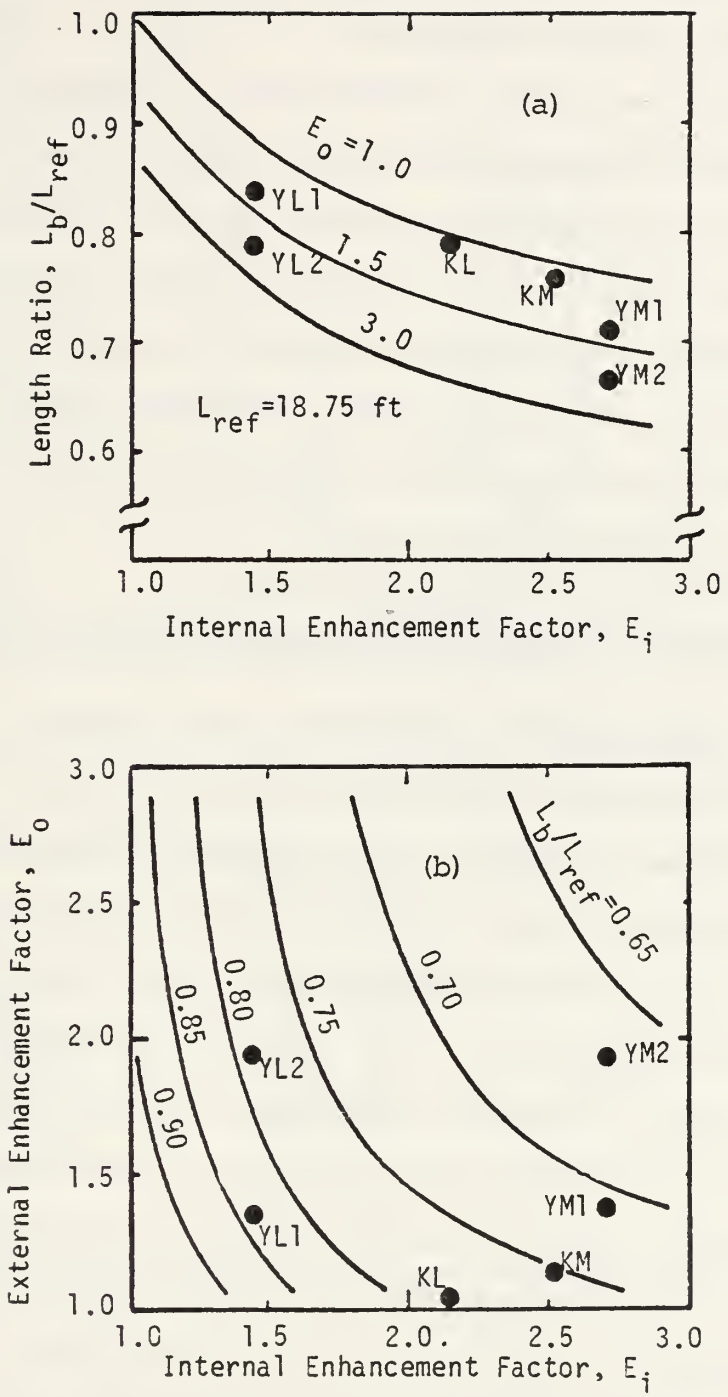


Figure 8. Effects of internal and external enhancement on tube length; baseline condenser.

The smooth-tube baseline is, as is typical, controlled in thermal resistance by the tube side film coefficient. For this reason internal enhancement is relatively more effective (about 2:1) than external enhancement. Figure 8b is a cross-plot of Fig. 8a and indicates the combinations of internal and external enhancement necessary for a given length reduction. Here again it is seen that internal enhancement is justifiable to large values relative to external enhancement or, by way of example, external enhancement beyond 1.5 may not be warranted unless the internal film coefficient is enhanced by a factor of at least 2.

Variations in Thermal Resistance through the Bundle

The importance of considering the limiting thermal resistance is further illustrated in Figs. 9a and 9b. Figure 9a illustrates the row-by-row variation in internal and external resistances for a condenser with no external enhancement. Without internal enhancement, the thermal circuit is unbalanced (dominated by the internal resistance) throughout the condenser. External enhancement in this case would clearly be gilding the thermal lily. With an internal enhancement of 2.0, however, the two film resistances are relatively balanced. Such would be the approximate case for the KL tube of Fig. 8.

If external enhancement is to be applied, on the other hand, such as in the case of YM1 in Fig. 8, additional internal

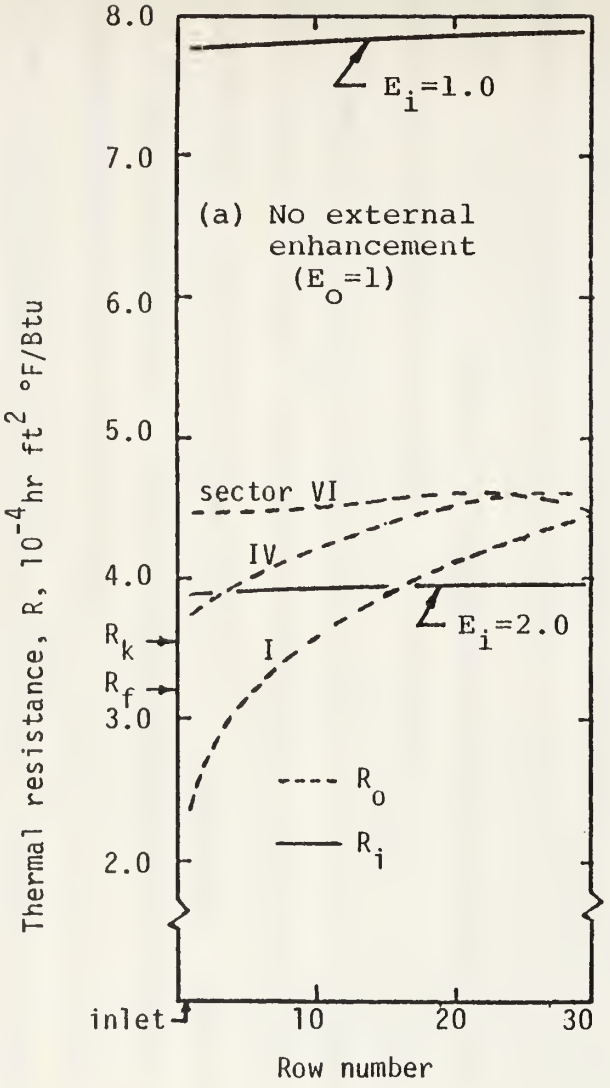
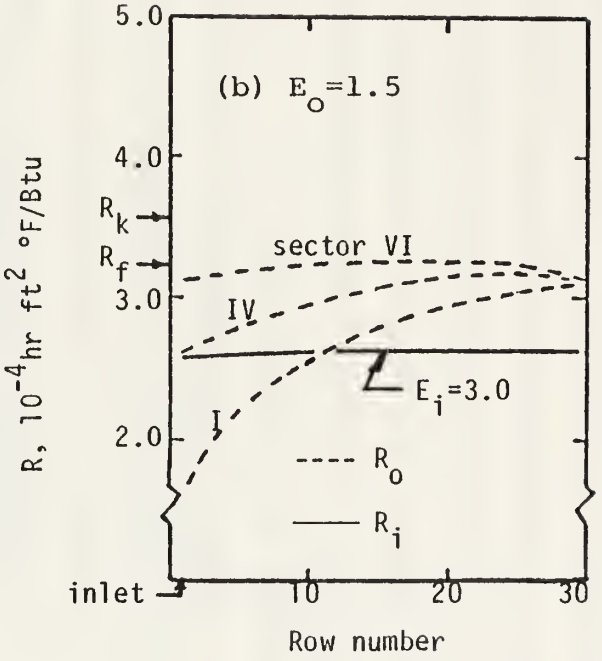


Figure 9. Row-by-row variations of thermal resistances.



enhancement is to be recommended. Such a case is illustrated in Fig. 9b where, again, the relative balance is obtained between the two film resistances by using an inside enhancement of $E_i = 3.0$ and an outside enhancement of $E_o = 1.5$. It should be noted that in Fig. 9b the film resistances have been lowered below the thermal resistances due to fouling (R_f) and tube wall resistance (R_k) (resistance due to the non-condensible gas film is negligible in this case). Therefore, further improvements would be most noticeable from reduction in R_f and/or R_k.

Figures 9a and 9b also illustrate the complicated nature of the shellside resistance. The dashed lines indicate the distribution of external resistance in sectors I, IV, and VI of the condenser, with sector I at the top of the bundle (center ray at 15^o) and proceeding clockwise in 30^o increments to sector VI. In sector I a procession radially inward from row 1 to row 30 is in the direction of gravity and each successive row is inundated by the row above - thus the continuous increase in R_o in sector I. In sector VI, however, each row radially inward is subject to less inundation so that a general improvement is realized from the point of view of condensate inundation. In every sector, however, the vapor velocity is decreasing in a radially inward direction and the beneficial effect of vapor velocity is correspondingly less in regions toward the center of the bundle. In the top

sector (sector I) condensate inundation and vapor shear effects change in the same direction with resistance increasing radially inward. In the bottom sector (sector VI) the inundation and vapor shear change oppositely and there is a general balance. It will be noted that near the bundle exit (entrance to the air cooler section) in sector VI the decreases in vapor shear effects no longer overcome the changes due to reduced inundation and the resistance begins to decrease. Sector IV is also illustrated in these figures and is seen to represent something of a mean behavior among the sectors. The spread between sectors in the external resistance, R_o, is seen to be reduced in Fig. 9b because of reduction in the relative effect of vapor shear with external enhancement.

Influence of Vapor Shear and Condensate Inundation

Figures 10a and 10b illustrate the potentially deceptive nature of the influence of vapor shear and condensate inundation in condenser bundles. Figure 10a examines the relative influence of the two effects upon required tube length and their dependency on internal enhancement. In this case the favorable effect of vapor shear is roughly balanced by that of inundation and in terms of required bundle length they are by no means independent of each other. Without enhancement the two effects are essentially equivalent so that the HEI method, which neglects them both, appears to be adequate (for

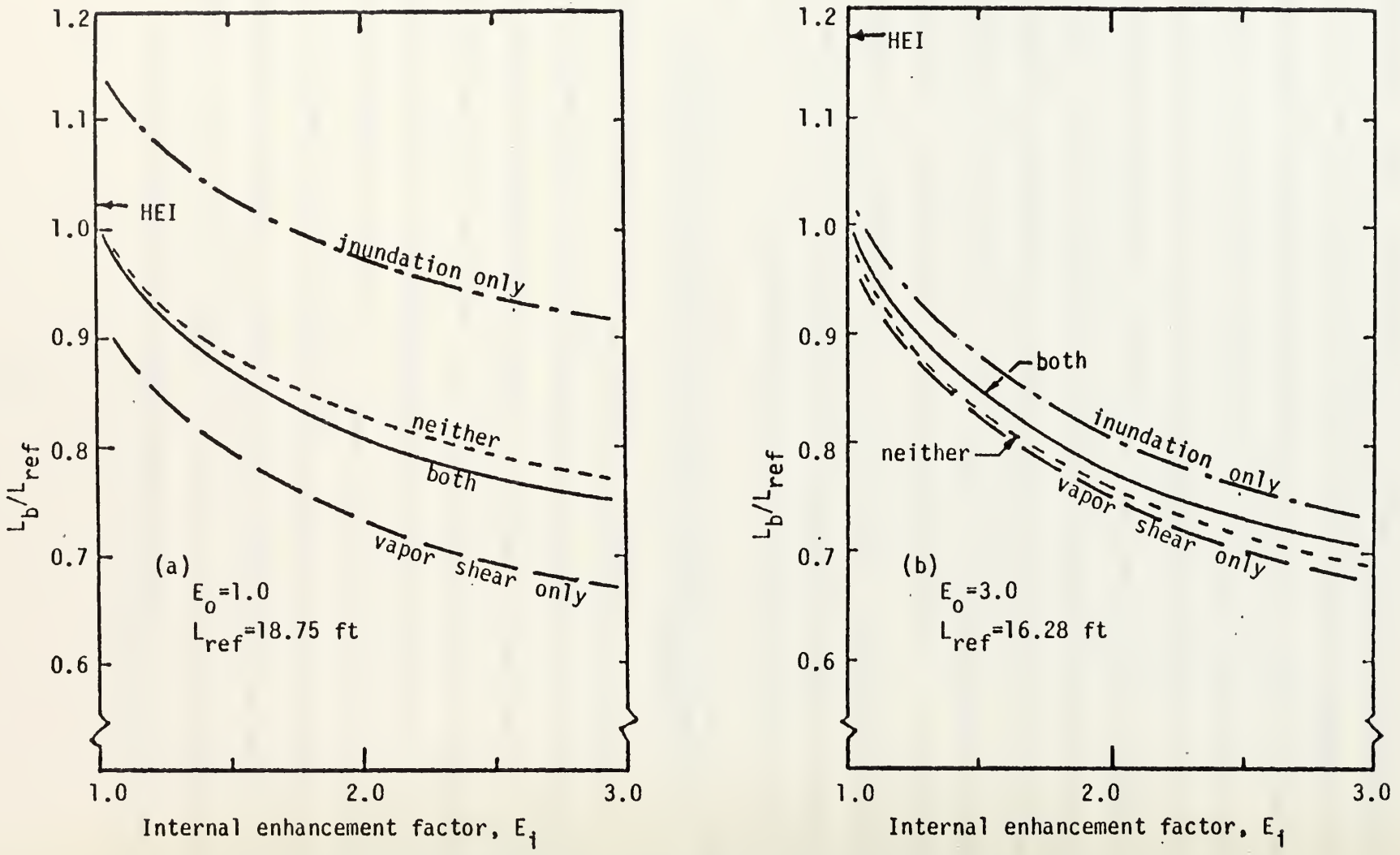
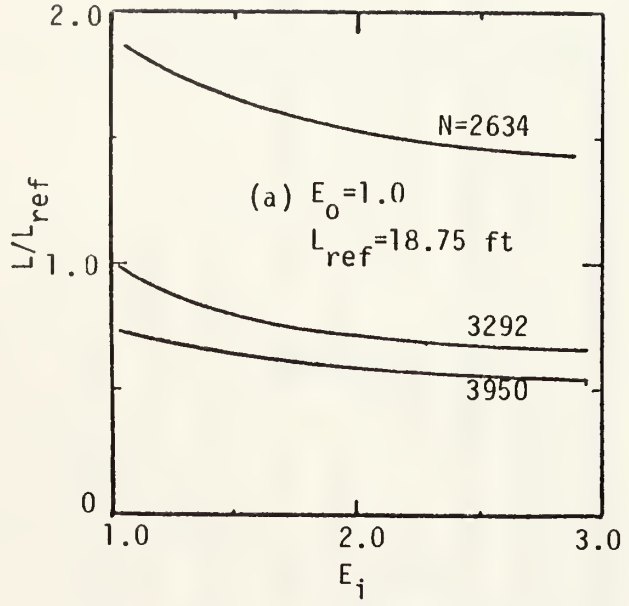


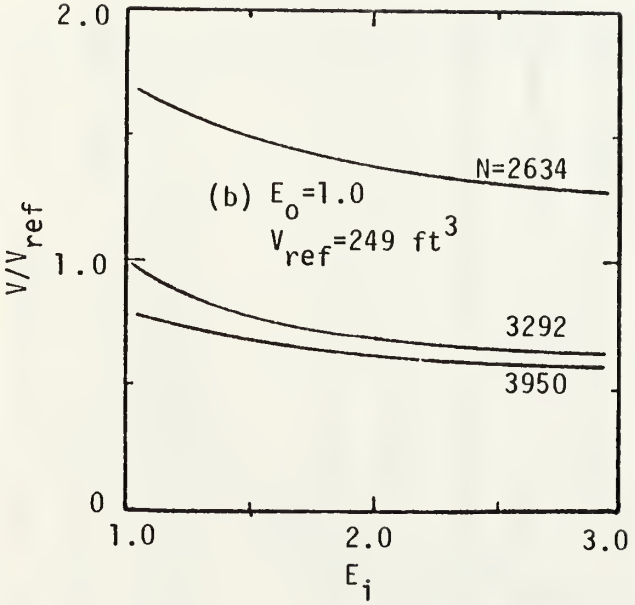
Figure 10. Relative influences of condensate inundation and vapor shear; variations with enhancements.

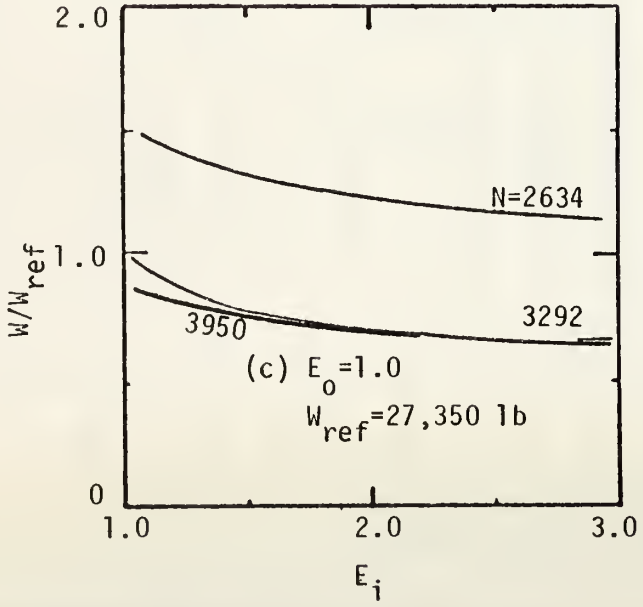
rather serendipitous reasons). With enhancement, however, when row-by-row thermal performance must be considered, the neglect of either vapor shear or condensate inundation can lead to erroneous results (e.g., the neglect of vapor shear would indicate no improvement with an internal enhancement of about 1.7). Figure 10b shows that when external enhancement is large, these effects are less important because of the dominance of thermal resistances other than those due to the shellside film.

Enhancement in Bundles of Various Diameters

The number of possible comparisons such as those shown here is virtually limitless. As a final example, it might be useful to illustrate some of the influences to be expected with enhancement when the number of tubes in the bundle and hence the bundle diameter is allowed to vary. Figures 11a-11f illustrate this effect for a range of internal enhancement factors with no external enhancement (Figs. 11a-11c) and with $E_o = 3.0$ (Figs. 11d-11f). In each set of figures the changes in bundle length, volume, and weight are shown for variations of $\pm$ 20% in the number of tubes in the bundle with the cooling water velocity held constant at 8.0 ft/sec. The reader will draw his own conclusions but a few interesting points may be highlighted here.

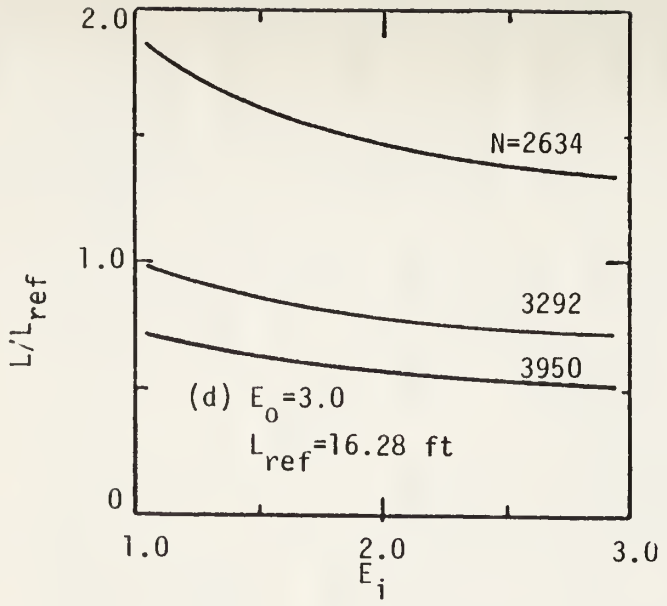


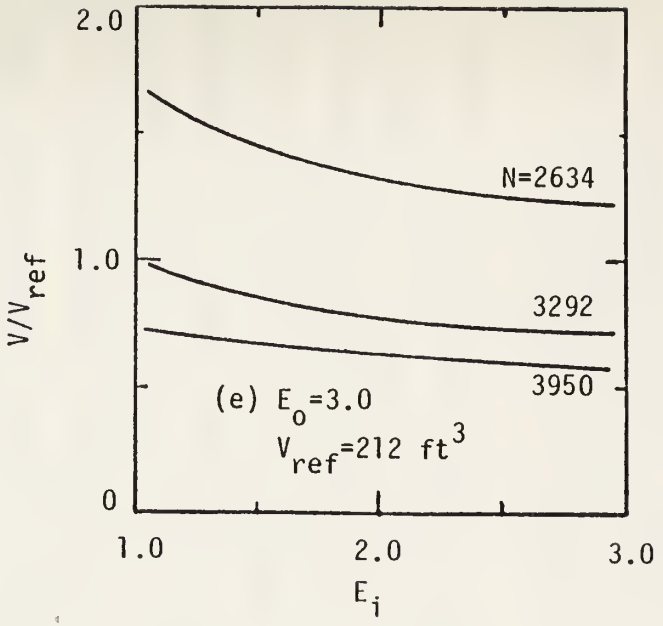


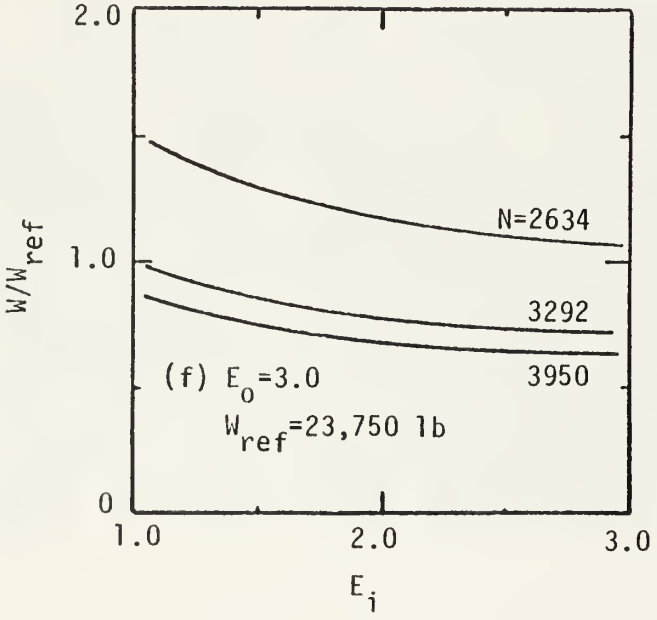


number of tubes N	bundle diameter ft.
2634	3.73
3292	4.15(baseline)
3950	4.57

Figure 11. Variations of bundle length, volume, and weight. Baseline heat duty with cooling water velocity of 8 ft/s; (a)-(c) no external enhancement.







number of tubes N	bundle diameter ft.
2634	3.73
3292	4.15(baseline)
3950	4.57

Figure 11 (continued). Variations of bundle length, volume, and weight. Baseline heat duty with cooling water velocity of 8 ft/s; (d)-(f) external enhancement factor E_o=3.0.

Comparing Figures a and d, b and e, and c and f, it will be seen that bundle length, volume, and weight may all be reduced through enhancement ($E_i = E_o = 3.0$) by factors of about 38% with the number of tubes held constant at the baseline value of 3292.

An increase in the number of tubes will require an increase in the bundle diameter while allowing, at the same time, a decrease in the tube length necessary to sustain the given heat load. These two effects are in opposition as regards bundle volume and weight and in the case of no enhancement (Figs. 11a-11c, $E_i = 1.0$) the decrease in length (about 27%) is sufficient to allow decreases in both volume (20%) and weight (13%). At high levels of internal enhancement, however, the allowable length reduction due to additional tubes is somewhat less and although volume reduction is still obtained the trend in bundle weight decreases and is eventually reversed with $E_i = 2.5$ and $E_o = 1$. For example, the length reduction accompanying a 20% increase in tubes is about 11%, with a volume reduction of 5.4% and a negligible change in weight. At even higher values of E_i it is seen that a 20% increase in tubes leads to an increase in bundle weight - an effect that is opposite to that for the situation without enhancement. Reversals in trends, such as these, are often impossible to predict if steam-side interaction effects are not taken into account.

If, on the other hand, it is desirable to reduce the number of tubes (for space considerations or to reduce cooling water flow rate, for example) a 20% decrease in the number of tubes will give a 10% reduction in bundle diameter. Without enhancement, this would require increases in length, volume, and weight of 90%, 70%, and 26%, respectively. If enhancement ($E_i = E_o = 3.0$) is utilized, however, the percentage increases in length and volume are only 15% and 6% while the bundle weight is decreased by about 7%. Thus, enhancement can allow condenser modifications for "packaging" purposes that might otherwise be impossible.

In the examples cited in Fig. 11, the condenser cooling water velocity has been held constant at 8.0 ft/s. For variable bundle diameters, the cooling water flow rate must therefore change in proportion with the number of tubes. These variations and constraints are used here for illustrative purposes and they represent only a few of the cases under consideration. It should also be remarked that here we have made only minor mention of the changes in cooling water head loss and pumping power that accompany the many variations shown in Figs. 8-11. Obviously, the relative merits of adjustments such as these depend upon the premiums to be placed upon the costs and benefits. If increases in bundle diameter can be tolerated, for instance, there are significant payoffs to be had in reductions in length, volume, weight, and cooling water pumping power.

SUMMARY

The authors wish to again remind the reader that these calculations are most trustworthy when viewed as bases for comparisons. The extremely complex nature of the flow and heat transfer in condenser bundles leaves much to be accomplished through further research. It is hoped that, with these precautions, the utility of a code such as MORCON has been illustrated. It is expected that future design comparisons such as these will be expedited by the development of a numerical optimization code, based upon MORCON, to alleviate the serendipity required to optimize such complex phenomena as condenser bundles.

In closing, it is to be emphasized that several other performance factors and design variables, not mentioned here, are under study. The various tube-side and shell-side pressure drop legacies associated with enhancement are calculated and these constitute some of the "costs" to be balanced against the benefits of enhancement. A paramount factor yet to be understood is the extent to which fouling offsets the benefits of enhancement. Other design variables, such as tube material, tube diameter and wall thickness, condenser steam inlet pressure, and cooling water velocity and flow rate are under consideration. A change to titanium tubes will, in itself, generate a reduction in bundle weight by a factor of approximately 3 because of reduced metal density

and tube wall thicknesses. With all design variables left to vary within reasonable constraints, it is expected that improvements in tube bundle weight and volume may be realized in excess of those cited here and with acceptable penalties in terms of pressure drops and pumping powers.

CONCLUDING REMARKS

On the basis of work reported here and elsewhere, it is apparent that the continued advancement of the technology associated with surface condensers will require improvements in the understanding and definition of the flow conditions on the two-phase multi-component side of the problem. Whereas the prediction of the performance of single tubes - with vapor-side conditions well defined - has seemed adequate in the past, this situation may be attributed to conservative design attitudes and to the fact that thermal resistances other than those on the vapor side have dominated the overall thermal circuit. Advanced condenser designs that seek optimal performance (minimum weight, maximum efficiency, etc.) will require a level of analytical sophistication that exceeds present-day standards.

A case in fact is that in which enhanced tubes are contemplated for use in condenser bundles. The prediction of condenser performance based upon single-tube theory and experiment cannot be expected to be reliable. Overall condenser

performance may exceed or fall short of such predictions depending upon the selection of the tubes themselves as well as their geometry and location in the condenser bundle.

Computer-based analyses can be used to advantage in the estimation of the tube-to-tube variation of flow conditions within a condenser bundle. In this report, a condenser computer code of moderate complexity has been described and its use has been demonstrated in several sample cases. The results of these computer experiments have served to illustrate the importance of internal detail in the prediction of the performance of condensers utilizing enhanced tubes. In addition, these studies have shown that judicious use of enhanced tubes can lead to considerable improvements in condenser performance as well as the realization of heretofore unattainable design options.

