Technical Document

INSTALLATION DESIGN CALCULATIONS
USER'S GUIDE

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INSTALLATION DESIGN CALCULATIONS
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INSTALLATION DESIGN CALCULATIONS – USER'S GUIDE

1.0 INTRODUCTION

The *Installation Design Calculation* software (Allison Calc) is an engineering tool. Use Allison Calc to quickly make the following calculations:

- Multiple Joint Driveline Analysis
- Cooling Analyses
  - Oil-to-Water (OTW)
  - Oil-to-Air (OTA)
  - Combination OTW and OTA Systems
- Hose and Fitting Pressure Drop Analysis

The technical background for the driveline calculations can be found in the following documents:

- *Basic Driveline Design*
- *Driveline Design – Special Cases*

The technical background for the cooling and pressure drop calculations can be found in the following documents:

- *Transmission Cooling – Basic*
- *Transmission Cooling – Retarder*
- *Technical Document (TD) 157, Transmission Cooling Tests*

This software is a companion tool to the technical data, replacing the required hand calculations.

The Installation Design Calculations do not check for valid input data. If a calculation does not seem to work or the results are questionable, redo the calculation, making certain that all input data is correct.

NOTE: Allison Transmission does not assume responsibility or liability of any nature for the use made of this software and the calculations contained therein.

Every effort has been made to ensure completeness and accuracy of all calculations. If errors or discrepancies are encountered, please notify Allison Application Engineering, Indianapolis.

2.0 REFERENCED DOCUMENTS

Unless otherwise noted, all documents referenced in this document may be found in the Extranet channel of the Allison Transmission website, *www.allisontransmission.com*. To locate the referenced documents, which are identified by *italic* font, look for Tech Data under the Engineering heading on the Extranet home page. Contact your Allison Transmission representative if you do not have access to the Allison Transmission Extranet. A list of all items referenced in this document can be found at the end of this document.

3.0 OPENING MENU AND GENERAL INSTRUCTIONS

3.1 OPENING MENU

As shown in Figure 3-1, the opening screen contains the menu of available programs:

- Multiple Joint Driveline Analysis
- Oil-to-Water (OTW) Cooling Analysis
- Oil-to-Air (OTA) Cooling Analysis
- OTW and OTA Combination Cooling Analysis
- Hose and Fitting Pressure Drop Analysis

Select the desired analysis. The input screen for the chosen analysis will appear.

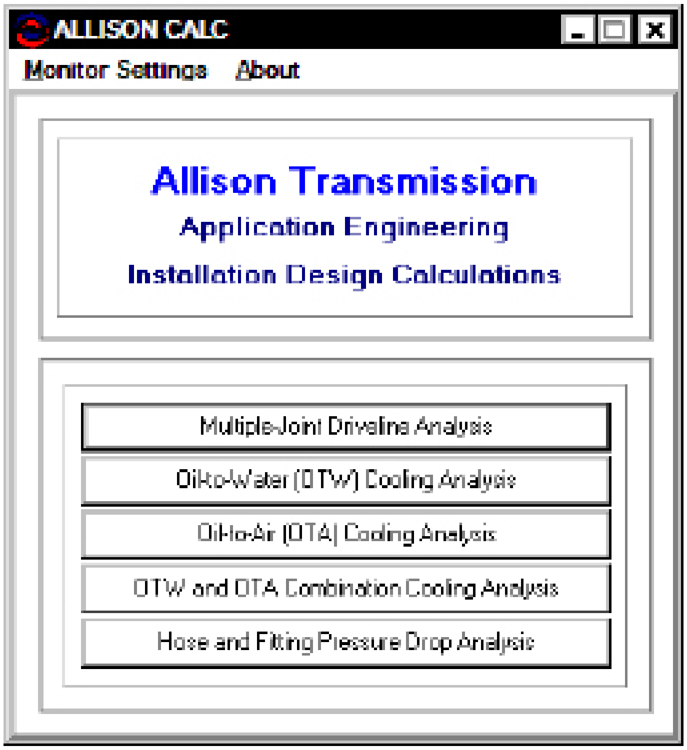


Figure 3-1: Opening Menu Screen

3.2 COMMON BUTTONS

The command buttons described below are common to all of the analyses.

