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DEVELOPMENT TESTING

VOLUME III
MODULAR RADIATOR SYSTEM
TEST DATA CORRELATION WITH
THERMAL MODEL

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VOUGHT SYSTEMS DIVISION
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To
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This volume is one of a series of reports describing the development tests conducted on a candidate Shuttle heat rejection system at the National Aeronautics and Space Administration - Johnson Space Center during the period from March to July 1973. The complete test series are reported in the following volumes:

- Volume I: Overall Summary
- Volume II: Modular Radiator System Tests
- Volume III: Modular Radiator System Test Data Correlation With Thermal Model
- Volume IV: Modular Radiator System Test Data
- Volume V: Integrated Radiator/Expendable Cooling System Tests
- Volume VI: Water Ejector Plume Tests
- Volume VII: Improved Radiator Coating Adhesives Tests
- Volume VIII: Tube Anomaly Investigation

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1.0 SUMMARY

This volume presents the results of an analysis which compares the performance predictions of a thermal model of a multi-panel modular radiator system (MRS) with thermal vacuum test data. The correlation of the thermal model is one of the objectives of the MRS test phase of the Shuttle heat rejection system development tests conducted at NASA-JSC from March to July 1973.

Comparisons between measured and predicted individual panel outlet temperatures and pressure drops and system outlet temperatures have been made over the full range of heat loads, environments and plumbing arrangements expected for the Shuttle radiators. Both two sided and one sided radiation have been included. The model predictions show excellent agreement with the test data for the maximum design conditions of high load and hot environment. Predictions under minimum design conditions of low load-cold environments indicate good agreement with the measured data, but evaluation of low load predictions should consider the possibility of parallel flow instabilities due to main system freezing. Performance predictions under intermediate conditions in which the majority of the flow is not in either the main or prime system are adequate although model improvements in this area may be desired. The primary modeling objective of providing an analytical technique for performance predictions of a multi-panel radiator system under the design conditions has been met.
2.0 INTRODUCTION

Accurate predictions of the Space Shuttle radiator system performance is of prime importance in the design and development of this heat rejection system. The proposed location of the radiators attached to and/or deployed from the cargo bay doors introduces many design variables such as radiation from one side only, two-sided radiation or back-to-back panels. The worst case orbit and vehicle attitude must be determined analytically for each of these configurations to optimize the radiator design. The use of flow reversal or flow proportioning valves introduces more variables which must be considered. Due to the size of the radiator system (up to 1440 ft²) it is impractical to determine the optimum radiator system by test. An accurate model is needed to parametrically study all design variables and insure optimum radiator performance.

The uniqueness of the modular panel concept, the valve stagnation method of heat load control and the large size of the radiator system present several modeling criteria not encountered in previous radiator systems. The multi-panel configuration proposed for use on the Shuttle requires that the model predict interaction between the panels; thus, dictating a separate model for each panel. In order to maintain similarity between the models, accurate predictions are required over a wide range of inlet temperatures in addition to the usual environment and flow variations. The downstream panel performance predictions must be as good as the upstream panel predictions and the individual panel errors must not accumulate to compromise the total radiator system performance.

The developmental testing of the Modular Radiator System (MRS) discussed in Volume II, Modular Radiator System Tests, of this report provides approximately 300 hours of thermal vacuum test data for thermal model correlation. The test panels are of a different size (6' x 12') than the anticipated baseline panels (approximately 11' x 15') and the baseline panels will probably have a different number of tubes, tube spacing and fin thickness. However, the modeling techniques developed from the test panel correlation analyses can be used for the baseline system model, thus improving the confidence of baseline system performance predictions.

This volume of the report presents the results of an analysis to correlate the system thermal model with the test data. A description of the
model is given in Section 3.0. Comparisons of pre-test predictions with test data and a discussion of the selection criteria for post test correlation are given in Section 4.0. Sections 5.0 and 6.0 present a discussion of the results and conclusions about the model adequacy.
3.0 MODEL DESCRIPTION

The primary objective of the thermal model is to provide a tool for performance predictions of the radiator system under the design conditions of maximum and minimum heat rejection. The maximum heat rejection capability must be in the most severe environment and the minimum heat rejection must be in the most favorable environment for heat rejection. Predictions of intermediate heat loads and environments are desirable, but are of secondary importance.

Each of the eight modular test panels consists of 12 tubes arranged in a "U" shaped pattern as shown in Figure 1. The innermost tube is designated the prime tube and the other eleven tubes comprise the main system. The heat rejection of the panel is regulated by controlling the flow split through the main system and the prime tube. At high heat loads approximately 99% of the flow is routed to the bank of main tubes and essentially all of the panel heat rejection is from the main system. The minimum panel heat rejection occurs when approximately 99% of the flow is routed to the prime tube. With a low flow and cold environment the main tubes begin to sequentially stagnate (freeze) with the outermost tube flow stoppage occurring first. In the minimum heat rejection condition most of the main system tubes are frozen and nearly all of the panel heat rejection is from the prime system. During the transition from the minimum to maximum heat load the stagnated tubes sequentially thaw from the inside to the outside tube as the heat load demands until all tubes are flowing and the maximum heat rejection is obtained.

The model objectives and system operating characteristics discussed above have been used in the construction of the thermal model. A single tube is used to model the bank of eleven main tubes as depicted in Figure 2. The single tube fluid-to-tube heat transfer and pressure drop characteristics are based on tube number 6 of the main system with a factor of 11 applied so that the total area for heat transfer between the fluid and tube in the model matches the main bank of tubes. Table 1 summarizes the test panel dimensions and the model parameters used. In order to conserve the number of nodes required in the model, only tube nodes are used. A tube node is defined as any node in contact with the fluid. Thus the tube node includes the tube and the radiating fin between each tube. The fluid-to-tube heat transfer computation uses the
tube temperature.

\[ Q = h A_T (T_T - T_F) \]  

(1)

where

- \( Q \) = heat transfer rate BTU/hr
- \( h \) = fluid heat transfer coefficient, BTU/hr-ft\(^2\)-°R
- \( A_T \) = fluid-tube heat transfer area, ft\(^2\)
- \( T_T \) = tube temperature, °R
- \( T_F \) = fluid temperature, °R

However, use of the tube temperature in computing the net radiation heat transfer from the panel requires that the fin effectiveness be considered.

\[ Q = 4 \pi \sigma \varepsilon A T_T^4 - \eta A Q_{ABS} \]  

(2)

where

- \( \varepsilon \) = panel emissivity, dimensionless
- \( \sigma \) = Stephan Boltzmann constant, BTU/hr-ft\(^2\)-°R\(^4\)
- \( \eta \) = fin radiation effectiveness, dimensionless
- \( A \) = area for radiation, ft\(^2\)
- \( Q_{ABS} \) = heat absorbed from the environment, BTU/hr-ft\(^2\)

Therefore, the product \( \eta A \) is input to the model rather than the radiation area. As previously discussed, in some operating conditions one or more of the main tubes can stagnate, thus reducing the fin effectiveness. For the model to predict accurate results under all operating conditions a variable fin effectiveness is required. It is not practical to obtain performance data, by either testing or prediction with a detailed model, which would give the test panel effectiveness variation over a wide range of inlet temperatures, flowrates and environments. A main system \( \eta \) of 0.90 was calculated for the maximum heat load condition with all tubes flowing. This constant value was input to the model in accordance with the primary objective of providing a model for maximum heat load predictions.

For low load conditions the majority of heat rejection is from the prime tube with most of the main tubes stagnated. This condition is modeled
by inputting an ηA product for the entire panel with the majority of the flow in the prime tube. The η calculated for this condition is 0.063.

The resulting model thus consists of two separate models - one for the main system for maximum heat rejection conditions and one for the prime system for minimum heat rejection conditions. There are no thermal connections between the two systems. It is realized that this technique will result in temperature predictions of the main system tube below -211°F (freezing point of R-21). This is due to the constant high main system fin effectiveness in the model, whereas the actual fin effectiveness is reduced as tubes stagnate. The frozen main tube should not have an adverse effect on steady-state low load predictions; however, transient predictions between maximum and minimum heat rejection is not possible since once the main tube stagnates the model will not predict destagnation. Figure 3 shows a typical system model schematic.

In order to correlate the model to the test data it is necessary to predict the flow split among the panels. The panel flows are influenced by the panel supply and return lines, valves and flowmeters as well as the panel characteristics and temperature. During the test the valves were manually adjusted (partially closed) at ambient conditions to give equal flow in each parallel path since there are different numbers of valves, flowmeters, and line lengths in each path. The thermal model included the actual line lengths and estimated full open valve pressure drop characteristics. However the approach used in the correlation analysis was to artificially make the flow distribution match the test values. This was done since the flow distribution was manually adjusted during the test and the modeling of the partially closed test valves is not an objective of this analysis.

During the third week of testing the radiators were allowed to radiate from both sides with a simulated Shuttle cargo bay door on one side (see Figure 4). The test configuration was designed to yield an effective radiation area from the cavity, formed by the panel and simulated door of 0.67 times the panel area. This factor is based on analysis of the Shuttle configuration considering reflection between the curved radiator and door. The thermal model also used this factor. Verification of the model under the test conditions does not verify the model for flight use because the test configuration is based on analysis only.
4.0 CORRELATION ANALYSES

Pretest analyses were conducted for the originally planned 56 test points. This data was used for real time evaluation of the test conditions and results during the test. For most of the test points, deviations from the planned test flow rates, inlet temperatures and environments prevent the use of the pre-test analysis for correlation purposes. Also, as discussed in Volume II, several of the test conditions were altered considerably due to operational difficulties with the environment simulators. Figures 5 thru 14 show a comparison of test results and predictions for several test points for which the test conditions were close to those planned. As indicated, the model predictions agree well with the data with differences attributed to different test conditions. Appendix A presents the complete pre-test predictions, including a definition of the planned conditions. This data is of interest even though many of the test points were never run since it gives MRS performance predictions under typical Shuttle conditions.

The test points used for post test correlation were chosen to give comparisons over a wide range of operating conditions. It is not practical to run the entire test sequence; however proper selection of the test points for correlation will yield a model of known accuracy for any anticipated operating condition. The most important operating condition is at the maximum heat load and maximum design environment. Accurate performance predictions for this condition are required to insure that the radiator system capacity is sufficient to meet the load. A high heat load with a cold environment condition is best to determine model adequacy and highlight possible sources of error. Table 2 lists the test points chosen for correlation and the range of variables covered. As indicated low and high heat loads, low and high environments, skewed environments, various plumbing configurations, and one and two sided radiation conditions are considered in the correlation analyses.

The correlation analysis concentrated on steady state performance predictions. Transient predictions have been made for the two-sided radiation set point change test points to show the effect of transient inlet temperatures and panel flow rates. No correlation was done for the transient environment test points because only steady state environment data is available at this time.
Recovery transients (minimum-maximum) heat load transients were also not correlated since the model does not predict tube freezing.
5.0 RESULTS
5.1 High Load - Hot Environment

Figures 15 through 18 present temperature maps comparing the correlation analysis results and the test data for the four test points with high heat loads and a hot environment. Three different panel flow arrangements were examined with 2, 4 and 8 parallel flow paths. For these test points the majority of the flow is through the main system. Individual panel flows ranged from approximately 230 to 590 lb/hr. A nominal environment of 130 BTU/hr-ft\(^2\) was imposed on all panels during these test points. This is representative of the maximum absorbed heat expected for the Space Shuttle radiators with a solar absorptivity of 0.25 and an emissivity of 0.90.

As shown on the temperature maps, the analysis and test data for the main system temperatures show excellent agreement. The maximum difference is 4.7°F with most of the differences 3.0°F or less. All mixed main system outlet temperatures agree within 2.0°F. The predicted prime system temperatures are consistently lower than the test temperatures. This is attributed to the modeling technique which does not account for the thermal interaction between the prime and main system. The test data indicate that with full main system flow the hot innermost main tube (adjacent of the prime tube) affects the prime tube temperature. The test conditions had the prime inlet lower than the main system inlet resulting the prime system having a temperature rise in the first panels. For example TP-1A has a prime inlet temperature of 91.5°F and the prime outlet of panels 1 and 5 are 105°F and 108°F. The model does not consider the hot main tube adjacent to the prime tube and thus predicts a lower prime temperature. However, due to the low prime flow, the prime temperatures do not influence total system performance as indicated by the mixed prime and main temperatures of Figures 15 through 18. Thus prediction of the prime temperatures under these conditions are not important. This is further illustrated by the heat rejection rates presented in Tables 3 through 6. Individual panel and total system heat rejection computed from the predicted and test data are compared for the four test points of interest. This data indicates that although the predicted prime heat rejection is in considerable error, there is negligible effect on the total panel heat rejection. The panel and system heat rejection data also indicate the good agreement between the analysis and test.
5.2 High Load - Cold Environment

Correlation to the high load - cold environment test results is a good indication of model adequacy since large temperature drops with relatively high flow rates occur under these conditions. The environment does not have a strong effect on panel temperatures and small model errors are amplified. Figures 19 and 20 present the comparative temperature maps for test points 10 and 51. Good correlation is shown for the main system with the exception of panel 1 outlet temperature for test point 10. No explanation is offered for the approximately 9°F difference between the predicted and measured temperature other than a possible measurement error. The reported environment for panel 1 was higher than the other panels suggesting a possible error in the computed environment. However, the results of an environment perturbation analysis shown in Figure 21 indicates that environment errors much greater than 5% would be required to account for the temperature differences.

The prime system temperatures do not show as good agreement as the main system especially for test point 51. The discussion of the prime system predictions given in paragraph 5.1 also applies to this case. Although the prime system flow is high the temperature drop is small and the contribution to total heat rejection is small.

Although the predicted and measured main and prime system outlets of test point 10 are nearly identical, the measured prime and main mixed temperature is 5.7°F below the predicted value. This is attributed to either a measurement error or heat transfer to the system return line which is not considered in the model.