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Appendix A. MORCON Listing

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CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCMOR00010
C                        NAVAL POSTGRADUATE SCHOOL                      CMOR00020
C                          MONTEREY, CALIFORNIA                         CMOR00030
C                                                                       CMOR00040
C          COMPUTER CODE FOR SURFACE CONDENSER DESIGN AND ANALYSIS       CMOR00050
C                                                                       CMOR00060
C                              MORCON                                   CMOR00070
C                                                                       CMOR00080
C     THIS CODE IS AN ADAPTATION OF THE ORCONI CODE DEVELOPED BY THE    CMOR00090
C     OAK RIDGE NATIONAL LABORATORY.  OTHER THAN MINOR MODIFICATIONS,   CMOR00100
C     MORCON IS ORCONI WITH THE EFFECTS OF VAPOR SHEAR ADDED AND WITH   CMOR00110
C     THE CALCULATION OF COOLING WATER HEAD LOSS AND PUMPING POWER.     CMOR00120
C                        5 AUGUST, 1982                                 CMOR00130
C                                                                       CMOR00140
C                                                                       CMOR00150
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCMOR00160
      COMMON/INPT/ ALST ,ANT ,BAFFLE ,HFCOFL, CBI ,EXITER ,FOUL ,GAS ,  MOR00170
     , GD , OUTPUT ,PRCCLR ,RADFLG ,SOD ,SDOMIN ,SECFLG ,SKW ,STBI ,    MOR00180
     , STSETI ,VELBI , VSFLG ,WNCI ,XSI ,XW ,VPSMII100,6), VPSH(C(100) ,MOR00190
     , FCAVE ,FAHI ,FNHC ,FNHF ,HBI ,STBIP,ANTP,VELBIP,ADJF,IOENT(20),  MOR00200
     , INSTM ,IRLOAT ,ITRAN ,IPNCH ,NRWSP ,NRWSCP ,NRWS ,NRWSC,         MOR00210
     , FAHFI, TLEESH, FC, FSXP                                          MOR00220
      COMMON/INTEG/IFNC ,IFNCC ,ILNG ,ISEC , IVNO ,IVNCC ,J ,JGAS ,JPC ,MOR00230
     , IFEND ,IFENCC ,IGT ,IAT,IVAP,IRAIN                               MOR00240
      COMMON AI ,AMLSEX ,AMOLNC ,AMWNC ,AO , ASS ,AW ,AXI ,BNDIAM ,CCCR MOR00250
     , (2), DELPLE ,GB ,HFG ,HMO ,HNOC , PMIXI ,PMAEXI ,PSATEX ,RADINS ,MOR00260
     , SDI , SDO ,SF ,SG ,SHWINV ,STBAVE , STB2ES ,STFC ,STSAEX ,TB2 ,  MOR00270
     , TFC , TNCC ,TNOFR ,TSATEX, VELEXT ,VG , VLCMAX ,VNC ,VNOC ,WB ,  MOR00280
     , WNCC ,WSEXII ,XNC , SMIBI, SMIB2, SMWB, SUMQ, SMTBIC, SMTB2C,    MOR00290
     , SMWSC, SLMQC                                                     MOR00300
      COMMON/DIM1/ C (6),DELP (6),WGAS (6) ,XP (6) ,WSPI(6)             MOR00310
      COMMON/DIM2/ ALMTCC(100), GFLOWC(100),PMIXC (100),PSATC (100),RCC MOR00320
     , (100), SMIC (100),SMWFC 1100),STSAT(1100), UNC (1301,VELC (1001,  MOR00330
     , VNREC (100),VFSHC( 1100), VPSHMC(100),WCNOC (100),WSC (1001,     MOR00340
     , HEFFC(100), RCUTC(100) ,QDAC(100) , CUMDPC(100)                  MOR00350
      COMMON/DIM3/ ALMTD 1100,6) , AMF (100,6), GFLOW (100,6),PMIX     MOR00360
     , (100,6), PSAT 1100,6), RC (100,6),SMI (100,6), SHN (100,6),STSAT MOR00370
     , (100,6) ,UN (100,6), VEL (100,6),VNRE (100,6) ,VPSH (100,6),     MOR00380
     , VPSHM (100,6),WCND (100,6), WS (100,6) , HEFF(100,6) , RDUT(100, MOR00390
     , 6) ,QDAI(00,6) ,CUMDP(100,6),ACTFLW (100), RADIUS (1001, TBNPR   MOR00400
     , (100)                                                            MOR00410
      DIMENSION AIN(11),YN(111                                          MOR00420
      INTEGER GAS(5)                                                    MOR00430
      SC=32.174                                                         MOR00440
      VLCMAX=150.0                                                      MOR00450
      CALL ZERO(VPSHI,2800)                                             MOR00460
C                                                                       MOR00470
   10 CALL INPUT(6160,6290)                                             MOR00480
C                                                                       MOR00490
      WRITE(6,10500)                                                    MOR00500
10500 FORMAT (1H , 10HINPUT DONE)                                       MOR00510
      NERR = 0                                                          MOR00520
      IHNO = 0                                                          MOR00530
      ADJF = 6.0 * (2.0 - HFCOFL)                                       MOR00540
      IF (JGAS.EQ.1) AMWNC = 28.965                                     MOR00550
      IF (JGAS.EQ.2) AMWNC = 44.                                        MOR00560
      IF (JGAS.EQ.3) AMWNC = 36.5                                       MOR00570
      PI = 3.1416                                                       MOR00580
      SDO=SOD/12.0                                                      MOR00590
CCCCC                                                                   MOR00600
C          COMPUTE BUNDLE GEOMETRY                                      MOR00610
CCCCC                                                                   MOR00620
C     CONDENSER SECTION                                                 MOR00630
      ANT = ANT * ADJF / SECFLG                                         MOR00640
      TNC=ANT*(1.0-PRCCLR/100.0)                                        MOR00650
      NCROWS = (TNC*1.1035)**0.5/2.0                                    MOR00660
      NTMS = 1                                                          MOR00670
      NCROWV = NCROWS                                                   MOR00680
      CPFCTR = 2.0*PI/(SDO*SDO*12.0)                                    MOR00690
      SPFCTR = 1.732*SDO*SDO                                            MOR00700
      ISEC = SECFLG                                                     MOR00710
   20 BNDRAD = FLOAT(NCROWS)*SDO*SDO                                    MOR00720
```

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FILE: MORCON   FORTRAN A   NAVAL POSTGRADUATE SCHOOL

      BNDRAD = BNDRAC * RADFLG                                          MOR00730
C  CALC. FOR EACH ROW(I), RADIUS AND NO. OF TUBES                       MOR00740
      RADIUS(1)=BNDRAD                                                  MOR00750
      TBNPR(1)=RADIUS(1)*GMFCTR                                         MOR00760
      RADSQ = BNDRAD**2                                                 MOR00770
   30 CONTINUE                                                          MOR00780
      SUMTUB = 0.0                                                      MOR00790
      DO 70 I=1,NOROWS                                                  MOR00800
         SUMTUB = TBNPR (I) *12.0 + SUMTUB                              MOR00810
         IHNO = I                                                       MOR00820
         IF (SUMTUB-TNCI 60,40,40                                       MOR00830
   40    CONTINUE                                                       MOR00840
         CPRT = 1. - PRCCLR/100.                                        MOR00850
         CPR1 = ISUMTUB-TBNPR(I)*12.)/ANT                               MOR00860
         CPR2 = SUMTUB/ANT                                              MOR00870
         IF (ABS(CPRT-CPR1).GT.ABS(CPRT-CPR2)) GO TO 50                 MOR00880
         IHNO = I - 1                                                   MOR00890
         SUMTUB = SUMTUB - TBNPR (I) * 12.0                             MOR00900
         RADINS = RADIUS (I - 1) - SDO * SDO / 2.0                      MOR00910
         GO TO 80                                                       MOR00920
   50 CONTINUE                                                          MOR00930
         RADINS = RADIUS (1) - SDO * SDO / 2.0                          MOR00940
      GO TO 80                                                          MOR00950
   60 RADIUS (I + 1) = RADIUS (I) - 0.866 * SDO * SDO                   MOR00960
   70 TBNPR(I+1) = GMFCTR * RADIUS(I+1)                                 MOR00970
CCCCC                                                                   MOR00980
C  AT THIS POINT *OD  70* HAS BEEN SATISFIED & SUMTUB ) TND.            MOR00990
C  AN ADDITIONAL ROW WILL BE ADDED IF ROOM REMAINS-IE--RADIUS(IHNO+1),0. MOR01000
CCCCC                                                                   MOR01010
      NCROWS = NCROWS + 1                                               MOR01020
      IF (RADIUS(IHNO+1).GT.0.0) GO TO 30                               MOR01030
CCCCC                                                                   MOR01040
C  IF RADIUS(IHNO + 1) ) 0.0, A BIGGER DIAM. BUNDLE IS REQUIRED TO      MOR01050
C  ACCOMODATE THE REQUIRED NO. OF TUBES.                                MOR01060
CCCCC                                                                   MOR01070
      NCROWS = NCROWSV + NTMS                                           MOR01080
      NTMS = NTMS + 1                                                   MOR01090
      GO TO 20                                                          MOR01100
   80 CONTINUE                                                          MOR01110
      TNCC = ( ANT - SLMTUB ) / ADJF * SECFLG                           MOR01120
      IF (PRCCLR.EQ.0.0) TNOC = 0.0                                     MOR01130
      TNC = SLMTUB                                                      MOR01140
C     WRITE(6,9127) TNC, TNOC, SUMTUB                                   MOR01150
C9127 FORMAT(1H , 4X, 3E20.6)                                           MOR01160
      HNC = FLOAT(IHNO)                                                 MOR01170
CCCCC                                                                   MOR01180
C     IF NO. OF CONDENSER TUBE ROWS(IHNO) .GT. 99, GO TO NEXT CASE      MOR01190
CCCCC                                                                   MOR01200
      IF (IHNC.LT.99) GO TO 90                                          MOR01210
      WRITE(6,10000) IHNO                                               MOR01220
      GO TO 10                                                          MOR01230
   90 IF (NRWS.EQ.0..OR.NRWS.EQ.IHNO) GO TO 100                         MOR01240
      WRITE(6,10100) NRWS,IHNO                                          MOR01250
      GO TO 10                                                          MOR01260
  100 CONTINUE                                                          MOR01270
CCCCC                                                                   MOR01280
C  REVISED EST. OF NO. OF TUBES ABOVE ROW(I) FOR THE 6 SECTOR GEOMETRY  MOR01290
C     CONCEPT. ADJUSTED FOR VACANT SPACE(VC(I) IN BUNDLE CENTER WITH    MOR01300
C     OPTION OF BAFFLES AT 2 & 4 O'CLOCK POSITIONS. 5/30/68             MOR01310
C     NO BAFFLES IF BAFFLE = 0.                                         MOR01320
C     BAFFLES IF BAFFLE = 1.                                            MOR01330
CCCCC                                                                   MOR01340
      CALL ZERO(ANF,2400)                                               MOR01350
      DO 130 I=1,IHNC                                                   MOR01360
         AL01 = 0.96593 * RADIUS(I)                                     MOR01370
         AL03 = 0.25882 * RADIUS(I)                                     MOR01380
         AL02 = (RADSQ - AL03**2)**0.5                                  MOR01390
         ALTB = 0.500 * RADIUS(I)                                       MOR01400
         AL041 = 0.0                                                    MOR01410
         IF (RADINS.GT.AL03) AL041 = (RADINS**2-AL03**2)**0.5           MOR01420
         ANF(I,1) = (AL02 -AL01)/SPFCTR                                 MOR01430
         AL05 = 0.70711 * RADIUS(I)                                     MOR01440
```

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FILE: MCRCON   FORTRAN A   NAVAL POSTGRADUATE SCHOOL

      ALC6 = (RADSQ - ALO5**2)**0.5
         ANF(1,2) = (ALC6 - ALO5)/SPFCTR
         ALO42 = 0.0
         IF (RADINS.GT.ALO5) ALO42 = (RADINS**2 - ALO5**2)**0.5
         ALO43 = 0.0
         IF (RADINS.GT.ALO1) ALO43 = (RADINS**2 - ALO1**2)**0.5
         ALO9 = (RADSQ - ALO1**2)**0.5
         IF (BAFFLE.EQ.1.0) GO TO 110
         ANF(1,3) = (ALO9-ALO3)/SPFCTR
         ANF(1,4) = (ALO9 + ALO3 - 2.*ALO43)/SPFCTR
         ANF(1,5) = (ALO6 + ALO5 - 2.*ALO42)/SPFCTR
         ANF(1,6) = (ALO2 + ALO1 - 2.*ALO41)/SPFCTR
         GO TO 120
  110 CONTINUE
C  (BAFFLED SYSTEM CALCS. (BETWEEN SECTORS 2 & 3 AND 4 & 5.)
      ALTB = 0.55768 * RADIUS(1)
         IF (ALTB.GT.ALO9) ALTB = ALO9
         ANF(1,3) = (ALTB - ALO3)/SPFCTR
         ANF(1,4) = (ALTB + ALO3 - 2.*ALO43)/SPFCTR
      ALTB=.4062*RADIUS(1)
         IF(ALO42.LT.ALTB) ALO42 = ALTB
         ANF(1,5) = (ALO5 - ALO42)/SPFCTR
      ALTB=.1454*RADIUS(1)
         IF(ALO41.LT.ALTB) ALO41 = ALTB
         ANF(1,6) = (ALO1 - ALO41)/SPFCTR
  120 CONTINUE
      DO 130 JJ=1,ISEC
         NF = ANF(1,JJ) * 1.25
         ANF(1,JJ) = NF
         IF (ANF(1,JJ).LE.0.5) ANF(1,JJ) = 0.0
  130    CONTINUE
      SDI=(DD-2.0*XW)/12.0
      AXI=(PI*SDI**2)/4.0
      SDO=(SCC-SDI)/(ALOG(SCO/SDI)
      BNDIAM = 2.0*(BNDRAD + SCO*SOO/2.0)
C     COOLER SECTION
      IVNCC =1
      IF (PRCCLR.EC.C.C) GO TO 150
      HTCLR = RADIUS(1)-RADINS
      VNCC=(HTCLR-SDCI)/( SDOMIN *SOO * 0.866)
      IVNCC=TNCC/VNOC
      FNCC=FLOAT(IVNCC)
      VNCC=TNCC/FNCC
      IVNCC=VNCC + .5
CCCCC
C     IF NO. OF COOLER TUBE ROWS(IVNOC) .GT. 99, GO TO NEXT CASE
CCCCC
      IF (IVNCC.LT.99) GO TO 140
      WRITE(6,10200) IVNOC
      GO TO 10
  140 CONTINUE
      VNCC=FLOAT(IVNOC)
  150 CONTINUE
CCCCC
C     CALCULATION OF VALUES PRIOR TO ENTERING THE BUNDLE
CCCCC
  160 CONTINUE
      IHS = 0
      ILAG = 0
      WNCC = WNCI
      WNCI = WNCI * ADJF / SECFLG
      WSI = WSI *ADJF / SECFLG
      WBI = WBI * ADJF / SECFLG
      TSATI=STSATI+459.69
      PSATI=PSATFN(TSATI)
      AMCLNC=WNCI/AMWNC
      IF (VELBI.EQ.0.) GO TO 170
      IF (STBI.LE.1.) STBI = VPSH(1,1)
      WBI = 3600.0 * ANT * AXI * ROEFN ( CBI, STBI) * VELBI
  170 CONTINUE
      WB = WBI / ANT
      GB=WB/(3600.0*AXI)

FILE: MCRCON   FORTRAN A   NAVAL POSTGRADUATE SCHOOL

      HFG=HFGFN(TSATI)                                                  MOR02170
      CALL ZERO(ALMTD,2400)                                             MOR02180
      CALL ZERO(QFLOW,43200)                                            MOR02190
      CALL ZERO(ALMTCP,7600)                                            MOR02200
  180 AMCLSS=WSI/18.015                                                 MOR02210
      AMOLST=AMCLSS*AMOLNC                                              MOR02220
      PMIXI=PSATI*(AMOLST/AMOLSS)                                       MOR02230
      VGI=VGFN(TSATI,PMIXI)                                             MOR02240
      CPB=CPFN(CBI,STBI)                                                MOR02250
      STIFES=(WSI+WFC)/( WBI*CPB)+STB)                                  MOR02260
      SVNCI=10.729*TSATI/(AMWNC *PMIXI )                                MOR02270
      SVMIXI = 1.0/ (AMCLSS / (AMOLST * VGI) + AMOLNC/ (SVNCI * AMOLST))MOR02280
      C2=288.0*SG*SVMIXI                                                MOR02290
      A = 1. + .02*(SECFLG-1.0)                                         MOR02300
      DO 190 J=1,ISEC                                                   MOR02310
         WGAS (J) = WNCI / 12.0 * A                                     MOR02320
         WS (1,J) = WSI / 12.0 * A                                      MOR02330
  190    A = A - 0.04                                                   MOR02340
  200 CONTINUE                                                          MOR02350
      ASS=0                                                             MOR02360
      JRC = 0                                                           MOR02370
      IRENO = C                                                         MOR02380
      IRENOC = 0                                                        MOR02390
      ICT = 0                                                           MOR02400
      IRT = 0                                                           MOR02410
      AI=PI*SDI*ALST                                                    MOR02420
      AC=PI*SCC*ALST                                                    MOR02430
      AO=PI*SDO*ALST                                                    MOR02440
      SPWINV=(AC*XW)/(12.0*SKW*AW)                                      MOR02450
C  CALC. BUNDLE FACE AREA                                               MOR02460
      BNDFAR = 2.0*PI*(BNDRAD + SDO/2.0)*ALST                           MOR02470
C CALC. FOR EACH ROW(I) THE AREA OPEN TO FLOW                           MOR02480
      PATHAR = (SDO-1.0)*SDO*ALST                                       MOR02490
      DO 210 I=1,IHNC                                                   MOR02500
  210    ACTFLW(I) = PATHAR * TBNPR(I)                                  MOR02510
      ACTFLW(IHNC+1) = ALST * RADINS * PI / 6.0                         MOR02520
      VEL1=((WSI+WNCI)*SVMIX1)/(3600.0*BNOFAR)                          MOR02530
      AENT =12.0 * ACTFLW(1)                                            MOR02540
      ARATIO=AENT/BNDFAR                                                MOR02550
      VEL2=VEL1/ARATIO                                                  MOR02560
      IF (ARATIO-0.715) 220,220,230                                     MOR02570
  220 DELP12=C.5*(1.0-ARATIO)*VEL2**2/G2                                MOR02580
      GO TO 240                                                         MOR02590
  230 DELP12=C.75*(1.0-ARATIO)*VEL2**2/G2                               MOR02600
  240 DELP23=(VEL2**2-VEL1**2)/G2                                       MOR02610
CCCCC                                                                   MOR02620
C     BUNDLE ENTRY                                                      MOR02630
CCCCC                                                                   MOR02640
      CALL SECALC(AMCLSS,AMOLST,DELP12,DELP23,SVMIX1,NERR)              MOR02650
      WRITE(6,10600)                                                    MOR02660
10600 FORMAT (11H , 11HSECALC DONE)                                     MOR02670
      IF (NERR.EQ.01 GO TO 250                                          MOR02680
      GO TO 280                                                         MOR02690
CCCCC                                                                   MOR02700
C     AVERAGE CONDITION AFTER CONDENSER SECTION AND BEFORE COOLER       MOR02710
C     SECTION.                                                          MOR02720
CCCCC                                                                   MOR02730
  250 PMIXT=PMIX(1,1)-DELPVE                                            MOR02740
      WSUMX=0.C                                                         MOR02750
      DO 260 J=1,ISEC                                                   MOR02760
  260    WSUMX=WSUMX + WS(IHNO+1,J)                                     MOR02770
      WSEXIT = WSUMX * (1.0 + HFCDFL)                                   MOR02780
      AMLSEX=WSEXIT/18.015                                              MOR02790
      PSATEX=PMIXT* AMLSEX / (AMLSEX + WNCC/AMWNC)                      MOR02800
      TSATEX=TSATFN(PSATEX)                                             MOR02810
      STSAEX=TSATEX-459.69                                              MOR02820
      VELEXT=0.0                                                        MOR02830
      DO 270 J=1,ISEC                                                   MOR02840
  270    VELEXT=VELEXT+VEL(IHNO + 1, J)                                 MOR02850
      VELEXT=VELEXT/SECFLG                                              MOR02860
CCCCC                                                                   MOR02870
C     CALCULATION THROUGH COOLER                                        MOR02880
```

```
CCCCC                                                                   MOR02890
      HACCSV = HNOC                                                     MOR02900
      VACCSV = VNOC                                                     MOR02910
      IVACSV = IVNCC                                                    MOR02920
      CALL COCLEX(DELPC)                                                MOR02930
      WRITE(6,10700)                                                    MOR02940
10700 FORMAT (1H , 11HCCOLEX DONE)                                      MOR02950
      WS) = WS) / ADJF * SECFLG                                         MOR02960
      IF (EXITFR.EQ.C.) GO TO 280                                       MOR02970
      EXFR1 = ABS(IVNOC+1) / WS1 * 100.                                 MOR02980
      CALL ADJLST (EXFR1,EXITFR,WS1,WS,ALST, IWS,ILNG,INSTM,&280, X1N,  MOR02990
     , YN,WSIMAX,WSIMIN,ALSTMX,ALSTMN,M1                                MOR03000
      HNCC = HACCSV                                                     MOR03010
      VNCC = VACCSV                                                     MOR03020
      IVNCC = IVNOSV                                                    MOR03030
      WS) = WS1 * ADJF / SECFLG                                         MOR03040
      IF (INSTM.EQ.1) GO TO 180                                         MOR03050
      GO TO 20C                                                         MOR03060
  280 CONTINUE                                                          MOR03070
      TAC = TAC / ADJF * SECFLG                                         MOR03080
      XTFR1 = ABS(IVNCC+1) / WS1                                        MOR03090
      WRITE(6,10400) XTFR1, TNO, TNOC                                   MOR03100
      HAC)= HACC                                                        MOR03110
      CALL OUTFI(DELFC,VEL2,NERR)                                       MOR03120
      TAC = TAC * ADJF / SECFLG                                         MOR03130
      GO TO 10                                                          MOR03140
  290 RETURN                                                            MOR03150
10000 FORMAT('C',15,T7, ' TUBE ROWS IN CNDNSR, WHICH EXCEEDS PROGRAM DIMMOR03160
     'ENSIONS. PROCEEDING TO NEXT CASE.' )                              MOR03170
10100 FORMAT(1H0,'****INPUT ERROR, INCORRECT NO. OF ROWS IN CONDENSER,  MOR03180
     ,NRWS=',I10,'  IHAC=',)10)                                         MOR03190
10200 FORMAT('C'/ 15,T7,' TUBE ROWS IN COOLER, WHICH EXCEEDS PROGRAM DIMMOR03200
     'ENSIONS. PROCEEDING TO NEXT CASE.'1                               MOR03210
10400 FORMAT('C',T3, 'COOLER EXIT STEAM FRAC. ',F7.4, T40,              MOR03220
     , 'ACTUAL TUBES IN CONDENSER',F8.1, T75,'ACTUAL TUBES IN COOLER',  MOR03230
     , F8.1 )                                                           MOR03240
      END                                                               MOR03250
                                                                        MOR03260
                                                                        MOR03270
                                                                        MOR03280
                                                                        MOR03290
                                                                        MOR03300
      SUBROUTINE ZERO(A,N)                                              MOR03310
      DIMENSION A(1)                                                    MOR03320
      N4=N/4                                                            MOR03330
      DO 1 J=1,N4                                                       MOR03340
    1 A(J)=0.                                                           MOR03350
      RETURN                                                            MOR03360
      END                                                               MOR03370
                                                                        MOR03380
                                                                        MOR03390
                                                                        MOR03400
                                                                        MOR03410
      SUBROUTINE ADJLST (EXFR1,EXITFR,WS1,WS,ALST, IWS,ILNG,INSTM,*,    MOR03420
     , X1N,YN,WSIMAX,WSIMIN,ALSTMX,ALSTMN,M1                            MOR03430
C******                                                                 MOR03440
C     SUBROUTINE ADJLST CORRECTS EITHER INPUT STEAM OR TUBE LENGTH      MOR03450
C     TO GIVE A PREDETERMINED EXIT STEAM FRACTION (FROM THE COOLER)     MOR03460
C     AS A PERCENT OF STEAM INPUT.    JAH   4/70                        MOR03470
C******                                                                 MOR03480
      DIMENSION X1N(11),YN(11)                                          MOR03490
      IF (ABS((EXITFR-EXFR1)/EXITFR).LT..10) GO TO 120                  MOR03500
      IF (ILNG.NE.0.OR.IWS.NE.01 GO TO 10                               MOR03510
      WSIMAX = 0.                                                       MOR03520
      WSIMIN = 0.                                                       MOR03530
      ALSTMX = 0.                                                       MOR03540
      ALSTMN = 0.                                                       MOR03550
   10 CONTINUE                                                          MOR03560
      EXTFR = EXITFR / 100.                                             MOR03570
      XTFR1 = EXFR1 / 100.                                              MOR03580
      IF (EXFR1.LT.EXITFR) GO TO 20                                     MOR03590
      ALSTMN = ALST                                                     MOR03600
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      WSIMAX = WSI                                                      MOR03610
      GO TO 30                                                          MOR03620
   20 WSIMIN = WSI                                                      MOR03630
      ALSTMX = ALST                                                     MOR03640
   30 CONTINUE                                                          MOR03650
      IF (INSTM.EQ.0) GO TO 70                                          MOR03660
      IF (IWS.LE.10) GO TO 40                                           MOR03670
      WRITE(6,10200) WSIMAX,WSIMIN,EXFR1                                MOR03680
      GO TO 13C                                                         MOR03690
   40 CONTINUE                                                          MOR03700
C******                                                                 MOR03710
C     ADJUSTMENT FOR  INLET STEAM                                       MOR03720
C******                                                                 MOR03730
      DELWP = ABS(WSIMAX-WSIMIN)                                        MOR03740
      WSICLD = WSI                                                      MOR03750
      WSI = XTR(WSI,XTFR1,IWS,EXTFR,-1.0,X1N,YN,M)                      MOR03760
      IF (WSI.GT.WSIMIN) GO TO 50                                       MOR03770
      DELW = WSIMIN * C.01 / IWS                                        MOR03780
      IF (DELW.GT.DELWP) DELW = DELWP / 2.0                             MOR03790
      WS) = WSIMIN + DELW                                               MOR03800
      GO TO 60                                                          MOR03810
   50 IF (WSIMAX.EQ.0..OR.WSI.LT.WSIMAX) GO TO 60                       MOR03820
      DELW = WSIMAX * 0.01 / IWS                                        MOR03830
      IF (DELW.GT.DELWP) DELW = DELWP / 2.                              MOR03840
      WS) = WSIMAX - DELW                                               MOR03850
   60 CONTINUE                                                          MOR03860
      WRITE(6,10100) IWS,WSIOLD,XTFR1,WSI                               MOR03870
      IWS = IWS + 1                                                     MOR03880
      GO TO 11C                                                         MOR03890
   70 CONTINUE                                                          MOR03900
      IF (ILNG.LE.10) GO TO 80                                          MOR03910
      WRITE(6,10300) ALSTMX,ALSTMN,ALST,EXFR1                           MOR03920
      GO TO 13C                                                         MOR03930
   80 CONTINUE                                                          MOR03940
C****                                                                   MOR03950
C     ADJUSTMENT FOR TUBE LENGTH                                        MOR03960
C******                                                                 MOR03970
      DELAP = ABS(ALSTMX-ALSTMN)                                        MOR03980
      ALTCLD = ALST                                                     MOR03990
      ALST = XTR(ALST,XTFR1,ILNG,EXTFR,1.0,X1N,YN,M)                    MOR04000
      IF (ALST.GT.ALSTMN) GO TO 90                                      MOR04010
      DELA = ALSTMN * 0.01 / ILNG                                       MOR04020
      IF (DELA.GT.DELAP) DELA = DELAP / 2.0                             MOR04030
      ALST = ALSTMN + DELA                                              MOR04040
      GO TO 10C                                                         MOR04050
   90 IF (ALST.LT.ALSTMX.OR.ALSTMX.EQ.0.) GO TO 100                     MOR04060
      DELA = ALSTMX * C.01 / ILNG                                       MOR04070
      IF (DELA.GT.DELAP) DELA = DELAP / 2.0                             MOR04080
      ALST = ALSTMX - DELA                                              MOR04090
  100 CONTINUE                                                          MOR04100
      WRITE(6,10000) ILNG,ALTOLD,XTFR1,ALST                             MOR04110
      ILNG = ILNG + 1                                                   MOR04120
  110 RETURN                                                            MOR04130
  120 WRITE(6,10400)                                                    MOR04140
  130 RETURN1                                                           MOR04150
10000 FORMAT(1H0,15,' ALTCLD =',F10.3,'  XTFR1 =',F7.4,' ALST = ',F10.3)MOR04160
10100 FORMAT(1H0,15,' WSIOLD =',F10.3,'  XTFR1 =',F7.4,' WSI = ',F10.3) MOR04170
10200 FORMAT('CNO CONVERGENCE ON EXITFR IN 10 TRIES,   WSIMAX = ',E15.7,MOR04180
     '   WSIMIN = ',E15.7, '  EXFR1 = ',F10.5)                          MOR04190
10300 FORMAT (1H0                                                       MOR04200
     , ' NO CONVERGENCE FOR EXITFR AFTER 10 TRIES,  ALSTMX =',E12.5,    MOR04210
     , '  ALSTMN =',E12.5,'  ALST =',E12.5,'  EXFR1 =',E12.5)           MOR04220
10400 FORMAT('C',10X,'CONVERGENCE CRITERIA MET FOR EXIT STEAM')         MOR04230
      END                                                               MOR04240
                                                                        MOR04250
                                                                        MOR04260
      SUBROUTINE CCOLEX(DELPC)                                          MOR04270
CCC                                                                     MOR04280
C     SUBROUTINE CCOLEX    CIRC 99 -- 360/CS  12/20/68                  MOR04290
                                                                        MOR04300
                                                                        MOR04310
                                                                        MOR04320
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C                                                                       MOR04330
CCC                                                                     MOR04340
      COMMON/INPT/ ALST ,ANT ,BAFFLE ,HFCOEL, CB) ,EXITER ,FOUL ,GAS ,  MOR04350
     , CO , OUTPUT ,PRCCLR ,RADFLG ,SOD ,SODMIN , SECFLG ,SKW ,STBI ,   MOR04360
     , STSAT1 ,VELBI , VSFLG ,WNCI ,WSI ,XW ,VPSHI(100,6), VPSHIC(100) ,MOR04370
     , FDAVE ,ENNI ,ENNO ,ENNF ,WBI ,STBIP,ANTP,VELBIP,ADJF,IDENT(20),  MOR04380
     , INSTM ,IFLOAT ,ITRAN ,IPNCH ,NRWSP ,NRWSCP ,NEWS ,NRWSC,         MOR04390
     , ENNFI, TUPESW, FC, FEXP                                          MOR04400
      COMMON/INTEG/IHNO ,IHNCC ,ILNG ,ISEC , IVNO ,IVNOC ,J ,JGAS ,JRC ,MOR04410
     , IFEND ,IKENOC ,IOT ,IBT,IVAP,IKAIN                               MOR04420
      COMMON AI ,AMLSEX ,AMOLNC ,AMWNC ,AO , ASS ,AW ,AXI ,BNDIAM ,COOR MOR04430
     , (3) ,DELPVE ,GB ,HFG ,HNO ,HNCC , PMIXI ,PMXEXT ,PSATEX ,RADINS ,MOR04440
     , SOI , SCO ,SF ,SG ,SHWINV ,STBAVE , STB2ES ,STFC ,STSAEX ,TB2 ,  MOR04450
     , TAO , TACC ,TNOER ,TSATEX ,VELEXT ,VG , VLCMAX ,VNO ,VNOC ,WB ,  MOR04460
     , WNCC ,WSEXIT ,XNC , SMTBI, SMTB2, SMWB, SUMQ, SMTBIC, SMTB2C,    MOR04470
     , SWEC, SUMQC                                                      MOR04480
      COMMON/DIM1/ C (6),DELP (6),WGAS (6),WP (6) ,WSP(6)               MOR04490
      COMMON/DIM1/ALMTCC(100), GFLOWC(100),PMIXC (100),PSATC (100),RCC  MOR04500
     , (100), SHC (100),SHNFC (100),STSATC(100), UNC (100),VELC (100),  MOR04510
     , WNREC (100),VPSHC (100), VPSHFC(100),WCNDC (100),WSC (100),      MOR04520
     , HEFFC(100) ,ROUTC(100) ,QOACC(100) , CUMQPC(100)                 MOR04530
      COMMON/DIM16/ ALMTO (100,6) , ANF (100,6), GFLOW (100,6),PMIX     MOR04540
     , (100,6), PSAT (100,6), RC (100,6),SFI (100,6), SHN (100,6),STSAT MOR04550
     , (100,6) ,UN (100,6), VEL (100,6),VNRE (100,6) , VPSH (100,6),    MOR04560
     , VPSHN (100,6),WCND (100,6), WS (100,6) , HEFF(100,6) , ROUT(100, MOR04570
     , 6) ,QOA(100,6) ,CUMQP(100,6),AOTFLW (100), RADIUS (100), TBNPR   MOR04580
     , (100)                                                            MOR04590
      INTEGER GAS(5)                                                    MOR04600
      II = 2                                                            MOR04610
      SMTBIC = 0.0                                                      MOR04620
      SWBC = 0.0                                                        MOR04630
      SMTB2C = 0.0                                                      MOR04640
      SUMQC = 0.0                                                       MOR04650
      IF (PRCCLR.EQ.0.0) GO TO 240                                      MOR04660
      AMLSCC = WNCC / AMWNC                                             MOR04670
      AXCC = SOC*WNCC*ALST * (SODMIN - 1.0)                             MOR04680
      SVGEXT=VGFN(TSATEX,PMXEXT)                                        MOR04690
      SVMXEX=1C.7294*TSATEX/( AMWNC*(PMXEXT))                           MOR04700
      AMLT = AMLSEX + AMLSCC                                            MOR04710
      SVMXEX = 1.0 / (AMLSEX / (AMLT * SVGEXT) + AMLSCC / (AMLT *       MOR04720
     , SVMXEX ))                                                        MOR04730
      VELC(1)=(WSEXIT*WNCC)*SVMXEX/(AXOC*3600.0)                        MOR04740
      IF (VELC(1).GT.VLCMAX) WRITE(6,10200) VELC(1),IVNOC,HNOC          MOR04750
      IF (ITRAN.EQ.1) GC TO 20                                          MOR04760
      AXCM=(WSEXIT*WNCC)*SVMXEX/(VLCMAX*3600.0)                         MOR04770
      IF (AXCM.LT.AXCC) GO TO 10                                        MOR04780
      AXCC = AXCM                                                       MOR04790
      WNCC=AXOC/( SOC*ALST * (SODMIN - 1.0 ))                           MOR04800
      VNCC=TNCC/HNCC                                                    MOR04810
      IVNOC = VNOC + 0.1                                                MOR04820
      HNCC = TACC / FLOAT(IVNOC)                                        MOR04830
      AXCC = SOC * HNCC * ALST * (SODMIN-1.)                            MOR04840
      IF (IVNCC.LT.1) IVNOC = 1                                         MOR04850
      VELC(1)=(WSEXIT*WNCC)*SVMXEX/(AXOC*3600.0)                        MOR04860
      WRITE(6,1C400) VELC(1),IVNOC,HNOC                                 MOR04870
   10 IF (NRWSC.EQ.0) GC TC 20                                          MOR04880
      IF (NRWSC.NE.IVNCC) WRITE(6,10000) NRWSC,IVNOC                    MOR04890
   20 CZ=288.0*SG*SVMXEX                                                MOR04900
      IF (VELC(1)-VELEXT) 30,30,40                                      MOR04910
   30 A2DA1=VELC(1)/VELEXT                                              MOR04920
      CELPCT=((1.0-A2DA1*VELEXT**2)/G2                                  MOR04930
      GC TO 70                                                          MOR04940
   40 A2DA1=VELEXT/VELC(1)                                              MOR04950
      IF (A2DA1-0.715) 60,60,50                                         MOR04960
   50 DELPCT=(C.75*(1.0-A2DA1)*VELC(1)**2)/G2                           MOR04970
      GC TO 70                                                          MOR04980
   60 DELPCT=(C.4*(1.25-A2DA1)*VELC(1)**2)/G2                           MOR04990
   70 PMIXC(1)=PMXEXT-DELPCT -(VELC(1)**2 -VELEXT**2)/G2                MOR05000
      PSATC(1)=PMIXC(1)*AMLSEX/(AMLSEX+AMLSCC)                          MOR05010
      PAL=PSATC(1)                                                      MOR05020
      IF (PAL.GT.0.0) GO TO 80                                          MOR05030
      IK = 1                                                            MOR05040
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      WRITE(6,10300) PMIXC(1),IN                                        MOR05050
      GC TO 25C                                                         MOR05060
   80 CCNTINUE                                                          MOR05070
      TAL = TSATEX(PAL)                                                 MOR05080
      STSATC(1) = TAL - 459.69                                          MOR05090
      WSC(1)=WSEXIT                                                     MOR05100
      VG=VGFN(TAL,PMIXC(1))                                             MOR05110
      AMLSSC = WSC(1)/18.015                                            MOR05120
      VNC=10.729 * TAL / (AMWNC * PMIXC(1))                             MOR05130
      VMIX=1.0/((AMLSSC /(VG*(AMLSSC +AMLSCC))) +(AMLSCC/(VNC* (AMLSSC +MOR05140
     , AMLSCC))))                                                       MOR05150
      VELC(1)=(WSC(1)*WNCC)*VMIX/(AXOC*3600.0)                          MOR05160
      NFC = (VNCC+1.) / 2.0                                             MOR05170
      ANFC = NFC                                                        MOR05180
      IRCWC = C                                                         MOR05190
      DC 230 IK=1,IVNOC                                                 MOR05200
      I=IK                                                              MOR05210
      LJ = 7                                                            MOR05220
      STBI = VPSHIC(I)                                                  MOR05230
      IF (STBI.LT.STBIP) STBI = STBIP                                   MOR05240
      CALL HETTRN(STSATC(I),ANFC ,WSC(I),WNCC, UNC(I),ALMTDC(I),        MOR05250
     , SHC(I),SHNFC(I),RCC(I),ROUTC(I) ,AXOC,VNREC(I),OUMMY,            MOR05260
     , VPSHC(I),HEFFC(I),LJ,II,II                                       MOR05270
      IF (ASS.NE.0.) GC TO 250                                          MOR05280
      HFG=HFGFN(STSATC(I))                                              MOR05290
      WCNDC(I)=UNC(I)*AC*HNOC*ALMTDC(I)/HFG                             MOR05300
      CALL PRSCRP(TAL ,VMIX,WSC(I),WNCC,AXCC,SOC,VPSHC(I), DELTPC ,     MOR05310
     , ENNF)                                                            MOR05320
      JJ = 0                                                            MOR05330
   90 WSC(I+1)=WSC(I)-WCNOC(I)                                          MOR05340
      GFLOWC(I) = (WSC(I)+WNCC)/ AXOC                                   MOR05350
      IF (I.GT.1) GO TO 100                                             MOR05360
      IF (WSC(I+1)) 110,110,160                                         MOR05370
C     IF (IROWC.EQ.1 FRCRM IS FORCING A DECREASING COND. RATE           MOR05380
  100 IF (IROWC.EQ.1) GC TC 110                                         MOR05390
C     IF PREVIOUS COND. RATE PREDICTS STEAM FLOW WILL BC NEG. AFTER THE MOR05400
C     NEXT ROW , SET CONDENSATE TO ONE-THIRD OF STEAM FLOW.             MOR05410
      IF (WSC(I-1)-3.0*WCNDC(I-1)) 110,110,160                          MOR05420
  110 WCNDC(I)= WSC(I) / 3.                                             MOR05430
      IRCWC = 1                                                         MOR05440
      STSATC(I+1) = STFC                                                MOR05450
      TSATMN=STSATC(I+1)+459.69                                         MOR05460
      PMIN=PSATFN(TSATMN)                                               MOR05470
      WCNDC(I)=WSC(I)*(PSATC(I)-PMIN)/PSATC(I)                          MOR05480
      WSC(I+1)=WSC(I)-WCNDC(I)                                          MOR05490
      QGC=(WSC(I)+CPSFN(TAL) /18.015*WNCC*CPAFN(TAL,JGAS) / AMWNC) *    MOR05500
     , (TAL - TSATMN)                                                   MOR05510
      CIC=QGC*WCNOC(I)*HFG                                              MOR05520
      IF (STSATC(I)-TB2) 120,120,130                                    MOR05530
  120 TB2 = STSATC(I) - 0.1                                             MOR05540
  130 CCNTINUE                                                          MOR05550
      IF (STSATC(I+1).GT.STBI) GO TO 140                                MOR05560
      ALMTDC(I) = ALMTCC(I-1)                                           MOR05570
      GC TO 15C                                                         MOR05580
  140 CCNTINUE                                                          MOR05590
      ALMTDC(I)=((STSATC(I+1)-STBI)-(STSATC(I)-TB2))/ALOG((STSATC(I+    MOR05600
     , 1)- STBI)/(STSATC(I)-TB2))                                       MOR05610
  150 CCNTINUE                                                          MOR05620
      UNC(I)=QIC/(AC*HNCC*ALMTDC(I))                                    MOR05630
      AMLSSC = WSC(I+1)/18.015                                          MOR05640
      PMIXC(I+1)=PMIXC(I)-DELTPC                                        MOR05650
      PSATC(I+1)=(PMIXC(I+1)*AMLSSC) / (AMLSSC + AMLSCC)                MOR05660
      TSATC = TSATMN                                                    MOR05670
      GC TO 21C                                                         MOR05680
  160 AMLSSC = WSC(I+1)/18.015                                          MOR05690
      PMIXC(I+1)=PMIXC(I)-DELTPC                                        MOR05700
      PSATC(I+1)=(PMIXC(I+1)*AMLSSC) / (AMLSSC + AMLSCC)                MOR05710
      PAL=PSATC(I+1)                                                    MOR05720
      IF (PAL.GT.0.) GC TO 170                                          MOR05730
      WRITE(6,10300) PMIXC(I),I                                         MOR05740
      GC TO 25C                                                         MOR05750
  170 CCNTINUE                                                          MOR05760
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      TSATC = TSATFN(PAL)                                                   MOR05770
      STSATC(I+1) = TSATC - 459.69                                          MOR05780
      IF (ABS(TSATC-TAL).LT.0.001) TSATC = TAL - 0.001                      MOR05790
      WCNDF=TUNC(I)*AC*HNOC*ALMTDC(I)-TWSC(I )*CPSFN(TSATC) / 18.015+       MOR05800
     , HNCC*CPAFN(TSATC,JGAS) / AMWNC) *(TAL - TSATC)) / HFG                MOR05810
      IF (ABS(WCNDP/WCNDC(I)-1.01-.005) 200,180,180                         MOR05820
  180 WCNDC(I)=WCNDP                                                        MOR05830
      JY = JY + 1                                                           MOR05840
      IF (JY-5) 90,50,190                                                   MOR05850
  190 WRITE(6,1C100)                                                        MOR05860
  200 CONTINUE                                                              MOR05870
      WCNDC(I) = WCNDP                                                      MOR05880
      WSC(I+1) = WSC(I) - WCNDC(I)                                          MOR05890
      AMLSSC = WSC(I+1)/18.015                                              MOR05900
      PSATC(I+1)=(PMIXC(I+1)*AMLSSC) / (AMLSSC + AMLSCC)                    MOR05910
      PAL=PSATC(I+1)                                                        MOR05920
      TSATC = TSATFN(PAL)                                                   MOR05930
      STSATC(I+1) = TSATC - 459.69                                          MOR05940
  210 VG=VGFN(TSATC ,PMIXC(I+1))                                            MOR05950
      VNC=(0.725*TSATC /(AMWNC * PMIXC(I+1))                                MOR05960
      VMIX=(1.02/(AMLSSC /(VG*(AMLSSC +AMLSCC))+(AMLSCC/(VNC*              MOR05970
     , (AMLSSC + AMLSCC)))                                                  MOR05980
      VELC(I+1)=(WSC(I+1)+WNCC(I*VMIX/(3AXOC *3600.0)                       MOR05990
      SMTBIC = SMTBIC + WB * HNOC * STBI                                    MOR06000
      SMTBC = SMTBC + WB * HNOC                                             MOR06010
      SMTB2C = SMTB2C + WB * HNOC * TB2                                     MOR06020
      SUMQC = SUMQC + UNC(I) * AO * ALMTDC(I) * HNOC                        MOR06030
      QCAC(I) = UNC(I) * ALMTDC(I)                                          MOR06040
      CUMDPC(I) = (PMIX(1)*27.7) - (PMIXC(I)*27.7)                          MOR06050
      TAL = TSATC                                                           MOR06060
      IF (MOD(I,2)) 230,220,230                                             MOR06070
  220 ANFC = ANFC - 1.C                                                     MOR06080
  230 CONTINUE                                                              MOR06090
      DELPC=PMIXC(I)-PMIXC(IVNOC+1)                                         MOR06100
  240 CONTINUE                                                              MOR06110
      IF (ASS.NE.0.) WSC(IVNOC+1) = WSC(I)                                  MOR06120
      IF (FRCCLR.EC.C.) WSC(IVNOC+1) = WSEXIT                               MOR06130
      RETURN                                                                MOR06140
  250 DO 260 IFX=1,IVNCC                                                    MOR06150
      UNC(IFX) = UNC(IFX-1)                                                 MOR06160
  260 WSC(IFX) = WSC(IFX-1)                                                 MOR06170
      WSC(IVNOC+1) = WSC(IVNOC)                                             MOR06180
      RETURN                                                                MOR06190
10000 FORMAT(1HO,'****  INCORRECT NO. OF ROWS IN COOLER,   NRWSC =',I10,    MOR06200
     ,'  IVNCC =',I10)                                                      MOR06210
10100 FORMAT(1HO, 25HNO CONVERGENCE FOR WCNDC(,I2, 2H). (                   MOR06220
10200 FORMAT(1HO,'**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEE    MOR06230
     ,DS MAX ALLOWABLE,  VELC(I) =',E15.5/15X,I10,' ROWS OF TUBES',F10.3    MOR06240
     ,' TUBES PER ROW')                                                     MOR06250
10300 FORMAT(1HO,'**** SATURATED STEAM PRESSURE IN COOLER HAS GONE NEGAT    MOR06260
     ,IVE,   PMIXC =',E15.5,'   ROW', I5)                                   MOR06270
10400 FORMAT('C    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,      MOR06280
     ,VELC(I) =',E12.5/' ',I9,'ROWS OF TUBES',F10.3,'TUBES PER ROW')        MOR06290
      END                                                                   MOR06300
                                                                            MOR06310
                                                                            MOR06320
                                                                            MOR06330
      SUBROUTINE HETTRN(STSAT,ANF,WS,WNC,VNF,ALMTD, SHI,SHNF, RC,ROUT ,     MOR06340
     , AXC,XNRE,XNU, VPSHN,XHEFF,LJ,II,IA(                                  MOR06350
C**   DEC 69 REV.   COLBJ,FDAVE                                             MOR06360
CCCCC                                                                       MOR06370
C     HETTRN IS CALLED BY SECALC IN ORDER TO DETERMINE THE THERMAL          MOR06380
C     PERFORMANCE OF THE "MEAN" TUBE IN THE CURRENT ROW AND SECTOR          MOR06390
CCCCC                                                                       MOR06400
      COMMON/(APT/ ALST ,ANT ,BAFFLE ,HFCOFL, CBI ,EXITER ,FOUL ,GAS ,      MOR06410
     , GC , OUTPUT ,PRCCLP ,RADFLG ,SOD ,SODMIN , SECFLG ,SKW ,STBI ,       MOR06420
     , STSAT1 ,VELBI , VSFLG ,WNC1 ,WSI ,XW ,VPSHI(100,6), VPSHIC(100) ,    MOR06430
     , FDAVE ,ENHI ,ENHC ,ENHF ,WBI ,STBIP,ANTP,VELBIP,ADJF,(DENT(20),      MOR06440
     , IRSTM ,IFLOAT ,ITRAN ,IPNCH ,NRWSP ,NRWSCP ,NRWS ,NRWSC,             MOR06450
     , ENHFI, TUBESW, FC, FEXP                                              MOR06460
      COMMON/INTEG/IHNC ,IHNCC ,ILNG ,ISEC ,IVNO ,IVNOC ,J ,JGAS ,JRC ,     MOR06470
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FILE: MCRCON   FORTRAN A   NAVAL POSTGRADUATE SCHOOL