- **Back**: returns to previous screen without clearing the data
- **Calculate**: calculates data and displays the results screen
- **Clear**: clears the data on the current screen
- **Continue**: advances to the next screen
- **Done**: returns to the first input screen of the current analysis and clears the data
- **End**: closes the program. On the last screen of each analysis it returns to the opening menu.
- **File**: Opens a dialog box for saving the output to a file. The default file type is text (filename.txt).
- **Menu**: Returns to the opening menu screen.
- **OK**: advances to next screen
- **Print**: Opens a dialog box for sending the output to a printer. Can not be used for printing to a file. Use the file command to print to a file.

4.0 MULTIPLE JOINT DRIVELINE ANALYSIS

Allison Calc assumes that the user is familiar with driveline design. Refer to *Basic Driveline Design* for a technical discussion of how driveline design and installation affects the transmission.

4.1 DESCRIPTION OF CALCULATIONS

Allison Calc calculates angular accelerations resulting from a vehicle drivetrain with Cardan universal joints operating at angles. The resulting accelerations are checked against Allison Transmission limits for satisfactory driveline and transmission operation. In addition to the accelerations, joint coordinates are provided to assist in driveline design.

Three driveline configurations are covered:

- **Output Driveline Without Propshaft-Mounted Driveline Retarder**. This is the typical vehicle driveline. The driveline consists of multiple shafts and joints connecting the transmission and the axle.
- **Output Driveline With Propshaft-Mounted Driveline Retarder**. This is a special case driveline. A retarding device, or another large inertia source, is attached to a propshaft between the transmission and axle. This is **not** an Allison output retarder which is integral to the transmission.

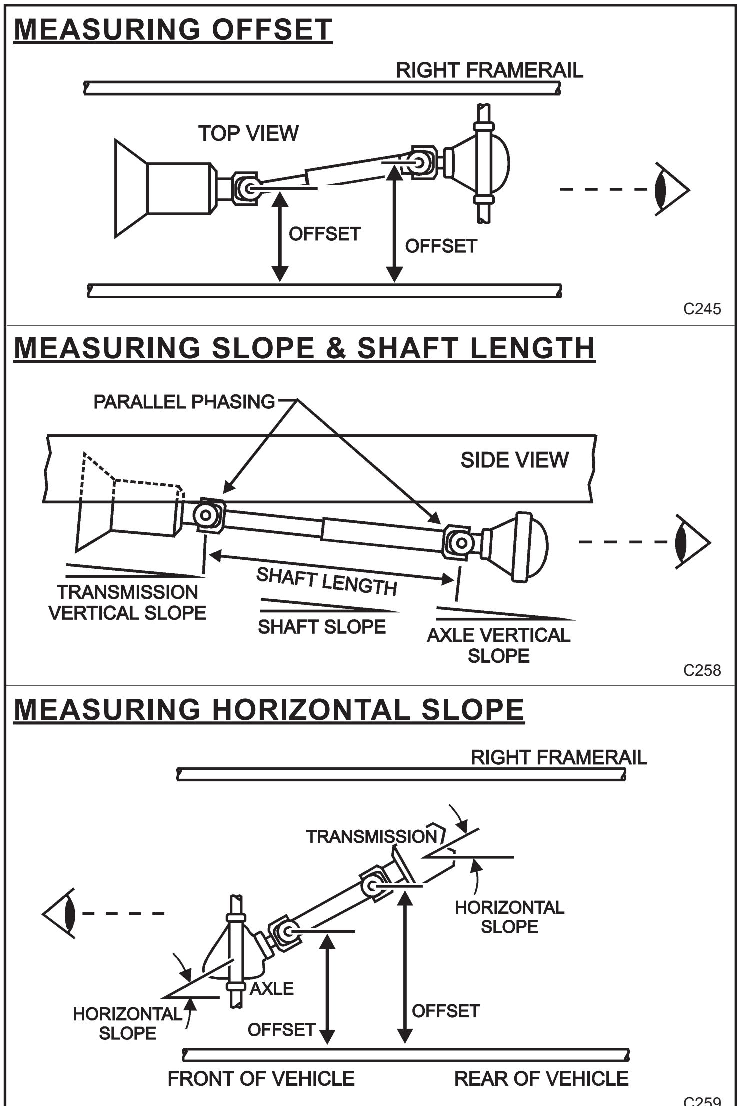
- **Input Driveline Between Engine and Transmission**. This is the typical arrangement for a remote-mounted transmission. The driveline consists of shafts and joints between the engine and the transmission input. Remote-mounted transmissions may be found in some off-highway vehicles.