Tables 7 and 8 compare the panel and system heat rejection computed from the analysis and test data. The prime system predicted heat rejection deviates considerably from the test data, especially for test point 51. The main system heat rejection compares favorably and the prime system error is damped out in the total heat rejection. The predicted system heat rejection is within 4% of the test data for test point 51 and within 0.3% for test point 10.

5.3 Low Load - Cold Environment

As discussed in paragraph 3.0, the modeling technique does not allow accurate main system predictions under low load conditions. The correlation analysis under low load conditions was conducted to determine the severity of the low load modeling restrictions and to give an indication of when the low load predictions become unacceptable. The general poor correlation of the main system is reflected in the temperature maps shown in Figures 22 through 24.
for test points 17, 17A and 36. The main system temperatures are consistently predicted lower than the test values. Predictions for test points 17A and 36 show main panel outlets below the freezing point of R-21 (-211°F). This is because the main panel efficiency is input at a constant value to obtain accurate predictions for the high heat load case. The test panel effectiveness is greatly reduced due to low flow in the outer tubes; thus, the test temperatures are above the predicted values. For test point 17A the panels with a predicted outlet below -211°F are in series and the only effect is a high panel pressure drop in addition to the cold temperature predictions. Test point 36 however, has 3 parallel flow paths and the prediction of frozen panels results in a main system flow instability with all main flow routed to one leg.

The predicted prime temperatures are in fair agreement with the test data. The predicted values are generally higher than the test values indicating that the previous agreement that the hot main temperatures caused the prime predictions to be low is valid. Under the low load conditions the main system has less effect on the prime system.

Since the prime system has a small temperature drop, even small differences in predicted and measured temperatures can cause large percentage differences in the heat rejection. This is illustrated by the heat rejection data in Tables 9 through 11. Test point 17A prime system outlet is predicted only 0.4°F higher than the measured temperature but the predicted heat rejection is 11% lower than the test data. However, the heat rejection is only 115 BTU/hr lower than the test. The total system predicted and test heat rejection rates compare favorably for test points 17 and 17A even though the main system predicted heat rejection is high.

5.5 High Load - Skewed Environment

Figures 25 through 31 present temperature maps comparing the predicted and measured data for high load conditions with hot environments on some panels and cold environments on others. This data is also for two sided radiation, except for Figure 30, with a simulated cargo bay door on one side as shown in Figure 4. The predicted temperatures are in fair agreement for all test points in this group. Test points 53-56 and 59 are part of the transient correlation analysis (paragraph 5.5). For these test points the predictions used a temperature control valve to predict the flow split between the prime and main systems. All other analysis used test values for the main and prime systems flow since correlation under known conditions is required. The flow
split predictions are dependent on the temperature predictions and small errors tend to be amplified by different flow rates. The predicted flows are in general agreement with the test values, but errors as large as 117 lb/hr. do occur (Figure 27, test point 55 total main flow). It should be noted that the individual leg measured flow rates do not sum to the total measured flow. The correlation analysis assumed the total flow measurements were more accurate and the leg flow rate measurements were used only to estimate the percentage of the total flow in each leg.

The main temperature predictions correlate adequately with the test data with the best agreement for test points 27 and 49. The prime temperature predictions are low for the reasons previously discussed in addition to the fact that the prime tube is located at the junction of the radiator and cargo bay door simulator and the effective radiation area may be less than the analytically determined factor of 0.67.

Tables 12 through 18 show the heat rejection computed from the predicted and test data. The predicted main system heat rejection agrees closely with the test data. The prime heat rejection is in considerable error. As in previous cases the prime system has a small affect on the total heat rejection and the total predicted and test values show good agreement.

5.4 Low Load - Skewed Environment

During some Shuttle operating conditions, it is possible that some radiator panels could absorb heat while others are rejecting heat. A comparison of predicted and test temperature maps under this condition are shown in Figures 32 and 33. The temperature map for test point 14 (Figure 32) indicates the same general trend for those panels with a low environment as previously discussed, i.e., the main and prime temperature predictions are low. Panels 4 and 2 have a high environment (180 BTU/hr-ft²) and absorb heat. As indicated, the temperature rise across panel 4 (33.5°F predicted vs 32.8°F measured) and panel 2 (26°F predicted vs 25.3°F measured) shows good correlation.

The temperature map for test point 47 (Figure 33) is another illustration of the low load prediction capabilities of the model. The cold environment on panels 5, 7, 8 and 6 results in a predicted main system outlet below -211°F and flow stoppage in this leg. The prime temperature predictions are in good agreement with the measured data for this test point.
Tables 19 and 20 show the comparative heat rejection of the individual panels and systems. The total main heat rejection for test point 14 is in considerable error, but panels 2 and 4 predictions match the test data indicating the model correctly predicts heat absorption. As in previous analyses the prime system heat rejection for both test points have large percentage errors even though the prime temperatures agree.

5.5 Transient Correlation

Transient environment data was not available at the time of this analysis, so the model could not be verified in this area. However, test points 53-56 and 59 examined the radiator response to changes in the outlet temperature control point, which resulted in transient prime and main system flows. Between test points 55 and 56 there was also a transient in the prime inlet temperature (from approximately 162 to 135°F in a 1.5 hour period). The main inlet remained constant during this time. Figures 34 and 35 compare the analysis and test data for these test points. The predicted flow rates and outlet temperatures show good agreement throughout the transient. The outlet temperature transients for these test points are of the same order as expected for the orbital environment variations indicating that the model should provide good predictions with cyclical orbital environments.

5.6 Pressure Drop Correlation

The test systems contained numerous valves to allow the plumbing arrangements to be changed during the test. These valves and unequal supply and return lines resulted in unequal pressure drop characteristics of parallel flow paths. Also, flowmeters in some flow paths increased the flow resistance. During the test each flow system was artifically balanced under ambient conditions by partially closing one or more of the flow control valves. The correlation analysis was also conducted with artifically balanced flows to match the test data; thus the model flow distribution prediction has not been verified. Individual measured panel pressure drops can be compared to predicted values to verify the model. If panel pressure drops can be accurately predicted, the correct flow distribution should follow since pressure drop predictions of flow in adiabatic supply and return lines is straight forward.
A survey of all predicted and measured pressure drops shown on the temperature maps of Figures 15 through 33 indicates good correlation. Table 21 summarizes this data and gives the percentage error for each panel. Panel 1 measured pressure drop was consistently much higher than the other panels and the predicted values. This panel had a different tube restrictor design than the other panels and is not included in the pressure drop correlation analysis. The predicted pressure drops for those points which the model predicts a main system freeze-up are in considerable error as expected. Test points 53-59 pressure drops do not show as good agreement also because of differences in the main flow rates. For all other test points the maximum error is less than 1.0 psi. Panel flow rates ranged from approximately 800 to 6 lb/hr.
6.0 CONCLUSIONS

A thermal model of the Modular Radiator System proposed for use on the Space Shuttle has been developed and verified by comparison to thermal-vacuum test data. The test panel configuration is thermally similar to the anticipated flight hardware configuration, and application of the test panel modeling techniques to the flight panel should provide an accurate model for the radiator system performance evaluation.

The model predictions show excellent agreement with the test data for the high heat load-hot environment conditions; thus indicating that one of the primary objectives of the model (providing good predictions under maximum load design conditions) has been met. The second primary objective of providing good performance predictions under the minimum load design conditions has also been met, although low load correlations were generally not as good as the high load. Careful evaluation of the low load predictions are required to insure that flow instability in parallel flow paths caused by erroneous panel freeze predictions do not cause large errors in system performance. As expected, predictions under conditions in which the majority of the flow is not routed to either the prime or main system are the least accurate, but are considered adequate.

Transient performance predictions have been verified by comparisons to test data in which the flow split between the prime and main systems varied due to changes in the mixed outlet temperature control point. These flow variations are similar to expected orbital variations caused by changing environments.

Comparison of predicted and measured panel pressure drops over a wide range of flows and temperatures indicates accurate model predictions and should insure accurate panel flow rate predictions in any panel plumbing arrangement.

The correlation analyses indicated that improvements in the predictions of intermediate load and/or environment conditions could be made by considering the thermal interface between the prime and main system. The present model is adequate for the stated objectives and revisions for test panel correlation were not considered necessary at this time. As the flight
configuration evolves and performance prediction criteria are more firmly established, consideration should be given to accounting for the prime/main interaction and developing a technique for modeling the variable panel effectiveness if so required.
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### TABLE 3

**HEAT REJECTION**

**TEST POINT a 1A**

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**SYSTEM**

| Predicted | 21.1 | 24126.4 | 24147.5 |
| Test      | 38.4 | 24245.6 | 24284. |
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**HEAT REJECTION**

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**SYSTEM**

| Predicted | 128.3 | 28031.1 | 28159.4 |
| Test      | 53.8  | 29175.4 | 29229.2 |

*Data wasn't available for Panels 3,4,7,8, since flow splits were not measured.*
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**HEAT REJECTION**

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HEAT REJECTION
TEST POINT α 10
BTU/HR

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**SYSTEM**

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| Test           | 1709.7 | 2468.8 | 4178.5 |</p>
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**SYSTEM**

| Predicted | 3157.3    | 44007.0    | 47164.3    |
| Test      | 945.9     | 43911.3    | 44857.2    |
TABLE 13
HEAT REJECTION

TEST POINT \( y = 54 \)

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Test      | 1411.8 | 67791.4 | 69203.2 |
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**HEAT REJECTION**

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**SYSTEM**

Predicted | 3043.7 | 43460.0 | 46503.7|
Test       | 1136.3 | 43366.9 | 44503.2|
### TABLE 16
HEAT REJECTION

TEST POINT 59

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**SYSTEM**

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**HEAT REJECTION**

**TEST POINT \( \pm 49 \)**

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**SYSTEM**

| Predicted Test | 212.2 | 22817.6 | 23029.8 |
|                | 175.3 | 22055.2 | 22230.5 |
# TABLE 18

HEAT REJECTION

TEST POINT **γ 27**

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**SYSTEM**

<p>| Predicted Test | 299.4 | 62128.4 | 62427.8 |
|                | 236.9 | 60464.1 | 60700.9 |</p>
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**SYSTEM**

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**TABLE 19**

HEAT REJECTION

TEST POINT α 14
### TABLE 20

#### HEAT REJECTION

**TEST POINT **47

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**SYSTEM**

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## Table 21: Comparison of Pressure Drops

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ERROR = PREDICTED - MEASURED
FIGURE 1 MODULAR RADIATOR PANEL CONFIGURATION
FOUR NODE THERMAL MODEL

PHOTOGRAPHIC COPY OF PANEL THERMAL MODEL

TEST PANEL

FIGURE 2 PANEL THERMAL MODEL
Fluid Nodes Shown
For Tube Nodes Add 200

FIGURE 3 TYPICAL SYSTEM MODEL SCHEMATIC
PANELs PLUMBEd IN THE Y CONFIGURATION....

FIGURE 4 TWO-SIDED RADIATOR CONFIGURATION

AND EACH FITTED WITH A SIMULATED CARGO BAY DOOR....

....REPRESENTS TWO-SIDED RADIATION FROM THE FORWARD 30 FT OF THE RADIATORS
FIGURE 5 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA

TEST POINT 2-1

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<td>163(148.7)</td>
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<tr>
<td>Flow Main</td>
<td>2171(2099)</td>
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Panel 1
- \( Q_{AB} \), 55.6(60.8)
- Temp Main, 131.0(129.6)
- Temp Prime, 129.1(92)

Panel 2
- \( Q_{AB} \), 35.2(39.2)
- Temp Main, 98.8(57.4)
- Temp Prime, 70.0(65)

Panel 3
- \( Q_{AB} \), 35.2(39.7)
- Temp Main, 102.2(100)
- Temp Prime, 99.6(80)

Panel 4
- \( Q_{AB} \), 35.2(34.2)
- Temp Main, 78.5(76)
- Temp Prime, 80.9(72)

Panel 5
- \( Q_{AB} \), 55.6(59.6)
- Temp Main, 131.1(129.6)
- Temp Prime, 129.0(94)

Panel 6
- \( Q_{AB} \), 64.5(71.4)
- Temp Main, 71.3(73)
- Temp Prime, 69.5(72)

Panel 7
- \( Q_{AB} \), 64.5(71.6)
- Temp Main, 106.6(106)
- Temp Prime, 104.8(84)

Panel 8
- \( Q_{AB} \), 64.5(70.3)
- Temp Main, 87.0(87)
- Temp Prime, 85.6(81)

Numbers in parenthesis are test values.
Numbers not in parenthesis are predicted values.