     , IRENO ,IRENOC ,ICT ,IBT,(VAP,IRAIN                                   MOR06490
     'COMMON AI ,AMLSEX ,AMOLNC ,AMWNC ,AO , ASS ,AW ,AXI ,BND(AM ,COCR     MOR06500
     , (3), DELPVE ,GB ,HFG ,HNO ,HNCC ,PMIX1 ,PMXEXT ,PSATEX ,RADINS ,     MOR06510
     , SCI , SCO ,SF ,SG ,SHWINV ,STBAVE , STB2ES ,STFO ,STSAEX ,TB2 ,      MOR06520
     , TAC , TACC ,TACER ,TSATEX ,VELEXT ,VG , VLCMAX ,VNO ,VNOC ,WB ,      MOR06530
     , WACC ,WSEX(1 ,XAC , SMTB1, SMTB2, SMWB, SUMQ, SMTBIC, SMTB2C,        MOR06540
     , SMWNC, SUMQC                                                         MOR06550
      DIMENSION A2(3(,E20K(3)                                               MOR06560
      INTEGER GAS(5(                                                        MOR06570
      DATA HEFF,UEST,OGFLM,DLFLM/2100.,700.,0.05,2.0/                       MOR06590
      DATA R2,E2CK / 3.617,3.996,3.838,97.0,190.0,140.75/                   MOR06600
      K = 0                                                                 MOR06610
      RC=WNC/(WS+WNC(                                                       MOR06620
      TSAT=STSAT+459.69                                                     MOR06630
      GMAX =(WS+WNC( / AXO                                                  MOR06640
      PSAT = PSATFN(TSAT)                                                   MOR06650
      AMELSS = WS / 18.C15                                                  MOR06660
      AMCLSC = WNC / AMWNC                                                  MOR06670
      AMCLT = AMCLSS + AMOLSC                                               MOR06680
      AMWAV = (WS+WNC) / AMOLT                                              MOR06690
      PMWNC = SQRT(AMWNC) * AMOLSC / AMOLT                                  MOR06700
      RMWSC = 4.24444 * AMCLSS / AMOLT                                      MOR06710
      AVIS = (SMUFN(TSAT) * RMWSC + AMUFN(TSAT,JGAS) * RMWNC) / (RMWSC +    MOR06720
     , RMWNC)                                                               MOR06730
      HSTO = HFGFN(STSAT)                                                   MOR06740
      EP=GF*3600.0                                                          MOR06750
      STEAVE=( STBI+ TB2 ) / 2.0                                            MOR06760
      DELFLM = DLFLM                                                        MOR06770
      DLGFLM = DGFLM                                                        MOR06780
      STBC = STSAT - DELFLM - DLGFLM                                        MOR06790
      STFO=(STSAT+STBC)/2.0                                                 MOR06800
      XNRE = SCC * (WS+WNC)/(AXO * 3600. * AVIS)                            MOR06810
      IF (XNRE.GE.100.( GO TO 30                                            MOR06820
      GO TO (10,20),II                                                      MOR06830
   10 IF (IRENC.EQ.0( WRITE(6,10600) XNRE,LJ,IR                             MOR06840
      IRENO = 1                                                             MOR06850
      GO TO 30                                                              MOR06860
   20 IF (IRENCC.EQ.0) WRITE(6,10700( XNRE,LJ,IR                            MOR06870
      IRENOC = 1                                                            MOR06880
   30 CONTINUE                                                              MOR06890
      COLBJ = EXP(0.53883 - 0.544 * ALOG(XNRE))                             MOR06900
      IF (HNC).EQ.0.) GO TO 40                                              MOR06910
      PATM = PSAT / 14.7                                                    MOR06920
      PGP = PSAT * (AMCLSC/AMOLSS)                                          MOR06930
      TSATK = TSAT / 1.8                                                    MOR06940
      CALL OFSVIY(TSATK,PATM,18.015,AMWNC,2.655,R2(JGAS),363.,              MOR06950
     , E2CK(JGAS),0.,0.,DG,DGG(                                             MOR06960
C*****                                                                      MOR06970
C  0.258 CONVERTS CM2/S TO FT2/HR AND 3600. CONVERTS VISCOSITY TO          MOR06980
C  LB/F-HR FROM LB-F-S.          0.258 * 3600. = 928.8                     MOR06990
C*****                                                                      MOR07000
      XNSCH = (AVIS * TSAT * 10.73 / ((PSAT+PGB) * AMWAV * DG)( * 928.8     MOR07010
      CJ = COLBJ * GMAX / (XNSCH ** 0.666667 )                              MOR07020
CCCCC                                                                       MOR07030
C     BEGIN ITERATION BASED UPON CURRENT ESTIMATE OF AVERAGE COOLING        MOR07040
C     WATER TEMPERATURE                                                     MOR07050
CCCCC                                                                       MOR07060
   40 TB2 = STSAT - (STSAT - STBI) / EXP(UEST * AO / (WB * CPFN(CBI,        MOR07070
     , STBAVE)))                                                            MOR07080
      STEAVE = (STBI + TB2) / 2.                                            MOR07090
      SKBU = SKBIN10.,STFO)                                                 MOR07100
      SKB = SKBFN(CBI,STBAVE)                                               MOR07110
      BMU = BMUFN(CBI,STBAVE)                                               MOR07120
      SHBI = CFFN(CBI,STBAVE)                                               MOR07130
      XNREB = SCI * BP / BMU                                                MOR07140
      XNPRB = SHBI * BMU / SKB                                              MOR07150
CCCCC                                                                       MOR07160
C     TUBE-SIDE HEAT TRANSFER COEFFICIENT (DITTUS-BOELTER CORRELATION)      MOR07170
CCCCC                                                                       MOR07180
      SHI = 0.023 * (XNREB( ** 0.8 * XNPRB ** 0.33333 * (SKB / SDI) *       MOR07190
     , ENHI                                                                 MOR07200
      RIN=AO/(SHI*AI)
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FILE: PCPCCN   FORTRAN A   NAVAL POSTGRADUATE SCHOOL