Since the majority of analyses will be for the output driveline without a propshaft-mounted retarder, the discussion and example concentrate on this configuration. The two special cases are covered briefly.

4.2 INPUT DATA

Figure 4-1 illustrates the various input parameters required for the typical output driveline. Angles and dimensions are obtained either from engineering layout drawings or actual vehicle measurements. The Multiple Joint Driveline Analysis has two input screens. When all data has been entered on the initial screen, select **OK** for the second input screen to appear. The input parameters are described as follows:

- **Title or Comments** (optional) – Enter information that describes the vehicle and driveline. Two lines are provided. This entry is optional.
- **Input Data** – Select U.S. units or SI Metric units.
- **Output Data** – Select U.S. units or SI Metric units.
- **Analyst Name** (optional) – Enter name of the user. This entry is optional.
- **Type of Driveline** – Select type of driveline to be analyzed.
- **Number of Joints** – Enter the number of joints in the driveline. The minimum number of joints is 2, the maximum number of joints is 8.
- **Transmission Output rpm** – enter the transmission output speed which is the same as driveline speed for an output driveline. This value can be obtained from iSCAAN or calculated. If calculated, be sure to account for transmission overdrive ratios, if used.
- **Vertical Slope (degrees)**
  - **Transmission** – Enter the vertical slope of the transmission as viewed from the side, (Figure 4-1). If applicable, a negative slope (-) may be entered.
  - **Axle** – Enter the vertical slope of the



The positions right, left, front and rear are always based on a view looking from behind the rear axle toward the engine/transmission.

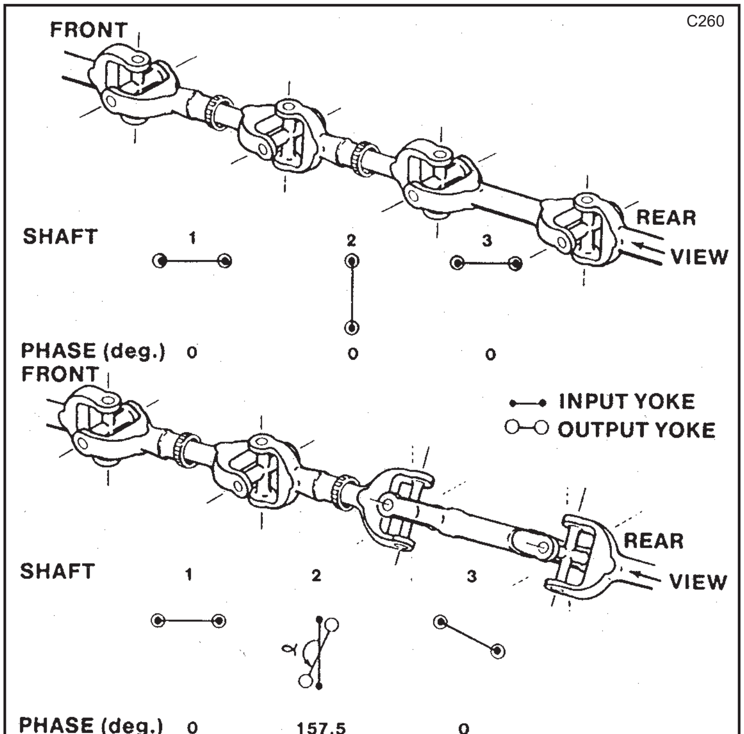
The sign of the vertical slope is determined by
positive (+) if front of component is higher than rear
negative (-) if front of component is lower than rear

The sign of the horizontal slope is determined by
positive (+) if end nearest engine is closer to left frame rail
negative (-) if end nearest engine is closer to right frame rail

Figure 4-1: Driveline Parameters

axle as viewed from the side (Figure 4-1).