Tout Main, 65.1(64.7)
Tout Prime, 70.0(74)
Temp Mixed Prime and Main, 65.1(65.8)
FIGURE 6 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA
TEST POINT 10

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<td>156.8(159.1)</td>
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</tbody>
</table>

<table>
<thead>
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<th>Panel 3</th>
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<tbody>
<tr>
<td>Q_ABS 30(34.8)</td>
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</table>

<table>
<thead>
<tr>
<th>Temp Main</th>
<th>Temp Prime</th>
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<tbody>
<tr>
<td>26.4(16.3)</td>
<td>151.4(153.4)</td>
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<tr>
<td>-6.1(-17.5)</td>
<td>146.2(150.6)</td>
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<table>
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<th>Panel 7</th>
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<tbody>
<tr>
<td>Q_ABS 30(32.6)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Temp Main</th>
<th>Temp Prime</th>
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<tbody>
<tr>
<td>-27.8(-35)</td>
<td>141.1(147.8)</td>
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<table>
<thead>
<tr>
<th>Tout Main</th>
<th>Tout Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>-27.6(-35)</td>
<td>141.1(145)</td>
</tr>
</tbody>
</table>

Temp Mixed Prime and Main 40.2(55.3)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values
FIGURE 7 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA

TEST POINT 12

\[ \begin{align*}
T_{in\ Main} & = 26.8(14.2) \\
T_{in\ Prime} & = 151.4(154.3) \\
Flow\ Main & = 600(573) \\
Flow\ Prime & = 499(536)
\end{align*} \]

\[ \begin{align*}
Flow\ Main & = 308(265) \\
Flow\ Prime & = 252(312)
\end{align*} \]

\[ \begin{align*}
Panel\ 1 & \quad Q_{ABS} = 30(32.8) \\
Temp\ Main & = -8.5(-16.4) \\
Temp\ Prime & = 147.2(149.9)
\end{align*} \]

\[ \begin{align*}
Panel\ 3 & \quad Q_{ABS} = 30(31.8) \\
Temp\ Main & = 1.3(-33.8) \\
Temp\ Prime & = 143(144)
\end{align*} \]

\[ \begin{align*}
Panel\ 4 & \quad Q_{ABS} = 20(7.9) \\
Temp\ Main & = -45.5(-52.9) \\
Temp\ Prime & = 140.7(141.1)
\end{align*} \]

\[ \begin{align*}
Panel\ 2 & \quad Q_{ABS} = 20(7.4) \\
T_{out\ Main} & = -56.3(-65) \\
T_{out\ Prime} & = 138.5(144.0)
\end{align*} \]

\[ \begin{align*}
Panel\ 5 & \quad Q_{ABS} = 30(30.7) \\
Temp\ Main & = -9.8(-16.4) \\
Temp\ Prime & = 147.2(150.5)
\end{align*} \]

\[ \begin{align*}
Panel\ 7 & \quad Q_{ABS} = 30(31) \\
Temp\ Main & = -32.9(-35) \\
Temp\ Prime & = 142.9(144)
\end{align*} \]

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values
FIGURE 8 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA

TEST POINT 21

Tin Main 162.4(162.7)
Tin Prime 162.4(166.4)
Flow Main 2173(2198)
Flow Prime 22.8(13.8)

Flow Prime

Flow Main 493(628)
Flow Main 493(596)
Flow Main 594(607)
Flow Main 593(616)

Panel 1
\[ Q_{ABS} = 160(161.6) \]

Panel 2
\[ Q_{ABS} = 160(161.7) \]

Panel 5
\[ Q_{ABS} = 160(158.6) \]

Panel 6
\[ Q_{ABS} = 160(161.6) \]

Panel 3
\[ Q_{ABS} = 160(161.1) \]

Panel 4
\[ Q_{ABS} = 160(161.5) \]

Panel 7
\[ Q_{ABS} = 160(159.3) \]

Panel 8
\[ Q_{ABS} = 160(160.9) \]

Temp Main 101(106)
Temp Main 101(110)
Temp Main 108(108)
Temp Main 107(105)

Temp Prime 125(102)
Temp Prime 125(105)
Temp Prime 132(104)
Temp Prime 132(105)

Temp Main 70(78)
Temp Main 70(83)
Temp Main 77(78)
Temp Main 77(75)

Temp Prime 94(86)
Temp Prime 95(87)
Temp Prime 107(85)
Temp Prime 107(92)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main 74(78)
Tout Prime 99(81)
Temp Mixed Main and Prime 74(78)
FIGURE 9 COMPARISON OF PRE-TFST PREDICTIONS AND TEST DATA

TEST POINT 22-2

Tin Main 162.4(163.6)
Tin Prime 162.4(165.5)
Flow Main 2174(2186)
Flow Prime 22.8(15.1)

Flow Main 493(619)
Flow Main 494(589)
Flow Main 593(607)
Flow Main 592(616)

Panel 1 Q_{ABS} 133(132.2)
Panel 2 Q_{ABS} 133(132.4)
Panel 5 Q_{ABS} 171(168.9)
Panel 6 Q_{ABS} 171(169.5)

Panel 3 Q_{ABS} 133(131.5)
Panel 4 Q_{ABS} 133(133.6)
Panel 7 Q_{ABS} 171(168.8)
Panel 8 Q_{ABS} 171(173.8)

Temp Main 93.6(98)
Temp Main 93.7(102)
Temp Main 109.8(111)
Temp Main 102.8(106)

Temp Prime 124.4(95)
Temp Prime 124.5(98)
Temp Prime 132.4(100)
Temp Prime 132.1(102)

Temp Main 58.3(64.7)
Temp Main 58.4(70)
Temp Main 80.6(82)
Temp Main 80.6(80)

Temp Prime 92.1(70)
Temp Prime 92.3(73)
Temp Prime 108.1(79)
Temp Prime 108.1(88)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main 70.6(74)
Tout Prime 701.1(72)
Temp Mixed Main and Prime 70.9(74)
FIGURE 10 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA

TEST POINT 23-1

- Tin Main: 142.1 (140.2)
- Tin Prime: 142.1 (142.1)
- Flow Main: 2174 (2198)
- Flow Prime: 22.8 (14.8)

Flow Prime → Flow Main

Flow Main 492 (611) → Panel 1: Q_{ABS} 158 (159)

Temp Main: 89.8 (94)
Temp Prime: 108.4 (95)

Panel 2: Q_{ABS} 158 (160) → Flow Main

Temp Main: 89.9 (96)
Temp Prime: 108.5 (97)

Flow Main 493 (574) → Panel 3: Q_{ABS} 158 (159)

Temp Main: 63.1 (71)
Temp Prime: 84.3 (72)

Panel 4: Q_{ABS} 158 (159.5) → Flow Main

Temp Main: 63.2 (75)
Temp Prime: 84.4 (74)

Flow Main 595 (592) → Panel 5: Q_{ABS} 130 (127)

Temp Main: 88.9 (88)
Temp Prime: 113.1 (88)

Panel 6: Q_{ABS} 130 (127) → Flow Main

Temp Main: 88.8 (85)
Temp Prime: 113.2 (89)

Flow Main 594 (598) → Panel 7: Q_{ABS} 130 (129)

Temp Main: 58.9 (58.4)
Temp Prime: 58.4 (55.3)

Panel 8: Q_{ABS} 130 (130) → Flow Prime

Temp Main: 58.8 (55.3)
Temp Prime: 88.9 (73)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main: 60.8 (64.7)
Tout Prime: 86.7 (67.9)
Temp Mixed Main and Prime: 61.1 (64.7)
FIGURE 11 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA

TEST POINT 24-1

Values in parentheses are predicted values.

**Test Values:**
- Tin Main: 116.2 (116)
- Tin Prime: 116.2 (116)
- Flow Main: 2174 (2198)
- Flow Prime: 22.8 (15.8)

**Flow Main and Prime Data:**

- Panel 1: Q<sub>ABS</sub> = 158 (155.6)
  - Temp Main: 76.7 (80)
  - Temp Prime: 88.5 (85)

- Panel 2: Q<sub>ABS</sub> = 158 (154)
  - Temp Main: 76.7 (83)
  - Temp Prime: 88.6 (86)

- Panel 3: Q<sub>ABS</sub> = 158 (154)
  - Temp Main: 56.3 (61.6)
  - Temp Prime: 70.1 (61.6)

- Panel 4: Q<sub>ABS</sub> = 158 (157)
  - Temp Main: 56.4 (66.8)
  - Temp Prime: 70.1 (65.8)

- Panel 5: Q<sub>ABS</sub> = 130 (124)
  - Temp Main: 74.2 (75)
  - Temp Prime: 92.1 (78)

- Panel 6: Q<sub>ABS</sub> = 130 (129)
  - Temp Main: 74.2 (72)
  - Temp Prime: 92.2 (80)

- Panel 7: Q<sub>ABS</sub> = 130 (127)
  - Temp Main: 50.4 (50)
  - Temp Prime: 71.9 (55.3)

- Panel 8: Q<sub>ABS</sub> = 130 (122)
  - Temp Main: 50.4 (45.8)
  - Temp Prime: 71.7 (64.7)

- Tout Main: 53.1 (55.3)
- Tout Prime: 71.2 (58.4)
- Temp Mixed Main and Prime: 53.3 (56.3)
FIGURE 12 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA

TEST POINT 25-1

<table>
<thead>
<tr>
<th></th>
<th>Tin Main</th>
<th>96.1(95)</th>
<th>Tin Prime</th>
<th>96.1(95)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Main</td>
<td>2174(2186)</td>
<td>Flow Prime</td>
<td>22.8(14.7)</td>
<td></td>
</tr>
</tbody>
</table>

Flow Prime

Flow Main 491(576)
Flow Main 492(567)
Flow Main 596(562)
Flow Main 595(581)

Panel 1
QABS 158(151.1)
Temp Main 66.5(68.9)
Temp Prime 73.7(78)

Panel 2
QABS 158(151.2)
Temp Main 66.5(72)
Temp Prime 73.8(79)

Panel 3
QABS 158(153.3)
Temp Main 61.0(55.3)
Temp Prime 60.0(52.4)

Panel 4
QABS 158(153.5)
Temp Main 51.0(54.5)
Temp Prime 59.8(58.4)

Panel 5
QABS 130(114.5)
Temp Main 62.8(62.7)
Temp Prime 76.5(70)

Panel 6
QABS 130(126.2)
Temp Main 62.7(60.5)
Temp Prime 72.6(72)

Panel 7
QABS 130(124.7)
Temp Main 43.7(42.7)
Temp Prime 60.2(47.9)

Panel 8
QABS 130(128.9)
Temp Main 43.7(40.6)
Temp Prime 60.0(57.4)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main 47.0(49)
Tout Prime 60.1(54.2)
Temp Mixed Main and Prime 47.1(50)
FIGURE 13 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA

TEST POINT 20

$T_{in \text{ Main}} \ 53(52.1)$
$T_{in \text{ Prime}} \ 53(45.8)$
$F_{low \text{ Main}} \ 526(396)$
$F_{low \text{ Prime}} \ 1671(1842)$

Flow Prime (897) → Flow Main

Flow Main 118(95.6)

Flow Main 118(101.6) → Flow Main 145(91.6) → Flow Main 145(98.2)

Panel 1 $Q_{ABS} \ 174(164.0)$
Panel 2 $Q_{ABS} \ 174(167)$
Panel 3 $Q_{ABS} \ 174(164.7)$
Panel 4 $Q_{ABS} \ 174(171.5)$
Panel 5 $Q_{ABS} \ 70(66.7)$
Panel 6 $Q_{ABS} \ 70(69.1)$
Panel 7 $Q_{ABS} \ 70(68.7)$
Panel 8 $Q_{ABS} \ 70(69.4)$

Temp Main 48(50)
Temp Prime 52.8(54.2)
Temp Main 46.8(51.1)
Temp Prime 52.7(47.9)

Temp Main 48(53.2)
Temp Prime 52.8(54.2)
Temp Main 46.8(56.3)
Temp Prime 52.7(47.9)

Temp Main-13.7(-21)
Temp Prime 51.3(53.2)
Temp Main -39.6(-36.2)
Temp Prime 49.6(45.8)

Temp Main-13.8(-29.2)
Temp Prime 51.3(52.1)
Temp Main -39.7(-45.6)
Temp Prime 49.6(53.2)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main 0.2(8.7)
Tout Prime 61.1(46.9)
Temp Mixed Main and Prime 39.3(40.6)
FIGURE 14 COMPARISON OF PRE-TEST PREDICTIONS AND TEST DATA

TEST POINT 29

Flow Main 583(594)
Flow Main 614(567)
Flow Main 501(473)
Flow Main 476(466)

Panel 1
Q_{ABS} 110(109.8)
Temp Main 53.0(54.2)
Temp Prime 53.3(55.3)

Panel 2
Q_{ABS} 110(110.5)
Temp Main 53.0(56.3)
Temp Prime 53.3(55.3)

Panel 3
Q_{ABS} 110(110.7)
Temp Main 53.0(55.3)
Temp Prime 53.5(51.1)

Panel 4
Q_{ABS} 110(110.7)
Temp Main 53.1(55.3)
Temp Prime 53.6(52.1)

Panel 5
Q_{ABS} 110(110.6)
Temp Main 53.0(56.3)
Temp Prime 53.4(55.3)

Panel 6
Q_{ABS} 110(111.7)
Temp Main 53.0(55.3)
Temp Prime 53.4(55.3)

Panel 7
Q_{ABS} 25(26.6)
Temp Main 33.3(35.3)
Temp Prime 32.2(52.1)

Panel 8
Temp Main
Temp Prime

Tout Main 44.3(46.9)
Tout Prime 44.2(53.7)
Temp Mixed Main and Prime 44.3(46.9)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values
CONFIGURATION a

FIGURE 15 TEST POINT IA CORRELATION

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Main</th>
<th>Prime</th>
</tr>
</thead>
<tbody>
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<td>91.5(91.5)</td>
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<tr>
<td>Flow</td>
<td>1094.(1094.)</td>
<td>13.2(13.2)</td>
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<tr>
<td>Panel 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Main</td>
<td>545.1(611.)</td>
<td>548.9(607.)</td>
</tr>
<tr>
<td>Flow Prime</td>
<td>6.6(8.2)</td>
<td>6.6(7.6)</td>
</tr>
<tr>
<td>Temp Main</td>
<td>142.7(139.2)</td>
<td>143.3(141.1)</td>
</tr>
<tr>
<td>Temp Prime</td>
<td>88.9(105.)</td>
<td>89.3(108.)</td>
</tr>
<tr>
<td>Panel 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp Main</td>
<td>105.8(105.)</td>
<td>106.5(105.)</td>
</tr>
<tr>
<td>Temp Prime</td>
<td>85.4(99.)</td>
<td>85.9(102.)</td>
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<tr>
<td>Panel 3</td>
<td></td>
<td></td>
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<tr>
<td>ΔP Main</td>
<td>5.6(6.5)</td>
<td>5.6(5.7)</td>
</tr>
<tr>
<td>Panel 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp Main</td>
<td>119.8(118.)</td>
<td>20.8(119.)</td>
</tr>
<tr>
<td>Temp Prime</td>
<td>86.6(100.)</td>
<td>87.3(119.)</td>
</tr>
<tr>
<td>Panel 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔP Main</td>
<td>5.5(6.5)</td>
<td>5.6(5.7)</td>
</tr>
<tr>
<td>Panel 6</td>
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<td></td>
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<tr>
<td>Temp Main</td>
<td>97.2(98.)</td>
<td>97.7(98.)</td>
</tr>
<tr>
<td>Temp Prime</td>
<td>84.9(96.)</td>
<td>85.2(96.)</td>
</tr>
<tr>
<td>Panel 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔP Main</td>
<td>5.4(5.7)</td>
<td>5.4(5.1)</td>
</tr>
<tr>
<td>Panel 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp Main</td>
<td>105.8(105.)</td>
<td>106.5(105.)</td>
</tr>
<tr>
<td>Temp Prime</td>
<td>85.4(99.)</td>
<td>85.9(102.)</td>
</tr>
<tr>
<td>Panel 9</td>
<td></td>
<td></td>
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<tr>
<td>ΔP Main</td>
<td>5.3(5.7)</td>
<td>5.4(5.7)</td>
</tr>
<tr>
<td>Temperature Mixed</td>
<td>97.3(96.)</td>
<td>97.4(97.)</td>
</tr>
<tr>
<td>Temperature Main</td>
<td></td>
<td>97.3(96.)</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values
FIGURE 16 TEST POINT 45 CORRELATION

Test Main 116.4(112.7)
Test Prime 79.4(112.7)
Temp Mixed Main and Prime 119.8(112.7)

Numbers in parentheses are test values
Numbers not in parentheses are predicted values
CONFIGURATION Y

FIGURE 17 TEST POINT CORRELATION

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>T\text{in} Main</td>
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</tr>
<tr>
<td>T\text{in} Prime</td>
<td>111.5(111.5)</td>
</tr>
<tr>
<td>Flow Main</td>
<td>2223. (2223.)</td>
</tr>
<tr>
<td>Flow Prime</td>
<td>47.1 (47.1)</td>
</tr>
</tbody>
</table>

Flow Main 550.9(602.)