      BNF = ANF                                                          MOR07210
      IF (ANF.LE.1.0) BNF = 1.0                                          MOR07220
CCCCC                                                                    MOR07230
C     CONDENSATE FILE HEAT TRANSFER COEFFICIENT (BASIC NUSSELT THEORY)   MOR07240
CCCCC                                                                    MOR07250
      SHMK=0.725*(SKBC**3*ROEFN(0.0,STFO)**2*HFGFN(STFO)* 416975040.0/   MOR07260
     , (EMUFN(C,STFO)*SCO*DELFLM)) ** .25 * ENHO                         MOR07270
CCCCC                                                                    MOR07280
C  THIS IS THE PLACE TO ENTER CORRECTIONS TO EXTERNAL FILM COEFFICIENT   MOR07290
C  FOLLOWING IS A CORRECTION ACCORDING TO FUJII, ET. AL, TO ACCOUNT FOR  MOR07300
C  EFFECTS OF VAPOR SHEAR AT HIGH VAPOR REYNOLDS NUMBERS                 MOR07310
CCCCC                                                                    MOR07320
            SHMK1 = SHMK                                                 MOR07330
            ANUS = SHMK*SOO/SKBO                                         MOR07340
            IF(IVAP.LT.1) GO TO 42                                       MOR07350
            EMUL = EMUFN(0.,STSAT)                                       MOR07360
            EMUS = SMLFN(TSAT)*3600.                                     MOR07370
            RHOL = ROEFN(0.,STSAT)                                       MOR07380
            RHOS = 1./VOEFN(TSAT,PSAT)                                   MOR07390
            VISRAT = (EMUS/RHOS)/(EMUL/RHOL)                             MOR07400
            RETP = XNRE*VISRAT                                           MOR07410
            TERM = SQRT(RETP)/ANUS                                       MOR07420
            IF(TERM.LT..2781) GO TO 42                                   MOR07430
            ANUSP = 1.24*(ANUS**0.81*(RETP**0.1)                         MOR07440
            GO TO 43                                                     MOR07450
 42         ANUSP = ANUS*0.70/0.725                                      MOR07460
 43         SHMKP = ANUSP*SKBC/SOO                                       MOR07470
            SHMK = SHMKP                                                 MOR07480
C                                                                        MOR07490
C                                                                        MOR07500
C*************************************************************************MOR07510
C*                                                                      #MOR07520
C*       IF HC > 40,000                                                 #MOR07530
C*                                                                      #MOR07540
C*************************************************************************MOR07550
      IF (SHMK .GT. 40000.) GO TO 49                                     MOR07560
      IF (SHMK.LT.40000..AND.OELFLM.GT..0001) GO TO 50                   MOR07570
      IF (II.EQ.1.AND.ASS.EQ.0.) WRITE(6,10800)SHMK,OELFLM,LJ,IR         MOR07580
      IF (II.EQ.2.AND.ASS.EQ.0.) WRITE(6,10900)SHMK,OELFLM,IR            MOR07590
      ASS = 1.                                                           MOR07600
      DLFLM = 2.0                                                        MOR07610
      GO TO 180                                                          MOR07620
   49 CONTINUE                                                           MOR07630
   50 CONTINUE                                                           MOR07640
CCCCC                                                                    MOR07650
C     CORRECTION FOR CONDENSATE INNUNDATION                              MOR07660
CCCCC                                                                    MOR07670
      IF(IPAIN.LT.1) BNF = 1.                                            MOR07680
      IF (FOAVE.LT.0..OR.BNF.LT.2.) GO TO 60                             MOR07690
      FOAVN = C.6*FOAVE + (1.-0.5647*FOAVE) / BNF ** .20                 MOR07700
      FOAVM = C.6*FOAVE + (1.-0.5647*FOAVE) / (BNF-1) ** .20             MOR07710
      SHNF = SHMK * (BNF * FOAVN - (BNF-1.) * FOAVM)                     MOR07720
      GO TO 70                                                           MOR07730
   60 SHNF = C.55 * (BNF ** 0.9 - (BNF-1.) ** 0.9) * SHMK                MOR07740
C     TOTAL THERMAL RESISTANCE LESS THAT DUE TO NON-CONDENSIBLE GASES     MOR07750
   70 RFACT = RIN + SHNINV + FOUL + 1. / SHNF                            MOR07760
C                                                                        MOR07770
C     COMPUTE LOG MEAN DELTA TEMP., ALMTD                                MOR07780
C                                                                        MOR07790
      HOMCI = STSAT - ST1                                                MOR07800
      HIMCO = STSAT - TB2                                                MOR07810
      HCCT = HOMCI/HIMCO                                                 MOR07820
C     IF EITHER INLET OR OUTLET DELTA T IS NEG., ALMTD = PREVIOUS VALUE  MOR07830
      IF (HIMCO.GT.0.0.AND.HOMCI.GT.0.0) GO TO 80                        MOR07840
      ALMTD = C.001                                                      MOR07850
      IF (IDT.EQ.0) WRITE(6,10400) HOMCI,HIMCO,LJ,IR,II                  MOR07860
      IDT = 1                                                            MOR07870
      GO TO 100                                                          MOR07880
C     IF INLET/OUTLET DELTA T RATIO IS NEAR 1.0, ALMTD = ARITH. AVG.     MOR07890
   80 IF (RODT.LT.0.9.OR.ROOT.GT.1.1) GO TO 90                           MOR07900
      ALMTD = C.5 * (HOMCI + HIMCO)                                      MOR07910
      IF (JRC.EQ.0) WRITE(6,10500) STSAT,ST1,TB2,LJ,IR,II                MOR07920
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      JRC = 1                                                            MOR07930
      GO TO 100                                                          MOR07940
   90 ALMTD = (HOMCI - HIMCO) / ALOG(RODT)                               MOR07950
  100 CONTINUE                                                           MOR07960
      IF (WNC).NE.0.) GO TO 110                                          MOR07970
C     UPDATE IF NO NON-CONDENSIBLE GASES ARE PRESENT                     MOR07980
      FCCT = 1. / SHNF                                                   MOR07990
      UTEST = 1. / RFACT                                                 MOR08000
      XNL = SHNF * SCO / SKBO                                            MOR08010
C     CONVERGENCE TEST                                                   MOR08020
      IF (ABS(UEST-UTEST)/UTEST.LT..001) GO TO 170                       MOR08030
      UESTSV = UEST                                                      MOR08040
      UEST = UTEST                                                       MOR08050
      IF (K.GT.4) UEST = 0.5 * (UTEST + UESTSV)                          MOR08060
      STHC = STSAT - (STSAT-STBAVE) * UTEST / SHNF                       MOR08070
      STCC = STSAT                                                       MOR08080
      STFO = (STCO +STHC) / 2.                                           MOR08090
      DGFLM = 0.                                                         MOR08100
      DLFLM = STCO - STHO                                                MOR08110
      DELFLM = DLFLM                                                     MOR08120
      K = K + 1                                                          MOR08130
      IF (K.LT.20) GO TO 40                                              MOR08140
      WRITE(6,10100) UESTSV,UTEST                                        MOR08150
      GO TO 170                                                          MOR08160
  110 CONTINUE                                                           MOR08170
CCCCC                                                                    MOR08180
C     ACCOUNTING FOR THE NON-CONDENSIBLE GAS FILM                        MOR08190
CCCCC                                                                    MOR08200
      STCO = STSAT - DLGFLM                                              MOR08210
      T = (TSAT + STCC + 459.69) / 2.0                                   MOR08220
      DTDP = 1./((6452.562 + 2.*837533.2 /T) / T**2) * EXP(14.15012 -    MOR08230
     , (6452.562 + 837533.2 /T) /T))                                     MOR08240
      BCNF = -1.*(CJ * HSTC / ALMTD + (PGB * DTDP/ALMTD +1.) / RFACT)    MOR08250
      CONE = CJ * HSTO / (ALMTD * RFACT)                                 MOR08260
      UTEST = (-SQRT(BCNE**2 - 4.*CONE) - BONE) / 2.                     MOR08270
      DENOM = 1. - UTEST * RFACT                                         MOR08280
      IF (DENOM.GT.1.E-7) GO TO 120                                      MOR08290
      HEFF = 1.0E8                                                       MOR08300
      GO TO 130                                                          MOR08310
  120 HEFF = UTEST / DENOM                                               MOR08320
  130 CONTINUE                                                           MOR08330
      FCCT = (HEFF + SHNF ) / ( HEFF * SHNF )                            MOR08340
      TDIF = STSAT - STBAVE                                              MOR08350
      IF (TDIF.GT.0) GO TO 140                                           MOR08360
      IF (IBT.EQ.0) WRITE(6,10300) STSAT,STBAVE,LJ,IR                    MOR08370
      IBT = 1                                                            MOR08380
      TDIF = .1                                                          MOR08390
  140 CONTINUE                                                           MOR08400
      DELTAU = TDIF * UTEST                                              MOR08410
      DGFLM = DELTAU / HEFF                                              MOR08420
      DLFLM = DELTAU / SHNF                                              MOR08430
      STCO = STSAT - DGFLM                                               MOR08440
      STHO = STCO - DLFLM                                                MOR08450
      STFC = (STCO + STHO) / 2                                           MOR08460
      XNL = SOC / (SKBC * ROUT)                                          MOR08470
C     CONVERGENCE TEST                                                   MOR08480
      IF (ABS(UTEST-UEST)/UTEST.LT..001) GO TO 150                       MOR08490
      DELFLM = OLFLM                                                     MOR08500
      DLGFLM = DGFLM                                                     MOR08510
      UESTSV = UEST                                                      MOR08520
      UEST = UTEST                                                       MOR08530
      K = K + 1                                                          MOR08540
      IF (K.GT.4) UEST = 0.5 * (UTEST + UESTSV)                          MOR08550
      IF (K.LT.20) GO TO 40                                              MOR08560
      WRITE(6,10100) UESTSV,UTEST                                        MOR08570
      GO TO 170                                                          MOR08580
  150 IF (ABS(DELFLM-DLFLM).LT..01) GO TO 160                            MOR08590
      DELFLM = DLFLM                                                     MOR08600
      DLGFLM = DGFLM                                                     MOR08610
      K = K +1                                                           MOR08620
      IF (K.LT.20) GO TO 40                                              MOR08630
      WRITE(6,10200) DELFLM,LJ,IR                                        MOR08640
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  160 IF (ABS(OLGFLM-DGFLM).LT..001) GO TO 170                          MOR08650
      OLGFLM = DGFLM                                                    MOR08660
      K = K + 1                                                         MOR08670
      IF (K.LT.20) GO TO 40                                             MOR08680
      WRITE(6,10000) DLGFLM,UEST,UTEST,LJ,IR                            MOR08690
  170 VNF = UTEST                                                       MOR08700
      VPSHM = TB2                                                       MOR08710
      XHEFF = HEFF                                                      MOR08720
      ROLT = 1. / ROLT                                                  MOR08730
  180 RETURN                                                            MOR08740
10000 FORMAT(1HO,' NO CONVERGENCE IN FILM TEMPERATURES', ' DLGFLM=',    MOR08750
     , E12.5,' UEST =',E12.5,' UTEST =',E12.5/' SECTOR = ', I5,         MOR08760
     , ' ROW=' ,I5)                                                     MOR08770
10100 FORMAT(1HO,' NO CONVERGENCE IN UESV, UEST = ',E12.5,' UTEST = ',  MOR08780
     , E12.5)                                                           MOR08790
10200 FORMAT(1HO,' NO CONVERGENCE IN DELFLM, DELFLM=',E12.5,            MOR08800
     , ' SECTOR=',I5,' ROW=',I5)                                        MOR08810
10300 FORMAT(1HO,                                                       MOR08820
     , '  SAT STEAM TEMP LESS THAN AVG BRINE TEMP,    STSAT =',E12.5,   MOR08830
     , ' STBAVE =',E12.5,'   SECTOR',I3,'   ROW',I4)                    MOR08840
10400 FORMAT(1HO,' EITHER INLET OR OUTLET DELTA T IS NEG.,  INLET =',   MOR08850
     , E13.6,'  OUTLET = ',E13.6,'  SECTOR',I3,'  ROW',2I3)             MOR08860
10500 FORMAT(1HO,' INPUT/OUTLET DELTA T RATIO IS NEAR 1.0, STSAT=',     MOR08870
     , E13.6,'  STBI=',E13.6,'  TB2=',E13.6,'  SECTOR',I3,'  ROW',2I5)  MOR08880
10600 FORMAT(1HO,'REYNOLDS NUMBER IN CONDENSER ON SHELL SIDE HAS FALLEN MOR08890
     ,BELOW 10C,  RENO = ',E15.6,' SECTOR',I5,'  ROW  ',I5)             MOR08900
10700 FORMAT(1HO,'REYNOLDS NUMBER IN COOLER    ON SHELL SIDE HAS FALLEN MOR08910
     ,BELOW 10C,  RENO = ',E15.6,' SECTOR',I5,'  ROW  ',I5)             MOR08920
10800 FORMAT(1HO,' RUN TERMINATING IN CONDENSER.  SHMK  =',E13.6,       MOR08930
     , ' DELFLM = ',E13.6,' SECTOR ',I5,'  ROW ',I5)                    MOR08940
10900 FORMAT(1HO,' RUN TERMINATING IN COOLER      SHMK  =',E13.6,       MOR08950
     , ' DELFLM = ',E13.6,' ROW =',I5)                                  MOR08960
11000 FORMAT (1HO,' ERROR FLAG... EXTERNAL H.T. COEFF. = ',             MOR08970
     , E14.8 )                                                          MOR08980
      END                                                               MOR08990
                                                                        MOR09000
                                                                        MOR09010
      SUBROUTINE INPUT(*,*)                                             MOR09020
      COMMON/INPT/ ALST ,ANT ,BAFFLE ,HFCOFL, CBI ,EXITFR ,FOUL ,GAS ,  MOR09030
     , CC , OUTPUT ,PACCLR ,RADFLG ,SOD ,SDDMIN , SECFLG ,SKW ,STBI ,   MOR09040
     , STSAT1 ,VELBI , VSFLG ,WNCI ,WSI ,XW ,VPSHI(100,6), VPSHIC(100) ,MOR09050
     , FOAVE ,ENHI ,ENHO ,ENHF ,WBI ,STBIF,ANTP,VELBIP,ACJF,IOENT(20),  MOR09060
     , INSTM ,IFLOAT ,ITRAN ,IPNCH ,NRWSP ,NRWSCP ,NRWS ,NRWSC,         MOR09070
     , ENHFI, TUBESW, FC, FEXP                                          MOR09080
      COMMON/INTG/IHNC ,IHNOC ,ILNG ,ISEC , IVNO ,IVNOC ,J ,JGAS ,JRC , MOR09090
     , IFENO ,IFENOC ,IDT ,IBT,IVAP,IRAIN                               MOR09100
      INTEGER GAS(5), GASA/'A'/, GASC/'C'/, GASM/'M'/                   MOR09110
      READ(5,1C600,END=200) IR,IDENT                                    MOR09120
CCCCC                                                                   MOR09130
C     USE ONLY CCLS 2-6C FOR IDENT                                      MOR09140
C     IR IN CCL 1 OF IDENT CARD INDICATES READ STATEMENTS TO BE         MOR09150
C     EXECUTED. ( A 5 INDICATES THAT NO CARDS WILL BE READ.)            MOR09160
C                                                                       MOR09170
C                CONTROL FLAG INTERPRETATIONS                           MOR09180
C     OUTPUT = 1   GIVES FULL DETAIL OUTPUT                             MOR09190
C     OUTPUT = 0   GIVES SUMMARY OUTPUT ONLY                            MOR09200
C     ITRAN = 1    ASSUMES INLET BRINE TEMPS EQUAL TO OUTLET FROM       MOR09210
C     PREVIOUS STAGE                                                    MOR09220
C     ITRAN  = 0   USES STBI FOR INLET BRINE TEMPS FOR ALL TUBES        MOR09230
C     NRWS   = 0   READS INLET BRINE TEMPS FROM CARDS                   MOR09240
C     NRWS   = C   WILL NOT READ CARDS                                  MOR09250
C     IFLCAT = 1   FLOATING POINT OUTPUT                                MOR09260
C     IFLOAT = C   FIXED POINT OUTPUT                                   MOR09270
C     IPNCH  = 1   OUTLET BRINE TEMPS PUNCHED FOR INPUT TO NEXT STG     MOR09280
C     IPNCH  = 0   NO CARD OUTPUT                                       MOR09290
C     INSTM  = 1   CODE WILL USE INLET STEAM CONVERGENCE LOOP           MOR09300
C     INSTM  = 0   CODE WILL USE TUBE LENGTH CONVERGENCE LOOP           MOR09310
C     IVAP   = 1,0 VAPOR SHEAR (WILL, WILL NOT) BE INCLUDED.           MOR09320
C     IRAIN  = 1,0 CONDENSATE INUNDATION (WILL, WILL NOT) BE INCLUDED.  MOR09330
CCCCC                                                                   MOR09340
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      GO TO (40,20,20,10,50),IR                                         MOR09370
   10 READ(5,1C100) ANTP,PACCLR,SDO,SDDMIN,CD,XW,SKW,NRWSP,NRWSCP       MOR09380
   20 READ(5,1C500) WBI,VELBIP,CBI,STBIP,FOUL,ENHI                      MOR09390
   30 READ(5,1C600) GAS,SECFLG,HFCOFL,RADFLG,BAFFLE,FOAVE,EXITFR,OUTPUT,MOR09400
     ,  INSTM,ITRAN,IFLCAT,IPNCH                                        MOR09410
   40 READ(5,1C500) WSI,WNCI,STSAT1,ALST,ENHO,ENHF                      MOR09420
      READ (5,10505) ENHFI, TUBESW,FC,FEXP                              MOR09430
      READ(5,1C510)IVAP,IRAIN                                           MOR09440
   50 CONTINUE                                                          MOR09450
      ANT = ANTP                                                        MOR09460
      VELBI = VELBIP                                                    MOR09470
      STBI = STBIP                                                      MOR09480
      NRWS = NRWSP                                                      MOR09490
      NRWSC = NRWSCP                                                    MOR09500
      JGAS = 0                                                          MOR09510
      DO 60 I=1,5                                                       MOR09520
         IF (GAS(I).EQ.GASA) JGAS = 1                                   MOR09530
         IF (GAS(I).EQ.GASC) JGAS = 2                                   MOR09540
         IF (GAS(I).EQ.GASM) JGAS = 3                                   MOR09550
         IF (JGAS.NE.0) GO TO 70                                        MOR09560
   60 CONTINUE                                                          MOR09570
      JGAS = 4                                                          MOR09580
   70 CONTINUE                                                          MOR09590
      ISEC = SECFLG                                                     MOR09600
      WRITE(6,11000)                                                    MOR09610
      WRITE(6,10000) IOENT                                              MOR09620
      WRITE(6,11100) ANT,PACCLR,SDO,SDDMIN,CD,XW,SKW,NRWS,NRWSC         MOR09630
      WRITE(6,11300)WBI,VELBI,CBI,STBI,FOUL,ENHI                        MOR09640
      WRITE(6,11200)GAS,SECFLG,HFCOFL,RADFLG,BAFFLE,FOAVE,EXITFR,OUTPUT,MOR09650
     ,  INSTM,ITRAN,IFLCAT,IPNCH                                        MOR09660
      WRITE(6,11400) WSI,WNCI,STSAT1,ALST,ENHO,ENHF                     MOR09670
      WRITE (6,11405) ENHFI, TUBESW, FC, FEXP                           MOR09680
      WRITE (6,11410) IVAP,IRAIN                                        MOR09690
      IF (JGAS.NE.4) GO TO 80                                           MOR09700
      WRITE(6,11500)                                                    MOR09710
      JGAS = 1                                                          MOR09720
   80 CONTINUE                                                          MOR09730
      IF (NRWS.GT.0) GO TO 120                                          MOR09740
      IF (ITRAN.EQ.1) GO TO 150                                         MOR09750
      DO 100 J=1,ISEC                                                   MOR09760
         DO 90 I=1,ICO                                                  MOR09770
   90 VPSHI(I,J) = STBI                                                 MOR09780
  100 CONTINUE                                                          MOR09790
      DO 110 I=1,100                                                    MOR09800
  110 VPSHIC(I) = STBI                                                  MOR09810
      GO TO 160                                                         MOR09820
  120 DO 130 J=1,ISEC                                                   MOR09830
  130    READ(5,10900) (VPSHI(I,J),I=1,NRWS)                           MOR09840
      READ(5,1C500)(VPSHIC(I),I=1,NRWSC)                                MOR09850
      JJ = NRWSC + 1                                                    MOR09860
      DO 140 I=JJ,100                                                   MOR09870
  140 VPSHIC(I) = VPSHIC(I-1)                                           MOR09880
  150 CONTINUE                                                          MOR09890
      WRITE(6,10400)                                                    MOR09900
      IF (NRWS.NE.0) GO TO 160                                          MOR09910
      NRWS = IFAC                                                       MOR09920
      NRWSC = IVNOC                                                     MOR09930
  160 IF (NRWSC.GE.NRWS) GO TO 170                                      MOR09940
      WRITE(6,10100) (I,(VPSHI(I,J),J=1,6),VPSHIC(I),I=1,NRWSC)         MOR09950
      N = NRWSC + 1                                                     MOR09960
      WRITE(6,1C200) (I,(VPSHI(I,J),J=1,6),I=N,NRWS)                    MOR09970
      GO TO 180                                                         MOR09980
  170 WRITE(6,1C100) (I,(VPSHI(I,J),J=1,6),VPSHIC(I),I=1,NRWSI          MOR09990
      IF (NRWS.EQ.NRWSC) GO TO 180                                      MOR10000
      N = NRWS + 1                                                      MOR10010
      WRITE(6,1C300) (I,VPSHIC(I),I=N,NRWSC)                            MOR10020
  180 CONTINUE                                                          MOR10030
      WRITE(6,11600) IDENT                                              MOR10040
      WRITE(6,11700)                                                    MOR10050
      WRITE(6,11800) ANT ,OD ,WSI ,PACCLR ,XW ,WBI ,ALST , SKW ,VELBI , MOR10060
     ,  SOD ,FCLL ,STSAT1 ,SDDMIN ,FOAVE ,STBI                          MOR10070
      WRITE(6,11900) RADFLG ,CBI ,SECFLG ,ENHI ,EXITFR ,BAFFLE , ENHO , MOR10080
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     , WNCI ,HFCOFL ,ENHF                                                    MOR10090
      IF (ITRAN.EQ.1) GO TO 190                                              MOR10100
      WRITE(6,10500)                                                         MOR10110
      RETURN                                                                 MOR10120
  190 WRITE(6,10500)                                                         MOR10130
      ANT = ANT * ADJF / SECFLG                                              MOR10140
      RETURN 1                                                               MOR10150
  200 RETURN 2                                                               MOR10160
10000 FORMAT('0  CARD 1      CASE IDENTIFICATION AND NOTES'/' ',10X,         MOR10170
     , 19A4,A3)                                                              MOR10180
10100 FORMAT(1F ,I4,7E15.6)                                                  MOR10190
10200 FORMAT(1F ,I4,6E15.6)                                                  MOR10200
10300 FORMAT(1F ,I4,15E15.6)                                                 MOR10210
10400 FORMAT(1HC,30X,26HINLET  BRINE  TEMPERATURES/1HO,5H  ROW,7X,1H1,       MOR10220
     , 14X,1H2,14X,1H3,14X,1H4,14X,1H5,14X,1H6,11X,6HCOOLER)                 MOR10230
10500 FORMAT('1')                                                            MOR10240
10600 FORMAT(1I,19A4,A3)                                                     MOR10250
10700 FORMAT(7F10.0,2I5)                                                     MOR10260
10800 FORMAT (5A1, 4F5.2, F5.3, 2F5.2, 4I5)                                  MOR10270
10900 FORMAT(8F10.3)                                                         MOR10280
10905 FORMAT(4F10.3)                                                         MOR10290
10910 FORMAT(2I5)                                                            MOR10300
11000 FORMAT(1H1,47X,25HCIRCULAR CONDENSER INPUT DATA )                      MOR10310
11100 FORMAT(1HO,'  CARD 2   ANT       PRCCLR     SOO      SOOMIN    OO    MOR10320
     ,'    XW        SKW       NRWS  NRWSC'/1H ,F16.0,F10.2,4F10.4,        MOR10330
     ,'F8.2,2I8)                                                             MOR10340
11200 FORMAT(1HO,'  CARD 4   GAS      SECFLG  HFCOFL  RADFLG  BAFFLE  FOA MOR10350
     ,'VE   EXITER  OUTFUT  INSTM   ITRAN   IFLOAT   IPNCH'/                MOR10360
     ,1H ,11X,5A1, 4F8.2,2F8.4,  F8.2, 4I8)                                 MOR10370
11300 FORMAT(1HO,'  CARD 3   WBI       VELBI      CBI       STBI        FCU MOR10380
     ,'L      ENHI'/1H ,7X,F10.0,F10.3,F10.5,F10.4,F10.5,F10.3)             MOR10390
11400 FORMAT(1HO,'  CARD 5   WSI       WNCI       STSATI    ALST      ENH MOR10400
     ,'O      ENHF'/1H ,6X,F10.0,F10.2,F10.2,F10.3,F10.3,F10.3)             MOR10410
11405 FORMAT(1HO,'  CARD 6  ENHFI      TUBESW       FC         FEXP       '/ MOR10420
     , 1H ,6X,4F10.3)                                                        MOR10430
11410 FORMAT(1HO,'  CARD 7  IVAP       IRAIN       '/1H ,7X,15,5X,15)       MOR10440
11500 FORMAT(1HO,T41,'INERT GAS NOT SPECIFIED -- PROGRAM ASSUMES AIR'1       MOR10450
11600 FORMAT(1H1, 35HCASE  IDENTIFICATION AND NOTES ****  , 19A4,A3)         MOR10460
11700 FORMAT(1HC, 22HGEOMETRY SPECIFICATION ,9X,                             MOR10470
     , 26HTUBING SPECIFICATION ,25X,                                         MOR10480
     , 33HFLOW AND PROPERTIES SPECIFICATION )                                MOR10490
11800 FORMAT('0',T3,'NO. OF TUBES',F17.2, T36,'OUTSIDE DIAM., INCHES',       MOR10500
     , F19.4, T60,'STEAM FLOW, LBS/HR',F22.0/ 1X,T3 ,                        MOR10510
     , 'FCL. TUBES IN COOLER',F9.2, T36,'WALL THICKNESS, INCHES',F18.4,      MOR10520
     , T60,'COOLANT FLOW, LBS/HR.',F19.0/ 1X,T3 ,'LENGTH OF TUBES, FT.',     MOR10530
     , F9.2, T36,'WALL COND.,BTU/HR/SW.F/DEG.F.', F11.4, T60,                MOR10540
     , 'COOLANT VELOCITY, FT/SEC.',F15.1/ 1X,T3 ,'S/D, CONDENSER',F15.3,     MOR10550
     , T36,'FOULING FACTOR',F26.4, T60,'STEAM TEMP., DEG. F.',F20.2/         MOR10560
     , 1X,T3 ,'S/D COOLER',F19.3, T36,'TUBE FLOOD FACTOR(FDAVE)',F16.4,      MOR10570
     , T60,'COOLANT TEMP., DEG. F.',F18.2)                                   MOR10580
11900 FORMAT(' ',T3 ,'BUNDLE RADIUS FACTOR',F9.2, T36,                       MOR10590
     , 'ENHANCEMENT FACTORS', T60,'WT. FRAC. OF NACL IN COOLANT',F12.5/       MOR10600
     , 1X,T3 ,'SECTOR MODEL',F17.2, T38,'INSIDE FILM',F27.4, T60,            MOR10610
     , 'EXIT STEAM FRACTION,PCT. OF INPUT',F7.4/ 1X,T3 ,'BAFFLE FLAG',       MOR10620
     , F10.2, T38,'OUTSIDE FILM',F26.4, T60,                                 MOR10630
     , 'NON-CONDENSIBLE FLOW, LB/HR. ',F12.2/ 1X,T3,'SYM. FLAG',F20.2,       MOR10640
     , T38,'FRICTION FACTOR',F23.4)                                          MOR10650
      END                                                                    MOR10660
                                                                             MOR10670
                                                                             MOR10680
                                                                             MOR10690
                                                                             MOR10700
      SUBROUTINE OUTFIL(CELPC,VEL2,NERR)                                     MOR10710
      COMMON/INPI/ ALST ,ANT ,BAFFLE ,HFCOFL, CBI ,EXITER ,FOUL ,GAS ,       MOR10720
     , CC , OUTPUT ,PRCCLR ,RADFLG ,SOO ,SOOMIN , SECFLG ,SKW ,STBI ,        MOR10730
     , STSATI ,VELBI ,VSFLG ,WNCI ,WSI ,XW ,VPSHI(100,6), VPSHIC(100) ,      MOR10740
     , FEAVE ,ENHI ,ENHC ,ENHF ,WBI ,STBIP,ANTP,VELBIP,ADJF,IDENT(20),       MOR10750
     , IASTM ,IFLOAT ,ITRAN ,IPNCH ,NRWSP ,NRWSCP ,NRWS ,NRWSC,              MOR10760
     , ENHFI ,TUBESW, FC, FEXP                                               MOR10770
      COMMON/INTEG/IENC ,IENOC ,ILNG ,ISEC , IVNO ,IVNOC ,J ,JGAS ,JRC ,     MOR10780
     , IRENO ,IRENOC ,IT ,IBT ,IVAP,IRAIN                                    MOR10790
      COMMON AI ,AMLSEC ,APOLNC ,AMWNC ,AO , ASS ,AW ,AXI ,BNDIAM ,COOR      MOR10800

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     , (3), OELPVE ,GB ,HFG ,HNO ,HNCC , PMIX1 ,PMXEXT ,PSATEX ,RADINS ,     MOR10810
     , SOI , SCC ,SF ,SG ,SHWINV ,STBAVE , STB2ES ,STFO ,STSATX ,TB2 ,       MOR10820
     , TNO , TNCC ,TNOFR ,TSATEX ,VELEXT ,VG , VLCMAX ,VNC ,VNOC ,WB ,       MOR10830
     , WNCC ,WSEXIT, XNC , SMTBI, SMTB2, SMWB, SUMQ, SMTBIC, SMTB2C,         MOR10840
     , SMWBC, SUMQC                                                          MOR10850
      COMMON/DIM1/ C (6),DELP (6),WGAS (6),WP (6) ,WSP(6)                    MOR10860
      COMMON/DIM2/ ALMTCC(100), GFLOWC(100),PMIXC (100),PSATC (100),RCC      MOR10870
     , (100), SMIC (100),SMNFC (100),STSATC(100), UNC (100),VELC (100),      MOR10880
     , VNREC (100),VFSHC (100), VPSHPC(100),WCNDC (100),WSC (100),           MOR10890
     , HEFFC(100) ,RCUTC(100) ,QOACC(100) , CUMOPC(100)                      MOR10900
      COMMON/DIM3/ ALMTO (100,6) , ANF (100,6), GFLOW (100,6),PMIX          MOR10910
     , (100,6), PSAT (100,6), RC (100,6),SHI (100,6), SHN (100,6),STSAT      MOR10920
     , (100,6), UN(100,6), VEL(100,6), VNRE(100,6), VPSHI(100,6), VPSHN      MOR10930
     , (100,6),WCNO (100,6), WS (100,6) , HEFF(100,6) , RCUT(100,6) ,        MOR10940
     , QOA(100,6) ,CUMOP(100,6),AOTFLW (100), RADIUS (100), TBNPR (100)      MOR10950
      INTEGER CASE(5)                                                        MOR10960
      IF (NERR.EQ.0.AND.ASS.EQ.0.) GO TO 10                                  MOR10970
      GO TO 11C                                                              MOR10980
   10 CONTINUE                                                               MOR10990
      IF (PRCCLR.GT.C.0) GO TO 20                                            MOR11000
      WSC(1) = WSEXIT                                                        MOR11010
      ARCOOL = C.0                                                           MOR11020
      AVTBIC = 0.0                                                           MOR11030
      AVTB2C = 0.0                                                           MOR11040
      QTCOOL = 0.0                                                           MOR11050
      STB2CL = 0.0                                                           MOR11060
      DTCOL2 = C.0                                                           MOR11070
      UPCCCL = 0.0                                                           MOR11080
      OLTCT2 = 0.0                                                           MOR11090
      UPAVG = C.0                                                            MOR11100
      ACTCLR = 0.0                                                           MOR11110
      ACTCND = C.0                                                           MOR11120
      VPSHWC = 0.0                                                           MOR11130
      QELPC = C.0                                                            MOR11140
      TCNCP2 = C.0                                                           MOR11150
      HENDC = C.0                                                            MOR11160
      WENDC = C.0                                                            MOR11170
      WCNDCT = C.0                                                           MOR11180
      IVNOC = C                                                              MOR11190
   20 CONTINUE                                                               MOR11200
      WBI = WBI / ADJF * SECFLG                                              MOR11210
      ANT = ANT / ADJF * SECFLG                                              MOR11220
      ARCOND = AO * INC                                                      MOR11230
      WCNDT=WSI-WSC(1)                                                       MOR11240
      CTCND = SUMC * (1.0 + HFCOFL)                                          MOR11250
      AVTB2 = SMTB2 / SMWB                                                   MOR11260
      AVTBI = SMTBI / SMWB                                                   MOR11270
      AVTBIT = (SMTBI + SMTBIC) / (SMWB + SMWBC)                             MOR11280
      AVTB2T = (SMTB2 + SMTB2C) / (SMWB + SMWBC)                             MOR11290
      IF (VELBI.NE.0.) GO TO 30                                              MOR11300
      VELBI = WBI / (3600. * ( ANT ) * AXI * ROEFN(CBI,AVTBIT))              MOR11310
   30 CONTINUE                                                               MOR11320
      PI = 3.1415927                                                         MOR11330
      BLNL2P = ALST/2.                                                       MOR11340
CCCC                                                                         MOR11350
C     BUNDLE OVERALL DESIGN CHARACTERISTICS AND PUMPING POWER                MOR11360
CCCC                                                                         MOR11370
      BUNVOL = (PI*BNDIAM**2.)*ALST/8.                                       MOR11380
      BUNWT = PI*ANT*ALST*TUBESW*XW*(DO - XW)/144.                           MOR11390
      PML = BMLFN(CBI,AVTBIT)                                                MOR11400
      RETUB = SDI*GB*3600./BMU                                               MOR11410
      IF(FC.LE.C.) GO TO 31                                                  MOR11420
      FRIFAC = FC*(RETUB/100000.)**FEXP                                      MOR11430
      GO TO 32                                                               MOR11440
   31 FRIFAC = 0.3164*ENHFI/RETUB**.25                                       MOR11450
   32 CONTINUE                                                               MOR11460
      HDLOSS = (FRIFAC*ALST*VELBI**2.)/(2.*SDI*SG)                           MOR11470
      PMPPWR = HDLOSS*WBI/1.98E06                                            MOR11480
C                                                                            MOR11490
      CTCND2 = (AVTB2 - AVTBI) / ALOG((STSATI - AVTBI) / (STSATI -           MOR11500
     , AVTB2))                                                               MOR11510
      UPCOND = QTCCND / (ARCOND * CTCND2)                                    MOR11520
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      IF (PRCCLR.EQ.C.C) GO TO 40                                          MOR11530
      AVTBIC = SMTBIC / SMWBC                                              MOR11540
      AVTB2C = SMTB2C / SMWBC                                              MOR11550
      ARCCCL=AC*TNCC                                                       MOR11560
      WCACCT=WSC(I)-WSC(IVNOC+1)                                           MOR11570
      QTCOOL = SUMCC                                                       MOR11580
      CTCCL2 = (AVTB2C - AVTBIC) / ALOG((STSAEX - AVTBIC) / (STSAEX -      MOR11590
     * AVTB2C))                                                            MOR11600
      UPCCCL = CTCCCL / (ARCOOL * CTCOL2 )                                 MOR11610
      DLTCT2 = (AVTB2T - AVTBIT)/ ALOG((STSAT1 - AVTBIT) / (STSAT1 -       MOR11620
     * AVTB2T))                                                            MOR11630
      UPAVG = (QTCCND + QTCOOL) / (AC * ANT * DLTOT2)                      MOR11640
   40 CONTINUE                                                             MOR11650
      VNCC = FLOAT(IVNCC)                                                  MOR11660
      UBARW = C.0                                                          MOR11670
      UBARWC = 0.0                                                         MOR11680
      VPSHW = C.0                                                          MOR11690
      VPSHWC = 0.0                                                         MOR11700
      VEL3 = 0.0                                                           MOR11710
      DO 60 J=1,ISEC                                                       MOR11720
      DO 50 I=1,IHNO                                                       MOR11730
   50 UBARW = UBARW + UN(I,J) * TBNPR(I) * (1.0 + HFCOFL)                  MOR11740
      VEL3 = VEL3 + VEL(IHNO,J)                                            MOR11750
   60 CONTINUE                                                             MOR11760
      UBARW = UBARW/TNC                                                    MOR11770
      VEL3 = VEL3 / SECFLG                                                 MOR11780
      IF (PRCCLR.EQ.0.0) GO TO 80                                          MOR11790
      DO 70 I=1,IVNOC                                                      MOR11800
   70 UBARWC = UBARWC + UNC(I)                                             MOR11810
      UBARWC = UBARWC/VNCC                                                 MOR11820
      ACTCLR = QTCCCL/(UBARWC*ARCOOL)                                      MOR11830
   80 CONTINUE                                                             MOR11840
      UAVGW =(UBARW*TNC + UBARWC*TNCC)/ ANT                                MOR11850
      ACTCND = CTCCND/(UBARW*AC*TNO)                                       MOR11860
      ACTCA = (CTCCCL+CTCOND)/(UAVGW*ANT*AO)                               MOR11870
C  REGULAR OUTPUT PKG                                                      MOR11880
      TNCFR = TNCC/(TNOC+TNO)*100.                                         MOR11890
      TCRCP1 = STSAT(1,II - STSAEX                                         MOR11900
      THCFR = TNC/(TNO + TNOC) *100.0                                      MOR11910
      VC(DID = 2.0*RADINS                                                  MOR11920
      HNO = FLOAT(IHNO)                                                    MOR11930
      IF (PRCCLR.EQ.C.C) GO TO 90                                          MOR11940
      TCRCP2 = STSATC(I) - STSATC(IVNOC+1)                                 MOR11950
      DELPCA = PMIX1 - PMIXC(IVNOC+1)                                      MOR11960
      TCRCP3 = STSAT1 - STSATC(IVNOC+1)                                    MOR11970
      HBNDC = C.666*VNCC*SDDMIN*SOO + SDO                                  MOR11980
      WBNDC = VNCC*SCOMIN*SDO + SDO                                        MOR11990
      EXSTFR = WSC(IVNCC+1)/WS1 * 100.0                                    MOR12000
      EXNCFR= WNCI/(WNCI+WSC(IVNOC+1))*100.0                               MOR12010
   90 CONTINUE                                                             MOR12020
      IF (PRCCLR.GT.0.0) GO TO 100                                         MOR12030
      EXSTFR = WSEXIT / SW1 * 100.                                         MOR12040
      EXNCFR = WNCI / (WNCI + WSEXIT) * 100.                               MOR12050
      DELPCA = PMIX1 - PMXEXT                                              MOR12060
      TCRCP3 = STSAT1 - STSAEX                                             MOR12070
  100 CONTINUE                                                             MOR12080
      ARTCT = ARCOND + ARCCOL                                              MOR12090
                                                                           MOR12100
      CTCTAL = CTCCND + QTCOOL                                             MOR12110
C     CONVERT C TO MEGA BTU S                                              MOR12120
      CTCCND = CTCCND / 1.E06                                              MOR12130
      CTCCOL = CTCCCL / 1.E06                                              MOR12140
      CTCTAL = CTOTAL / 1.E06                                              MOR12150
      WRITE(6,10100) IDENT                                                 MOR12160
      WRITE(6,10200)                                                       MOR12170
      WRITE(6,10300) UBARW, ADTCND, DELPVE, TOROP1, VEL2 , VEL3 , SOD,     MOR12180
     , THCFR,CTCCND,ARCCND,UBARWC, AETCLR, DELPC, TOROP2, VELC(I),         MOR12190
     , VELC(IVNCC) , SODMIN,TNOFR,QTCCOL,ARCCCL, UAVGW, ADTCA, DELPCA,     MOR12200
     , TCRCP3, CTOTAL, ARTOT                                               MOR12210
      WRITE(6,10400) BADIAM, VOIDID, HNO                                   MOR12220
      WRITE(6,10500) HBNDC, WBNDC, ALST, EXSTFR, EXNCFR                    MOR12230
      WRITE(6,10600)                                                       MOR12240
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      WRITE(6,10700) AVTBI,AVTB2,WS),AVTBIC,AVTB2C,WBI,AVTBIT,AVTB2T,      MOR12250
     , VELBI,WCNDT,WCNDCT                                                  MOR12260
      WRITE(6,10800) CTCNO2,UPCOND, CTCOL2, UPCOOL, DLTOT2, UPAVG          MOR12270
      WRITE(6,10805) BUNL2P, BUNVOL, BUNWT, RETUB, FRIFAC, HDLOSS,         MOR12280
     , PMPPWR                                                              MOR12290
      IF (OUTPLT.EQ.0.) GO TO 150                                          MOR12300
C  FULL OUTPUT PKG                                                         MOR12310
  110 CONTINUE                                                             MOR12320
      DO 140 J=1,ISEC                                                      MOR12330
      WRITE(6,11800) IDENT, J                                              MOR12340
      WRITE(6,11700)                                                       MOR12350
      IF (IFLCAT.EQ.C) GO TO 120                                           MOR12360
      WRITE(6,11200)(I,STSAT(I,J),PM)X(I,J),WS(I,J),VEL(I,J),RC(I,J),     MOR12370
     ,UN(I,J),SHN((I,J),SHI(I,J),ROUT(I,J), I=1, IHNO)                     MOR12380
      WRITE(6,12100) STSAT(IHNO+1,J),PMIX(IHNO+1,J),WS()HNO+1,J)           MOR12390
      WRITE(6,10C00)                                                       MOR12400
      WRITE(6,11000)(I,VNREC(I,J),QOA(I,J),VPSH(),J),GFLOW(),J),           MOR12410
     , VPSHI(I,J),VPSHH(I,J),HEFF()J),TBNPR())),CUMOP(I,J),I=1,IHNO)       MOR12420
      IF (PRCCLR.EC.C.0.OR.J.LT.1SEC) GO TO 140                            MOR12430
      WRITE(6,11900) IDENT                                                 MOR12440
      WRITE(6,11600)                                                       MOR12450
      WRITE(6,11200)(I,STSATC(I),PMIXC(I),WSC())),VELC(II,RCC(I),          MOR12460
     , UNC())), SHNFC(I),SHIC(I),ROUTC(I) ,I=1,)VNOC)                      MOR12470
      WRITE(6,12000) STSATC(IVNOC+1),PMIXC(IVNOC+1),WSC(IVNCC+1)           MOR12480
      WRITE(6,11100)                                                       MOR12490
      WRITE(6,11200)(1,VNREC())),QOAC(I),VPSHC(I),GFLOWC())),VPSHIC(I)),   MOR12500
     ,   VPSHHC(II,HEFFC(I),HNOC , CUMDPC()I,I=1,)VNOC)                    MOR12510
      GO TO 130                                                            MOR12520
  120 CONTINUE                                                             MOR12530
      WRITE(6,11400)(),STSAT(),J),PMIX(I,J),WS(I,J),VEL(I,J),RC(I,J),      MOR12540
     ,   UN(I,J),SHN ((I,J),SHI(I,J),ROUT(I,J),I=1,IHNO)                   MOR12550
      WRITE(6,12100) STSAT()HNO+1,J),PMIX(IHNO+1,J),WS()HNO+1,J)           MOR12560
      WRITE(6,10C00)                                                       MOR12570
      WRITE(6,11300)(I,VNRE(),J),QOA(),J),VFSH(I,J),GFLOW(I,J),            MOR12580
     ,   VPSHI(I,J),VPSHH(),J),HEFF(I,J),TBNPR(I),CUMOP(),J),I=1,IHNO)     MOR12590
      IF (PRCCLR.EC.0.0.OR.J.LT.1SEC) GO TO 140                            MOR12600
      WRITE(6,11900) IDENT                                                 MOR12610
      WRITE(6,11600)                                                       MOR12620
      WRITE(6,11400)(1,STSATC())),PMIXC())),WSC()),VELC(I),RCC(I),         MOR12630
     ,   UNC(I), SHNFC(I),SHIC(I),ROUTC(I) ,I=1,IVNOC)                     MOR12640
      WRITE(6,12100) STSATC()VNOC+1),PMIXC(IVNOC+1),WSC(INVONC+1)          MOR12650
      WRITE(6,11100)                                                       MOR12660
      WRITE(6,11300)(),VNREC(1),QOAC()),VPSHC(I),GFLOWC(I),VPSHIC(I),      MOR12670
     ,   VPSHHC(I),HEFFC()),HNOC , CUMDPC(I),I=1,IVNOC)                    MOR12680
  130 CONTINUE                                                             MOR12690
  140 CONTINUE                                                             MOR12700
  150 CONTINUE                                                             MOR12710
      DO 170 J=1,ISEC                                                      MOR12720
      DO 160 I=1,IHNC                                                      MOR12730
  160 VPSH(I,J) = VPSHH(I,J)                                               MOR12740
  170 CONTINUE                                                             MOR12750
      DO 180 I=1,IVNCC                                                     MOR12760
  180 VPSIC(I) = VPSHHC(I)                                                 MOR12770
      IF ((PNCF.EQ.0) GO TO 200                                            MOR12780
      DO 190 J=1,)SEC                                                      MOR12790
  190 WRITE(7,11400) (VPSHH(),J),I=1,)HNO)                                 MOR12800
      WRITE(7,11900) (VPSHHC(I),I=1,IVNOC)                                 MOR12810
  200 CONTINUE                                                             MOR12820
      RETURN                                                               MOR12830
10100 FORMAT('1',19A4,A3)                                                  MOR12840
10200 FORMAT(1HC,52X, 16HSUMMARY OF RESULTS /1H ,11X, 24HAREA AVERAGE  8HOMOR12850
     ,ACK CALC. ,68X, 16HHEAT   HEAT TRF.   /1H ,16X, 2HU.8X, 8HLOG MEANMOR12860
     , ,4X, 33HPRESSURE    TEMP.    STEAM VELOCITY ,                47H  TUBE MOR12870
     ,SPACING  TUBE FRACTION REMOVED, SURFACE,                            MOR12880
     ,                        /12X, 5HBTU/HR/SQ.FT. DELTA TEMP.    DROP MOR12890
     ,    DROP        FT/SEC ,8X, 6HRATIO, 20X, 7HMILLION /14X, 58H/DEGMOR12900
     ,. F.      DEG.F.    LBS/SQ.IN.  DEG.F.  INLET   OUTLET ,          MOR12910
     ,  6X,  41HS/D          PERCENT        BTU/HR    SQ.FT.    )       MOR12920
10300 FORMAT(1H0, 11HCONDENSER   , F8.2,6X,F8.4,5X,F7.4,3X,F7.4,1X,F6.2,MOR12930
     ,  2X,F6.2, 7X,F5.3,6X,F6.2,6X,F9.4,F9.2 /1X, 6HCOOLER ,5X,F8.2,6X,MOR12940
     ,  F8.4,5X,F7.4,3X,F7.4,1X,F6.2,2X,F6.2, 7X,F5.3,6X,F6.2,7X,F8.4,   MOR12950
     , F5.2/1X, 7HOVERALL ,4X,F8.2,6X,F8.4,5X,F7.4,3X,F7.4,45X,F9.4,     MOR12960
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     . F9.2 )
10400 FORMAT(1H0, 25HOUTSIDE BUNDLE DIAM., FT. , F6.2,4X,
     . 22HINSIDE VOID DIAM., FT. , F6.2,4X,
     . 26HNUMBER OF RADIAL TUBE ROWS , F4.0 )
10500 FORMAT(1H0, 18HCOOLER HEIGHT, FT. ,F6.2,5X,17HCOOLER WIDTH, FT. ,
     . F6.2,5X, 18HBUNDLE LENGTH, FT. ,F7.2/1H0,
     . 26HEXIT STEAM, PERCENT OF INPUT ,1PE11.3,9X,
     . 45HEXIT NON-CONDENSIBLES, PERCENT OF TOTAL EXIT FLOW ,5X, F6.2 )
10600 FORMAT('0',T16,'AVG. BRINE TEMPS',T70,'FLOWS' /' ',T15,
     . 'ENTRANCE        EXIT',T70,'LBS/HR')
10700 FORMAT('0',T2,'CONDENSER ',2F12.4,T52,'STEAM TO CONDENSER',F17.0 /
     . ' ',T2,'COOLER    ',2F12.4,T52,'COOLANT TO BUNDLE',F18.0 /' ',
     . T2,'OVERALL   ',2F12.4,T52,'COOLANT VELOCITY',F15.4,' F/S' /' ',
     . T52,'CONDENSATE FROM CONDENSER',F10.0 /' ',T52,
     . 'CONDENSATE FROM COOLER',F13.0)
10800 FORMAT(1H0,'   DTCND2 ','   UPCOND ','   DTCOL2 ','   UPCOOL ',
     . '   OUTDT2 ','   UPAVG ',/' ', 6F10.4//)
10805 FORMAT(1H0,'   BUNL2F ','   BUNVOL ','   BUNWT  ','   RETUB  ',
     . '   FRIFAC ','   HDLOSS ','   PMPPWR '/' ',1P7E10.3)
10900 FORMAT(1H1, 7X, 6H RENDS, 5X,9HHEAT FLUX,6X, 6H   SF , 7X,
     . 6H GFLOW , 7X ,6H  TB1  , 7X,6H  TB2  , 7X,6H HEFF , 7X,5HTBNPR,
     . 6X,8HCUM DELP)
11000 FORMAT(1H ,I3,1P9E13.4)
11100 FORMAT(1H0, 8X, 6HRENDSC, 5X,9HHEAT FLUX,6X, 6H  SFC , 7X,
     . 6HGFLOWC , 7X,6H  TB1  , 7X,6H  TB2  , 7X,6HHEFFC , 7X,5HTBNPR,
     . 6X,8HCUM DELP)
11200 FORMAT(1H ,I3,1P9E13.4)
11300 FORMAT(1H ,I3,F11.0,F12.0,F14.4,F13.3,2F13.2,1PE15.5,0PF9.2,F13.4)
11400 FORMAT(1H ,I3,F10.2,F12.4,F13.1,F12.1,F14.4,F12.0,F15.0,F12.0,
     . F14.0)
11500 FORMAT(1H1,19A4,A3,17H   COOLER SECTION )
11600 FORMAT(1H0,8X,6HSTSATC, 7X,5HPMIXC, 8X,3HWSC,10X,4HVELC, 9X,3HRCC,
     .    10X,3HUNC,10X,5HSHNFC, 8X,4HSHIC,8X,7HI/ROUTC)
11700 FORMAT(1H0,8X,5HSTSAT, 8X,4HPMIX, 9X,2HWS,11X,3HVEL,10X,2HRC,11X,
     . 2HUN,11X,4HSHNF, 9X,3HSHI,9X,6HI/ROUT)
11800 FORMAT(1H1,19A4,A3,'    J = ',I2)
11900 FORMAT(6F10.6)
12000 FORMAT(1H ,3X,1P3E13.4)
12100 FORMAT(1H ,3X,F10.2,F12.4,F13.1)
      END