- **Horizontal Slope (degrees)**
  - **Transmission** – Enter the angle formed by the centerline of the transmission and the centerline of the frame rail, when viewed from above. This assumes that the frame rails are parallel to each other. If the transmission and frame centerlines are parallel, enter zero (0). See Figure 4-1. This parameter is typically used for a V-drive transmission which is not parallel to the frame rails. If applicable, a negative slope (-) may be entered.
  - **Axle** – Enter the angle formed by the centerline of the differential pinion and the centerline of the frame rails, when viewed from above. This assumes that the frame rails are parallel. See Figure 4-1. If the axle and frame centerlines are parallel, enter zero (0). If applicable, a negative slope (-) may be entered.
- **Shaft Slopes (degrees)** – Enter the vertical slopes of the shafts, as viewed from the side. The propshafts are numbered from the transmission to the axle. The first propshaft is the one attached to the transmission. If applicable, negative slopes may be entered.
- **Joint Offsets (inches or millimeters)** – Enter the distance from the center of the U-joint to the left frame rail. Reference Figure 4-1. This assumes the frame rails are parallel and do not have any offsets along the length from which the joint offsets are measured. These values can also be entered as relative offsets. Establish a centerline on the first joint and measure the offsets of the other joints relative to this centerline. For example, if the joints are all on the centerline, then enter zeros (0's) for all of the joint offsets.
- **Shaft Lengths (inches or millimeters)** – The distance from joint center to joint center of the yokes at each end of each shaft. Refer to Figure 4-1.
- **Shaft Phases (degrees)** – This input defines any mis-phasing of the yokes. The yokes on a properly assembled shaft are parallel, or in the same plane. When looking down the shaft the yokes are in-line. A mis-phased shaft will have one yoke rotated from the parallel position. Figure 4-2 illustrates shaft phasing and proper measurement. Shaft phase is measured counterclockwise and is always entered as a positive value between 0 and 180 degrees.



Shaft phase is measured counter-clockwise, 0º < a < 180º, and is always entered as a positive value.

Figure 4-2: Shaft Phases

4.3 RESULTS

The first output screen is a summary of the input data. The second output screen is a tabulation of the results and a tabulation of the joint coordinates. The results tabulation includes:

- calculated effective angles
- angular accelerations
- Allison Transmission's acceleration limits
  - "OK" if within Allison Transmissions's limits
  - "Over Max Limit" if Allison's limits are exceeded
- joint coordinate data for use when designing or redesigning a driveline

The output parameters are described below:

- **Torsional Acceleration (radians/sec^2)** – The non-uniform (accelerating and decelerating) motion which would exist at the input shaft of the axle if the transmission were turning uniformly. Torsional acceleration is the same regardless which end of the driveline rotates uniformly (drive or coast).
- **Inertial Accelerations – Drive and Coast (radians/sec^2)** – A measure of the peak acceleration of each propshaft imparted by the U-joint angles. Acceleration in the drive mode is determined from the front with the input to the driveline (transmission output) rotating uniformly. Acceleration in the coast mode is determined from the rear with the output of the driveline (input to the axle) rotating uniformly.
- **Effective Angle (degrees)** – The resultant effect of the multiple angles reduced to a single equivalent angle. In other words, a single joint operating at this angle produces the same output motion as the multiple joint driveline. An effective angle is determined for torsional, inertial drive and inertial coast conditions. The effective angles are intermediate results used to determine accelerations.
- **Acceleration Limits (radians/sec^2)** – Figures 4-3a and 4-3b list Allison's angular acceleration limits for the various driveline configurations.
- **X, Y, and Z Coordinates (inches or millimeters)** – These coordinates locate a joint in the three dimensional space used in the analysis:
  - X coordinate is along the horizontal axis, viewed from the side
  - Y coordinate is along the vertical axis, viewed from the side
  - Z coordinate is along the vertical axis, viewed from the top.
- **Joint Angle (degrees)** – The vertical (viewed from side), horizontal (viewed from top), and true or actual joint angle.