Flow Prime 23.4 (32.7)

Flow Main 551. (574.)

Flow Prime 23.7(37.5)

Flow Main 560.5(562.)

Flow Main 560.6(563.)

Panel 1 \( \Delta P \) Main 5.7 (10.5)

Panel 2 \( \Delta P \) Main 5.7 (5.7)

Panel 3 \( \Delta P \) Main 5.6 (8.1)

Panel 4 \( \Delta P \) Main 5.6 (6.3)

Panel 5 \( \Delta P \) Main 5.9 (4.9)

Panel 6 \( \Delta P \) Main 5.9 (5.1)

Panel 7 \( \Delta P \) Main 5.7 (5.5)

Panel 8 \( \Delta P \) Main 5.7 (5.1)

Temp Main 133.4 (135.4)

Temp Prime 104.8 (113.)

Temp Main 133.1 (131.5)

Temp Prime 104.8 (114.)

Temp Main 133.4 (129.6)

Temp Prime 104.8 (115.)

Temp Main 133.2 (129.6)

Temp Prime 104.4 (117.)

Temp Main 113.1 (116.)

Temp Prime 100.7 (104.)

Temp Main 112.7 (111.)

Temp Prime 100.6 (105.)

Temp Main 113.3 (108.)

Temp Prime 99.8 (105.)

Temp Main 112.8 (109.)

Temp Prime 99.6 (109.)

Temp Mixed Main and Prime 112.7 (111.)

T\text{out} Main 113. (112.)

T\text{out} Prime 100.2 (103.)

Numbers in parenthesis are test values.

Numbers not in parenthesis are predicted values.
CONFIGURATION α

FIGURE 18 TEST POINT 4 CORRELATION

| Temp Main | 102.5 (102.) | Temp Prime | 84.2 (91.) |
| Temp Main | 94.8 (96.)   | Temp Prime | 83.5 (86.) |
| Temp Main | 89.6 (92.)   | Temp Prime | 82.8 (87.) |
| Temp Main | 88.1 (91.)   | Temp Prime | 83.3 (88.) |
| Temp Main | 103.2 (104.)| Temp Prime | 84.7 (92.) |
| Temp Main | 95.1 (96.)   | Temp Prime | 83.7 (90.) |
| Temp Main | 89.7 (91.)   | Temp Prime | 82.9 (88.) |
| Temp Main | 87.8 (91.)   | Temp Prime | 83.3 (88.) |

Flow Main: 551.577. Flow Prime: 6.7 (7.)
Flow Main: 555.585. Flow Prime: 6.7 (8.1)
Panel 1: ΔP Main 5.5 (6.9)
Panel 5: ΔP Main 5.6 (5.9)
Panel 3: ΔP Main 5.5 (5.7)
Panel 7: ΔP Main 5.5 (5.9)
Panel 4: ΔP Main 5.5 (5.9)
Panel 8: ΔP Main 5.5 (5.9)
Panel 2: ΔP Main 5.4 (6.1)
Panel 6: ΔP Main 5.5 (5.5)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Temp Mixed Prime and Main: 87.9 (90.)
Figure 19 Test Point 10 Correlation

Configuration α

<table>
<thead>
<tr>
<th>Flow Main</th>
<th>Flow Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>283. (283.</td>
<td>268. (268.)</td>
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</tbody>
</table>

Panel 1

<table>
<thead>
<tr>
<th>ΔP Main</th>
<th>Temp Main</th>
<th>Temp Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 (2.3)</td>
<td>74.7 (65.8)</td>
<td>157.9 (159.)</td>
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</tbody>
</table>

Panel 2

<table>
<thead>
<tr>
<th>ΔP Main</th>
<th>Temp Main</th>
<th>Temp Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4 (1.6)</td>
<td>20.7 (16.3)</td>
<td>153.8 (153.4)</td>
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</tbody>
</table>

Panel 3

<table>
<thead>
<tr>
<th>ΔP Main</th>
<th>Temp Main</th>
<th>Temp Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3 (1.2)</td>
<td>-14.21 (17.5)</td>
<td>149.8 (150.6)</td>
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</tbody>
</table>

Panel 4

<table>
<thead>
<tr>
<th>ΔP Main</th>
<th>Temp Main</th>
<th>Temp Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 (1.8)</td>
<td>-34.4 (32.7)</td>
<td>145.9 (147.8)</td>
</tr>
</tbody>
</table>

Panel 5

<table>
<thead>
<tr>
<th>ΔP Main</th>
<th>Temp Main</th>
<th>Temp Prime</th>
</tr>
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<tbody>
<tr>
<td></td>
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</tbody>
</table>

Panel 6

<table>
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<tr>
<th>ΔP Main</th>
<th>Temp Main</th>
<th>Temp Prime</th>
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<tbody>
<tr>
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<td></td>
<td></td>
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</tbody>
</table>

Panel 7

<table>
<thead>
<tr>
<th>ΔP Main</th>
<th>Temp Main</th>
<th>Temp Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tout Main -34.4 (-35.)
Tout Prime 145.9 (145.9)

Temp Mixed Prime and Main 61.04 (55.3)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

56
CONFIGURATION y

FIGURE 20 TEST POINT 51 CORRELATION

- Tin Main 159. (159.)
- Tin Prime 158.5 (158.5)
- Flow Main 1379. (1379.)
- Flow Prime 884. (884.)

Flow Prime 440.4 (448.)

Flow Main 341.5 (397.)

Panel 1 ΔP Main 2.2

Temp Main 31.9 (29.)
Temp Prime 149.9 (154.)

Panel 3 ΔP Main 1.9

Temp Main -37.1 (-37.)
Temp Prime 141.4 (150.)

Panel 5 ΔP Main 2.3

Temp Main 32.9 (30.)
Temp Prime 149.9 (155.)

Panel 6 ΔP Main 2.3

Temp Main 33.3 (30.)
Temp Prime 149.9 (156.)

Panel 2 ΔP Main 2.2

Temp Main 32.3 (33.)
Temp Prime 149.9 (151.)

Panel 4 ΔP Main 1.9

Temp Main -36.8 (-31.)
Temp Prime 141.4 (150.)

Panel 7 ΔP Main 2.0

Temp Main -35.7 (-40.)
Temp Prime 141.5 (151.5)

Panel 8 ΔP Main 2.0

Temp Main -35.6 (-38.)
Temp Prime 141.5 (151.4)

Flow Main 341.5 (382.)

Flow Prime 443.6 (505.)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main -36.3 (-35.)
Tout Prime 141.4 (150.6)
Temp Mixed Main and Prime 40.2 (39.5)
Panel 1 Environment Decreased 5%
Panels 3, 4, 7 Environment Increased 5%

Flow Main 283.8 (283.8)
Flow Prime 268.8 (268.8)

Panel 1
ΔP Main 1.5 (2.3)

Temp Main 73.5 (65.8)
Temp Prime 157.8 (159.8)

Panel 3
ΔP Main 1.2 (1.6)

Temp Main 21.0 (16.3)
Temp Prime 153.8 (153.4)

Panel 4
ΔP Main 1.4 (1.2)

Temp Main -13.0 (-17.5)
Temp Prime 149.8 (150.6)

Panel 7
ΔP Main 1.3 (1.8)

Temp Main -32.6 (-32.7)
Temp Prime 145.9 (147.8)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tin Main 163.6 (163.6)
Tin Prime 161.8 (161.8)
Flow Main 283.8 (283.8)
Flow Prime 268.8 (268.8)

58
FIGURE 22  TEST POINT 17  CORRELATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Main</th>
<th>Prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{in}$</td>
<td>55.3</td>
<td>53.2</td>
</tr>
<tr>
<td>Flow</td>
<td>17.1</td>
<td>17.1</td>
</tr>
<tr>
<td>Flow</td>
<td>549.</td>
<td>549.</td>
</tr>
</tbody>
</table>

Panel 1
- $\Delta P_{main}$: 0.03 [0.0]
- $T_{temp}$: -86.6 [-81.4]
- $T_{temp}$: 52.2 [53.2]

Panel 3
- $\Delta P_{main}$: 0.03 [0.2]
- $T_{temp}$: -99.4 [-84.1]
- $T_{temp}$: 51.2 [47.9]

Panel 4
- $\Delta P_{main}$: 0.04 [0.0]
- $T_{temp}$: -118.5 [-91.0]
- $T_{temp}$: 50.1 [46.9]

Panel 7
- $\Delta P_{main}$: 0.04 [0.2]
- $T_{temp}$: -117.5 [-89.1]
- $T_{temp}$: 49.1 [46.9]

$T_{out}$: -117.4 [-49.2]
$T_{out}$: 49.1 [46.9]

Temperatures in parentheses are test values.
Temperatures not in parentheses are predicted values.

Temp Mixed Prime and Main: 44.4 [46.9]
CONFIGURATION B

FIGURE 23 TEST POINT 17A CORRELATION

Flow Main 5.4(8.1)
Flow Prime 579.1(329.)

Panel 1
\( \Delta P \) Main 0.0(0.0)
Temp Main -116.2(-57.7)
Temp Prime 51.6(51.1)

Panel 3
\( \Delta P \) Main 0.1(0.2)
Temp Main -117.9(-74.5)
Temp Prime 50.6(46.9)

Panel 4
\( \Delta P \) Main 6.5(0.0)
Temp Main -220.4(-118.5)
Temp Prime 50.5(50.5)

Panel 2
\( \Delta P \) Main 25.8(0.2)
Temp Main -217.6(-152.3)
Temp Prime 49.4(49.4)

\( T_{out} \) Main -217.6(-152.3)
\( T_{out} \) Prime 49.4(49.4)

Temp Mixed Main and Prime 33.4(46.9)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Flow Main 6.2(14.8)
Flow Prime 589.9(337.)

Panel 5
\( \Delta P \) Main 0.0(0.0)
Temp Main -100.2(-59.4)
Temp Prime 51.7(51.1)

Panel 7
\( \Delta P \) Main 0.0(0.0)
Temp Main -105.2(-78.7)
Temp Prime 50.7(45.8)

Temp Main -113.3(-65.9)
Temp Prime 50.6(49.4)
**CONFIGURATION γ**

**FIGURE 24 TEST POINT 36 CORRELATION**

- **T_in Main**: 57.7 (57.7)
- **T_in Prime**: 53.5 (53.5)
- **Flow Main**: 52.5 (52.5)
- **Flow Prime**: 1053.1 (1053.1)

Flow Main 350.8 (372.0)

Panel 1 → ΔP Main

Panel 2 → ΔP Main 0.17 (0.2)

Panel 3 → ΔP Main

Panel 4 → ΔP Main 0.17 (0.2)

Panel 5 → ΔP Main 0.18 (0.2)

Panel 6 → ΔP Main 0.1 (0.4)

Panel 7 → ΔP Main 0.17 (0.2)

Panel 8 → ΔP Main 0.17 (0.2)

Temp Main

Temp Prime

Temp Main -192.8 (-117.6)

Temp Prime 51.5 (53.2)

Temp Main -215.8 (-157.1)

Temp Prime 49.5 (45.8)

Temp Main -168.1 (-155.0)

Temp Prime 49.5 (50.1)

Numbers in parenthesis are test values

Numbers not in parenthesis are predicted values

- **T_out Main**: -169.6 (-146.5)
- **T_out Prime**: 49.5 (46.9)
- **Temp Mixed Main and Prime**: 40.1 (40.6)
CONFIGURATION γ