      SUBROUTINE SECALC(AMOLSS,AMOLST,DELP12,DELP23,SVMIX1,NERR)
CCCCC
C     SECALC CONTROLS THE CALCULATION BY SECTORS.  HETTRN IS CALLED FOR
C     EACH ROW OF EACH SECTOR AND SECALC PERFORMS UPDATES FOR SUCCEEDING
C     ROWS AND SECTORS.  AFTER ALL CONDENSER SECTORS ARE COMPLETED, A
C     CHECK IS MADE TO DETERMINE THE UNIFORMITY OF STEAM-SIDE PRESSURE
C     AT THE SECTOR OUTLETS.  IF NECESSARY, SECTOR INLET STEAM FLOWS
C     ARE ADJUSTED AND CONDENSER CALCULATION IS REPEATED FROM THE
C     BEGINNING UNTIL UNIFORM OUTLET PRESSURES ARE ACHIEVED.
CCCCC
      COMMON/INPT/ ALST ,ANT ,BAFFLE ,HFCDFL, CBI ,EXITFR ,FOUL ,GAS ,
     . CC , OUTPUT ,PRCCLP ,RADFLG ,SDD ,SDDMIN , SECFLG ,SKW ,STBI ,
     . STSATI ,VELBI , VSFLG ,WNCI ,WSI ,XW ,VPSHI(100,6), VPSHIC(100) ,
     . FDAVE ,ENHI ,ENHO ,ENHF ,WBI ,STBIP,ANTP,VELBIP,ADJF,IDENT(20),
     . INSTM ,IFLOAT ,ITRAN ,IPNCH ,NRWSP ,NRWSCP ,NRWS ,NRWSC,
     . EMHF1, TUBESW, FC, FEXP
      COMMON/INTEG/IHNC ,IHNOC ,ILNG ,ISEC , IVNO ,IVNOC ,J ,JGAS ,JRC ,
     .   IKLNO ,IFENOC, IOT ,IBT,IVAP,IRAIN
      COMMON AI ,AMLSEX ,AMOLNC ,AMWNC ,AO , ASS ,AW ,AXI ,BNDIAM ,COOR
     . (3), DELPVE ,GB ,HFG ,HNO ,HNOC , PMIX1 ,PMXEXT ,PSATEX ,RADINS ,
     . SDI , SDO ,SF ,SG ,SHWINV ,STBAVE , STB2ES ,STFO ,STSAFX ,TB2 ,
     . TNO , TNOC ,TNOFR ,TSATEX ,VELEXT ,VG , VLCMAX ,VNO ,VNOC ,WB ,
     . WNCC ,WSEXIT ,XNC , SMTBI, SMTB2, SMWB, SUMQ, SMTBIC, SMTB2C,
     . SMWBC, SUMQC
      COMMON/OIMC/ C (6),DELP (6),WGAS (6),WP (6) ,WSP(6)
      COMMON/OIMI/ALMTC(100), GFLOWC(100) ,PMIXC (100) ,PSATC (100),RCC
     . (100), SHIC (100),SHNFC (100),STSATC(100), UNC (100),VELC (100),
     . VAREC (100),VPSHC (100), VPSHHC(100),WCNOC (100),WSC (100),
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     . HEFFC(100) ,RCUTC(100) ,QOAC(100) , CUMOPC(100)
      COMMON/OIM16/ ALMTO (100,6) , ANF (100,6), GFLOW (100,6),PMIX
     . (100,6), PSAT (100,6), RC (100,6),SHI (100,6), SHN (100,6),STSAT
     . (100,6) ,UN (100,6), VEL (100,6) ,VNRE (100,6) ,VPSH (100,6),
     . VPSHH (100,6),WCND (100,6), WS (100,6) , HEFF(100,6) , ROUT(100,
     . 6) ,QOA(100,6) ,CUMOP(100,6),ACTFLW (100), RADIUS (100), TBNPR
     . (100)
      INTEGER GAS(5)
      WSAVE = (WNCI + WSI)/12.0
      SSAVE = WSI/12.0
      IST = 0
C     FOR THE FIRST PASS THROUGH THE CONDENSER , (J=1)
C     SET UP FOR CALCULATION THRU CONDENSER USE DOUBLE SUBSCRIPTS. (I,J)
CCCCC
C     I---TUBE ROWS, 1 TO IHNO
C     J---PASS NO  , 1 TO 6
      IFLOOP=0
      II = 1
   10 CONTINUE
      SMTB1 = 0.0
      SMWB = 0.0
      SMTB2 = 0.0
      SUMQ = 0.0
C
C     LOOP ON SECTORS
C
      DO 230 J=1,ISEC
      DELP(J) = 0.
      PMIX(1,J) = PMIX1 - DELP12 - DELP23
      PSAT(1,J)=PMIX(1,J)*(AMOLSS/AMOLST)
      PAL=PSAT(1,J)
      TAL = TSATFN(PAL)
      STSAT(1,J) = TAL - 459.69
      VG=VGFN(TAL,PMIX(1,J))
      VNC=(10.729 * TAL) / (AMWNC * PMIX(1,J))
      VMIX=1.0/((AMOLSS/(VG*AMOLST))+(AMOLNC/(VNC*AMOLST)))
      VEL (1, J) = ( WS (1,J) + WGAS (J) ) * VMIX / (3600.0*
     . ACTFLW(1))
      IF (WNCI) 20,20,30
   20 WGAS(J) = 0.0
   30 WNC = WGAS(J)
      AMOLSC=WNC/AMWNC
      TB2 = STB2ES
      IROW = 0
      ASS = 0.0
C
C     LOOP ON ROWS
C
      DO 210 IL=1,IHNC
      I=IL
      IJX = 0
      LC = 0
      AXO = ACTFLW(I)
      L = J
      STBI = VPSHI(I,J)
      IF (STBI.LT.STBIP) STBI = STBIP
CCCCC
C     CALL TO HETTRN FOR CURRENT ROW IN CURRENT SECTOR
CCCCC
      CALL HETTRN(STSAT(I,J),ANF(I,J),WS(I,J),WNC,UN(I,J),ALMTO(I,
     .   J), SHI(I,J),SHN(I,J),RC(I,J),ROUT(I,J) ,AXO, VNRE(I,J),
     .   DUMMY , VPSHH(I,J),HEFF(I,J),L,II,I)
      IF (ASS.NE.0.) GO TO 190
      HFG=HFGFN(STSAT(I,J))
      WCND(I,J)=UN(I,J)*AO*ALMTO(I,J)/HFG * TBNPR (I)
C
      CALL PRSDRP(TAL,VMIX,WS(I,J),WNC,AXO,SDO,VPSH(I,J), DELPTP
     . ,ENHF)
C
      JX=0
   40 WS(I+1,J)=WS(I,J)-WCND(I,J)
      GFLOW(I,J) = (WS(I,J)+WNC)/AXO
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      IF (I.GT.1) GO TO 50                                              MOR14410
      IF (WS(I+1,JJ)) 60,60,90                                          MOR14420
C     IF IROW.EQ.1 PROGRM IS FORCING A DECREASING COND. RATE            MOR14430
   50 IF (IROW.EQ.1) GO TO 60                                           MOR14440
C     IF PREVIOUS COND. RATE PREDICTS STEAM FLOW WILL GO NEG. AFTER THE MOR14450
C     NEXT ROW, SET CONDENSATE TO ONE-HALF OF STEAM FLOW.               MOR14460
      IF(WS(I-1,JJ)-2.0*WCND(I-1,JJ)) 60,60,90                          MOR14470
   60 WCND(I,JJ) = WS(I,JJ) / 2.                                        MOR14480
      IROW = 1                                                          MOR14490
   70 CONTINUE                                                          MOR14500
      WS(I+1,JJ)=WS(I,JJ)-WCND(I,JJ)                                   MOR14510
      AMOLS = WS(I+1,JJ) / 18.015                                       MOR14520
      PMIX(I+1,JJ)=PMIX(I,JJ)-DELPTP                                    MOR14530
      PSAT(I+1,JJ)=PMIX(I+1,JJ)*AMOLS / (AMOLS + WNC / AMWNC)          MOR14540
      TSAT = TSATFN(PSAT(I+1,JJ))                                       MOR14550
      STSAT(I+1,JJ) = TSAT - 459.69                                     MOR14560
      IF (STSAT(I+1,JJ).LE.ST81) GO TO 80                               MOR14570
      ALMTD(I,JJ) = WCND(I,JJ) *HFG/(UN(I,JJ)*AO * TBNPR (I))          MOR14580
      GO TO 180                                                         MOR14590
   80 WCND(I,JJ) = 0.0                                                  MOR14600
      JJX = JJX + 1                                                     MOR14610
      IF(JJX.LT.3) GO TO 70                                             MOR14620
      IF (IST.EQ.0) WRITE(6,10300) STSAT(I+1,J),IL,J                    MOR14630
      IST = 1                                                           MOR14640
      GO TO 150                                                         MOR14650
   90 AMOLS = WS(I+1,JJ) / 18.015                                       MOR14660
      PMIX(I+1,JJ)=PMIX(I,JJ)-DELPTP                                    MOR14670
      PSAT(I+1,JJ)=PMIX(I+1,JJ)*AMOLS / (AMOLS + WNC / AMWNC)          MOR14680
      PAL = PSAT(I+1,JJ)                                                MOR14690
      IF (PALI 100,100,110                                              MOR14700
  100 WRITE(6,10000) I,J,PMIX(I+1,JJ),WS(I+1,JJ)                        MOR14710
      GO TO 150                                                         MOR14720
  110 TSAT = TSATFN(PAL)                                                MOR14730
      STSAT(I+1,JJ) = TSAT - 459.69                                     MOR14740
      IF (STSAT(I+1,JJ)-STFO) 120,120,130                               MOR14750
  120 STSAT(I+1,JJ) = STFO                                              MOR14760
      TSAT = STSAT(I+1,JJ) + 459.69                                     MOR14770
  130 CONTINUE                                                          MOR14780
      WCNDP=(UN(I,JJ)*AO*ALMTO(I,JJ) * TBNPR (I) - (WS(I,JJ) *         MOR14790
     * CPAFN(TSAT) / 18.015 + WNC * CPAFN(TSAT,JGAS) / AMWNC ) *        MOR14800
     * (TAL - TSAT)) / HFG                                             MOR14810
      IF (ABS(WCNDP/WCND(I,JJ)-1.0)-.005) 170,140,140                   MOR14820
  140 JJ=JJ+1                                                           MOR14830
      IF (JJ-5) 100,100,150                                             MOR14840
  150 WRITE(6,10100)IDENT,I,J,I,J                                       MOR14850
      GO TO 360                                                         MOR14860
  160 WCND(I,JJ)=WCNDP                                                  MOR14870
      GO TO 40                                                          MOR14880
  170 CONTINUE                                                          MOR14890
      WCND(I,JJ) = WCNDP                                                MOR14900
      WS(I+1,JJ)=WS(I,JJ)-WCND(I,JJ)                                   MOR14910
      AMOLS = WS(I+1,JJ) / 18.015                                       MOR14920
      PSAT(I+1,JJ)=PMIX(I+1,JJ)*AMOLS / (AMOLS + WNC / AMWNC)          MOR14930
      TSAT = TSATFN(PSAT(I+1,JJ))                                       MOR14940
      STSAT(I+1,JJ) = TSAT - 459.69                                     MOR14950
  180 VG=VGFN(TSAT,PMIX(I+1,JJ)                                         MOR14960
      AMOLSC = WNC/AMWNC                                                MOR14970
      VNC = (10.729 * TSAT ) / (AMWNC * PMIX(I+1,JJ)                   MOR14980
      VMIX=1.0/((AMOLS /(VG*(AMOLS + AMOLSC)))+(AMOLSC/ (VNC*          MOR14990
     * (AMOLS+AMOLSC))))                                              MOR15000
      VEL(I+1,JJ)=(WS(I+1,JJ)+WNC)/(ACTFLW (I+1))*VMIX/3600.0           MOR15010
      SMTB1 = SMTB1 + WB * STB1 * TBNPR(I)                              MOR15020
      SMWB = SMWB + WB * TBNPR(I)                                       MOR15030
      SMTB2 = SMTB2 + WB * TBNPR(I) * TB2                               MOR15040
      SUMQ = SUMQ + UN(I,J) * AO * ALMTO(I,J) * TBNPR(I)                MOR15050
      QCAL(I,J) = UN(I,J) * ALMTO(I,J)                                  MOR15060
      CUMDP(I,JJ) = (PMIX1*27.7) - 27.7*PMIX(I+1,J)                     MOR15070
      DELP(J) = DELPTP + DELPTP                                         MOR15080
      TAL = TSAT                                                        MOR15090
      GO TO 210                                                         MOR15100
  190 ASS = 0.0                                                         MOR15110
      DO 200 II = I,IHAC                                                MOR15120
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      UN(IT,J) = UN(IT-1,J)                                             MOR15130
  200 WS(IT,J) = WS(IT-1,J)                                             MOR15140
      WS(IHNO+1,J) = WS(IHNO,J)                                         MOR15150
      GO TO 220                                                         MOR15160
  210 CONTINUE                                                          MOR15170
  220 CONTINUE                                                          MOR15180
      VEL(1,J)=SVMIX*(WS(1,J)+WGAS(J))/(3600.0*AOTFLW(1))              MOR15190
      C(J) = (WS(1,J) + WGAS(J)) / SQRT(DELP(J))                        MOR15200
  230 CONTINUE                                                          MOR15210
CCCCC                                                                   MOR15220
C     CALCULATION OF CONDENSER OUTLET CONDITIONS AND ADJUSTMENT OF      MOR15230
C     SECTOR INLET FLOWS IF NECESSARY FOR PRESSURE BALANCE.             MOR15240
CCCCC                                                                   MOR15250
      PMXEXT = 0.0                                                      MOR15260
      DELPVE = 0.                                                       MOR15270
      CC 240 J=1,ISEC                                                   MOR15280
      DELPVE = DELPVE + DELP(J)                                         MOR15290
  240 PMXEXT=PMXEXT+PMIX(IHNO+1,J)                                      MOR15300
      PMXEXT = PMXEXT/SECFLG                                            MOR15310
      DELPVE = DELPVE / SECFLG                                          MOR15320
      TNOFF = TNOC / (TNOC + TNO/AOJF * SECFLG) * 100.0                 MOR15330
      OC 260 J=1,ISEC                                                   MOR15340
      IF (ABS((DELP(J)/DELPVE-1.0)-0.01) 260,260,250                    MOR15350
  250 IF (ABS(DELPVE).GT.0.0001) GO TO 270                              MOR15360
  260 CONTINUE                                                          MOR15370
      GO TO 370                                                         MOR15380
  270 CONTINUE                                                          MOR15390
      DLPVES = DELPVE                                                   MOR15400
      CONSM= 0.0                                                        MOR15410
      WNCFR = WNC1 / (WNC1 + WS1)                                       MOR15420
      DC 280 J=1,ISEC                                                   MOR15430
      CONSM = CONSM + C(J)                                              MOR15440
  280 CONTINUE                                                          MOR15450
      DELPVE = (WSAVE*SECFLG)**2 / CONSM**2                             MOR15460
      DELPVE = (DELPVE + DLPVES) / 2.0                                  MOR15470
      DMAX = ABS(DELPVE - DELP(1))                                      MOR15480
      JMAX = 1                                                          MOR15490
      DC 290 J=2,ISEC                                                   MOR15500
         DHOLD = ABS(DELPVE - DELP(J))                                  MOR15510
         IF (DHOLD.LE.DMAX) GO TO 290                                   MOR15520
         DMAX = DHOLD                                                   MOR15530
         JMAX = J                                                       MOR15540
  290    CONTINUE                                                       MOR15550
      WSPT = 0.0                                                        MOR15560
      WPT=0.0                                                           MOR15570
      DC 310 J=1,ISEC                                                   MOR15580
         WP(J) = C(J) * SQRT(DELPVE)                                    MOR15590
         WSP(J)=WP(J)*WSI/(WNCI+WSI)                                    MOR15600
         IF (J.EC.JMAX) GO TO 310                                       MOR15610
         FAC = WSP(J) - WS(1,J)                                         MOR15620
         AFAC = ABS(FAC)                                                MOR15630
         IF (AFAC.LT.1.E-3) GO TO 300                                   MOR15640
         CHGSC = 0.5 * WS(1,J)**0.26                                    MOR15650
         IF (IFLCOP.GT.3) CHGSC = CHGSC/IPLOOP * 2.0                    MOR15660
         WSP(J) = WS(1,J) + FAC/AFAC * SQRT(AFAC) * CHGSC               MOR15670
  300    CONTINUE                                                       MOR15680
         WSPT = WSPT + WSP(J)                                           MOR15690
      WGAS(J) = WSP(J) * WNCFR                                          MOR15700
         WP(J) = WSP(J) + WGAS(J)                                       MOR15710
         WPT = WPT + WP(J)                                              MOR15720
  310    CONTINUE                                                       MOR15730
      WSP(JMAX) = SSAVE*SECFLG - WSPT                                   MOR15740
      WSPT = WSPT + WSP(JMAX)                                           MOR15750
      WGAS(JMAX) = WSP(JMAX) * WNCFR                                    MOR15760
      WP(JMAX) = WSP(JMAX) + WGAS(JMAX)                                 MOR15770
      WPT = WPT + WP(JMAX)                                              MOR15780
      IFLOOP=IFLOOP + 1                                                 MOR15790
      KK = 1                                                            MOR15800
      DC 340 J=1,ISEC                                                   MOR15810
         IF (BAFFLE.EC.0.0) GO TO 340                                   MOR15820
C  THIS PACKAGE TRIES TO KEEP ORDERED FLOW QUANTITIES TO SECTORS.       MOR15830
C  IF THE BUNDLE IS BAFFLED THE ODD-NUMBERED SECTORS SHOULD HAVE        MOR15840
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C  MORE FLOW BECAUSE THERE ARE FEWER TUBES ABOVE THE AVERAGE FLOW        MOR15850
C  PATH AND THEREFORE LESS CONDENSATE RAIN TO OBSTRUCT FLOW.             MOR15860
         IF (KK.EQ.2) GO TO 320                                         MOR15870
         KK = KK + 1                                                    MOR15880
         IF (WSP(J).GE.WSP(J+1)) GO TO 330                              MOR15890
         SWTCH = WSP(J+1)                                               MOR15900
         WSP(J+1) = WSP(J)                                              MOR15910
         WSP(J) = SWTCH                                                 MOR15920
         SWTCF = WGAS(J+1)                                              MOR15930
         WGAS(J+1) = WGAS(J)                                            MOR15940
         WGAS(J) = SWTCH                                                MOR15950
         GO TO 330                                                      MOR15960
  320    KK = 1                                                         MOR15970
  330    CONTINUE                                                       MOR15980
  340    WS(I,J)=WSP(J)                                                 MOR15990
C                                                                       MOR16000
C      REPEAT CONDENSER CALCULATION IF PRESSURE UNIFORMITY IS NOT       MOR16010
C      ACHIEVED WITHIN 50 ITERATIONS.                                   MOR16020
C                                                                       MOR16030
      IF (IPLOOP-50) 10,10,350                                          MOR16040
  350 WRITE(6,10200)IDEA)                                               MOR16050
  360 NERR = 1                                                          MOR16060
  370 RETURN                                                            MOR16070
10000 FORMAT(1H0,'***SATURATED STEAM PRESSURE HAS GONE NEGATIVE,   ROW',MOR16080
     ',I5,'   SECTOR',I5,'   PMIX =',E15.5,'   WS = ',E15.5)           MOR16090
10100 FORMAT(1H1,15A4,A3/1H0,5X,2HI=,I2,5X,2HJ=,I1/1H0,                 MOR16100
     ' 24H0 CONVERGENCE FOR WCND(I2,1H,I1,1H)]                          MOR16110
10200 FORMAT(1H1,1944,A3,40HNO CONVERGENCE IN COND. DELTA P (IPLOOP) )  MOR16120
10300 FORMAT(1HC,                                                       MOR16130
     , 'STEAM TEMP., FALLEN BELOW BRINE INLET TEMP.,   STSAT =',E13.6,  MOR16140
     ,'   ROW ',I3,'   SECTOR ',I3)                                     MOR16150
      END                                                               MOR16160
                                                                        MOR16170
                                                                        MOR16180
                                                                        MOR16190
                                                                        MOR16200
CCCCC                                                                   MOR16210
C      FOLLOWING ARE UTILITY SUBROUTINES AND FUNCTION SUBROUTINES TO    MOR16220
C      EVALUATE VAPOR, MIXTURE, AND COOLING WATER PROPERTIES AS REQUIRED MOR16230
C      IN THE ANALYSIS.                                                 MOR16240
CCCCC                                                                   MOR16250
      SUBROUTINE DFSVTY(TK,PATM,AM1,AM2,R1,R2,E10K,E20K,V1,V2,DG,DGG)   MOR16260
C  DG = GAS DIFFUSIVITY, SQ.CM./SEC - CHEM.ENGRS.HANDBOOK, 4TH ED.,     MOR16270
C  R.H.PERRY, 14-20, 1963, MC GRAW-HILL (WILKE-LEE MOD.)                MOR16280
C  CID = VALUES OF COLLISION INTEGRAL, FUNCTION FITTED BY R.W.BROWELL   MOR16290
C        FROM TABLE 14-45 OF ABOVE REF. 4/11/68                         MOR16300
C  TK   = ABS. TEMP., DEG. KELVIN                                       MOR16310
C  PATM= ABS. PRESS., ATMOSPHERES                                       MOR16320
C  R12 = COLLISION DIA., ANGSTROMS                                      MOR16330
C  R1  = COMPONENT 1 COLLISION DIA., ANGSTROMS                          MOR16340
C  R2  = COMPONENT 2 COLLISION DIA., ANGSTROMS                          MOR16350
C  E12OK= COMBINED FORCE CONSTANT FOR COMPONENTS 1 & 2., DEG. KELVIN    MOR16360
C  DGG = GAS DIFFUSIVITY - GILLILAND'S CRUDE APPROX. METHOD,PP.14-21 REFMOR16370
      IF (E10K.EQ.0.0.AND.V1.EQ.0.0) GO TO 30                           MOR16380
      IF (E10K.EQ.0.0) GO TO 20                                         MOR16390
      IF (R1.GT.0.0) GO TO 10                                           MOR16400
      R1 = 1.1E * V1**.333                                              MOR16410
      R2 = 1.1E * V2**.333                                              MOR16420
   10 CONTINUE                                                          MOR16430
      R12 = (R1 + R2)/2.0                                               MOR16440
      E12OK = (E10K * E20K)**0.5                                        MOR16450
      TKOE = TK /E12OK                                                  MOR16460
      CID = 0.1605 /TKOE**1.2063 + 0.5328 /TKOE**0.1579                 MOR16470
      RTSM = (1./AM1 + 1./AM2)**0.5                                     MOR16480
      B = (10.7 -2.46*RTSM)*1.E-4                                       MOR16490
      DG = B * TK**1.5 * RTSM /PATM /R12**2 / CID                       MOR16500
      IF (V1.EQ.0.0) GO TO 40                                           MOR16510
   20 CONTINUE                                                          MOR16520
      DGG = 0.0043 * TK**1.5 * RTSM /PATM /(V1**.333+V2**.333)**2       MOR16530
      GO TO 40                                                          MOR16540
   30 CONTINUE                                                          MOR16550
      WRITE(6,10000)                                                    MOR16560