4.4 TYPICAL CASE: OUTPUT DRIVELINE

Figure 4-4 illustrates a typical 3-joint, 2-shaft output driveline and the parameters required for analysis. Collect the data before beginning the analysis. Worksheets

CHARACTERISTIC	MAXIMUM ACCEPTABLE (Radians / Sec^2)
Torsional Accelerations	
Entire driveline - all installations	500 max.
If installation has high inertia component:	
Transmission to component	100 max.
Component to axle	100 max.
Inertial Accelerations	
Design requirements	
Drive mode	1000 max.
Coast mode	1000 max.
As measured in vehicle	
Drive mode	1200 max.
Coast mode	1200 max.

Figure 4-3a: Torsional Vibration Acceptance Criteria - Output Driveline

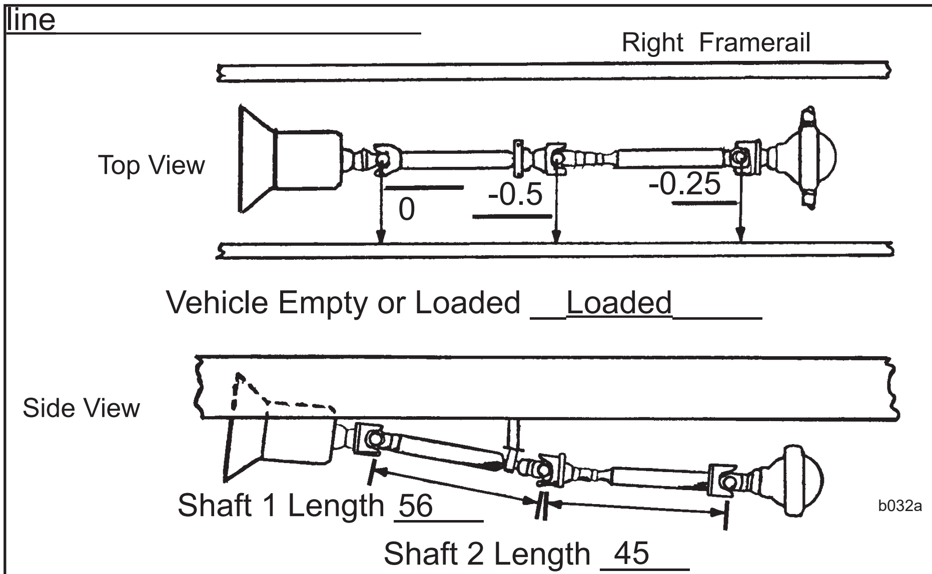
CHARACTERISTIC	MAXIMUM ACCEPTABLE (Radians / Sec^2)
Torsional Accelerations	
Input driveline - remote mount	100 max.
Inertial Accelerations	
Design requirements - 3000 rpm & above	
Drive mode	500 max.
Coast mode	500 max.
Design requirements - below 3000 rpm	
Inertial acceleration limits below 3000 rpm are based on a maximum recommended angle of 4 degrees. A limit is calculated using a 4 degree angle and the driveline speed and thus varies with speed.	

Figure 4-3b: Torsional Vibration Acceptance Criteria - Input Driveline

for various driveline configurations can be found in the *Transmission Installation Checklists* for each transmission Product Family.

This example is in U.S. units. The process is the same for metric units.

Figure 4-5a shows the data from the worksheet entered on the first input screen.



Vehicle Driveline Description: Sample Vehicle Sample 3-Joint Drive-

Number of Joints:	3
Transmission Output Speed:	3400 rpm
Transmission Vertical Slope:	4°
Axle Vertical Slope:	3°
Transmission Horizontal Slope:	0°
Axle Horizontal Slope:	0°
Shaft 1 Slope:	6°
Shaft 2 Slope:	1°
Joint 1 Offset:	0
Joint 2 Offset:	- 0.5 inch
Joint 3 Offset:	- 0.25 inch
Shaft 1 Length:	56 inches
Shaft 2 Length:	45 inches
Shaft 1 Phase:	0°
Shaft 2 Phase:	0°

Figure 4-4: Typical Three-Joint Driveline

Select **Calculate** to go to the second input screen.