FIGURE 25 TEST POINT 53 CORRELATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value (Test)</th>
<th>Value (Predicted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tin Main</td>
<td>164.1(164.1)</td>
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<tr>
<td>Tin Prime</td>
<td>134.25(134.25)</td>
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</tr>
<tr>
<td>Flow Main</td>
<td>974.1(970.)</td>
<td></td>
</tr>
<tr>
<td>Flow Prime</td>
<td>1266.9(1273.)</td>
<td></td>
</tr>
<tr>
<td>Flow Main</td>
<td>239.4(283.)</td>
<td>Flow Main 239.5(280.)</td>
</tr>
<tr>
<td>Flow Prime</td>
<td>632.2(620.)</td>
<td>Flow Prime 636.8(668.8)</td>
</tr>
<tr>
<td>Panel 1</td>
<td>ΔP Main 1.08</td>
<td>(2.0)</td>
</tr>
<tr>
<td>Panel 2</td>
<td>ΔP Main 1.06</td>
<td>(1.6)</td>
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<tr>
<td>Panel 3</td>
<td>ΔP Main 0.96</td>
<td>(1.4)</td>
</tr>
<tr>
<td>Panel 4</td>
<td>ΔP Main 0.95</td>
<td>(1.8)</td>
</tr>
<tr>
<td>Panel 5</td>
<td>ΔP Main 1.11</td>
<td>(1.8)</td>
</tr>
<tr>
<td>Panel 6</td>
<td>ΔP Main 1.0</td>
<td>(1.4)</td>
</tr>
<tr>
<td>Panel 7</td>
<td>ΔP Main 1.0</td>
<td>(1.8)</td>
</tr>
<tr>
<td>Panel 8</td>
<td>ΔP Main 1.0</td>
<td>(1.4)</td>
</tr>
<tr>
<td>Temp Main</td>
<td>63.4(61.6)</td>
<td></td>
</tr>
<tr>
<td>Temp Prime</td>
<td>130.6(133.1)</td>
<td></td>
</tr>
<tr>
<td>Temp Main</td>
<td>26.4(30.1)</td>
<td></td>
</tr>
<tr>
<td>Temp Prime</td>
<td>127.1(131.5)</td>
<td></td>
</tr>
<tr>
<td>Temp Main</td>
<td>27.5(27.5)</td>
<td></td>
</tr>
<tr>
<td>Temp Prime</td>
<td>126.9(132.5)</td>
<td></td>
</tr>
<tr>
<td>Temp Main</td>
<td>56.5(56.1)</td>
<td></td>
</tr>
<tr>
<td>Temp Prime</td>
<td>123.1(139.2)</td>
<td></td>
</tr>
<tr>
<td>Tout Main</td>
<td>15.96(-16.4)</td>
<td></td>
</tr>
<tr>
<td>Tout Prime</td>
<td>125(-131.5)</td>
<td></td>
</tr>
<tr>
<td>Temp Mixed Main</td>
<td>68.1(67.9)</td>
<td></td>
</tr>
</tbody>
</table>

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values
CONFIGURATION Y

FIGURE 26 TEST POINT 54 CORRELATION

Tin Main 163.1 (163.7)
Tin Prime 155.7 (155.5)
Flow Main 1856.4 (1950.4)
Flow Prime 364.4 (275.4)

Flow Prime 181.4 (144.4)
Flow Main 458.2 (568.4)
Flow Main 458.2 (545.4)
Flow Main 470.5 (547.5)
Flow Main 470.5 (563.5)

Panel 1 ΔP Main 3.9 (7.7)
Panel 2 ΔP Main 3.9 (5.3)
Panel 5 ΔP Main 4.1 (5.7)
Panel 6 ΔP Main 4.1 (5.7)

Temp Main 90.1 (93.1)
Temp Prime 142.8 (150.1)
Temp Main 89.5 (95.1)
Temp Prime 143.7 (151.4)
Temp Main 56.1 (59.5)
Temp Prime 138.2 (149.1)
Temp Main 56.3 (57.4)
Temp Prime 138.2 (151.1)

Panel 3 ΔP Main 3.8 (5.7)
Panel 4 ΔP Main 3.8 (5.3)
Panel 7 ΔP Main 3.9 (4.9)
Panel 8 ΔP Main 3.9 (5.1)

Temp Main 51.3 (57.4)
Temp Prime 132.5 (140.2)
Temp Main 51.0 (58.4)
Temp Prime 132.4 (141.1)
Temp Main -8.5 (-2.6)
Temp Prime 121.4 (137.2)
Temp Main -8.4 (-2.7)
Temp Prime 121.4 (136.9)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main 21.7 (27.9)
Tout Prime 127.2 (137.1)
Temp Mixed Main and Prime 40.6 (40.6)
CONFIGURATION γ

FIGURE 27 TEST POINT 55 CORRELATION

Tin Main 163.1(164.6)
Tin Prime 161.7(162.3)
Flow Main 1643.6(1727.)
Flow Prime 582.7(510.)

Flow Prime 290.2 (290.1)
Flow Main 405.2(499.)

Panel 1 AP Main 3.1 (5.7)
Temp Main 83.4(87.)
Temp Prime 152.9(159.)

Panel 3 AP Main 3.0 (4.0)
Temp Main 44.0(51.1)
Temp Prime 144.5(153.4)

Panel 4 AP Main 3.0 (4.3)
Temp Main 44.5(53.4)

Panel 5 AP Main 3.2 (4.2)
Temp Main 46.8(47.9)

Panel 6 AP Main 3.2 (4.2)
Temp Main 149.2(159.)

Panel 7 AP Main 3.0 (4.2)
Temp Main 20.4(-14.1)

Panel 8 AP Main 3.0 (4.2)
Temp Main 20.6(-15.2)

Temp Mixed Main and Prime 49.4(50.)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main 12.1(19.5)
Tout Prime 140.9(150.5)
FIGURE 28  TEST POINT 56  CORRELATION

Flow Prime 619.4 (669.7)

Flow Main 242.3 (274.7)

Panel 1 ΔP Main 1.1 (2.0)

Temp Main 64.1 (59.4)
Temp Prime 130.7 (133.1)

Panel 2 ΔP Main 1.1 (1.6)

Temp Main 63.9 (63.7)
Temp Prime 130.7 (134.6)

Panel 5 ΔP Main 1.1 (1.6)

Temp Main 13.6 (6.5)
Temp Prime 128.7 (132.1)

Panel 6 ΔP Main 1.1 (1.4)

Temp Main 14.2 (3.1)
Temp Prime 128.7 (133.1)

Flow Main 251.0 (269.0)

Panel 3 ΔP Main 0.98 (1.4)

Temp Main 28.2 (29.0)
Temp Prime 127.2 (132.5)

Panel 4 ΔP Main 0.98 (1.8)

Temp Main 27.8 (30.1)
Temp Prime 127.2 (132.5)

Panel 7 ΔP Main 1.0 (1.6)

Temp Main -53.3 (-62.6)
Temp Prime 123.1 (131.5)

Panel 8 ΔP Main 1.0 (1.4)

Temp Main -53.3 (-66.7)
Temp Prime 123.1 (139.2)

Flow Main 251.0 (275.0)

Flow Prime 624.0 (682.0)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main -12.5 (-17.5)
Tout Prime 125.2 (131.5)
Temp Mixed Main and Prime 68.5 (68.9)
FIGURE 29  TEST POINT 59  CORRELATION

Tin Main 163.(162.6)
Tin Prime 154.(154.3)
Flow Main 1867.5(1975.)
Flow Prime 372.6(266.)

Flow Main 460.9(576.)
Flow Main 460.9(552.)
Flow Main 472.8(547.)
Flow Main 472.8(563.)

Panel 1  ΔP Main 4.0  (7.3)
Panel 2  ΔP Main 4.0  (5.7)
Panel 5  ΔP Main 4.1  (5.1)
Panel 6  ΔP Main 4.1  (4.9)

Panel 3  ΔP Main 3.8  (5.1)
Panel 4  ΔP Main 3.8  (5.5)
Panel 7  ΔP Main 3.9  (5.1)
Panel 8  ΔP Main 3.9  (5.5)

Temp Main 89.8(93.)
Temp Prime 142.1(148.)
Temp Main 89.4(95.)
Temp Prime 142.1(149.5)
Temp Main 55.7(59.5)
Temp Prime 136.5(147.)
Temp Main 55.7(58.4)
Temp Prime 136.5(149.)
Temp Main 51.0(58.4)
Temp Prime 131.0(138.3)
Temp Main 50.1(59.5)
Temp Prime 130.8(139.2)
Temp Main -9.0(-1.5)
Temp Prime 119.9(134.4)
Temp Main -9.0(-2.6)
Temp Prime 119.9(143.1)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main 21.0(27.9)
Tout Prime 125.6(135.)
Temp Mixed Main and Prime 40.0(39.5)
CONFIGURATION γ

FIGURE 30 TEST POINT 49 CORRELATION

Tin Main 100.0 (100.0)
Tin Prime 89.5 (89.5)
Flow Main 2161.2 (2161.2)
Flow Prime 44.8 (44.8)

Flow Prime 22.2 (27.4)

Flow Main 535.6 (551.0)

Panel 1
ΔP Main 5.1 (10.5)

Panel 2
ΔP Main 5.1 (5.3)

Panel 3
ΔP Main 5.1 (7.7)

Panel 4
ΔP Main 5.1 (5.9)

Panel 5
ΔP Main 5.3 (4.5)

Panel 6
ΔP Main 5.3 (5.3)

Panel 7
ΔP Main 5.3 (4.3)

Panel 8
ΔP Main 5.3 (5.1)

Temp Main 90.3 (92.0)
Temp Prime 86.9 (89.0)

Temp Main 90.6 (92.0)
Temp Prime 87.1 (90.0)

Temp Main 90.9 (92.0)
Temp Prime 87.2 (90.0)

Temp Main 91.9 (92.0)
Temp Prime 87.3 (91.0)

Temp Main 48.9 (56.3)
Temp Prime 65.1 (71.0)

Temp Main 49.1 (49.0)
Temp Prime 65.3 (72.0)

Temp Main 67.3 (66.8)
Temp Prime 76.3 (78.0)

Temp Main 66.3 (65.8)
Temp Prime 75.7 (81.0)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values

Tout Main 58.1 (59.5)
Tout Prime 70.7 (74.0)

Temp Mixed Main and Prime 58.3 (59.5)
Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values
FIGURE 32  TEST POINT 14  CORRELATION

<table>
<thead>
<tr>
<th></th>
<th>Main</th>
<th>Prime</th>
</tr>
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<tbody>
<tr>
<td>Tin</td>
<td>18.4 (18.4)</td>
<td>152.4 (152.4)</td>
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<tr>
<td>Flow</td>
<td>1615.(1615.)</td>
<td>626.(626.)</td>
</tr>
<tr>
<td>Flow Main</td>
<td>801.9 (752.)</td>
<td>313.2 (342.)</td>
</tr>
<tr>
<td>Flow Prime</td>
<td>813.1 (786.)</td>
<td>312.8 (350.)</td>
</tr>
<tr>
<td>Panel 1</td>
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<td></td>
</tr>
<tr>
<td>AP Main</td>
<td>10.7 (15.0)</td>
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</tr>
<tr>
<td>Panel 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP Main</td>
<td>10.9 (12.1)</td>
<td></td>
</tr>
<tr>
<td>Panel 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP Main</td>
<td>10.6 (11.5)</td>
<td></td>
</tr>
<tr>
<td>Panel 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP Main</td>
<td>10.7 (11.7)</td>
<td></td>
</tr>
<tr>
<td>Panel 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP Main</td>
<td>10.9 (12.1)</td>
<td>148.9 (149.7)</td>
</tr>
<tr>
<td>Panel 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP Main</td>
<td>10.7 (12.1)</td>
<td></td>
</tr>
<tr>
<td>Panel 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP Main</td>
<td>10.8 (12.3)</td>
<td></td>
</tr>
<tr>
<td>Panel 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP Main</td>
<td>10.7 (12.1)</td>
<td></td>
</tr>
<tr>
<td>Panel 9</td>
<td></td>
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</tr>
<tr>
<td>AP Main</td>
<td>10.9 (12.1)</td>
<td></td>
</tr>
</tbody>
</table>

Numbers in parenthesis are test values.
Numbers not in parenthesis are predicted values.

Tout Main 7.6 (13.1)
Tout Prime 141.4 (138.3)
Temp Mixed Prime and Main 48.8 (49.1)
Figure 33: Test Point 47 - Correlation

configuration α

Flow Main 111.9 (67.3)
Flow Prime 494.4 (488.8)

Panel 1
AP Main 0.23 (0.4)

Temp Main 64.6 (73.1)
Temp Prime 51.9 (53.2)

Panel 2
AP Main 0.23 (0.2)

Temp Main 68.2 (73.1)
Temp Prime 52.1 (51.1)

Panel 3
AP Main 0.23 (0.2)

Temp Main 72.7 (77.1)
Temp Prime 52.4 (51.1)

Panel 4
AP Main 0.23 (0.0)

Temp Main 71.8 (73.1)
Temp Prime 52.6 (54.2)

Panel 5
AP Main 0.2 (0.4)

Temp Main 216.1 (-99.4)
Temp Prime 49.2 (51.1)

Panel 6
AP Main 0.3 (0.2)

Temp Main 211.7 (-179.1)
Temp Prime 46.4 (47.9)

Panel 7
AP Main 0.3 (0.4)

Temp Main 217.1 (151.3)
Temp Prime 48.8 (49.)

Panel 8
AP Main 0.3 (0.2)

Temp Main 212.5 (-172.7)
Temp Prime 47.4 (49.)

Tin Main 49.5 (49.5)
Tin Prime 51.5 (51.5)
Flow Main 111.1 (111.)
Flow Prime 988.9 (988.)