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   40 CONTINUE                                                          MOR16570
      RETURN                                                            MOR16580
10000 FORMAT('0  ** NEITHER FORCE CONSTANTS NOR MOLECULAR VOLUMES EXIST MOR16590
     ,AS ARGUMENTS. CALCULATIONS CANNOT PROCEED. **' )                  MOR16600
      END                                                               MOR16610
      FUNCTION XTR (X,Y,N,T,SW,X1N,YN,M)                                MOR16620
C*****                                                                  MOR16630
C       FUNCTION XTR ASSUMES A LOG-LOG MODEL, IE  LOG Y = A + B1 * LOG  MOR16640
C       AND PERFORMS A LINEAR LEAST SQUARE REGRESSION ON THE            MOR16650
C       TRANSFORMED POINTS.  ALL POINTS ARE USED FOR EACH REGRESSION    MOR16660
C       EXCEPT FOR THE FIRST , WHICH IS NOT USED AT ALL                 MOR16670
C*******                                                                MOR16680
      DIMENSION X1N(11),YN(11)                                          MOR16690
      IF (Y.LE.0.) Y = .00001                                           MOR16700
      IF (N.EQ.0) GO TO 30                                              MOR16710
      X1N(N) = ALOG(X)                                                  MOR16720
      YN(N) = ALOG(Y)                                                   MOR16730
      IF (N.LT.2) GO TO 40                                              MOR16740
      SX1N = 0.0                                                        MOR16750
      SYN = 0.0                                                         MOR16760
      IF (M.LT.N-3) M = N-3                                             MOR16770
      DO 10 I=M,N                                                       MOR16780
         SX1N = SX1N + X1N(I)                                           MOR16790
         SYN = SYN + YN(I)                                              MOR16800
   10    CONTINUE                                                       MOR16810
      X1BAR = SX1N / (N-M+1)                                            MOR16820
      YBAR = SYN / (N-M+1)                                              MOR16830
      SX12 = 0.0                                                        MOR16840
      SX1Y = 0.0                                                        MOR16850
      DO 20 I=M,N                                                       MOR16860
         SX12 = SX12 + (X1N(I) - X1BAR) ** 2                            MOR16870
         SX1Y = SX1Y + (X1N(I) - X1BAR) * (YN(I) - YBAR)                MOR16880
   20    CONTINUE                                                       MOR16890
      B1 = SX1Y / SX12                                                  MOR16900
      A = YBAR - B1 * X1BAR                                             MOR16910
      TA = ALOG(T)                                                      MOR16920
      XTR = EXP((TA-A) / B1)                                            MOR16930
      GO TO 50                                                          MOR16940
   30 M = 1                                                             MOR16950
   40 XTR = X * (1. + (Y-T) * 5. * SW)                                  MOR16960
C*****                                                                  MOR16970
C       CHANGE OF VARIABLE IS LIMITED TO 10 PERCENT                     MOR16980
C*****                                                                  MOR16990
   50 IF (ABS(XTR-X)/X.LT.0.1) GO TO 60                                 MOR17000
      XTR = X * (1. + 0.1 * ABS(Y-T)/(Y-T) * SW)                        MOR17010
   60 RETURN                                                            MOR17020
      END                                                               MOR17030
      FUNCTION AMUFN(T,JGAS)                                            MOR17040
      IMIX = 0                                                          MOR17050
      GO TO (30,20,10), JGAS                                            MOR17060
   10 IMIX = 1                                                          MOR17070
   20 CONTINUE                                                          MOR17080
C  INERT GAS IS CO2                                                     MOR17090
C**  VISCOSITY FOR CARBON DIOXIDE  LB/FT-SEC                           MOR17100
      GAS2 = 1.0 E-5 * (-0.046 + (2.282E-3 + (-6.131 E-7 + 9.699E-11 *T)MOR17110
     ,  *T) *T)                                                         MOR17120
      AMUFN = GAS2                                                      MOR17130
      IF (IMIX.EQ.0) RETURN                                             MOR17140
   30 CONTINUE                                                          MOR17150
C  INERT GAS IS AIR                                                     MOR17160
      GAS1 =1.CE-5*(0.1490+(0.238E-2)*T-(.7209E-6)*T**2+(.1184E-9)*T**3)MOR17170
      AMUFN = GAS1                                                      MOR17180
      IF (IMIX.EQ.0) RETURN                                             MOR17190
C  INERT GAS IS MIXTURE OF AIR & CO2                                    MOR17200
      GAS3 = (GAS1 + GAS2)/2.0                                          MOR17210
      AMUFN = GAS3                                                      MOR17220
      RETURN                                                            MOR17230
      END                                                               MOR17240
      FUNCTION BMUFN(C,T)                                               MOR17250
C     VISCOSITY OF SALINE SOLUTION,  RANGE OF DATA WAS 0 - 24 PERCENT   MOR17260
C     CONCENTRATION AND 40 - 210 DEGREES FARENHEIT.                     MOR17270
      A = T + 459.69                                                    MOR17280
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      BMOFN = DEXP(-C.11591155D+2*C + 0.126023290-1*C*R + 0.38637378D+4*MOR17290
     ,  C/R + C.4606532D-2*R + 0.47595941D+4/R - 0.10592525660+2)          MOR17300
      RETURN                                                               MOR17310
      END                                                                  MOR17320
      FUNCTION CPAFN(T,JGAS)                                               MOR17330
      MIX = 0                                                              MOR17340
      GO TO (3C,20,1C), JGAS                                               MOR17350
   1C MIX = 1                                                              MOR17360
   20 CONTINUE                                                             MOR17370
C  INERT GAS IS CO2                                                        MOR17380
C** HEAT CAPACITY FOR MW = 40.1   BTU/LB-MOL - DEG R                       MOR17390
      GAS2 = 0.209 * 4C.1                                                  MOR17400
      CPAFN = GAS2                                                         MOR17410
      IF (IMIX.EC.C) RETURN                                                MOR17420
   30 CONTINUE                                                             MOR17430
C  INERT GAS IS AIR                                                        MOR17440
C AIR CP, BTU / LB MOLE-DEGREE RANKIN                                      MOR17450
      GAS1 =7.135-0.58E4E-3*T +0.1393E-5*T**2 -0.3367E-9*T**3              MOR17460
      CPAFN = GAS1                                                         MOR17470
      IF (IMIX.EC.0) RETURN                                                MOR17480
C  INERT GAS IS MIXTURE OF AIR & CO2                                       MOR17490
      GAS3 = (GAS1 + GAS2)/2.0                                             MOR17500
      CPAFN = GAS3                                                         MOR17510
      RETURN                                                               MOR17520
      END                                                                  MOR17530
      FUNCTION CPFN(C,T)                                                   MOR17540
   10 IF (C-0.CC5) 2C,20,30                                                MOR17550
C*****EQUATION SPECIFIC HEAT FOR PURE WATER                                MOR17560
   20 CP= 1.01?1559 +(-0.24618473E-3 + 0.10282155E-5*T)*T                  MOR17570
      GO TO 4C                                                             MOR17580
C*****EQUATION SPECIFIC HEAT FOR BRINE                                     MOR17590
   30 CP=.9694E259+12.*(0.000104049651*T)-(.91199294*C) +(2.*(-           MOR17600
     ,  .COO64E2S655)*C*T)+(-1.5557794(C**2))+ (2.*(.007672146?1*(C**2)*  MOR17610
     ,  T)+16.7?E1008*(C**3))+ (2.*(-.0126(C354)*(C**3)*T)                 MOR17620
   40 CPFN=CP                                                              MOR17630
      RETURN                                                               MOR17640
      END                                                                  MOR17650
      FUNCTION CPSFN(T)                                                    MOR17660
C***                                                                       MOR17670
C     CPSFN CALCULATES THE HEAT CAP OF STEAM IN BTU/LB-MOL-R GIVEN T IN    MOR17680
C     DEG F, EQUATIONS FROM H. NORITAKE, BASED ON TABULATED VALUES IN      MOR17690
C     NASA TR-R-132                                                        MOR17700
C***                                                                       MOR17710
      CPSFN = (7.838 - (.2531E-3 - (.2892E-6 - .7693E-10*T )*T )*T )       MOR17720
      RETURN                                                               MOR17730
      END                                                                  MOR17740
      FUNCTION HFGFN(T)                                                    MOR17750
      HFGFN=1053.88-0.5703*T+.00012819*T**2-.0000008824*T**3               MOR17760
      RETURN                                                               MOR17770
      END                                                                  MOR17780
      SUBROUTINE PRSORPITSAT,VMIX,WS,WNC,AXO,SDO,SF,DELPTP,ENHF)           MOR17790
CCC                                                                        MOR17800
C     PRSCPP  REBUILT ON 9-16-69 TO USE EQUATION FOR SF                    MOR17810
CCC                                                                        MOR17820
      SG = 32.174                                                          MOR17830
      GSTAR = (WS*WNC) / (AXO*3600.)                                       MOR17840
      ANRE = (SDO * GSTAR) / SMUFN(TSAT)                                   MOR17850
      SF = (0.)02 + 52.2 / ANRE) * ENHF                                    MOR17860
      DELPTP = SF * GSTAR**2 * VMIX / (72.0 * SG)                          MOR17870
      RETURN                                                               MOR17880
      END                                                                  MOR17890
      FUNCTION PSATFN(T)                                                   MOR17900
      PSATFN=2.718**(14.15C119-(6452.5621/T)-(837533.21/T**2))             MOR17910
      RETURN                                                               MOR17920
      END                                                                  MOR17930
      FUNCTION RCEFN(C,T)                                                  MOR17940
C     DENSITY OF SALINE SOLUTION.  RANGE OF DATA WAS 0 - 26 PERCENT        MOR17950
C     CONCENTRATION AND 40 - 300 DEGREES FARENHEIT.                        MOR17960
      RCEFN = C.62707172E2 + 0.49364088E2 * C - (0.43955304E-2 +           MOR17970
     ,  C.32554667E-1 * C + (0.46076921E-4 - 0.63240299E-4 * C)*T)*T       MOR17980
      RETURN                                                               MOR17990
      END                                                                  MOR18000
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FILE: PCFCON   FORTRAN  A   NAVAL POSTGRADUATE SCHOOL

      FUNCTION SKBFN(C,T)                                                  MOR18010
C           THERMAL CONDUCTIVITY OF SALINE SOLUTION.  RANGE OF DATA        MOR18020
C           0 - 24 PERCENT CONCENTRATION AND 40 - 300 DEGREES FARENHEITMOR18030
      SKBFN=(.2015?S)3+.697989E-3*T-.12506E-5*T**2 -.2072E-10*T**3)*(-     MOR18040
     ,  .1C8710$*C+1.)                                                     MOR18050
      RETURN                                                               MOR18060
      END                                                                  MOR18070
      FUNCTION SMUFN(T)                                                    MOR18080
      SMUFN=1.CE-5*(0.122+(1.001E-3)*T+(2.892E-7)*T**2-(7.693E-11)*T**3)MOR18090
      RETURN                                                               MOR18100
      END                                                                  MOR18110
      FUNCTION TSATFN(P)                                                   MOR18120
      AA=ALOG(P)-14.15011S)                                                MOR18130
      DET=6452.5621**2-(4.0*AA*837533.21)                                  MOR18140
      IF (DET) 1C,2C,2C                                                    MOR18150
   10 WRITE(6,10000)                                                       MOR18160
      CALL EXIT                                                            MOR18170
   20 X=(-6452.5621+SQRT(DET))/(2.0*AA)                                    MOR18180
      Y=(-6452.5621-SQRT(DET))/(2.0*AA)                                    MOR18190
      IF (X-Y) 30,4C,4C                                                    MOR18200
   30 TSATFN=Y                                                             MOR18210
      GO TO 50                                                             MOR18220
   40 TSATFN=X                                                             MOR18230
   50 CONTINUE                                                             MOR18240
      RETURN                                                               MOR18250
10000 FORMAT(1H1,37HSUBROUTINE TSATFN FINDS COMPLEX ROOTS)                 MOR18260
      END                                                                  MOR18270
      FUNCTION VGFN(T,P)                                                   MOR18280
      X=ALOG(T/P)                                                          MOR18290
      VGFN= EXP(((.103758E-2*X-.0177861)*X+1.10267)*X-.72240)              MOR18300
      RETURN                                                               MOR18310
      END                                                                  MOR18320
```

Appendix B. Input Data Deck for Baseline Design