Figure 4-5b shows the data from the worksheet entered on the second input screen. Note that the number of data boxes is based on the number of joints in the driveline, as specified on the first input screen.

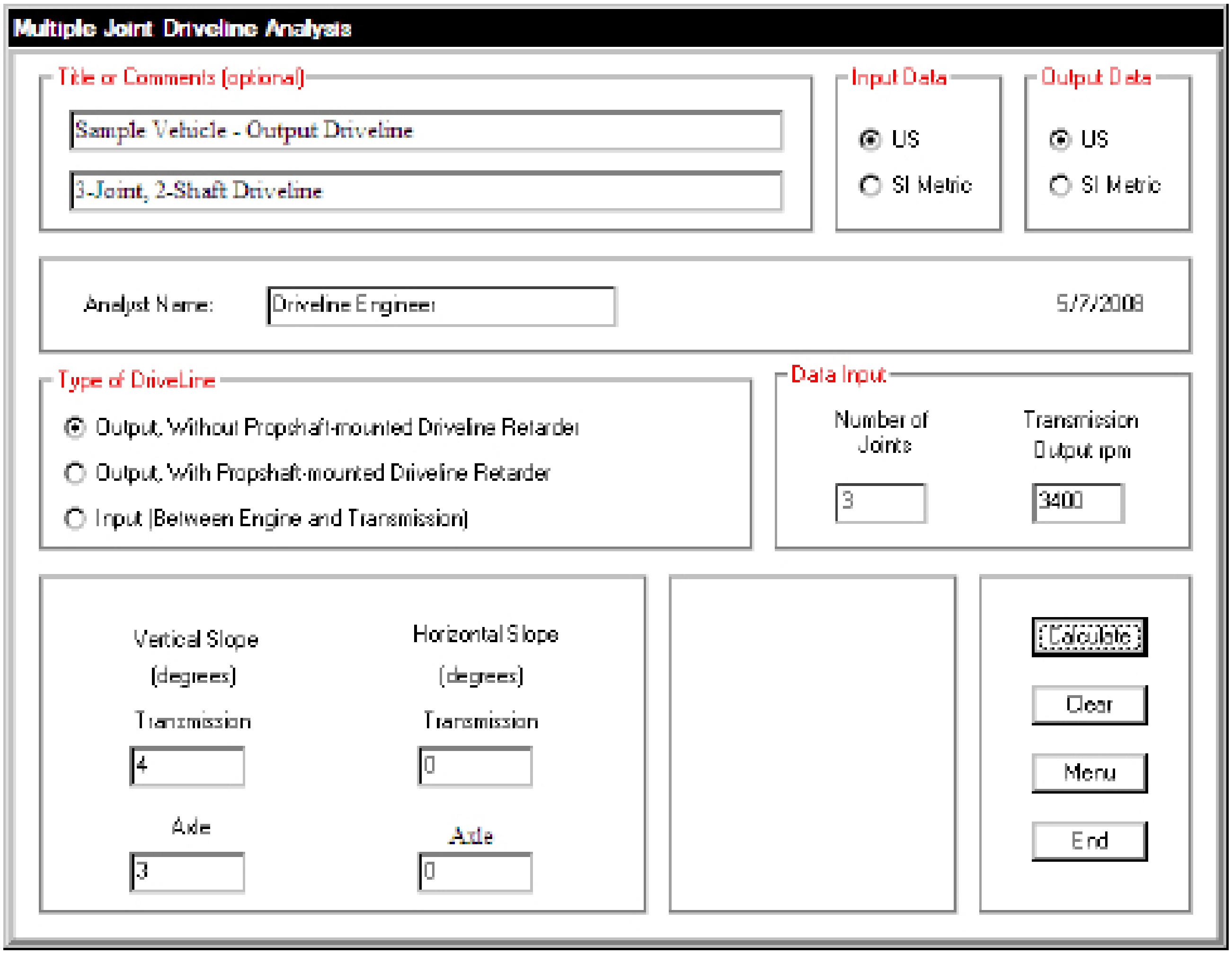


Figure 4-5a: Sample Driveline Input – First Screen

Select **OK** to display the first output screen.