Tout Main 68.5 (-8.3)
Tout Prime 49.3 (49.)
Temp Mixed Prime and Main 51.3 (43.7)

Numbers in parenthesis are test values
Numbers not in parenthesis are predicted values
FIGURE 34 TRANSIENT TEMPERATURE COMPARISONS

ANALYSIS TEST DATA

--- 0 Prime Outlet

--- Δ Main Outlet

TEST POINTS 54, 55, 56, 57

TIME - HOURS, DAY 81
FIGURE 35 TRANSIENT FLOW COMPARISON

ANALYSIS TEST DATA

--- 0 Prime Flow

Δ Main Flow

TEST POINTS 54, 55, 56, 59

FLOW LB/HR

TIME - HOURS, DAY 81
APPENDIX A

This appendix presents a summary of the MRS pre-test conditions and results. Tables A-1, A-2, and A-3 present the first, second and third week planned test conditions for each test point and an index to the results of the pre-test analyses. Tables A-4, A-5, and A-6 present environments on each of the eight panels for each test point. The pre-test results are shown on pages A-10 thru A-71.
<table>
<thead>
<tr>
<th>TEST POINT (TP)</th>
<th>TOTAL FLOW LOOP (LB/HR)</th>
<th>FLOW LOOPS</th>
<th>INLET TEMP. OR FROM TP</th>
<th>SIMULATED SHUTTLE FACE</th>
<th>ENVIRONMENT SIMULATES SUN DIRECTLY ON</th>
<th>TOTAL</th>
<th>INLET TEMP.</th>
<th>AGGREGATE</th>
<th>HEAT LOAD (BTU/YR)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1100</td>
<td>A-10</td>
<td>162.4</td>
<td>Cargo Bay 1</td>
<td>Cargo Bay 1 (Cyclic)</td>
<td>70</td>
<td>1100</td>
<td>162.4</td>
<td>70</td>
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<tr>
<td>2</td>
<td>1100</td>
<td>A-11</td>
<td>178.1</td>
<td>Cargo Bay 1</td>
<td>Cargo Bay 1 (Cyclic)</td>
<td>70</td>
<td>1100</td>
<td>178.1</td>
<td>70</td>
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<tr>
<td>3</td>
<td>2200</td>
<td>A-12</td>
<td>162.4</td>
<td>Cargo Bay 2</td>
<td>Cargo Bay 1 (Cyclic)</td>
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<td>162.4</td>
<td>162.4</td>
<td>57.7</td>
</tr>
<tr>
<td>4</td>
<td>1100</td>
<td>A-13</td>
<td>142.1</td>
<td>Cargo Bay 1</td>
<td>Cargo Bay 2 (Cyclic)</td>
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<td>1100</td>
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<td>1100</td>
<td>A-14</td>
<td>116.2</td>
<td>Cargo Bay 1</td>
<td>Cargo Bay 1 (Cyclic)</td>
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<td>116.2</td>
<td>116.2</td>
<td>42</td>
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<td>6</td>
<td>2200</td>
<td>A-15</td>
<td>96.1</td>
<td>Cargo Bay 1</td>
<td>Cargo Bay 1 (Cyclic)</td>
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<td>2200</td>
<td>96.1</td>
<td>70</td>
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**TABLE A-6**

**THIRD WEEK PRE-TEST ENVIRONMENTS**

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CONFIGURATION a
TEST POINTS 14

WEEK 1
TEST TIME ?
TOTAL FLOW 1100 lb/hr,
SIMULATED HEAT LOAD 60 K
ENVIRONMENT SIMULATES SUN ON CA. 100 F AV

Flow Main 5.41
Flow Prime 5.3

Temp Main 144.7
Temp Prime 147.3

ΔP1 7.3

Panel 1

Temp Main 112.3
Temp Prime 146.1

ΔP3 5.6

Panel 3

Temp Main 92.2
Temp Prime 92.2

ΔP2 7.0

Panel 2

ΔP4 5.7

Panel 4

ΔP5 7.3

Panel 5

ΔP7 5.8

Panel 7

ΔP6 7.0

Panel 6

ΔP8 5.7

Panel 8

Tin Main 172.8
Tin Prime 172.8

Flow Main 16.5
Flow Prime 12.8

Flow Main 5.44
Flow Prime 6.4

Tout Main 92.8
Tout Prime 96.6

Temp Mixed Prime and Main 92.8

Flow x (Tin - Tout) x Cp at = Qref
Tavg

Main 1085 x (172.8 - 92.8) x 274 = 25269

Prime 12.8 x (172.8 - 92.8) x 274 = 247

25,556 = Qtotal
CONFIGURATION α
TEST POINTS 2-2

WEEK 1

TEST TIME 8:34 AM (High Main OUTLET)

TOTAL FLOW 2280 GPH

SIMULATED HEAT LOAD 70 K

ENVIRONMENT SIMULATES SUN ON CALIF BAY

Flow Main 168.1
Flow Prime 13.6

Flow Main 2171
Flow Prime 2.5

Flow Main 1690
Flow Prime 12.7

Panel 1

ΔP1 26.6

Panel 5

ΔP5 26.6

Panel 3

ΔP3 22.0

Panel 7

ΔP7 22.0

Panel 4

ΔP4 21.5

Panel 8

ΔP8 21.4

Panel 2

ΔP2 26.0

ΔP6 26.0

Main 2171 (163 - 69.4) (1.65) 53.19
Flow x (Tin - Tout) x Cp at = 0° F
Tavg

Prime 25 (163 - 69.6) (1.65) 8.19
Flow x (Tin - Tout) x Cp at = Qreq
Tavg

Tout Main 65.4
Tout Prime 65.6

Temp Mixed Prime and Main 69.3

A-13
CONFIGURATION α

TEST POINTS 3

WEEK 1

TEST TIME 13 h.

TOTAL FLOW 1100 l/h

SIMULATED HEAT LOAD 57,700

ENVIRONMENT SIMULATES CARGO BAY

Flow Main 54.0
Flow Prime 6.3

Panel 1

ΔP1 7.2

Temp Main 118.1
Temp Prime 127.4

Panel 3

ΔP3 5.7

Temp Main 102.6
Temp Prime 115.5

Panel 4

ΔP4 5.7

Temp Main 93.0
Temp Prime 106.0

Panel 2

ΔP2 7.0

Temp Main 96.7
Temp Prime 99.4

Panel 5

ΔP5 7.1

Temp Main 118.2
Temp Prime 127.5

Panel 7

ΔP7 5.7

Temp Main 108.0
Temp Prime 115.5

Panel 6

ΔP6 7.0

Temp Main 86.9
Temp Prime 99.0

Flow Main 108.6
Flow Prime 12.7

Flow Main 54.5
Flow Prime 6.4

Tin Main 142.1
Tin Prime 142.1

Flow Main 108.6
Flow Prime 12.7

Tout Main 86.8
Tout Prime 99.2

Temp Mixed Prime and Main 86.9

\[ \text{MAIN} \times (\text{Tin} - \text{Tout}) \times \frac{\text{Cp at } \theta_{\text{req}}}{\text{Tavg}} \times 159.15 \]

\[ \text{PRIME} \times 12.7 (\text{Tin} - \text{Tout}) \times \frac{\text{Cp at } \theta_{\text{req}}}{\text{Tavg}} \times 45 \]

\[ \frac{16060}{\text{total}} \]
WEEK 1
TEST TIME 17 A.M.
TOTAL FLOW 1100 lb/hr
SIMULATED HEAT LOAD 42,000
ENVIRONMENT SIMULATES SUN ON CARBO BAY
Flow Main 54.0
Flow Prime 6.3

CONFIGURATION a
TEST POINTS 4

Panel 1
Temp Main 101.6
Temp Prime 106.8
ΔP1 7.14"

Panel 3
Temp Main 92.2
Temp Prime 99.5
ΔP3 6.02"

Panel 4
Temp Main 84.2
Temp Prime 93.9
ΔP4 5.70"

Panel 2
Temp Main 82.3
Temp Prime 91.6
ΔP2 6.94"

Panel 5
Temp Main 116.2
Temp Prime 116.2
Flow Main 1086
Flow Prime 12.7
Flow Main 54.5
Flow Prime 6.4

Panel 6
Temp Main 92.4
Temp Prime 93.6
ΔP6 7.05"

Panel 7
Temp Main 101.7
Temp Prime 106.8
ΔP7 7.05"

Panel 8
Temp Main 92.4
Temp Prime 99.4
ΔP8 5.63"

Main 1086 (116.2 - 92.4) x 0.026 9544
Flow x (Tin - Tout) x Cp at = Qreq
Tavg
Prime 12.7 (116.2 - 92) x 0.026 80.5
Flow x (Tin - Tout) x Cp at = Qreq
Tavg
Temp Mixed Prime and Main 82.5

A-15
CONFIGURATION B
TEST POINTS 5-1

WEEK 1
TEST TIME 20.1 (1 hour 40 min)
TOTAL FLOW 1140.9 lb/ft
SIMULATED HEAT LOAD 70 W
ENVIRONMENT SIMULATES CARGO BAY

Flow Main 4.69
Flow Prime 5.27

Panel 1
ΔP1 3.4 M
Temp Main 97.5
Temp Prime 108.1

Panel 3
ΔP3 4.4 M
Temp Main 89
Temp Prime 104.7

Panel 4
ΔP4

Flow Main 9.14
Flow Prime 1.84

Panel 5
ΔP5 0.5 M
Temp Main 97.0
Temp Prime 108.1

Panel 6
ΔP6

Flow Main 4.46
Flow Prime 9.09

Panel 7
ΔP7 0.5 M
Temp Main 88.8
Temp Prime 104.7

Panel 2
ΔP2

Main 914 (111 - 32.8) 251 1740
FLOW X (Tin - Tout) X Cc at = Qref
Tavg

Prime 184 (111 - 81.8) 260 1364
FLOW X (Tin - Tout) X Cc at = Qref
Tavg

19326
Qtotal

Temp Main 57.8
Temp Prime 97.0

Tout Main 32.6
Tout Prime 81.8

Tout Mixed Main and Prime 40.0

ΔP 4+2 = 35.4
CONFIGURATION B
TEST POINTS 5 - 2

WEEK 1
TEST TIME 7/6.6 (8:44 AM - 10:44 AM)
TOTAL FLOW 1180
SIMULATED HEAT LOAD 20 K
ENVIRONMENT SIMULATES SUN ON CAL 60 %

Flow Main 5.5
Flow Prime 2.5

Flow Main 10.6
Flow Prime 14.6

ΔP 6.7

ΔP 3.6

Temp Main 96.7
Temp Prime 104.6

Temp Main 96.7
Temp Prime 104.7

ΔF 5.8

ΔP 7.1

Temp Main 96.7
Temp Prime 97.1

ΔP 4

Temp Main 23.7
Temp Prime 26.4

ΔP 2

Temp Mixed Main and Prime 58.9

A-17
CONFIGURATION B  
TEST POINTS 5A (LOW MAIN CUTOFF)

WEEK 1
TEST TIME 20.0
TOTAL FLOW 100 ± 1.0
SIMULATED HEAT LOAD 50 ± 0.1 MW
ENVIRONMENT SIMULATES SUN ON C 60°C

Flow Main 1064
Flow Prime 14.4

Flow Main 555
Flow Prime 25

Panel 1
ΔP1 6.8

Temp Main 102.6
Temp Prime 108.7

Panel 3
ΔP3 6.6

Temp Main 93
Temp Prime 101.7

Panel 5

ΔP5 6.7

Temp Main 102.1
Temp Prime 108.3

Panel 7
ΔP7 6.7

Temp Main 92.4
Temp Prime 101.0

Panel 4
ΔP4

Main 1054
Flow X (Temp - Tout) x Cp at = Qreq
Tavg

Prime 14.8
Flow X (Temp - Tout) x Cp at = Qreq
Tavg

1454
Qtotal

Temp Main 63.3
Temp Prime 72.0

ΔP4 + 2 x 39.0

Panel 2
ΔP2

Tout Main 39.3
Tout Prime 55.6

Tout Mixed Main and Prime 40.0

C-2

A-19
WEEK 1
TEST TIME 25h
TOTAL FLOW 1100 NL/h
SIMULATED HEAT LOAD 31,000
ENVIRONMENT SIMULATES SUN ON CARROBAY
Flow Main 541
Flow Prime 63

Panel 1
Temp Main 88.7
Temp Prime 90.3
AP1 7.0

Panel 2
Temp Main 80.6
Temp Prime 82.5
AP2 6.9

Panel 3
Temp Main 83.9
Temp Prime 84.0
AP3 5.6

Panel 4
Temp Main 80.8
Temp Prime 82.5
AP4 5.6

Panel 5
Temp Main 96.1
Temp Prime 96.1

Panel 6
Temp Main 78.9
Temp Prime 76.7
AP6 7.0

Panel 7
Temp Main 84.0
Temp Prime 86.5
AP7 5.16

Panel 8
Temp Main 82.3
Temp Prime 82.3
AP8 5.6

Flow Main 1085
Flow Prime 12.7

Flow Main 54.5
Flow Prime 6.4

MAIN 1.085 (96.1 - 78.8) .357 4824
FLOW X (Tin - Tout) X Cp at = Qref
\[ Tavg \]

PRIME 12.7 (96.1 - 76) .356 6.5
FLOW X (Tin - Tout) X Cp at = Qref
\[ Tavg \]

1/5.89 Qtotal

Temp Mixed Prime and Main 76.8

A-20
CONFIGURATION B
TEST POINTS 8-1

WEEK 1
TEST TIME 32.1 (hours)
TOTAL FLOW 1100
SIMULATED HEAT LOAD 52.7K
ENVIRONMENT SIMULATES SUN ON CARGO BAY

Flow Main 853
Flow Prime 246

Panel 1
ΔP1 4.6

Panel 2

Panel 3
ΔP3 5.8

Panel 4

Panel 5

Panel 7
ΔP7 4.2

MAIN 853(103-90.7) 2.25 14505
FLOW X (Tin - Tout) X Cp at = Qref
Tavg

PRIME 246(103-90.7) 2.26 354

FLOW X (Tin - Tout) X Cp at = Qref
Tavg

TEMP MAIN 91.7
TEMP PRIME 101.6

TEMP MAIN 91.4
TEMP PRIME 101.6

TEMP MAIN 85.1
TEMP PRIME 99.7

TEMP MAIN 52.1
TEMP PRIME 45.8

ΔP4 = 312

TEMP OUT MAIN 25.6
TEMP OUT PRIME 90.7

TEMP OUT MIXED MAIN AND PRIME 40.3

A-23
CONFIGURATION B

TEST POINTS 8 - 2

WEEK TEST TIME 32.8 (4.9 x 2)
TOTAL FLOW 110.0
SIMULATED HEAT LOAD 7.275 K
ENVIRONMENT SIMULATES SUN ON CARBO BAY

Flow Main 555
Flow Prime 2.5

Temp Main 93.3
Temp Prime 96.1

Flow Main 11.84
Flow Prime 14.4

Flow Main 5.29
Flow Prime 7.1

Temp Main 93.0
Temp Prime 57.5

Temp Main 82.1
Temp Prime 94.4

Temp Main 6.8
Temp Prime 57.8

MAIN

\[ \frac{Q_{BA}}{103 - 56.3} = 2.54 \text{ Btu/sec} \]

\[ \frac{Q_{PRIME}}{103 - 71.9} = 1.16 \text{ Btu/sec} \]

\[ Q_{total} = 12.574 \text{ Btu/sec} \]

\[ \Delta P = \frac{Q_{BA}}{103 - 56.3} \]

\[ \Delta P_{4+2} = 49.3 \]