```
        10        20        30        40        50        60        70   75   80
4 MORCCN REPORT, BASELINE CASE, SMCOTH TUBE, 8/05/82
    1646.      6.00     1.350     1.350      .625     .0650     17.0    0    0
4046763.       0.0      .035      66.1   .000329      1.00
AIR    6.   0.  1.0  0.0  0.5 0.05  1.0     0    0    1    0
 189002.      33.7    133.73    38.000      1.00      1.
   1.000    558.CC     C.000     0.000
     1    1
```

Appendix C. Summary and Detailed Output for Baseline Design

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FILE: M        C        A   NAVAL POSTGRADUATE SCHOOL                                    PAGE 001

1                                          CIRCULAR CONDENSER INPUT DATA
0  CARD 1       CASE IDENTIFICATION AND NOTES
          MORCON REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82
0  CARD 2     ANT        PRCCLR      SOD        SDDMIN      OD         XW         SKW        NRWS  NRWSC
             1646.       6.00       1.3500     1.3500     0.6250     0.0650     17.00        0      0
0  CARD 3     WBI        VELBI      CBI        STBI        FOUL       ENHI
           4046763.       C.0      0.03500    66.1000     0.00033     1.000
C  CARD 4     GAS      SECFLG   HFCDFL   RADFLG   BAFFLE   FOAVE    EXITFR   OUTPUT   INSTM   ITRAN   IFLOAT   IPNCH
              AIR       6.00      0.0      1.00      0.0     0.5000   0.0500     1.00       0       0        1       0
0  CARD 5     WSI        WNCI       STSATI      ALST        ENHO       ENHF
           1890C3.       33.70     133.730     38.000      1.000      1.000
C  CARD 6   ENHFI      TUBESW        FC         FEXP
              1.CCO     558.000      0.0        0.0
C  CARD 7   IVAF       IRAIN
              1          1
1CASE IDENTIFICATION AND NOTES ****  MORCON REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82
CGEOMETRY SPECIFICATION          TUBING SPECIFICATION                          FLOW AND PROPERTIES SPECIFICATION
0 NO. OF TUBES          1646.00    OUTSIDE DIAM., INCHES            0.6250    STEAM FLOW, LBS/HR                189003.
  PCT. TUBES IN COOLER     6.00    WALL THICKNESS, INCHES           0.0650    COOLANT FLOW, LBS/HR.            4046763.
  LENGTH OF TUBES, FT.    38.00    WALL COND.,BTU/HR/SW.F/DEG.F.   17.0000    COOLANT VELOCITY, FT/SEC.            0.0
  S/D, CONDENSER           1.350   FOULING FACTOR                   0.0003    STEAM TEMP., DEG. F.               133.73
  S/D COOLER               1.350   TUBE FLOOD FACTOR(FOAVE)         0.5000    COOLANT TEMP., DEG. F.              66.10
  BUNDLE RADIUS FACTOR     1.00    ENHANCEMENT FACTORS                        WT. FRAC. OF NACL IN COOLANT      0.03500
  SECTOR MODEL             6.00      INSIDE FILM                    1.0000    EXIT STEAM FRACTION,PCT. OF INPUT 0.0500
  BAFFLE FLAG              0.0       OUTSIDE FILM                   1.0000    NON-CONDENSIBLE FLOW, LB/HR.        33.70
  SYM. FLAG                0.0       FRICTION FACTOR                1.0000
1
 INPUT DONE
OREYNOLDS NUMBER IN CONDENSER ON SHELL SIDE HAS FALLEN BELOW 100,  RENO =    0.917591E+02 SECTOR    6  ROW     28
 SECALC DONE
0**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.17068E+03
                    32 ROWS OF TUBES      3.000  TUBES PER ROW
C    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = C.14889E+03
        28ROWS OF TUBES      3.439TUBES PER ROW
OREYNOLDS NUMBER IN COOLER    ON SHELL SIDE HAS FALLEN BELOW 100,  RENO =    0.937834E+02 SECTOR    7  ROW     25
 COOLER DONE
C    0 ALTOLD =    38.000  XTFR1 = 0.0000 ALST =     37.909
 SECALC DONE
C**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.17529E+03
                    32 ROWS OF TUBES      3.000  TUBES PER ROW
C    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = 0.14745E+03
        27ROWS OF TUBES      3.566TUBES PER ROW
OREYNOLDS NUMBER IN COOLER    ON SHELL SIDE HAS FALLEN BELOW 100,  RENO =    0.527462E+02 SECTOR    7  ROW     26
 COOLER DONE
0    1 ALTOLD =    37.909  XTFR1 = 0.0003 ALST =     37.821
 SECALC DONE
0**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.17974E+03
                    32 ROWS OF TUBES      3.000  TUBES PER ROW
C    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = C.14560E+03
        26ROWS OF TUBES      3.703TUBES PER ROW
OREYNOLDS NUMBER IN COOLER    ON SHELL SIDE HAS FALLEN BELOW 100,  RENO =    0.786101E+02 SECTOR    7  ROW     25
 COOLER DONE
C    2 ALTOLD =    37.821  XTFR1 = 0.0001 ALST =     37.391
 SECALC DONE
C**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.20197E+03
                    32 ROWS OF TUBES      3.000  TUBES PER ROW
C    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = 0.14473E+03
        23ROWS OF TUBES      4.1o7TUBES PER ROW
 COOLER DONE
0    3 ALTOLD =    37.391  XTFR1 = 0.0008 ALST =     37.463
 SECALC DONE
0**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.19813E+03
                    32 ROWS OF TUBES      3.000  TUBES PER ROW
0    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = 0.14815E+03
        24ROWS OF TUBES      4.012TUBES PER ROW
 COOLER DONE
C    4 ALTOLD =    37.463  XTFR1 = 0.0008 ALST =     37.489
 SECALC DONE
C**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.19673E+03
                    32 ROWS OF TUBES      3.000  TUBES PER ROW
0    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = 0.14710E+03
        24ROWS OF TUBES      4.012TUBES PER ROW
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 CCOLEX CONE
O    5 ALTOLO =    37.469  XTFR1 = 0.0006 ALST =    37.497
 SECALC CONE
O**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.19634E+03
                    32 ROWS OF TUBES     3.000  TUBES PER ROW
C    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = 0.14681E+03
       24ROWS OF TUBES     4.012TUBES PER ROW
 CCCLEX CONE
O    6 ALTOLO =    37.497  XTFR1 = 0.0006 ALST =    37.564
 SECALC CONE
O**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.19287E+03
                    32 ROWS OF TUBES     3.000  TUBES PER ROW
O    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = 0.15022E+03
       25ROWS OF TUBES     3.852TUBES PER ROW
CREYNOLDS NUMBER IN COOLER    ON SHELL SIDE HAS FALLEN BELOW 100,  RENO =    0.898950E+02 SECTOR    7  ROW    25
 CCOLEX CONE
C    7 ALTOLO =    37.564  XTFR1 = 0.0002 ALST =    37.500
 SECALC CONE
C**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.19621E+03
                    32 ROWS OF TUBES     3.000  TUBES PER ROW
C    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = 0.14671E+03
       24ROWS OF TUBES     4.012TUBES PER ROW
 CCCLEX CONE
C    8 ALTOLO =    37.500  XTFR1 = 0.0006 ALST =    37.504
 SECALC CONE
O**** STEAM VELOCITY IN FRIST ROW OF COOLER TUBES EXCEEDS MAX ALLOWABLE,  VELC(1) =    0.19594E+03
                    32 ROWS OF TUBES     3.000  TUBES PER ROW
O    COOLER DIMENSIONS ADJUSTED TO LOWER STEAM VELOCITY,  VELC(1) = 0.14651E+03
       24ROWS OF TUBES     4.012TUBES PER ROW
 CCOLEX CONE
C          CONVERGENCE CRITERIA MET FOR EXIT STEAM
C COOLER EXIT STEAM FRAC.  0.0005      ACTUAL TUBES IN CONDENSER  1549.7  ACTUAL TUBES IN COOLER    96.3
1 PORCON REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82
C                                        SUMMARY OF RESULTS
                AREA AVERAGE  BACK CALC.                                                                  HEAT   HEAT TRF.
                    U,          LOG MEAN    PRESSURE   TEMP.    STEAM VELOCITY  TUBE SPACING  TUBE FRACTION REMOVED, SURFACE,
                BTU/HR/SQ.FT. DELTA TEMP,     DROP     DROP        FT/SEC          RATIO,                    MILLION
                  /DEG. F.      DEG.F.    LBS/SQ.IN.  DEG.F.  INLET   OUTLET      S/D          PERCENT       BTU/HR   SQ.FT.
CCONDENSER      533.73        35.9691       0.0700    1.1785 120.75   54.54       1.350         94.15       182.5716 9510.04
 COOLER         484.61        34.4132       3.0559   32.5948 147.84    3.69       1.350          5.85         9.8545  590.90
 OVERALL        530.86        35.8860       0.1633   34.3675                                               192.4261 10100.94
COUTSIDE BUNDLE DIAM., FT.   4.15     INSIDE VOID DIAM., FT.  0.48     NUMBER OF RADIAL TUBE ROWS 30.
OCOOLER HEIGHT, FT.  1.51     COOLER WIDTH, FT.  0.33     BUNDLE LENGTH, FT. 37.504
CEXIT STEAM, PERCENT OF INPUT  5.272E-02          EXIT NON-CONDENSIBLES, PERCENT OF TOTAL EXIT FLOW     252.73
O              AVG. BRINE TEMPS                                    FLOWS
              ENTRANCE      EXIT                                  LBS/HR
CCONDENSER     66.1008     116.4253          STEAM TO CONDENSER          189003.
 COOLER        66.1002     113.2591          COOLANT TO BUNDLE          4046762.
 OVERALL       66.1007     116.2401          COOLANT VELOCITY         8.0000 F/S
                                             CONDENSATE FROM CONDENSER   179249.
                                             CONDENSATE FROM COOLER        9654.

C   CTCND2    LPCOND    OTCOL2    UPCOOL    DLTOT2      UPAVG
    36.5202  515.9807   37.8695  440.3840   37.0739   513.8474

C   BUNL2F    EUNVOL    BUNWT     RETUB     FRIFAC    HOLOSS    PMPPWR
  1.875E+01 2.535E+02 2.735E+04 2.890E+04 2.427E-02 2.194E+01 4.485E+01


    GLOSSARY OF TERMS USED IN THE DETAILED OUTPUT

    FIRST COLUMN INDICATES ROW NUMBER.  INTEGER J DESIGNATES SECTOR.

    STSAT     MIXTURE TEMPERATURE ENTERING THE ROW, DEG F
    PMIX      MIXTURE PRESSURE, PSIA
    WS        STEAM WEIGHT FLOW RATE TO ROW, LB/HR
    VEL       MIXTURE VELOCITY AT MINIMUM CROSS SECTION, FT/SEC
    RC        WEIGHT FRACTION OF NON-CONDENSIBLE GASES
    UN        OVERALL HEAT TRANSFER COEFFICIENT FOR THE "MEAN" TUBE,
              BTU/HR-FT**2-DEG F
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SHNF CONDENSATE FILM HEAT TRANSFER COEFFICIENT, BTU/HR-FT**2-DEG F
SHI TUBE-SIDE HEAT TRANSFER COEFFICIENT, BTU/HR-FT**2-DEG F
1/ROUT STEAM-SIDE HEAT TRANSFER COEFFICIENT (CONDENSATE AND GAS), BTU/HR-FT**2-DEG F

RENCS STEAM-SIDE REYNOLDS NUMBER AT MINIMUM CROSS SECTION
HEAT FLUX LOCAL HEAT TRANSFER RATE PER UNIT AREA OF TUBE SURFACE, BTU/HR-FT**2
SF STEAM-SIDE FRICTION FACTOR
GFLOW WEIGHT FLOW RATE OF VAPOR AT CURRENT ROW, LB/HR
TBI COOLING WATER INLET TEMPERATURE, DEG F
TB2 COOLING WATER OUTLET TEMPERATURE, DEG F
HEFF HEAT TRANSFER COEEFICIENT OF NON-CONDENSIBLE FILM, BTU/HR-FT**2-DEG F
TBNPR NUMBER OF TUBES IN ROW
CUM DELP CUMULATIVE PRESSURE DROP FROM ENTRANCE, IN. H2O

1 MORCON REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82 J = 1

0	STSAT	PMIX	WS	VEL	RC	UN	SHNF	SHI	1/ROUT
1	1.3350E+02	2.4407E+00	3.1842E+04	1.2206E+02	1.7824E-04	5.8376E+02	4.0365E+03	1.6208E+03	4.0351E+03
2	1.3342E+02	2.4357E+00	2.9598E+04	1.1942E+02	1.8920E-04	5.8347E+02	4.0250E+03	1.6205E+03	4.0236E+03
3	1.3335E+02	2.4305E+00	2.8212E+04	1.1609E+02	2.0117E-04	5.6805E+02	3.4084E+03	1.6173E+03	3.4073E+03
4	1.3328E+02	2.4264E+00	2.6503E+04	1.1283E+02	2.1415E-04	5.6768E+02	3.3965E+03	1.6171E+03	3.3953E+03
5	1.3321E+02	2.4221E+00	2.4650E+04	1.0957E+02	2.2838E-04	5.5918E+02	3.1225E+03	1.6151E+03	3.1215E+03
6	1.3315E+02	2.4181E+00	2.3265E+04	1.0634E+02	2.4394E-04	5.5875E+02	3.1112E+03	1.6147E+03	3.1100E+03
7	1.3309E+02	2.4143E+00	2.1734E+04	1.0311E+02	2.6112E-04	5.5301E+02	2.9470E+03	1.6134E+03	2.9458E+03
8	1.3303E+02	2.4107E+00	2.0265E+04	9.9917E+01	2.8004E-04	5.5257E+02	2.9358E+03	1.6131E+03	2.9346E+03
9	1.3298E+02	2.4074E+00	1.8852E+04	9.6722E+01	3.0103E-04	5.4813E+02	2.8191E+03	1.6120E+03	2.8179E+03
10	1.3293E+02	2.4042E+00	1.7498E+04	9.3557E+01	3.2432E-04	5.4766E+02	2.8080E+03	1.6117E+03	2.8066E+03
11	1.3288E+02	2.4012E+00	1.6198E+04	9.0401E+01	3.5033E-04	5.4401E+02	2.7179E+03	1.6108E+03	2.7165E+03
12	1.3283E+02	2.3985E+00	1.4956E+04	8.7278E+01	3.7941E-04	5.4348E+02	2.7060E+03	1.6105E+03	2.7045E+03
13	1.3279E+02	2.3959E+00	1.3768E+04	8.4173E+01	4.1213E-04	5.4030E+02	2.6318E+03	1.6086E+03	2.6302E+03
14	1.3275E+02	2.3934E+00	1.2637E+04	8.1106E+01	4.4900E-04	5.3975E+02	2.6199E+03	1.6084E+03	2.6181E+03
15	1.3272E+02	2.3912E+00	1.1560E+04	7.8069E+01	4.9083E-04	5.3654E+02	2.5572E+03	1.6088E+03	2.5553E+03
16	1.3268E+02	2.3891E+00	1.0538E+04	7.5085E+01	5.3838E-04	5.3635E+02	2.5452E+03	1.6084E+03	2.5431E+03
17	1.3265E+02	2.3871E+00	9.5698E+03	7.2142E+01	5.9283E-04	5.3377E+02	2.4901E+03	1.6079E+03	2.4877E+03
18	1.3262E+02	2.3853E+00	8.6567E+03	6.9269E+01	6.5532E-04	5.3315E+02	2.4776E+03	1.6075E+03	2.4753E+03
19	1.3259E+02	2.3837E+00	7.7962E+03	6.6458E+01	7.2759E-04	5.3074E+02	2.4288E+03	1.6070E+03	2.4259E+03
20	1.3256E+02	2.3821E+00	6.9903E+03	6.3743E+01	8.1141E-04	5.3016E+02	2.4167E+03	1.6067E+03	2.4135E+03
21	1.3254E+02	2.3807E+00	6.2369E+03	6.1128E+01	9.0534E-04	5.2785E+02	2.3725E+03	1.6062E+03	2.3688E+03
22	1.3252E+02	2.3793E+00	5.5374E+03	5.8652E+01	1.0241E-03	5.2720E+02	2.3608E+03	1.6059E+03	2.3567E+03
23	1.3249E+02	2.3781E+00	4.8901E+03	5.6337E+01	1.1595E-03	5.2510E+02	2.3211E+03	1.6054E+03	2.3164E+03
24	1.3247E+02	2.3770E+00	4.2961E+03	5.4243E+01	1.3196E-03	5.2445E+02	2.3107E+03	1.6051E+03	2.3053E+03
25	1.3245E+02	2.3759E+00	3.7542E+03	5.2425E+01	1.5098E-03	5.2257E+02	2.2761E+03	1.6047E+03	2.2699E+03
26	1.3243E+02	2.3749E+00	3.2651E+03	5.0994E+01	1.7356E-03	5.2206E+02	2.2686E+03	1.6044E+03	2.2614E+03
27	1.3241E+02	2.3739E+00	2.8277E+03	5.0088E+01	2.0035E-03	5.2050E+02	2.2411E+03	1.6041E+03	2.2329E+03
28	1.3239E+02	2.3730E+00	2.4426E+03	4.9965E+01	2.3186E-03	5.2038E+02	2.2403E+03	1.6040E+03	2.2307E+03
29	1.3236E+02	2.3721E+00	2.1092E+03	5.1037E+01	2.6841E-03	5.1947E+02	2.2257E+03	1.6037E+03	2.2150E+03
30	1.3234E+02	2.3712E+00	1.8274E+03	5.4107E+01	3.0967E-03	5.2025E+02	2.2412E+03	1.6037E+03	2.2292E+03
	1.3231E+02	2.3701E+00	1.5969E+03						

1	RENOS	HEAT FLUX	SF	GFLOW	TBI	TB2	HEFF	TBNPR	CUM DELP
1	5.5373E+03	2.0159E+04	1.1143E-01	3.0679E+03	6.6100E+01	1.1868E+02	1.2181E+07	1.5184E+01	5.4477E-01
2	5.3778E+03	2.0126E+04	1.1171E-01	2.9792E+03	6.6100E+01	1.1862E+02	1.1530E+07	1.4731E+01	7.6680E-01
3	5.2189E+03	1.9870E+04	1.1200E-01	2.8906E+03	6.6100E+01	1.1817E+02	1.0519E+07	1.4278E+01	8.0167E-01
4	5.0641E+03	1.9836E+04	1.1231E-01	2.8049E+03	6.6100E+01	1.1912E+02	9.6888E+06	1.3824E+01	9.1972E-01
5	4.9100E+03	1.9686E+04	1.1263E-01	2.7191E+03	6.6100E+01	1.1772E+02	9.1082E+06	1.3371E+01	1.0312E+00
6	4.7585E+03	1.9667E+04	1.1297E-01	2.6350E+03	6.6100E+01	1.1764E+02	8.3849E+06	1.2917E+01	1.1364E+00
7	4.6076E+03	1.9556E+04	1.1333E-01	2.5513E+03	6.6100E+01	1.1737E+02	7.6741E+06	1.2464E+01	1.2354E+00
8	4.4585E+03	1.9536E+04	1.1371E-01	2.4687E+03	6.6100E+01	1.1730E+02	7.0072E+06	1.2010E+01	1.3286E+00
9	4.3110E+03	1.9448E+04	1.1411E-01	2.3867E+03	6.6100E+01	1.1708E+02	6.3774E+06	1.1557E+01	1.4161E+00
10	4.1652E+03	1.9428E+04	1.1453E-01	2.3058E+03	6.6100E+01	1.1702E+02	5.8150E+06	1.1103E+01	1.4982E+00
11	4.0203E+03	1.9354E+04	1.1498E-01	2.2254E+03	6.6100E+01	1.1683E+02	5.2849E+06	1.0650E+01	1.5750E+00
12	3.8775E+03	1.9334E+04	1.1546E-01	2.1462E+03	6.6100E+01	1.1678E+02	4.7293E+06	1.0197E+01	1.6469E+00
13	3.7360E+03	1.9271E+04	1.1597E-01	2.0678E+03	6.6100E+01	1.1661E+02	4.2697E+06	9.7431E+00	1.7139E+00
14	3.5967E+03	1.9251E+04	1.1651E-01	1.9906E+03	6.6100E+01	1.1656E+02	3.7921E+06	9.2897E+00	1.7764E+00
15	3.4591E+03	1.9185E+04	1.1709E-01	1.9144E+03	6.6100E+01	1.1643E+02	3.4007E+06	8.8362E+00	1.8345E+00
16	3.3243E+03	1.9174E+04	1.1770E-01	1.8398E+03	6.6100E+01	1.1636E+02	3.0115E+06	8.3829E+00	1.8886E+00
17	3.1917E+03	1.9115E+04	1.1835E-01	1.7663E+03	6.6100E+01	1.1624E+02	2.6541E+06	7.9293E+00	1.9387E+00
18	3.0625E+03	1.9103E+04	1.1904E-01	1.6948E+03	6.6100E+01	1.1616E+02	2.3367E+06	7.4759E+00	1.9851E+00
19	2.9364E+03	1.9049E+04	1.1977E-01	1.6250E+03	6.6100E+01	1.1607E+02	2.0409E+06	7.0225E+00	2.0281E+00
20	2.8148E+03	1.9037E+04	1.2054E-01	1.5578E+03	6.6100E+01	1.1602E+02	1.7830E+06	6.5690E+00	2.0679E+00
21	2.6979E+03	1.8986E+04	1.2134E-01	1.4931E+03	6.6100E+01	1.1590E+02	1.5444E+06	6.1156E+00	2.1046E+00

22	2.5874E+03	1.8975E+04	1.2216E-01	1.4319E+03	6.6100E+01	1.1584E+02	1.3329E+06	5.6621E+00	2.1387E+00
23	2.4841E+03	1.8927E+04	1.2300E-01	1.3748E+03	6.6100E+01	1.1574E+02	1.1438E+06	5.2087E+00	2.1704E+00
24	2.3907E+03	1.8816E+04	1.2382E-01	1.3232E+03	6.6100E+01	1.1565E+02	9.7804E+05	4.7553E+00	2.1999E+00
25	2.3097E+03	1.8873E+04	1.2458E-01	1.2784E+03	6.6100E+01	1.1560E+02	8.3237E+05	4.3018E+00	2.2276E+00
26	2.2457E+03	1.8864E+04	1.2522E-01	1.2431E+03	6.6100E+01	1.1555E+02	7.1005E+05	3.8484E+00	2.2540E+00
27	2.2050E+03	1.8827E+04	1.2565E-01	1.2207E+03	6.6100E+01	1.1547E+02	6.0694E+05	3.3950E+00	2.2796E+00
28	2.1988E+03	1.8816E+04	1.2571E-01	1.2174E+03	6.6100E+01	1.1546E+02	5.2404E+05	2.9415E+00	2.3050E+00
29	2.2451E+03	1.8799E+04	1.2522E-01	1.2433E+03	6.6100E+01	1.1558E+02	4.5951E+05	2.4881E+00	2.3314E+00
30	2.3793E+03	1.8809E+04	1.2390E-01	1.3176E+03	6.6100E+01	1.1540E+02	4.1629E+05	2.0346E+00	2.3607E+00

1 MORCCA REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82 J = 2

0

	STSAT	PRIX	WS	VEL	RC	UN	SHNF	SHI	1/RCUT
1	1.3350E+02	2.4407E+00	3.1749E+04	1.2170E+02	1.7824E-04	5.8372E+02	4.0349E+03	1.6208E+03	4.0336E+03
2	1.3342E+02	2.4357E+00	2.9905E+04	1.1905E+02	1.8923E-04	5.8343E+02	4.0234E+03	1.6205E+03	4.0220E+03
3	1.3335E+02	2.4309E+00	2.8119E+04	1.1571E+02	2.0125E-04	5.6802E+02	3.4070E+03	1.6173E+03	3.4059E+03
4	1.3328E+02	2.4265E+00	2.6469E+04	1.1243E+02	2.1427E-04	5.5955E+02	3.1324E+03	1.6155E+03	3.1314E+03
5	1.3321E+02	2.4222E+00	2.4766E+04	1.0920E+02	2.2847E-04	5.5913E+02	3.1212E+03	1.6151E+03	3.1201E+03
6	1.3315E+02	2.4182E+00	2.3181E+04	1.0596E+02	2.4411E-04	5.5341E+02	2.9567E+03	1.6137E+03	2.9557E+03
7	1.3309E+02	2.4145E+00	2.1657E+04	1.0274E+02	2.6128E-04	5.4901E+02	2.8399E+03	1.6126E+03	2.8389E+03
8	1.3303E+02	2.4109E+00	2.0193E+04	9.9555E+01	2.8021E-04	5.4856E+02	2.8292E+03	1.6123E+03	2.8281E+03
9	1.3298E+02	2.4076E+00	1.6784E+04	9.6367E+01	3.0123E-04	5.4494E+02	2.7391E+03	1.6113E+03	2.7380E+03
10	1.3293E+02	2.4044E+00	1.7433E+04	9.3205E+01	3.2456E-04	5.4444E+02	2.7277E+03	1.6110E+03	2.7264E+03
11	1.3288E+02	2.4015E+00	1.6137E+04	9.0053E+01	3.5062E-04	5.4129E+02	2.6535E+03	1.6102E+03	2.6521E+03
12	1.3284E+02	2.3987E+00	1.4898E+04	8.6926E+01	3.7978E-04	5.3854E+02	2.5908E+03	1.6096E+03	2.5894E+03
13	1.3280E+02	2.3962E+00	1.3715E+04	8.3843E+01	4.1250E-04	5.3755E+02	2.5795E+03	1.6092E+03	2.5779E+03
14	1.3276E+02	2.3938E+00	1.2586E+04	8.0772E+01	4.4949E-04	5.3547E+02	2.5244E+03	1.6086E+03	2.5228E+03
15	1.3272E+02	2.3915E+00	1.1513E+04	7.7746E+01	4.9137E-04	5.3485E+02	2.5129E+03	1.6083E+03	2.5110E+03
16	1.3269E+02	2.3894E+00	1.0493E+04	7.4754E+01	5.3911E-04	5.3254E+02	2.4637E+03	1.6077E+03	2.4617E+03
17	1.3266E+02	2.3875E+00	9.5282E+03	7.1818E+01	5.9368E-04	5.3193E+02	2.4519E+03	1.6074E+03	2.4496E+03
18	1.3263E+02	2.3857E+00	8.6160E+03	6.8933E+01	6.5649E-04	5.2971E+02	2.4073E+03	1.6069E+03	2.4048E+03
19	1.3260E+02	2.3840E+00	7.7584E+03	6.6125E+01	7.2901E-04	5.2907E+02	2.3954E+03	1.6066E+03	2.3926E+03
20	1.3257E+02	2.3825E+00	6.9533E+03	6.3356E+01	8.1335E-04	5.2697E+02	2.3546E+03	1.6061E+03	2.3514E+03
21	1.3255E+02	2.3811E+00	6.2020E+03	6.0776E+01	9.1177E-04	5.2631E+02	2.3428E+03	1.6058E+03	2.3392E+03
22	1.3252E+02	2.3798E+00	5.5032E+03	5.8280E+01	1.0274E-03	5.2565E+02	2.3308E+03	1.6056E+03	2.3267E+03
23	1.3250E+02	2.3786E+00	4.8567E+03	5.5943E+01	1.1640E-03	5.2366E+02	2.2940E+03	1.6051E+03	2.2894E+03
24	1.3248E+02	2.3774E+00	4.2634E+03	5.3821E+01	1.3258E-03	5.2303E+02	2.2835E+03	1.6048E+03	2.2782E+03
25	1.3246E+02	2.3764E+00	3.7221E+03	5.1968E+01	1.5183E-03	5.2120E+02	2.2511E+03	1.6044E+03	2.2450E+03
26	1.3244E+02	2.3754E+00	3.2335E+03	5.0492E+01	1.7473E-03	5.2076E+02	2.2434E+03	1.6042E+03	2.2363E+03
27	1.3241E+02	2.3745E+00	2.7967E+03	4.9529E+01	2.0197E-03	5.1918E+02	2.2176E+03	1.6038E+03	2.2094E+03
28	1.3239E+02	2.3736E+00	2.4120E+03	4.9329E+01	2.3411E-03	5.1903E+02	2.2164E+03	1.6037E+03	2.2069E+03
29	1.3237E+02	2.3727E+00	2.0790E+03	5.0295E+01	2.7151E-03	5.1923E+02	2.2215E+03	1.6036E+03	2.2106E+03
30	1.3234E+02	2.3717E+00	1.7972E+03	5.3202E+01	3.1394E-03	5.1898E+02	2.2183E+03	1.6036E+03	2.2063E+03
	1.3232E+02	2.3707E+00	1.5671E+03						

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	RENOS	HEAT FLUX	SF	GFLOW	T81	T82	HEFF	T8NPR	CUM DELP
1	5.5211E+03	2.0160E+04	1.1145E-01	3.0589E+03	6.6100E+01	1.1888E+02	1.2334E+07	1.5184E+01	5.4401E-01
2	5.3611E+03	2.0126E+04	1.1174E-01	2.9699E+03	6.6100E+01	1.1882E+02	1.1516E+07	1.4731E+01	6.7525E-01
3	5.2016E+03	1.9870E+04	1.1203E-01	2.8812E+03	6.6100E+01	1.1817E+02	1.0612E+07	1.4278E+01	7.9932E-01
4	5.0462E+03	1.9712E+04	1.1234E-01	2.7949E+03	6.6100E+01	1.1779E+02	9.8713E+06	1.3824E+01	9.1658E-01
5	4.8936E+03	1.9692E+04	1.1267E-01	2.7101E+03	6.6100E+01	1.1771E+02	8.9939E+06	1.3371E+01	1.0273E+00
6	4.7414E+03	1.9580E+04	1.1301E-01	2.6256E+03	6.6100E+01	1.1743E+02	8.3645E+06	1.2917E+01	1.1318E+00
7	4.5914E+03	1.9495E+04	1.1337E-01	2.5423E+03	6.6100E+01	1.1720E+02	7.6439E+06	1.2464E+01	1.2301E+00
8	4.4431E+03	1.9473E+04	1.1375E-01	2.4599E+03	6.6100E+01	1.1714E+02	7.0958E+06	1.2010E+01	1.3227E+00
9	4.2956E+03	1.9349E+04	1.1415E-01	2.3781E+03	6.6100E+01	1.1696E+02	6.3801E+06	1.1557E+01	1.4096E+00
10	4.1499E+03	1.9377E+04	1.1458E-01	2.2973E+03	6.6100E+01	1.1689E+02	5.7995E+06	1.1103E+01	1.4911E+00
11	4.0052E+03	1.9213E+04	1.1503E-01	2.2171E+03	6.6100E+01	1.1672E+02	5.2403E+06	1.0650E+01	1.5674E+00
12	3.8624E+03	1.9247E+04	1.1551E-01	2.1379E+03	6.6100E+01	1.1668E+02	4.7479E+06	1.0197E+01	1.6387E+00
13	3.7216E+03	1.9234E+04	1.1602E-01	2.0599E+03	6.6100E+01	1.1652E+02	4.2356E+06	9.7431E+00	1.7053E+00
14	3.5822E+03	1.9174E+04	1.1657E-01	1.9827E+03	6.6100E+01	1.1640E+02	3.8066E+06	9.2897E+00	1.7673E+00
15	3.4452E+03	1.9161E+04	1.1715E-01	1.9068E+03	6.6100E+01	1.1633E+02	3.3762E+06	8.8362E+00	1.8250E+00
16	3.3101E+03	1.9106E+04	1.1777E-01	1.8319E+03	6.6100E+01	1.1622E+02	3.0113E+06	8.3828E+00	1.8786E+00
17	3.1778E+03	1.9093E+04	1.1842E-01	1.7587E+03	6.6100E+01	1.1615E+02	2.6521E+06	7.9293E+00	1.9282E+00
18	3.0481E+03	1.9042E+04	1.1912E-01	1.6869E+03	6.6100E+01	1.1605E+02	2.3350E+06	7.4759E+00	1.9743E+00
19	2.9221E+03	1.9029E+04	1.1986E-01	1.6171E+03	6.6100E+01	1.1598E+02	2.0377E+06	7.0225E+00	2.0169E+00
20	2.7999E+03	1.8981E+04	1.2064E-01	1.5495E+03	6.6100E+01	1.1588E+02	1.7778E+06	6.5690E+00	2.0562E+00
21	2.6828E+03	1.8968E+04	1.2145E-01	1.4847E+03	6.6100E+01	1.1582E+02	1.5359E+06	6.1156E+00	2.0926E+00
22	2.5714E+03	1.8951E+04	1.2229E-01	1.4231E+03	6.6100E+01	1.1579E+02	1.3226E+06	5.6621E+00	2.1263E+00
23	2.4671E+03	1.8905E+04	1.2315E-01	1.3654E+03	6.6100E+01	1.1569E+02	1.1348E+06	5.2087E+00	2.1576E+00
24	2.3725E+03	1.8894E+04	1.2399E-01	1.3131E+03	6.6100E+01	1.1563E+02	9.6961E+05	4.7553E+00	2.1867E+00
25	2.2899E+03	1.8852E+04	1.2478E-01	1.2675E+03	6.6100E+01	1.1554E+02	8.2370E+05	4.3018E+00	2.2140E+00
26	2.2240E+03	1.8843E+04	1.2545E-01	1.2311E+03	6.6100E+01	1.1549E+02	7.0078E+05	3.8484E+00	2.2399E+00
27	2.1808E+03	1.8807E+04	1.2591E-01	1.2074E+03	6.6100E+01	1.1542E+02	5.9759E+05	3.3950E+00	2.2650E+00
28	2.1712E+03	1.8796E+04	1.2601E-01	1.2022E+03	6.6100E+01	1.1540E+02	5.1444E+05	2.9415E+00	2.2898E+00
29	2.2129E+03	1.8796E+04	1.2556E-01	1.2255E+03	6.6100E+01	1.1539E+02	4.4975E+05	2.4881E+00	2.3155E+00

20	2.3400E+03	1.8780E+04	1.2427E-01	1.2961E+03	6.6100E+01	1.1537E+02	4.0573E+05	2.0346E+00	2.3440E+00

1 MORCCA REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82 J = 3

C

	STSAT	PMIX	WS	VEL	RC	UN	SHNF	SHI	1/ROUT
1	1.3350E+02	2.4407E+00	3.1629E+04	1.2124E+02	1.7824E-04	5.8368E+02	4.0330E+03	1.6208E+03	4.0317E+03
2	1.3342E+02	2.4357E+00	2.9785E+04	1.1857E+02	1.8928E-04	5.6836E+02	3.4172E+03	1.6177E+03	3.4162E+03
3	1.3335E+02	2.4310E+00	2.8019E+04	1.1529E+02	2.0120E-04	5.5462E+02	2.9873E+03	1.6147E+03	2.9865E+03
4	1.3328E+02	2.4266E+00	2.6328E+04	1.1208E+02	2.1413E-04	5.5028E+02	2.8702E+03	1.6136E+03	2.8693E+03
5	1.3321E+02	2.4224E+00	2.4698E+04	1.0889E+02	2.2826E-04	5.4674E+02	2.7801E+03	1.6126E+03	2.7793E+03
6	1.3315E+02	2.4184E+00	2.3127E+04	1.0570E+02	2.4375E-04	5.4367E+02	2.7057E+03	1.6117E+03	2.7048E+03
7	1.3309E+02	2.4146E+00	2.1615E+04	1.0254E+02	2.6080E-04	5.4323E+02	2.6958E+03	1.6115E+03	2.6948E+03
8	1.3303E+02	2.4111E+00	2.0158E+04	9.9375E+01	2.7964E-04	5.4054E+02	2.6333E+03	1.6107E+03	2.6324E+03
9	1.3298E+02	2.4078E+00	1.8759E+04	9.6231E+01	3.0049E-04	5.3809E+02	2.5787E+03	1.6100E+03	2.5777E+03
10	1.3293E+02	2.4046E+00	1.7416E+04	9.3107E+01	3.2365E-04	5.3759E+02	2.5684E+03	1.6098E+03	2.5673E+03
11	1.3289E+02	2.4017E+00	1.6128E+04	8.9992E+01	3.4951E-04	5.3534E+02	2.5198E+03	1.6090E+03	2.5186E+03
12	1.3284E+02	2.3989E+00	1.4895E+04	8.6905E+01	3.7842E-04	5.3324F+02	2.4759E+03	1.6084E+03	2.4746E+03
13	1.3280E+02	2.3964E+00	1.3718E+04	8.3847E+01	4.1068E-04	5.3269E+02	2.4653E+03	1.6081F+03	2.4639F+03
14	1.3276E+02	2.3940E+00	1.2594E+04	8.0811E+01	4.4754F-04	5.3070E+02	2.4249E+03	1.6076E+03	2.4233E+03
15	1.3272E+02	2.3917E+00	1.1525E+04	7.7817E+01	4.8902E-04	5.3013E+02	2.4139E+03	1.6073E+03	2.4122E+03
16	1.3269E+02	2.3896E+00	1.0509E+04	7.4859E+01	5.3628E-04	5.2822E+02	2.3764E+03	1.6068E+03	2.3745E+03
17	1.3266E+02	2.3877E+00	9.5473E+03	7.1966E+01	5.9025E-04	5.2761E+02	2.3652E+03	1.6066E+03	2.3631E+03
18	1.3263E+02	2.3859E+00	8.6285E+03	6.9107E+01	6.5230E-04	5.2658E+02	2.3536E+03	1.6062E+03	2.3513E+03
19	1.3260E+02	2.3842E+00	7.7826E+03	6.6326E+01	7.2399E-04	5.2517E+02	2.3165E+03	1.6058E+03	2.3159E+03
20	1.3257E+02	2.3827E+00	6.9804E+03	6.3638E+01	8.0712E-04	5.2448E+02	2.3072E+03	1.6056E+03	2.3042E+03
21	1.3255E+02	2.3813E+00	6.2306E+03	6.1052E+01	9.0417E-04	5.2382E+02	2.2956E+03	1.6053F+03	2.2922E+03
22	1.3253E+02	2.3799E+00	5.5232E+03	5.8595E+01	1.0180E-03	5.2203E+02	2.2631E+03	1.6048E+03	2.2593E+03
23	1.3250E+02	2.3787E+00	4.8890E+03	5.6311E+01	1.1520E-03	5.2139E+02	2.2525E+03	1.6046E+03	2.2481E+03
24	1.3248E+02	2.3776E+00	4.2967E+03	5.4238E+01	1.3106E-03	5.2077E+02	2.2422E+03	1.6044E+03	2.2371E+03
25	1.3246E+02	2.3765E+00	3.7565E+03	5.2445E+01	1.4988E-03	5.1914E+02	2.2140E+03	1.6040E+03	2.2082F+03
26	1.3244E+02	2.3755E+00	3.2688E+03	5.1040E+01	1.7220E-03	5.1866F+02	2.2069E+02	1.6037E+03	2.2001E+03
27	1.3242E+02	2.3745E+00	2.8327E+03	5.0166E+01	1.9866E-03	5.1835E+02	2.2021E+03	1.6037E+03	2.1942E+03
28	1.3240E+02	2.3736E+00	2.4484E+03	5.0071E+01	2.2977E-03	5.1820E+02	2.2016E+03	1.6035E+03	2.1926E+03
29	1.3237E+02	2.3727E+00	2.1155E+03	5.1175E+01	2.6583E-03	5.1748E+02	2.1904E+03	1.6032E+03	2.1802E+03
30	1.3235E+02	2.3717E+00	1.8341E+03	5.4292E+01	3.0648E-03	5.1824E+02	2.2051E+03	1.6033E+03	2.1937E+03
	1.3232E+02	2.3707E+00	1.6040E+03						

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	RENOS	HEAT FLUX	SF	QFLOW	TB1	TB2	HEFF	TBNPR	CUM DELP
1	5.5002E+03	2.0159E+04	1.1149E-01	3.0473E+03	6.6100E+01	1.1888E+02	1.2318E+07	1.5184E+01	5.4300E-01
2	5.3396E+03	1.9897E+04	1.1177E-01	2.9580E+03	6.6100E+01	1.1824E+02	1.1586E+07	1.4731E+01	6.7323E-01
3	5.1832E+03	1.9662E+04	1.1207E-01	2.8710E+03	6.6100E+01	1.1762E+02	1.0682E+07	1.4278E+01	7.9646E-01
4	5.0306E+03	1.9570E+04	1.1238E-01	2.7862E+03	6.6100E+01	1.1740E+02	9.8635E+06	1.3824E+01	9.1304E-01
5	4.8797E+03	1.9496E+04	1.1270E-01	2.7024E+03	6.6100E+01	1.1720E+02	9.2748E+06	1.3371E+01	1.0232E+00