Temp Main 20.6
Temp Prime 22.4

Tout Main 56.3
Tout Prime 71.7

Tout Mixed: n and Prime 56.6

A-24
CONFIGURATION a

TEST POINTS 9

WEEK 1

TEST TIME 38 hr

TOTAL FLOW 1100 l/h

SIMULATED HEAT LOAD 42,000

ENVIRONMENT SIMULATES SUN ON CAVITY

Flow Main 248

Flow Prime 301

Flow Main 248

Flow Prime 302

Panel 1

ΔP1 1.5# / 6.3#

Panel 3

ΔP3 1.1# / 5.8#

Panel 4

ΔP4 1.1# / 5.8#

Panel 5

ΔP5 1.4# / 6.3#

Panel 7

ΔP7 1.1# / 5.8#

Panel 8

ΔP8 1.1# / 5.8#

Panel 6

ΔP6 1.4# / 6.3#

MAIN 49.5 (116.2 + 49.8) / 247.6 11.6

FLOW X (Tin - Tout) x Cp at = Qref

Tavg

PRIME 604 (114.2 - 104.9) / 364.1 18.01

FLOW X (Tin - Tout) x Cp at = Qref

Tavg

49.20

Qtotal

Tin Main 116.2

Tin Prime 116.2

Flow Main 495

Flow Prime 604

Temp Main 34.6

Temp Prime 113.3

Temp Main 8.9

Temp Prime 110.4

Temp Main 35.2

Temp Prime 113.3

Temp Main 8.5

Temp Prime 110.4

Temp Main 33.4

Temp Prime 110.4

Temp Main 49.7

Temp Prime 104.9

Temp Main 49.7

Temp Prime 104.9

Tout Main 49.8

Tout Prime 104.9

Temp Mixed Prime and Main 39.4
CONFIGURATION α

**TEST POINTS 10**

**WEEK** 1

**TEST TIME 42 h$$\frac{1}{4}$$**

**TOTAL FLOW 1100.16 l/h**

**SIMULATED HEAT LOAD 70,000**

**ENVIRONMENT SIMULATES SUN ON CAVITY**

Flow Main 348
Flow Prime 200

**Flow Main 350**

**Flow Prime 201**

**Panel 1**

Temp Main 37.3
Temp Prime 156.8

**Panel 5**

Temp Main 74.7
Temp Prime 156.8

**Panel 3**

ΔP1 3.1\(\text{W}^2\)
3.9\text{A}

ΔP5 3.1\(\text{W}^2\)
3.6\text{P}

**Panel 7**

Temp Main 26.8
Temp Prime 154.5

**Panel 4**

ΔP3 2.5\(\text{W}^2\)
2.7\text{P}

ΔP8 2.2\(\text{W}^2\)
2.7\text{P}

**Panel 8**

Temp Main -5.6
Temp Prime 146.2

**Panel 2**

Temp Main 27.8
Temp Prime 141.1

ΔP2 2.7\(\text{W}^2\)
2.7\text{P}

ΔP6 2.2\(\text{W}^2\)
2.7\text{P}

**Panel 6**

Temp Main -27.4
Temp Prime 141.1

**Flow Main**

698 \((162.4 + 27.4)\) l / h

**Flow Prime**

401 \((162.4 - 141.1)\) l / h

\[ \frac{\text{Flow} \times (\text{Tin} - \text{Tout}) \times \text{Cp at} \times \text{Qref}}{\text{Tavg}} \]

\[ \frac{355.29}{\text{Total}} \]

\[ \text{Temp Mixed Prime and Main} 40.2 \]
CONFIGURATION B

TEST POINTS  12

WEEK 1
TEST TIME  5.4
TOTAL FLOW  1100
SIMULATED HEAT LOAD
ENVIRONMENT SIMULATES
SUN ON OPPOSITE CAVITY

Tin Main  26.8
Tin Prime  151.4

Flow Main  600
Flow Prime  499

Flow Main  308
Flow Prime  252

\( \Delta P_1 = 2.2 \text{ m} \)
\( \Delta P_5 = 1.9 \text{ m} \)

PANEL 1

Temp Main  -8.5
Temp Prime  147.2

PANEL 7

Temp Main  -32.4
Temp Prime  142.9

\( \Delta P_2 = \frac{1.9}{4.3} \text{ m} \)

PANEL 4

Temp Main  -45.5
Temp Prime  140.7

\( \Delta P_4 + 2 = 15.2 \text{ m} \)

PANEL 2

\( \Delta P_2 = \frac{1.9}{4.3} \text{ m} \)

Temp Main  -56.3
Temp Prime  138.5

\( \Delta P_4 + 2 = 32.8 \text{ m} \)

MAIN
FLOW \( x (T_{in} - T_{out}) \times C_p \) at \( T_{aveg} \)

\( Q_{total} \)

PRIME
FLOW \( x (T_{in} - T_{out}) \times C_p \) at \( T_{aveg} \)

\( Q_{total} \)
CONFIGURATION B
TEST POINTS 13

WEEK 1
TEST TIME 5:00
TOTAL FLOW 1029
SIMULATED HEAT LOAD 62.9
ENVIRONMENT SIMULATES SUN ON CAVITY

Flow Main 529
Flow Prime 35

ΔP1 6.4

Panel 1

Temp Main -2.8
Temp Prime 9.7

Panel 2

ΔP2 5.7

Temp Main -36.4
Temp Prime 25.7

Panel 3

ΔP3 5.1

Temp Main -35.7
Temp Prime 23.7

Panel 4

ΔP4

Main 1029 (8.5 - 365) 239 -11066
FLOW X (Tin - Tout) X Cp at = Qreq
Tavg

Prime 62.9 (110.4 - 88.9) 26 - 366
FLOW X (Tin - Tout) X Cp at = Qreq
Tavg

-10,680
Qtotal

Panel 5

ΔP5 5.7

Temp Main -24.5
Temp Prime 91.7

Panel 6

ΔP6

Temp Main -36.7
Temp Prime 25.3

Panel 7

ΔP7 5.7

Temp Main -36.7
Temp Prime 25.3

Flow Main 501
Flow Prime 34

ΔP6 5.7

A-29
WEEK 1
TEST TIME 62 k
TOTAL FLOW 2200 W/L
SIMULATED HEAT LOAD 70,000
ENVIRONMENT SIMULATES SUN ON ONE CASE

Flow Main 833
Flow Prime 259

Test Points 14

Configuration α

Temp Main -16.8
Temp Prime 142.2

ΔP1 12.8 M 7.4 P

Panel 1

Temp Main -25.9
Temp Prime 138.2

ΔP3 10.8 M 6.9 P

Panel 3

Temp Main 19.9
Temp Prime 138.6

ΔP4 10.2 M 6.9 P

Panel 4

Temp Main 55.5
Temp Prime 138.9

ΔP2 13.1 M 7.4 P

Panel 2

ΔP5 12.8 M 7.4 P

Temp Main -16.7
Temp Prime 142.2

Panel 5

ΔP7 10.4 M 6.9 P

Temp Main -25.7
Temp Prime 138.3

Panel 7

ΔP8 10.4 M 6.9 P

Temp Main -36.3
Temp Prime 134.2

Panel 8

ΔP6 12.3 M 7.4 P

Temp Main -45.5
Temp Prime 130.2

Panel 6

FLOW X (Tin - Tout) X Cp at = Qreq

Temp Mixed Prime and Main 39.7

FLOW X (Tin - Tout) X Cp at = Qreq

Tout Main 6.2
Tout Prime 134.6

-A30
CONFIGURATION a

WEEK 1
TEST TIME 62h
TOTAL FLOW 22001/h
SIMULATED HEAT LOAD 42,000
ENVIRONMENT SIMULATES SUN ON ONE CAVITY

Flow Main 625
Flow Prime 419

Flow Main 685
Flow Prime 419

Temp Main -45.6
Temp Prime 105.6

Temp Main -54.3
Temp Prime 104.5

Temp Main 116
Temp Prime 104.5

Temp Main 56.1
Temp Prime 105.3

Flow X (Tin - Tout) X Cp at = Qreq
Tavg

MAIN (33.6 + 2.9) .239 = 9477

PRIME (101.6 - 102.4) .361 = 946

Flow Mixed Prime and Main 39.4
WEEK 1
TEST TIME 13.5
TOTAL FLOW 92300
SIMULATED HEAT LOAD --
ENVIRONMENT SIMULATES SUN ON BILLY CYCLIC CAVITY
Flow Main 79.4
Flow Prime 1415

Tin Main 57.5
Tin Prime 53

Flow Main 143
Flow Prime 2232

Flow Main 94.6
Flow Prime 101.7

PANEL 1

Temp Main -54.4
Temp Prime 52.4

AP1 6.5

PANEL 5

Temp Main -48.8
Temp Prime 52.4

PANEL 3

Temp Main -79.6
Temp Prime 51.5

AP3 6.2

PANEL 7

Temp Main -81.5
Temp Prime 51.8

PANEL 4

Temp Main -17.1
Temp Prime 51.3

AP4 36.0

PANEL 8

Temp Main -87.2
Temp Prime 51.3

PANEL 2

Temp Main -120.1
Temp Prime 50.7

AP2 40.5

PANEL 6

Temp Main -81.2
Temp Prime 50.6

MAIN (6.3 (53 + 100.2) + 136.5853)
FLOW X (Tin - Tout) X Cp at = Qreq
Tavg

PRIME (63 - 50.7) x 246 1150
FLOW X (Tir. - Tout) X Cp at = Qreq
Tavg

70.4 3
Qtotal

Tout Main -160.2
Tout Prime 50.7

Temp Mixed Prime and Main 40.2

A-32
CONFIGURATION α

TEST POINTS (HIGH MAIN OUTLET)

WEEK 1ST
TEST TIME 7:35
TOTAL FLOW 230°C
SIMULATED HEAT LOAD |
ENVIRONMENT SIMULATES SUN ON CAVITY
Flow Main 767
Flow Prime 1015

Flow Main 87.6
Flow Prime 1015

Flow Main 163
Flow Prime 2032

Flow Main
Flow Prime

Tin Main 53
Tin Prime 53

ΔP1 60.5
ΔP5 60.4

ΔP2 60.5
ΔP6 60.3

ΔP3 56.2
ΔP7 56.1

ΔP4 56.0
ΔP8 56.0

Temp Main
Temp Prime

-54.4
-52.4

-91.8
-51.8

-126.2
-51.2

-131.4
-50.6

ΔP
ΔP

Tout Main
Tout Prime

-97.8
-50.7

ΔQ
ΔQ

6451

Flow X (Tin - Tout) X C p at = Qreq
Tavg

Flow X (Tin - Tout) X C p at = Qreq
Tavg

Temps Mixed Prime and Main 40.4

PANEL 1
PANEL 5

PANEL 2
PANEL 6

PANEL 3
PANEL 7

PANEL 4
PANEL 8

A-33
WEEK 1
TEST POINTS 17

TEST TIME 604
TOTAL FLOW 1100
SIMULATED HEAT LOAD 7000
ENVIRONMENT SIMULATES SUN ON BELLY

Flow Main 27.7
Flow Prime 52.1

Flows

Main: 56 (53 + 124.7)
Flow x (Tin - Tout) x Cp at = Qreq/Tavg

Prime: 104.3 (53 - 48.4)
Flow x (Tin - Tout) x Cp at = Qreq/Tavg

TOTAL 351
Qtot

Temp Main -101.0
Temp Prime 51.8

Temp Main -121.0
Temp Prime 56.7

Temp Main -124.7
Temp Prime 44.7

Temp Main -124.7
Temp Prime 48.7

Temp Mixed Prime and Main 40.3

Panel 1

AP 1 P 120 P

Panel 2

AP 2 P 120 P

Panel 3

AP 3 P 15.6 P

Panel 4

AP 4 P 15.6 P

Panel 5

AP 5 P 15.6 P

Panel 6

AP 6 P 15.6 P

Panel 7

AP 7 P 15.6 P

Panel 8

AP 8 P 15.6 P

Flow Main 28.1
Flow Prime 53.2

A-34
CONFIGURATION a
TEST POINTS 19

WEEK 1
TEST: 2/4
TOTAL LOAD 2200
SIMULATED HEAT LOAD 70 K
ENVIRONMENT SIMULATES SUN ON CAREDAY
Flow In 1462
Flow Prime 126

PANEL 1
Temp Main 84.3
Temp Prime 14.7

PANEL 3
Temp Main 85.6
Temp Prime 101.6

PANEL 4
Temp Main 56.6
Temp Prime 113.3

PANEL 2
Temp Main 51.3
Temp Prime 11.3

PANEL 5
Tin Main 98.0
Tin Prime 116.0
Flow Main 271
Flow Prime 25.2

PANEL 7
Temp Main 44.6
Temp Prime 12.6

PANEL 8
Temp Main 61.0
Temp Prime 24.5

FLOW • (Tin - Tout) • C_P at = Qreq
Tavg
FAHM 25.2 (1161.58.4) 257.323
FLOW • (Tin - Tout) • C_P at = Qreq
Tavg
29573
Q TOTAL