6	4.7303E+03	1.9430E+04	1.1303E-01	2.6194E+03	6.6100E+01	1.1702E+02	8.4691E+06	1.2917E+01	1.1272E+00
7	4.5823E+03	1.9397E+04	1.1339E-01	2.5373E+03	6.6100E+01	1.1698E+02	7.7368E+06	1.2464E+01	1.2252E+00
8	4.4353E+03	1.9336E+04	1.1377E-01	2.4557E+03	6.6100E+01	1.1682E+02	7.0246E+06	1.2010E+01	1.3174E+00
9	4.2898E+03	1.9282E+04	1.1417E-01	2.3749E+03	6.6100E+01	1.1668E+02	6.4576E+06	1.1557E+01	1.4041E+00
10	4.1458E+03	1.9267E+04	1.1459E-01	2.2951E+03	6.6100E+01	1.1660E+02	5.8061E+06	1.1103E+01	1.4854E+00
11	4.0028E+03	1.9210E+04	1.1504E-01	2.2158E+03	6.6100E+01	1.1648E+02	5.2493E+06	1.0650E+01	1.5616E+00
12	3.8616E+03	1.9163E+04	1.1552E-01	2.1375E+03	6.6100E+01	1.1636E+02	4.7260E+06	1.0197E+01	1.6329E+00
13	3.7222E+03	1.9148E+04	1.1602E-01	2.0602E+03	6.6100E+01	1.1629E+02	4.2618E+06	9.7431E+00	1.6995E+00
14	3.5843E+03	1.9098E+04	1.1656E-01	1.9838E+03	6.6100E+01	1.1619E+02	3.8411E+06	9.2857E+00	1.7616E+00
15	3.4486E+03	1.9084E+04	1.1713E-01	1.9087E+03	6.6100E+01	1.1612E+02	3.4168E+06	8.8262E+00	1.8194E+00
16	3.3150E+03	1.9037E+04	1.1774E-01	1.8346E+03	6.6100E+01	1.1603E+02	3.0235E+06	8.3828E+00	1.8731E+00
17	3.1841E+03	1.9023E+04	1.1839E-01	1.7622E+03	6.6100E+01	1.1597E+02	2.6767E+06	7.9293E+00	1.9230E+00
18	3.0560E+03	1.9003E+04	1.1909E-01	1.6913E+03	6.6100E+01	1.1592E+02	2.3545E+06	7.4759E+00	1.9692E+00
19	2.9312E+03	1.8959E+04	1.1980E-01	1.6222E+03	6.6100E+01	1.1582E+02	2.0681E+06	7.0225E+00	2.0120E+00
20	2.8104E+03	1.8946E+04	1.2056E-01	1.5555E+03	6.6100E+01	1.1577E+02	1.7940E+06	6.5690E+00	2.0517E+00
21	2.6952E+03	1.8927E+04	1.2136E-01	1.4915E+03	6.6100E+01	1.1572E+02	1.5549E+06	6.1156E+00	2.0884E+00
22	2.5854E+03	1.8886E+04	1.2218E-01	1.4308E+03	6.6100E+01	1.1563E+02	1.3416E+06	5.6621E+00	2.1224E+00
23	2.4835E+03	1.8873E+04	1.2301E-01	1.3745E+03	6.6100E+01	1.1558F+02	1.1534E+06	5.2087E+00	2.1541F+00
24	2.3910E+03	1.8856E+04	1.2382E-01	1.3234E+03	6.6100E+01	1.1553E+02	9.8635E+05	4.7553E+00	2.1836E+00
25	2.3110E+03	1.8819E+04	1.2457E-01	1.2792E+03	6.6100E+01	1.1545F+02	8.4062E+05	4.3018E+00	2.2113E+00
26	2.2483E+03	1.8809E+04	1.2520E-01	1.2445E+03	6.6100E+01	1.1541E+02	7.1701E+05	3.8484F+00	2.2378F+00
27	2.2089E+03	1.8790E+04	1.2561E-01	1.2229E+03	6.6100E+01	1.1539F+02	6.1304E+05	3.3950E+00	2.2634E+00
28	2.2039E+03	1.8790E+04	1.2566E-01	1.2203E+03	6.6100E+01	1.1535E+02	5.2925E+05	2.9415E+00	2.2889E+00
29	2.2517E+03	1.8769E+04	1.2515E-01	1.2469E+03	6.6100E+01	1.1530E+02	4.6581E+05	2.4881E+00	2.3154E+00
30	2.3879E+03	1.8779E+04	1.2382E-01	1.3226E+03	6.6100E+01	1.1531E+02	4.2182E+05	2.0346E+00	2.3450E+00

1 MORCCA REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82 J = 4

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	STSAT	PMIX	WS	VEL	RC	UN	SHNF	SHI	1/ROUT
1	1.3350E+02	2.4407E+00	3.1392E+04	1.2033E+02	1.7824E-04	5.4155E+02	2.6508E+03	1.6125E+03	2.6503E+03
2	1.3342E+02	2.4358E+00	2.9608E+04	1.1787E+02	1.8898E-04	5.3793E+02	2.5096E+03	1.6115E+03	2.5690E+03
3	1.3335E+02	2.4311E+00	2.7885E+04	1.1474E+02	2.0065E-04	5.3610F+02	2.5302E+03	1.6109E+03	2.5297E+03
4	1.3328E+02	2.4267E+00	2.6220E+04	1.1161E+02	2.1339E-04	5.3438E+02	2.4944E+03	1.6103E+03	2.4938E+03
5	1.3322E+02	2.4226E+00	2.4611E+04	1.0850E+02	2.2734E-04	5.3393E+02	2.4859E+03	1.6099E+03	2.4852E+03

6	1.3315E+02	2.4186E+00	2.3058E+04	1.0538E+02	2.4265E-04	5.3229E+02	2.4524E+03	1.6094E+03	2.4517E+03
7	1.3309E+02	2.4149E+00	2.1560E+04	1.0227E+02	2.5950E-04	5.3073E+02	2.4211E+03	1.6088E+03	2.4203E+03
8	1.3304E+02	2.4114E+00	2.0119E+04	9.9169E+01	2.7809E-04	5.3024E+02	2.4122E+03	1.6084E+03	2.4113E+03
9	1.3299E+02	2.4080E+00	1.8731E+04	9.6077E+01	2.9868E-04	5.2974E+02	2.4027E+03	1.6081E+03	2.4018E+03
10	1.3294E+02	2.4045E+00	1.7397E+04	9.2995E+01	3.2157E-04	5.2821E+02	2.3730E+03	1.6077E+03	2.3720E+03
11	1.3289E+02	2.4020E+00	1.6119E+04	8.9934E+01	3.4707E-04	5.2769E+02	2.3635E+03	1.6073E+03	2.3624E+03
12	1.3285E+02	2.3992E+00	1.4894E+04	8.6890E+01	3.7560E-04	5.2716E+02	2.3536E+03	1.6071E+03	2.3525E+03
13	1.3280E+02	2.3967E+00	1.3723E+04	8.3867E+01	4.0765E-04	5.2563E+02	2.3249E+03	1.6066E+03	2.3236E+03
14	1.3277E+02	2.3943E+00	1.2606E+04	8.0879E+01	4.4376E-04	5.2507E+02	2.3149E+03	1.6063E+03	2.3135E+03
15	1.3273E+02	2.3920E+00	1.1542E+04	7.7922E+01	4.8465E-04	5.2449E+02	2.3044E+03	1.6061E+03	2.3029E+03
16	1.3270E+02	2.3899E+00	1.0531E+04	7.5006E+01	5.3115E-04	5.2389E+02	2.2938E+03	1.6058E+03	2.2921E+03
17	1.3266E+02	2.3880E+00	9.5725E+03	7.2134E+01	5.8429E-04	5.2328E+02	2.2830E+03	1.6056E+03	2.2811E+03
18	1.3263E+02	2.3862E+00	8.6672E+03	6.9329E+01	6.4528E-04	5.2173E+02	2.2550E+03	1.6052E+03	2.2529E+03
19	1.3260E+02	2.3845E+00	7.8153E+03	6.6598E+01	7.1556E-04	5.2116E+02	2.2443E+03	1.6049E+03	2.2419E+03
20	1.3258E+02	2.3829E+00	7.0158E+03	6.3954E+01	7.9705E-04	5.2046E+02	2.2333E+03	1.6046E+03	2.2306E+03
21	1.3255E+02	2.3815E+00	6.2688E+03	6.1418E+01	8.9196E-04	5.1981E+02	2.2224E+03	1.6044E+03	2.2193E+03
22	1.3253E+02	2.3801E+00	5.5737E+03	5.9018E+01	1.0031E-03	5.1917E+02	2.2117E+03	1.6042E+03	2.2082E+03
23	1.3251E+02	2.3789E+00	4.9309E+03	5.6789E+01	1.1337E-03	5.1856E+02	2.2015E+03	1.6040E+03	2.1974E+03
24	1.3248E+02	2.3777E+00	4.3402E+03	5.4782E+01	1.2878E-03	5.1754E+02	2.1919E+03	1.6037E+03	2.1872E+03
25	1.3246E+02	2.3767E+00	3.8013E+03	5.3066E+01	1.4701E-03	5.1735E+02	2.1834E+03	1.6035E+03	2.1780E+03
26	1.3244E+02	2.3756E+00	3.3142E+03	5.1745E+01	1.6857E-03	5.1656E+02	2.1768E+03	1.6033E+03	2.1704E+03
27	1.3242E+02	2.3747E+00	2.8790E+03	5.0981E+01	1.9401E-03	5.1665E+02	2.1729E+03	1.6032E+03	2.1655E+03
28	1.3240E+02	2.3737E+00	2.4951E+03	5.1022E+01	2.2379E-03	5.1656E+02	2.1727E+03	1.6031E+03	2.1642E+03
29	1.3237E+02	2.3727E+00	2.1627E+03	5.2314E+01	2.5810E-03	5.1684E+02	2.1793E+03	1.6031E+03	2.1696E+03
30	1.3235E+02	2.3718E+00	1.8814E+03	5.5688E+01	2.9657E-03	5.1775E+02	2.1960E+03	1.6032E+03	2.1852E+03
	1.3232E+02	2.3706E+00	1.6513E+03						

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	RENOS	HEAT FLUX	SF	GFLOW	T81	T82	HEFF	T8NPR	CUM DELP
1	5.4590E+03	1.9501E+04	1.1156E-01	3.0245E+03	6.6100E+01	1.1719E+02	1.2361E+07	1.5184E+01	5.4102E-01
2	5.3079E+03	1.9413E+04	1.1183E-01	2.9404E+03	6.6100E+01	1.1699E+02	1.1660E+07	1.4731E+01	6.6977E-01
3	5.1584E+03	1.9358E+04	1.1212E-01	2.8573E+03	6.6100E+01	1.1686E+02	1.0797E+07	1.4278E+01	7.9187E-01
4	5.0100E+03	1.9310E+04	1.1242E-01	2.7748E+03	6.6100E+01	1.1674E+02	9.9945E+06	1.3824E+01	9.0752E-01
5	4.8627E+03	1.9289E+04	1.1273E-01	2.6930E+03	6.6100E+01	1.1666E+02	9.1500E+06	1.3371E+01	1.0169E+00
6	4.7161E+03	1.9239E+04	1.1307E-01	2.6116E+03	6.6100E+01	1.1655E+02	8.5214E+06	1.2917E+01	1.1203E+00
7	4.5707E+03	1.9156E+04	1.1342E-01	2.5305E+03	6.6100E+01	1.1644E+02	7.7969E+06	1.2464E+01	1.2178E+00
8	4.4266E+03	1.9176E+04	1.1379E-01	2.4505E+03	6.6100E+01	1.1636E+02	7.0828E+06	1.2010E+01	1.3097E+00
9	4.2834E+03	1.9153E+04	1.1418E-01	2.3714E+03	6.6100E+01	1.1630E+02	6.4684E+06	1.1557E+01	1.3961E+00
10	4.1412E+03	1.9105E+04	1.1460E-01	2.2925E+03	6.6100E+01	1.1621E+02	5.8727E+06	1.1103E+01	1.4773E+00
11	4.0007E+03	1.9091E+04	1.1505E-01	2.2146E+03	6.6100E+01	1.1614E+02	5.2887E+06	1.0650E+01	1.5534E+00
12	3.8613E+03	1.9069E+04	1.1552E-01	2.1373E+03	6.6100E+01	1.1608E+02	4.7884E+06	1.0197E+01	1.6247E+00
13	3.7235E+03	1.9028E+04	1.1602E-01	2.0609E+03	6.6100E+01	1.1600E+02	4.3314E+06	9.7431E+00	1.6913E+00
14	3.5877E+03	1.9011E+04	1.1655E-01	1.9857E+03	6.6100E+01	1.1593E+02	3.8859E+06	9.2897E+00	1.7535E+00
15	3.4537E+03	1.8991E+04	1.1711E-01	1.9114E+03	6.6100E+01	1.1588E+02	3.4712E+06	8.8362E+00	1.8115E+00
16	3.3218E+03	1.8971E+04	1.1771E-01	1.8384E+03	6.6100E+01	1.1583E+02	3.0604E+06	8.3828E+00	1.8654E+00
17	3.1925E+03	1.8951E+04	1.1835E-01	1.7668E+03	6.6100E+01	1.1578E+02	2.7038E+06	7.9293E+00	1.9155E+00
18	3.0661E+03	1.8912E+04	1.1902E-01	1.6969E+03	6.6100E+01	1.1570E+02	2.3799E+06	7.4759E+00	1.9620E+00
19	2.9435E+03	1.8897E+04	1.1973E-01	1.6290E+03	6.6100E+01	1.1564E+02	2.0961E+06	7.0225E+00	2.0052E+00
20	2.8250E+03	1.8879E+04	1.2047E-01	1.5634E+03	6.6100E+01	1.1559E+02	1.8260E+06	6.5690E+00	2.0452E+00
21	2.7116E+03	1.8861E+04	1.2124E-01	1.5006E+03	6.6100E+01	1.1554E+02	1.5691E+06	6.1156E+00	2.0823E+00
22	2.6043E+03	1.8843E+04	1.2203E-01	1.4413E+03	6.6100E+01	1.1550E+02	1.3732E+06	5.6621E+00	2.1168E+00
23	2.5047E+03	1.8826E+04	1.2283E-01	1.3862E+03	6.6100E+01	1.1545E+02	1.1809E+06	5.2087E+00	2.1490E+00
24	2.4151E+03	1.8809E+04	1.2360E-01	1.3367E+03	6.6100E+01	1.1541E+02	1.0118E+06	4.7553E+00	2.1790E+00
25	2.3385E+03	1.8794E+04	1.2430E-01	1.2944E+03	6.6100E+01	1.1537E+02	8.6666E+05	4.3018E+00	2.2074E+00
26	2.2794E+03	1.8772E+04	1.2488E-01	1.2618E+03	6.6100E+01	1.1535E+02	7.4230E+05	3.8484E+00	2.2345E+00
27	2.2449E+03	1.8769E+04	1.2523E-01	1.2428E+03	6.6100E+01	1.1533E+02	6.3734E+05	3.3950E+00	2.2608E+00
28	2.2459E+03	1.8760E+04	1.2522E-01	1.2435E+03	6.6100E+01	1.1532E+02	5.5249E+05	2.9415E+00	2.2872E+00
29	2.3019E+03	1.8764E+04	1.2469E-01	1.2747E+03	6.6100E+01	1.1527E+02	4.8738E+05	2.4881E+00	2.3149E+00
30	2.4494E+03	1.8773E+04	1.2328E-01	1.3566E+03	6.6100E+01	1.1525E+02	4.4418E+05	2.0346E+00	2.3458E+00

1 PORCCN REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82 J = 5

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	STSAT	PMIX	WS	VEL	RC	UN	SHNF	SHI	1/ROUT
1	1.3250E+02	2.4407E+00	3.1249E+04	1.1976E+02	1.7824E-04	5.2557E+02	2.3240E+03	1.6092E+03	2.3236E+03
2	1.3342E+02	2.4356E+00	2.9488E+04	1.1739E+02	1.8888E-04	5.2566E+02	2.3176E+03	1.6088E+03	2.3171E+03
3	1.3335E+02	2.4312E+00	2.7784E+04	1.1432E+02	2.0047E-04	5.2515E+02	2.3098E+03	1.6085E+03	2.3093E+03
4	1.3328E+02	2.4268E+00	2.6134E+04	1.1124E+02	2.1312E-04	5.2472E+02	2.3022E+03	1.6082E+03	2.3016E+03
5	1.3322E+02	2.4227E+00	2.4539E+04	1.0817E+02	2.2697E-04	5.2426E+02	2.2945E+03	1.6078E+03	2.2939E+03
6	1.3316E+02	2.4188E+00	2.2998E+04	1.0510E+02	2.4217E-04	5.2386E+02	2.2864E+03	1.6076E+03	2.2858E+03
7	1.3310E+02	2.4151E+00	2.1512E+04	1.0203E+02	2.5889E-04	5.2332E+02	2.2784E+03	1.6072E+03	2.2777E+03
8	1.3304E+02	2.4115E+00	2.0080E+04	9.8970E+01	2.7735E-04	5.2281E+02	2.2697E+03	1.6068E+03	2.2690E+03
9	1.3299E+02	2.4082E+00	1.8701E+04	9.5916E+01	2.9780E-04	5.2233E+02	2.2612E+03	1.6066E+03	2.2604E+03
10	1.3294E+02	2.4051E+00	1.7377E+04	9.2876E+01	3.2049E-04	5.2181E+02	2.2526E+03	1.6063E+03	2.2517E+03
11	1.3289E+02	2.4022E+00	1.6105E+04	8.9849E+01	3.4578E-04	5.2128E+02	2.2435E+03	1.6060E+03	2.2425E+03
12	1.3285E+02	2.3995E+00	1.4887E+04	8.6842E+01	3.7406E-04	5.2137E+02	2.2457E+03	1.6058E+03	2.2446E+03
13	1.3281E+02	2.3969E+00	1.3722E+04	8.3853E+01	4.0582E-04	5.2086E+02	2.2366E+03	1.6057E+03	2.2355E+03

14	1.3277E+02	2.3945E+00	1.2610E+04	8.0896E+01	4.4159E-04	5.2028E+02	2.2271E+03	1.6053E+03	2.2258E+03
15	1.3273E+02	2.3922E+00	1.1550E+04	7.7972E+01	4.8208E-04	5.1969E+02	2.2171E+03	1.6050E+03	2.2157E+03
16	1.3270E+02	2.3902E+00	1.0543E+04	7.5089E+01	5.2809E-04	5.1909E+02	2.2070E+03	1.6048E+03	2.2054E+03
17	1.3267E+02	2.3882E+00	9.5893E+03	7.2258E+01	5.8060E-04	5.1913E+02	2.2082E+03	1.6047E+03	2.2064E+03
18	1.3264E+02	2.3864E+00	8.6872E+03	6.9483E+01	6.4085E-04	5.1856E+02	2.1986E+03	1.6044E+03	2.1966E+03
19	1.3261E+02	2.3847E+00	7.8376E+03	6.6782E+01	7.1027E-04	5.1793E+02	2.1882E+03	1.6042E+03	2.1859E+03
20	1.3258E+02	2.3831E+00	7.0403E+03	6.4172E+01	7.9064E-04	5.1729E+02	2.1777E+03	1.6040E+03	2.1751E+03
21	1.3256E+02	2.3817E+00	6.2952E+03	6.1674E+01	8.8414E-04	5.1664E+02	2.1672E+03	1.6037E+03	2.1643E+03
22	1.3253E+02	2.3803E+00	5.6023E+03	5.9316E+01	9.9335E-04	5.1670E+02	2.1688E+03	1.6036E+03	2.1654E+03
23	1.3251E+02	2.3791E+00	4.9609E+03	5.7130E+01	1.1217E-03	5.1613E+02	2.1599E+03	1.6034E+03	2.1560E+03
24	1.3249E+02	2.3779E+00	4.3714E+03	5.5172E+01	1.2728E-03	5.1555E+02	2.1508E+03	1.6032E+03	2.1463E+03
25	1.3247E+02	2.3768E+00	3.8337E+03	5.3514E+01	1.4510E-03	5.1502E+02	2.1429E+03	1.6030E+03	2.1377E+03
26	1.3244E+02	2.3758E+00	3.3476E+03	5.2263E+01	1.6613E-03	5.1534E+02	2.1495E+03	1.6030E+03	2.1434E+03
27	1.3242E+02	2.3748E+00	2.9127E+03	5.1574E+01	1.9089E-03	5.1511E+02	2.1466E+03	1.6029E+03	2.1396E+03
28	1.3240E+02	2.3738E+00	2.5293E+03	5.1718E+01	2.1976E-03	5.1506E+02	2.1469E+03	1.6028E+03	2.1388E+03
29	1.3238E+02	2.3728E+00	2.1973E+03	5.3148E+01	2.5289E-03	5.1623E+02	2.1683E+03	1.6029E+03	2.1590E+03
30	1.3235E+02	2.3718E+00	1.9162E+03	5.6713E+01	2.8988E-03	5.1898E+02	2.2172E+03	1.6035E+03	2.2066E+03
	1.3232E+02	2.3706E+00	1.6858E+03						

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	RENOS	HEAT FLUX	SE	GELOW	TB1	TB2	HEEE	TBAPP	CUM DELP
1	5.4340E+03	1.9242E+04	1.1161E-01	3.0107E+03	6.6100E+01	1.1651E+02	1.2807E+07	1.5164E+01	5.3983E-01
2	5.2864E+03	1.9207E+04	1.1187E-01	2.9285E+03	6.6100E+01	1.1645E+02	1.1900E+07	1.4731E+01	6.6757E-01
3	5.1396E+03	1.9180E+04	1.1216E-01	2.8469E+03	6.6100E+01	1.1637E+02	1.0904E+07	1.4278E+01	7.8883E-01
4	4.9935E+03	1.9145E+04	1.1245E-01	2.7657E+03	6.6100E+01	1.1632E+02	9.9697E+06	1.3824E+01	9.0378E-01
5	4.8484E+03	1.9127E+04	1.1277E-01	2.6851E+03	6.6100E+01	1.1623E+02	9.2197E+06	1.3371E+01	1.0126E+00
6	4.7039E+03	1.9092E+04	1.1310E-01	2.6048E+03	6.6100E+01	1.1619E+02	8.4825E+06	1.2917E+01	1.1154E+00
7	4.5605E+03	1.9076E+04	1.1344E-01	2.5252E+03	6.6100E+01	1.1610E+02	7.7423E+06	1.2464E+01	1.2125E+00
8	4.4180E+03	1.9052E+04	1.1381E-01	2.4461E+03	6.6100E+01	1.1604E+02	7.1603E+06	1.2010E+01	1.3041E+00
9	4.2765E+03	1.9020E+04	1.1420E-01	2.3676E+03	6.6100E+01	1.1600E+02	6.4769E+06	1.1557E+01	1.3902E+00
10	4.1363E+03	1.9005E+04	1.1462E-01	2.2898E+03	6.6100E+01	1.1592E+02	5.9153E+06	1.1103E+01	1.4712E+00
11	3.9972E+03	1.8993E+04	1.1506E-01	2.2127E+03	6.6100E+01	1.1586E+02	5.3753E+06	1.0650F+01	1.5472E+00
12	3.8595E+03	1.8974E+04	1.1552E-01	2.1364E+03	6.6100E+01	1.1583E+02	4.8154E+06	1.0197E+01	1.6184E+00
13	3.7232E+03	1.8943E+04	1.1602E-01	2.0608E+03	6.6100E+01	1.1580E+02	4.3346E+06	9.7431E+00	1.6850E+00
14	3.5887E+03	1.8930E+04	1.1654E-01	1.9863E+03	6.6100E+01	1.1572E+02	3.9108E+06	9.2897E+00	1.7472E+00
15	3.4561E+03	1.8910E+04	1.1710E-01	1.9129E+03	6.6100E+01	1.1567E+02	3.4751E+06	8.8362E+00	1.8052E+00
16	3.3258E+03	1.8890E+04	1.1769E-01	1.8406E+03	6.6100E+01	1.1562E+02	3.1037E+06	8.3828E+00	1.8592E+00
17	3.1981E+03	1.8892E+04	1.1832E-01	1.7699E+03	6.6100E+01	1.1559E+02	2.7346E+06	7.9293E+00	1.9095E+00
18	3.0732E+03	1.8863E+04	1.1898E-01	1.7008E+03	6.6100E+01	1.1555E+02	2.4214E+06	7.4759E+00	1.9562E+00
19	2.9519E+03	1.8844E+04	1.1968E-01	1.6336E+03	6.6100E+01	1.1550E+02	2.1176E+06	7.0225E+00	1.9996E+00
20	2.8349E+03	1.8826E+04	1.2041E-01	1.5689E+03	6.6100E+01	1.1545E+02	1.8564E+06	6.5690E+00	2.0399E+00
21	2.7230E+03	1.8807E+04	1.2116E-01	1.5070E+03	6.6100E+01	1.1540E+02	1.6072E+06	6.1156E+00	2.0773E+00
22	2.6176E+03	1.8802E+04	1.2193E-01	1.4487E+03	6.6100E+01	1.1534E+02	1.3937E+06	5.6621E+00	2.1121E+00
23	2.5199E+03	1.8785E+04	1.2270E-01	1.3947E+03	6.6100E+01	1.1535E+02	1.1950E+06	5.2087E+00	2.1446E+00
24	2.4325E+03	1.8765E+04	1.2345E-01	1.3463E+03	6.6100E+01	1.1530E+02	1.0258E+06	4.7553E+00	2.1750E+00
25	2.3584E+03	1.8754E+04	1.2412E-01	1.3054E+03	6.6100E+01	1.1524E+02	8.8314E+05	4.3018E+00	2.2039E+00
26	2.3024E+03	1.8759E+04	1.2465E-01	1.2745E+03	6.6100E+01	1.1525E+02	7.5756E+05	3.8484E+00	2.2314E+00
27	2.2712E+03	1.8745E+04	1.2496E-01	1.2573E+03	6.6100E+01	1.1523E+02	6.5347E+05	3.3950F+00	2.2584E+00
28	2.2766E+03	1.8737E+04	1.2490E-01	1.2605E+03	6.6100E+01	1.1521E+02	5.6861E+05	2.9415E+00	2.2854E+00
29	2.3387E+03	1.8756E+04	1.2429E-01	1.2950E+03	6.6100E+01	1.1524E+02	5.0384E+05	2.4881E+00	2.3138E+00
30	2.4445E+03	1.8792E+04	1.2289E-01	1.3815E+03	6.6100E+01	1.1535E+02	4.6023E+05	2.0346E+00	2.3458E+00

1 MORCON REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82 J = 6

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	STSAT	PMIX	WS	VEL	RC	UN	SHWF	SHI	1/ROUT
1	1.3350E+02	2.4407E+00	3.1141E+04	1.1937E+02	1.7824E-04	5.2113E+02	2.2347E+03	1.6062E+03	2.2343E+03
2	1.3342E+02	2.4359E+00	2.9389E+04	1.1699E+02	1.8886E-04	5.2069E+02	2.2276E+03	1.6078E+03	2.2272E+03
3	1.3335E+02	2.4313E+00	2.7692E+04	1.1394E+02	2.0044E-04	5.2059E+02	2.2283E+03	1.6075E+03	2.2279E+03
4	1.3328E+02	2.4269E+00	2.6048E+04	1.1088E+02	2.1308E-04	5.2027E+02	2.2213E+03	1.6073E+03	2.2209E+03
5	1.3322E+02	2.4228E+00	2.4460E+04	1.0782E+02	2.2692E-04	5.2029E+02	2.2222E+03	1.6070E+03	2.2217E+03
6	1.3316E+02	2.4189E+00	2.2925E+04	1.0476E+02	2.4210E-04	5.1982E+02	2.2148E+03	1.6066E+03	2.2142E+03
7	1.3310E+02	2.4152E+00	2.1444E+04	1.0170E+02	2.5882E-04	5.1979E+02	2.2147E+03	1.6064E+03	2.2141E+03
8	1.3304E+02	2.4117E+00	2.0016E+04	9.8648E+01	2.7728E-04	5.1933E+02	2.2072E+03	1.6061E+03	2.2066E+03
9	1.3299E+02	2.4084E+00	1.8641E+04	9.5602E+01	2.9772E-04	5.1931E+02	2.2074E+03	1.6059E+03	2.2066E+03
10	1.3294E+02	2.4054E+00	1.7320E+04	9.2565E+01	3.2043E-04	5.1884E+02	2.1995E+03	1.6057E+03	2.1987E+03
11	1.3290E+02	2.4025E+00	1.6052E+04	8.9546E+01	3.4572E-04	5.1831E+02	2.1909E+03	1.6053E+03	2.1900E+03
12	1.3285E+02	2.3997E+00	1.4838E+04	8.6543E+01	3.7402E-04	5.1826E+02	2.1905E+03	1.6052E+03	2.1895E+03
13	1.3281E+02	2.3972E+00	1.3675E+04	8.3561E+01	4.0579E-04	5.1773E+02	2.1818E+03	1.6049E+03	2.1807E+03
14	1.3277E+02	2.3948E+00	1.2566E+04	8.0607E+01	4.4160E-04	5.1768E+02	2.1814E+03	1.6048E+03	2.1802E+03
15	1.3274E+02	2.3926E+00	1.1509E+04	7.7684E+01	4.8215E-04	5.1712E+02	2.1723E+03	1.6045E+03	2.1709E+03
16	1.3270E+02	2.3905E+00	1.0504E+04	7.4803E+01	5.2823E-04	5.1708E+02	2.1720E+03	1.6044E+03	2.1704E+03
17	1.3267E+02	2.3885E+00	9.5520E+03	7.1968E+01	5.8086E-04	5.1645E+02	2.1624E+03	1.6041E+03	2.1607E+03
18	1.3264E+02	2.3867E+00	8.6521E+03	6.9192E+01	6.4124E-04	5.1644E+02	2.1621E+03	1.6040E+03	2.1601E+03
19	1.3261E+02	2.3851E+00	7.8040E+03	6.6487E+01	7.1087E-04	5.1583E+02	2.1523E+03	1.6038E+03	2.1501E+03
20	1.3259E+02	2.3835E+00	7.0082E+03	6.3870E+01	7.9153E-04	5.1643E+02	2.1635E+03	1.6037E+03	2.1608E+03
21	1.3256E+02	2.3821E+00	6.2632E+03	6.1351E+01	8.8560E-04	5.1652E+02	2.1652E+03	1.6037E+03	2.1622E+03

22	1.3254E+02	2.3807E+00	5.5702E+03	5.8967E+01	9.9567E-04	5.1662E+02	2.1676E+03	1.6036E+03	2.1643E+03
23	1.3252E+02	2.3795E+00	4.9286E+03	5.6749E+01	1.1251E-03	5.1677E+02	2.1710E+03	1.6035E+03	2.1670E+03
24	1.3249E+02	2.3783E+00	4.3385E+03	5.4748E+01	1.2780E-03	5.1622E+02	2.1621E+03	1.6034E+03	2.1575E+03
25	1.3247E+02	2.3772E+00	3.8005E+03	5.3042E+01	1.4586E-03	5.1648E+02	2.1676E+03	1.6034E+03	2.1622E+03
26	1.3245E+02	2.3762E+00	3.3137E+03	5.1725E+01	1.6725E-03	5.1685E+02	2.1760E+03	1.6033E+03	2.1697E+03
27	1.3243E+02	2.3752E+00	2.8781E+03	5.0952E+01	1.9252E-03	5.1664E+02	2.1727E+03	1.6032E+03	2.1654E+03
28	1.3241E+02	2.3743E+00	2.4940E+03	5.0588E+01	2.2210E-03	5.1745E+02	2.1887E+03	1.6033E+03	2.1801E+03
29	1.3238E+02	2.3733E+00	2.1612E+03	5.2269E+01	2.5622E-03	5.1878E+02	2.2128E+03	1.6035E+03	2.2028E+03
30	1.3236E+02	2.3723E+00	1.8793E+03	5.5612E+01	2.9453E-03	5.1966E+02	2.2296E+03	1.6036E+03	2.2185E+03
	1.3233E+02	2.3712E+00	1.6486E+03						

1	RENOS	HEAT FLUX	SF	GFLOW	TB1	TB2	HEFF	TBNPR	CUM DELP
1	5.4153E+03	1.9150E+04	1.1164E-01	3.0003E+03	6.6100E+01	1.1631E+02	1.2544E+07	1.5184E+01	5.3696E-01
2	5.2686E+03	1.9125E+04	1.1191E-01	2.9187E+03	6.6100E+01	1.1623E+02	1.1741E+07	1.4731E+01	6.6589E-01
3	5.1226E+03	1.9104E+04	1.1219E-01	2.8375E+03	6.6100E+01	1.1617E+02	1.0947E+07	1.4278E+01	7.8638E-01
4	4.9772E+03	1.9069E+04	1.1249E-01	2.7567E+03	6.6100E+01	1.1612E+02	9.9985E+06	1.3824E+01	9.0057E-01
5	4.8327E+03	1.9052E+04	1.1280E-01	2.6764E+03	6.6100E+01	1.1607E+02	9.2077E+06	1.3371E+01	1.0087E+00
6	4.6890E+03	1.9034E+04	1.1313E-01	2.5966E+03	6.6100E+01	1.1595E+02	8.5334E+06	1.2917E+01	1.1105E+00
7	4.5460E+03	1.9016E+04	1.1348E-01	2.5172E+03	6.6100E+01	1.1595E+02	7.7723E+06	1.2464E+01	1.2074E+00
8	4.4039E+03	1.8994E+04	1.1385E-01	2.4383E+03	6.6100E+01	1.1588E+02	7.1356E+06	1.2010E+01	1.2984E+00
9	4.2628E+03	1.8978E+04	1.1424E-01	2.3600E+03	6.6100E+01	1.1584E+02	6.4681E+06	1.1557E+01	1.3840E+00
10	4.1227E+03	1.8947E+04	1.1466E-01	2.2822E+03	6.6100E+01	1.1591E+02	5.8855E+06	1.1103E+01	1.4645E+00
11	3.9841E+03	1.8933E+04	1.1510E-01	2.2054E+03	6.6100E+01	1.1573E+02	5.3677E+06	1.0650E+01	1.5400E+00
12	3.8466E+03	1.8919E+04	1.1557E-01	2.1292E+03	6.6100E+01	1.1570E+02	4.8521E+06	1.0197E+01	1.6108E+00
13	3.7106E+03	1.8899E+04	1.1606E-01	2.0538E+03	6.6100E+01	1.1564E+02	4.3344E+06	9.7431E+00	1.6769E+00
14	3.5763E+03	1.8886E+04	1.1659E-01	1.9794E+03	6.6100E+01	1.1561E+02	3.9070E+06	9.2897E+00	1.7387E+00
15	3.4438E+03	1.8867E+04	1.1715E-01	1.9060E+03	6.6100E+01	1.1556E+02	3.4690E+06	8.8362E+00	1.7964E+00
16	3.3135E+03	1.8856E+04	1.1775E-01	1.8338E+03	6.6100E+01	1.1553E+02	3.0954E+06	8.3828E+00	1.8500E+00
17	3.1856E+03	1.8838E+04	1.1838E-01	1.7630E+03	6.6100E+01	1.1548E+02	2.7448E+06	7.9293E+00	1.8999E+00
18	3.0607E+03	1.8827E+04	1.1905E-01	1.6939E+03	6.6100E+01	1.1546E+02	2.4162E+06	7.4759E+00	1.9463E+00
19	2.9392E+03	1.8810E+04	1.1975E-01	1.6266E+03	6.6100E+01	1.1541E+02	2.1151E+06	7.0225E+00	1.9893E+00
20	2.8219E+03	1.8824E+04	1.2049E-01	1.5617E+03	6.6100E+01	1.1539E+02	1.8431E+06	6.5690E+00	2.0293E+00
21	2.7092E+03	1.8809E+04	1.2126E-01	1.4993E+03	6.6100E+01	1.1540E+02	1.6033E+06	6.1156E+00	2.0663E+00
22	2.6022E+03	1.8806E+04	1.2205E-01	1.4404E+03	6.6100E+01	1.1538E+02	1.3848E+06	5.6621E+00	2.1008E+00
23	2.5035E+03	1.8805E+04	1.2284E-01	1.3856E+03	6.6100E+01	1.1536E+02	1.1900E+06	5.2087E+00	2.1329E+00
24	2.4142E+03	1.8779E+04	1.2361E-01	1.3362E+03	6.6100E+01	1.1535E+02	1.0228E+06	4.7553E+00	2.1625E+00
25	2.3380E+03	1.8782E+04	1.2431E-01	1.2941E+03	6.6100E+01	1.1533E+02	8.7341E+05	4.3018E+00	2.1912E+00
26	2.2791E+03	1.8791E+04	1.2488E-01	1.2616E+03	6.6100E+01	1.1531E+02	7.4558E+05	3.8484E+00	2.2183E+00
27	2.2441E+03	1.8776E+04	1.2524E-01	1.2424E+03	6.6100E+01	1.1530E+02	6.4220E+05	3.3950E+00	2.2447E+00
28	2.2449E+03	1.8785E+04	1.2523E-01	1.2429E+03	6.6100E+01	1.1532E+02	5.5629E+05	2.9415E+00	2.2710E+00
29	2.3002E+03	1.8802E+04	1.2466E-01	1.2738E+03	6.6100E+01	1.1536E+02	4.9071E+05	2.4881E+00	2.2986E+00
30	2.4466E+03	1.8808E+04	1.2330E-01	1.3550E+03	6.6100E+01	1.1538E+02	4.4646E+05	2.0346E+00	2.3295E+00

1 MORCCA REPORT, BASELINE CASE, SMOOTH TUBE, 8/05/82 COOLER SECTION

0	STSATC	FMIXC	WSC	VELC	RCC	UNC	SHNFC	SHIC	1/RCUTC
1	1.3196E+02	2.3475E+00	9.7539E+03	1.4784E+02	3.4431E-03	5.3852E+02	2.6097E+03	1.6061E+03	2.6002E+03
2	1.3184E+02	2.3410E+00	9.2951E+03	1.4130E+02	3.6125E-03	5.3785E+02	2.5956E+03	1.6057E+03	2.5859E+03
3	1.3173E+02	2.3346E+00	8.8377E+03	1.3470E+02	3.7987E-03	5.3840E+02	2.6111E+03	1.6053E+03	2.6001E+03
4	1.3164E+02	2.3288E+00	8.3805E+03	1.2805E+02	4.0051E-03	5.3766E+02	2.5963E+03	1.6049E+03	2.5844E+03
5	1.3155E+02	2.3236E+00	7.9244E+03	1.2135E+02	4.2347E-03	5.3826E+02	2.6128E+03	1.6045E+03	2.5997E+03
6	1.3146E+02	2.3188E+00	7.4683E+03	1.1460E+02	4.4921E-03	5.3745E+02	2.5960E+03	1.6042E+03	2.5817E+03
7	1.3139E+02	2.3146E+00	7.0135E+03	1.0782E+02	4.7821E-03	5.3813E+02	2.6145E+03	1.6039E+03	2.5985E+03
8	1.3132E+02	2.3108E+00	6.5586E+03	1.0100E+02	5.1120E-03	5.3722E+02	2.5953E+03	1.6036E+03	2.5778E+03
9	1.3126E+02	2.3075E+00	6.1050E+03	9.4166E+01	5.4898E-03	5.3796E+02	2.6161E+03	1.6034E+03	2.5961E+03
10	1.3120E+02	2.3046E+00	5.6511E+03	8.7291E+01	5.9241E-03	5.3682E+02	2.5932E+03	1.6030E+03	2.5709E+03
11	1.3114E+02	2.3021E+00	5.1983E+03	8.0403E+01	6.4411E-03	5.3772E+02	2.6180E+03	1.6030E+03	2.5920E+03
12	1.3109E+02	2.2999E+00	4.7454E+03	7.3489E+01	7.0515E-03	5.3630E+02	2.5903E+03	1.6026E+03	2.5607E+03
13	1.3105E+02	2.2981E+00	4.2935E+03	6.6570E+01	7.7879E-03	5.3720E+02	2.6152E+03	1.6025E+03	2.5836E+03
14	1.3100E+02	2.2966E+00	3.8414E+03	5.9629E+01	8.6964E-03	5.3548E+02	2.5854E+03	1.6021E+03	2.5435E+03
15	1.3095E+02	2.2954E+00	3.3906E+03	5.2693E+01	9.8415E-03	5.3650E+02	2.6201E+03	1.6020E+03	2.5670E+03
16	1.3090E+02	2.2944E+00	2.9395E+03	4.5742E+01	1.1335E-02	5.3554E+02	2.5766E+03	1.6014E+03	2.5113E+03
17	1.3084E+02	2.2936E+00	2.4899E+03	3.8805E+01	1.3354E-02	5.3472E+02	2.6193E+03	1.6012E+03	2.5294E+03
18	1.3076E+02	2.2930E+00	2.0402E+03	3.1859E+01	1.6250E-02	5.3034E+02	2.5588E+03	1.6001E+03	2.4376E+03
19	1.3065E+02	2.2926E+00	1.5929E+03	2.4946E+01	2.0718E-02	5.2927E+02	2.6131E+03	1.5994E+03	2.4171E+03
20	1.3046E+02	2.2924E+00	1.1468E+03	1.8046E+01	2.8548E-02	5.1713E+02	2.5166E+03	1.5962E+03	2.1905E+03
21	1.3004E+02	2.2922E+00	7.0711E+02	1.1245E+01	4.5491E-02	1.5910E+02	2.5680E+03	1.5891E+03	1.8014E+03
22	1.2279E+02	2.2921E+00	5.8093E+02	9.1828E+00	5.4830E-02	2.5787E+02	2.5935E+03	1.5614E+03	1.7285E+03
23	1.1603E+02	2.2921E+00	3.9778E+02	6.3152E+00	7.8103E-02	2.7651E+02	3.0109E+03	1.5340E+03	1.5268E+03
24	1.0871E+02	2.2921E+00	2.2439E+02	3.6541E+00	1.3058E-01	2.2951E+02	2.9573E+03	1.4976E+03	1.0140E+03
	9.9362E+01	2.2920E+00	9.4646E+01						

0	RENOSC	HEAT FLUX	SFC	GFLOWC	TB1	TB2	HEFFC	TBNPR	CUM DELP
1	6.4451E+03	1.9005E+04	1.1008E-01	3.5682E+03	6.6100E+01	1.1589E+02	7.2032E+05	4.0121E+00	2.9749E+00
2	6.1436E+03	1.8947E+04	1.1048E-01	3.4010E+03	6.6100E+01	1.1581E+02	6.6856E+05	4.0121E+00	3.1677E+00
3	5.8427E+03	1.8936E+04	1.1092E-01	3.2342E+03	6.6100E+01	1.1572E+02	6.1713E+05	4.0121E+00	3.3441E+00

4	5.5419E+03	1.8893E+04	1.1140E-01	3.0676E+03	6.6100E+01	1.1563E+02	5.6654E+05	4.0121E+00	3.5046E+00
5	5.2416E+03	1.8868E+04	1.1194E-01	2.9012E+03	6.6100E+01	1.1558E+02	5.1805E+05	4.0121E+00	3.6499E+00
6	4.9412E+03	1.8836E+04	1.1254E-01	2.7350E+03	6.6100E+01	1.1552E+02	4.7157E+05	4.0121E+00	3.7809E+00
7	4.6415E+03	1.8838E+04	1.1322E-01	2.5692E+03	6.6100E+01	1.1544E+02	4.2559E+05	4.0121E+00	3.8981E+00
8	4.3416E+03	1.8785E+04	1.1399E-01	2.4033E+03	6.6100E+01	1.1539E+02	3.8217E+05	4.0121E+00	4.0022E+00
9	4.0424E+03	1.8794E+04	1.1488E-01	2.2380E+03	6.6100E+01	1.1534E+02	3.3956E+05	4.0121E+00	4.0942E+00
10	3.7431E+03	1.8751E+04	1.1590E-01	2.0725E+03	6.6100E+01	1.1526E+02	2.9952E+05	4.0121E+00	4.1746E+00
11	3.4443E+03	1.8755E+04	1.1710E-01	1.9074E+03	6.6100E+01	1.1525E+02	2.6071E+05	4.0121E+00	4.2442E+00
12	3.1454E+03	1.8712E+04	1.1853E-01	1.7423E+03	6.6100E+01	1.1517E+02	2.2416E+05	4.0121E+00	4.3039E+00
13	2.8471E+03	1.8720E+04	1.2026E-01	1.5774E+03	6.6100E+01	1.1516E+02	1.8945E+05	4.0121E+00	4.3544E+00
14	2.5486E+03	1.8671E+04	1.2239E-01	1.4128E+03	6.6100E+01	1.1507E+02	1.5706E+05	4.0121E+00	4.3963E+00
15	2.2509E+03	1.8680E+04	1.2507E-01	1.2484E+03	6.6100E+01	1.1506E+02	1.2667E+05	4.0121E+00	4.4306E+00
16	1.9530E+03	1.8616E+04	1.2857E-01	1.0839E+03	6.6100E+01	1.1493E+02	9.8952E+04	4.0121E+00	4.4579E+00
17	1.6561E+03	1.8626E+04	1.3330E-01	9.2004E+02	6.6100E+01	1.1489E+02	7.3669E+04	4.0121E+00	4.4791E+00
18	1.3591E+03	1.8525E+04	1.4008E-01	7.5607E+02	6.6100E+01	1.1466E+02	5.1445E+04	4.0121E+00	4.4949E+00
19	1.0637E+03	1.8482E+04	1.5055E-01	5.9301E+02	6.6100E+01	1.1452E+02	3.2237E+04	4.0121E+00	4.5061E+00
20	7.6902E+02	1.8217E+04	1.6887E-01	4.3035E+02	6.6100E+01	1.1316E+02	1.6906E+04	4.0121E+00	4.5135E+00
21	4.7868E+02	5.3195E+03	2.0649E-01	2.7008E+02	6.6100E+01	1.1242E+02	5.9268E+03	4.0121E+00	4.5179E+00
22	3.9973E+02	7.6896E+03	2.2898E-01	2.2407E+02	6.6100E+01	1.0678E+02	5.1821E+03	4.0121E+00	4.5200E+00
23	2.8019E+02	7.2935E+03	2.8079E-01	1.5730E+02	6.6100E+01	1.0117E+02	3.0975E+03	4.0121E+00	4.5216E+00
24	1.6493E+02	5.2698E+03	3.9738E-01	9.4090E+01	6.6100E+01	9.3726E+01	1.5452E+03	4.0121E+00	4.5226E+00

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