MAIN 2171 (98-44.2) 25 2200

Tout Main 44.2
Tout Prime 58.4
Temp Mixed Prime and Main 44.3
CONFIGURATION α

TEST POINTS 19-2

WEEK 1
TEST TIME 9.0 (High Mass Test)
TOTAL FLOW 2206
SIMULATED HEAT LOAD 20k
ENVIRONMENT SIMULATES SUN ON CARGO DAY

Flow Main 104.4
Flow Prime 12.5

PANEL 1

Temp Main 93.3
Temp Prime 124

PANEL 3

Temp Main 84.6
Temp Prime 101.6

PANEL 4

Temp Main 61.2
Temp Prime 71.3

PANEL 2

Temp Main 37.8
Temp Prime 56.6

PANEL 5

Temp Main 93.3
Temp Prime 107.7

PANEL 7

Temp Main 55.6
Temp Prime 101.6

PANEL 8

Temp Main 72.5
Temp Prime 81.1

PANEL 6

Temp Main 58.0
Temp Prime 59.8

FLOW X (Tin - Tout) X Cp at = Qreq

Tavg

Tavg

PRIME 25.2 (116 - 579) 357 376
FLOW X (Tin - Tout) X Cp at = Qreq
Tavg

27736
Qtotal

A-37
CONFIGURATION a

TEST POINTS 20-1

WEEK 1

TEST TIME 58.8 hr (low main pulled)

TOTAL FLOW 2200

SIMULATED HEAT LOAD 52.7 K

ENVIRONMENT SIMULATES SUN ON CARGO BAY

Flow Main 106.2
Flow Prime 12.6

PANEL 1

Temp Main 69.4
Temp Prime 88.1

ΔP1 26.4

PANEL 3

Temp Main 56.5
Temp Prime 55.5

ΔP3 21.5

PANEL 4

Temp Main 45.6
Temp Prime 23.7

ΔP4 21.1

PANEL 2

ΔP2 23.5

PANEL 5

ΔP5 26.2

ΔP7 21.1

Temp Main 56.5
Temp Prime 95.4

PANEL 6

Temp Main 36.7
Temp Prime 52.9

ΔP6 23.8

Tout Main 42.4
Tout Prime 54.5

Temp Mixed Prime and Main 42.5

Q total 2793
CONFIGURATION α

TEST POINTS 20-2

WEEK 1
TEST TIME 94.5 hr (high max intake)
TOTAL FLOW 2200
SIMULATED HEAT LOAD 52.7 K
ENVIRONMENT SIMULATES SUN ON CAR 40 BAY
Flow Main 164.4
Flow Prime 12.5

Flow Main
93.0
Flow Prime
106.0
Flow Main
2171
Flow Prime
25.2
Flow Main
16.7
Flow Prime
12.7

Temp Main
89.4
Temp Prime
40.1
ΔP1 24.9

Temp Main
86.5
Temp Prime
95.5
ΔP3 21.5

Temp Main
59.2
Temp Prime
20.1
ΔP4 21.1

Temp Main
36.1
Temp Prime
51.4
ΔP2 26.5

ΔP6 25.8

Tavg

FLOW X (Tin - Tout) X Cp ac = Qreq

Tavg

FLOW X (Tin - Tout) X Cp ac = Qreq

Temp Mixed Prime and Main
45.8

A-39
WEEK 2nd
TEST TIME 4
TOTAL FLOW 2500
SIMULATED HEAT LOAD 10K
ENVIRONMENT SIMULATES SUN ON CARGO BAY

CONFIGURATION Y
TEST POINTS 2

Tin Main 167.4
Tin Prime 163.9
Flow Main 2173
Flow Prime 22.8

Flow Main 98.6
Flow Prime 10.3

Flow Main 49.3
Flow Prime 5.16

Flow Main 49.3
Flow Prime 5.18

Flow Main 594
Flow Prime 6

Flow Main 573
Flow Prime 6

Flow Main
Flow Prime

Panel 1 ΔP1 6
Temp Main 101
Temp Prime 125

Panel 2 ΔP2 6
Temp Main 101
Temp Prime 125

Panel 3 ΔP3 4.7
Temp Main 70
Temp Prime 94

Panel 4 ΔP4 4.7
Temp Main 70
Temp Prime 95

Panel 5 ΔP5 2.4
Temp Main 108
Temp Prime 132

Panel 6 ΔP6 2.4
Temp Main 137
Temp Prime 132

Panel 7 ΔP7 6.1
Temp Main 107
Temp Prime 107

Panel 8 ΔP8 6.7
Temp Main 117
Temp Prime 117

Temp Main
Temp Prime

Tout Main 74
Tout Prime 99
Tout Mixed Main and Prime 114

FLOW X (Tin - Tout) X Cp at = Qreq
Tavg

FLOW X (Tin - Tout) X Cp at = Qreq
Tavg

51.6678
(total)
WEEK 2nd
TEST TIME 9.25
TOTAL FLOW 2866
SIMULATED HEAT LOAD 10K
ENVIRONMENT SIMULATES SUN ON SPRING DAY (CYCLIC)

CONFIGURATION Y
TEST POINTS 22 LOW MAIN

MAIN
FLOW X (Tin - Tout) x Cp at = Qreq
Tavg

Tin Main 18.2
Tin Prime 16.7

Flow Main 273
Flow Prime 22.8

Flow Main

Flow Prime

Flow Main 185
Flow Prime 10.3

Flow Main 492
Flow Prime 5.3

Flow Main 492
Flow Prime 5.3

Panel 2 ΔP2 6.1

Panel 3 ΔP3 4.7

Panel 4 ΔP4 4.7

Panel 5 ΔP5 8.5

Panel 6 ΔP6 7.8

Panel 7 ΔP7 6.7

Panel 8 ΔP8 6.7

Temp Main 100.1
Temp Prime 125.1

Temp Main 18.4
Temp Prime 26.6

Temp Main 65.6
Temp Prime 65.6

Temp Main 65.5
Temp Prime 65.5

Temp Main 65.4
Temp Prime 65.4

Temp Main 65.4
Temp Prime 65.4

Temp Main 65.4
Temp Prime 65.4

Temp Main 65.4
Temp Prime 65.4

Temp Main 65.4
Temp Prime 65.4

Temp Main 65.4
Temp Prime 65.4

Temp Main 65.4
Temp Prime 65.4

Temp Main 65.4
Temp Prime 65.4

Tout Main 66.8
Tout Prime 79.5
Tout Mixed Main and Prime 67.1
WEEK 3
TEST TIME 11.: HIGH MAIN OUTLET
TOTAL FLOW 28°C
SIMULATED HEAT LOAD 57.7 K
ENVIRONMENT SIMULATES SUN ON CARGO BAY (CYCLIC FLIGHT)

CONFIGURATION Y
TEST POINTS 13. - 2

Flow Main 12.7
Flow Prime 10.3

Flow Main 493
Flow Prime 51

Panel 1 ΔP1 6.0
Temp Main 83.2
Temp Prime 19.6

Panel 3 ΔP3 4.7
Temp Main 52.8
Temp Prime 30.4

Panel 2 ΔP2 6.0
Temp Main 52.3
Temp Prime 30.7

Panel 4 ΔP4 4.7
Temp Main 52.5
Temp Prime 30.6

Panel 5 ΔP5 8.4
Temp Main 28.7
Temp Prime 15.1

Panel 7 ΔP7 0.7
Temp Main 14.4
Temp Prime 24.4

Panel 6 ΔP6 8.4
Temp Main 33.6
Temp Prime 14.6

Temp Main 52.1
Temp Prime 31.1

Tout Main 14.1
Tout Prime 24.1
Tout Mixed Main and Prime 24.1

FLOW X (Tin - Tout) X Cp at = qrej Tav
PRIME: 0.8(4.9 - 2.1) - 2638 = 327.8
FLOW X (Tin - Tout) X Cp at = qrej Tav
44,363.2
(Total)
Flow Main 680
Flow Prime 335

Flow Main 39.5
Flow Prime 161.6

PANEL 1 $\Delta p_1 = 2.9$
Temp Main 42.2
Temp Prime 153

PANEL 2 $\Delta p_2 = 2.9$
Temp Main 45.4
Temp Prime 153

PANEL 3 $\Delta p_3 = 1.5$
Temp Main -17.2
Temp Prime 143

PANEL 4 $\Delta p_4 = 2.5$
Temp Main 143
Temp Prime 143

PANEL 5 $\Delta p_5 = 4.1$
Temp Main 48.1
Temp Prime 153.1

PANEL 6 $\Delta p_6 = 4.1$
Temp Main 48.0
Temp Prime 153.0

PANEL 7 $\Delta p_7 = 2.0$
Temp Main -13.7
Temp Prime 143.4

PANEL 8 $\Delta p_8 = 2.0$
Temp Main -13.5
Temp Prime 143.5

Tout Main 11.4
Tout Prime 14.7

Tout Mixed Main and Prime 16.3

Flow Main 1499
Flow Prime 695

CONFIGURATION Y
TEST POINTS 30 - 31

MAIN $\frac{1499(1634 - (-159))}{2525} = \frac{-flow (T_{in} - Tout) \times Cp at = Q_{req}}{Tavg}$

PRIME $\frac{98(1474 - 1422)}{2807} = 395%$
FLOW X (T_{in} - Tout) \times Cp at = Q_{req} Tavg

$\frac{74256}{total}$
WEEK 2:5
TEST TIME 47.999 HIGH MAIN OR PUMP TEST POINTS 30-2
TOTAL FLOW 2.02
SIMULATED HEAT LOAD 9.967
ENVIRONMENT SIMULATES SUN ON BELLY (CYCLIC CAVITY)

Flow Main 68.1
Flow Prime 3.83

Flow Main 340.4
Flow Prime 16.77

PANEL 1 ΔP1 2.7
Temp Main 36.1
Temp Prime 16.14

PANEL 2 ΔP2 2.9
Temp Main 36.0
Temp Prime 16.14

PANEL 3 ΔP3 2.0
Temp Main -27.2
Temp Prime 141

PANEL 4 ΔP4 2.9
Temp Main -27.1
Temp Prime 141

PANEL 5 ΔP5 4.1
Temp Main 53.7
Temp Prime 152.6

PANEL 6 ΔP6 4.1
Temp Main 53.6
Temp Prime 152.6

PANEL 7 ΔP7 3.2
Temp Main -4.4
Temp Prime 143.2

PANEL 8 ΔP8 3.3
Temp Main -4.5
Temp Prime 143.2

Temp Main -27
Temp Prime 141

Tout Main -14.7
Tout Prime 140.0

Tout Mixed Main and Prime 46.6
WEEK 3
TEST TIME 32 hrs
TOTAL FLOW 6,000 lb/h
SIMULATED HEAT LOAD 31,000 Btu/h
ENVIRONMENT SIMULATES SUN ON CARGEU
WEEK 3
TEST TIME 3:00 AM
TOTAL FLOW 2000 L/hr
SIMULATED HEAT LOAD 2000
ENVIRONMENT SIMULATES SUN ON 45° TO CALL ORB ZKB SHADOWED

CONFIGURATION
TEST POINTS 37

MAIN
FLOW X (Tin - Tout) x Cp at = Qreq
Tavg

PRIME
FLOW X (Tin - Tout) x Cp at = Qreq
Tavg

Flow Main 515
Flow Prime 508

Flow Main 256
Flow Prime 254

Flow Main 256
Flow Prime 254

Flow Main 313
Flow Prime 274

Flow Main 312
Flow Prime 274

Flow Main 313
Flow Prime 274

Flow Main 312
Flow Prime 274

Panel 1
ΔP 1.6 M
4.4 P

Temp Main 53.1
Temp Prime 53.0

Panel 2
ΔP 2.4 M
4.1 P

Temp Main 53.1
Temp Prime 53.0

Panel 3
ΔP 1.2 M
4.1 P

Temp Main 53.1
Temp Prime 53.0

Panel 4
ΔP 1.2 M
4.1 P

Temp Main 53.1
Temp Prime 53.0

Panel 5
ΔP 2.4 M
5.1 P

Temp Main 53.0
Temp Prime 53.0

Panel 6
ΔP 2.4 M
5.1 P

Temp Main 53.0
Temp Prime 53.0

Panel 7
ΔP 1.2 M
4.1 P

Temp Main 53.1
Temp Prime 53.0

Panel 8
ΔP 1.2 M
4.1 P

Temp Main 53.1
Temp Prime 53.0

Tout Main 27.3
Tout Prime 52.0
Tout Mixed Main and Prime 39.3
WEEK 3

TEST TIME 22
TOTAL FLOW 2,300 m³/h
SIMULATED HEAT LOAD 7,000
ENVIRONMENT SIMULATES SUN ON BELLY

CONFIGURATION Y

TEST POINTS

MAIN
FLOW x (Tin - Tout) x Cp at = Qreq
Tavg

PRIME
FLOW x (Tin - Tout) x Cp at = Qreq
Tavg

Flow Main 66
Flow Prime 461

Flow Main 34
Flow Prime 491

Panel 1 ΔP1 15.2 P
Temp Main -118.2
Temp Prime 564

Panel 2 ΔP2 15.2 P
Temp Main -118.2
Temp Prime 564

Panel 3 ΔP3 14.1 P
Temp Main -118.2
Temp Prime 564

Panel 4 ΔP4 14.1 P
Temp Main -118.2
Temp Prime 564

Panel 5 ΔP5 13.5 P
Temp Main -118.2
Temp Prime 564

Panel 6 ΔP6 12.5 P
Temp Main -118.2
Temp Prime 564

Panel 7 ΔP7 16.2 P
Temp Main -118.2
Temp Prime 564

Panel 8 ΔP8 16.2 P
Temp Main -118.2
Temp Prime 564

Flow Main 44
Flow Prime 530

Flow Main 44
Flow Prime 529

Tout Main -115.2
Tout Prime 50.7
Tout Mixed Main and Prime 39.2
CONFIGURATION e
TEST POINTS 45

Flow Main 2/24
Flow Prime 42

Flow Main 946
Flow Prime 97

Flow Main 32
Flow Prime 3.2

Flow Main 34.5
Flow Prime 3.1

Flow Main 26.6
Flow Prime 3.6

Flow Main 20.1
Flow Prime 3.7

Flow Main 22.1
Flow Prime 3.7

Flow Main 91
Flow Prime 94

Flow Main 53
Flow Prime 54

Flow Main 91
Flow Prime 53

Flow Main 92
Flow Prime 52

Flow Main 93
Flow Prime 52

Flow Main 94
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Flow Main 90
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Flow Main 100
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Flow Main 240
Flow Prime 200