Figure 4-6a shows the first output screen. This screen is a summary of the input data.

Select **Continue** to display the Results screen.

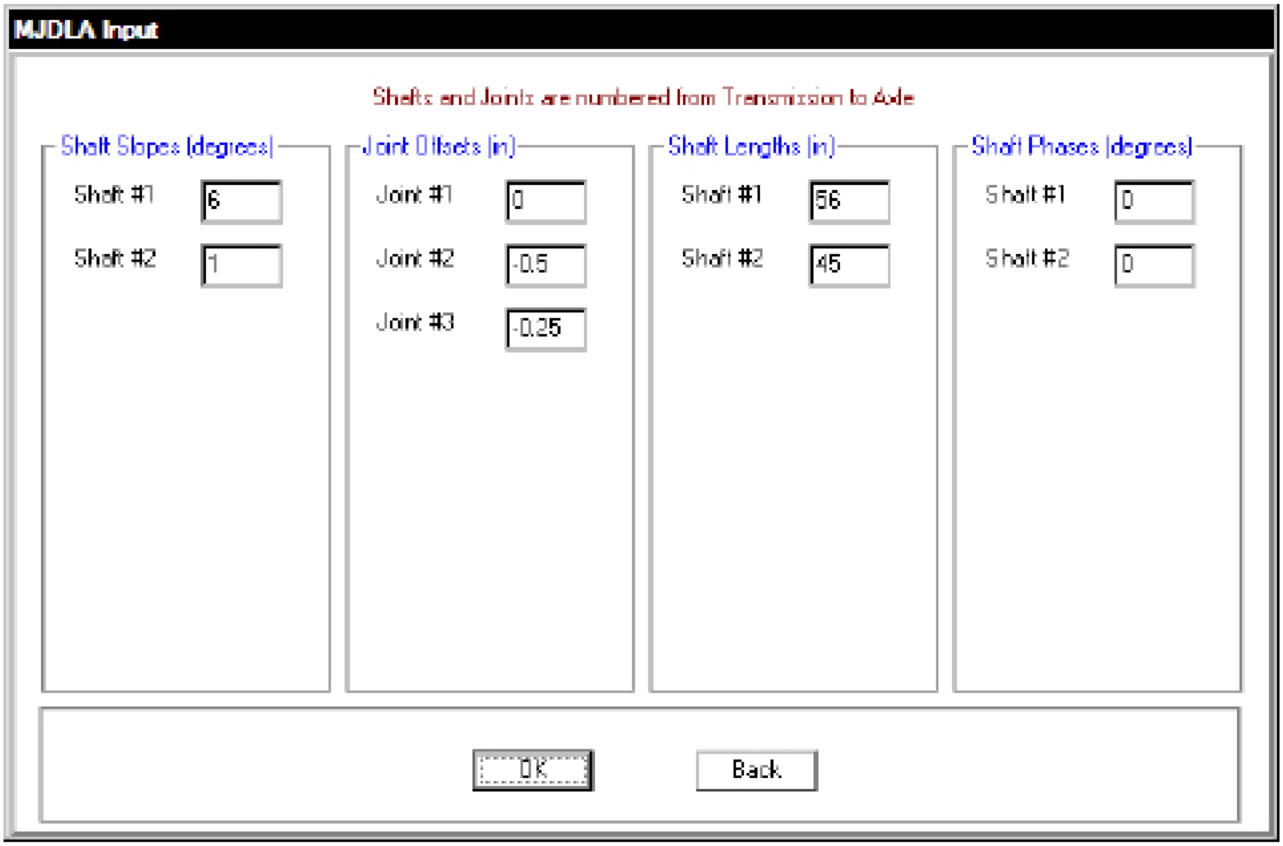


Figure 4-5b: Sample Driveline Input – Second Screen

Figure 4-6b shows the Driveline Analysis Results screen. The calculated accelerations are checked against Allison Transmission's limits and labeled as follows:

• OK if within Allison's limits

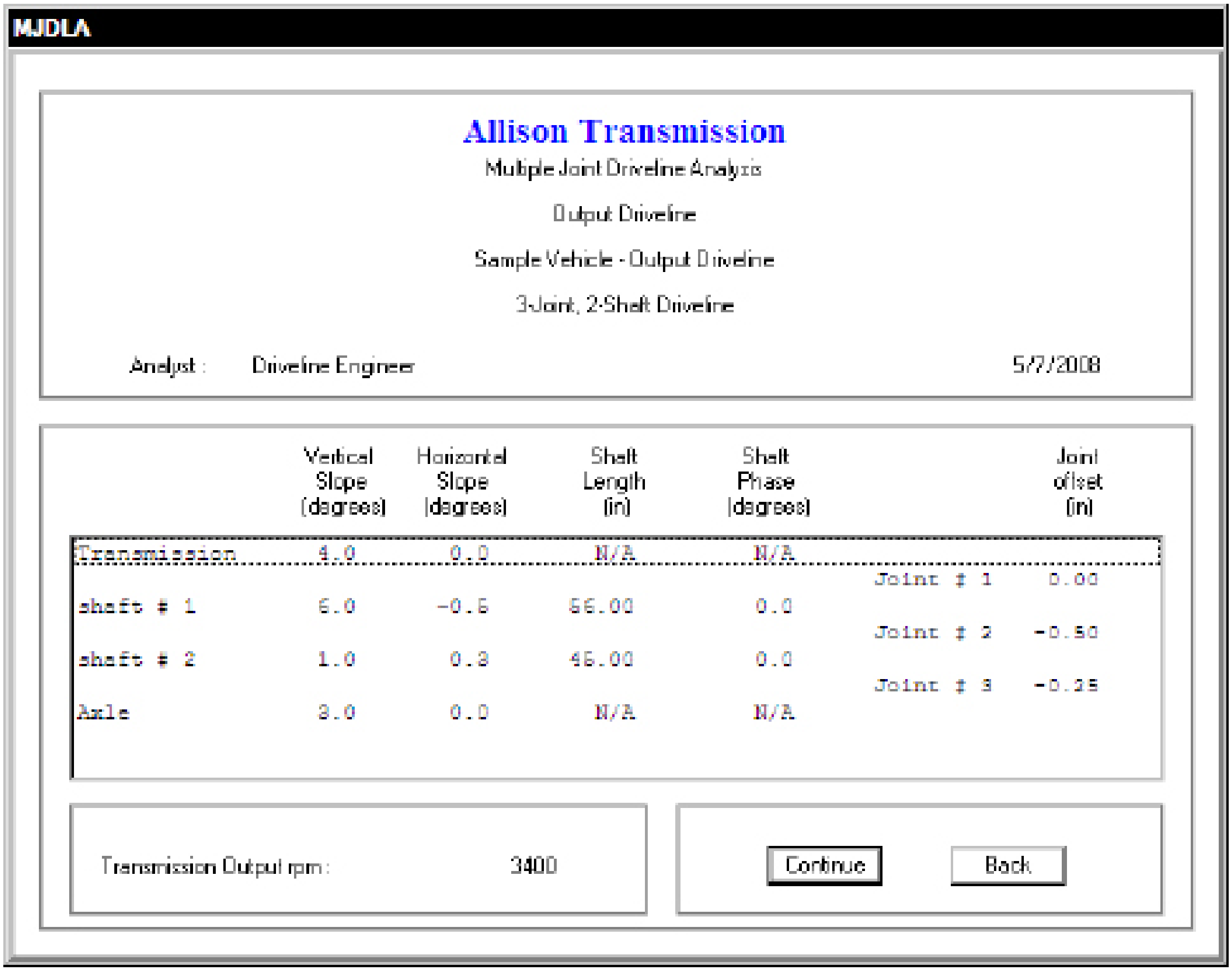


Figure 4-6a: Sample Driveline Output – Input Data Summary Screen

• Over Max Limit if Allison's limits are exceeded

As described in 3.2, Common Buttons, use the buttons at the bottom of the screen to:
• go back to the previous screen
• print the analysis
• save the output to a file
• end the program

4.5 SPECIAL CASE: OUTPUT DRIVELINE WITH PROPSHAFT-MOUNTED DRIVELINE RETARDER

To analyze this configuration, three calculations must be made:

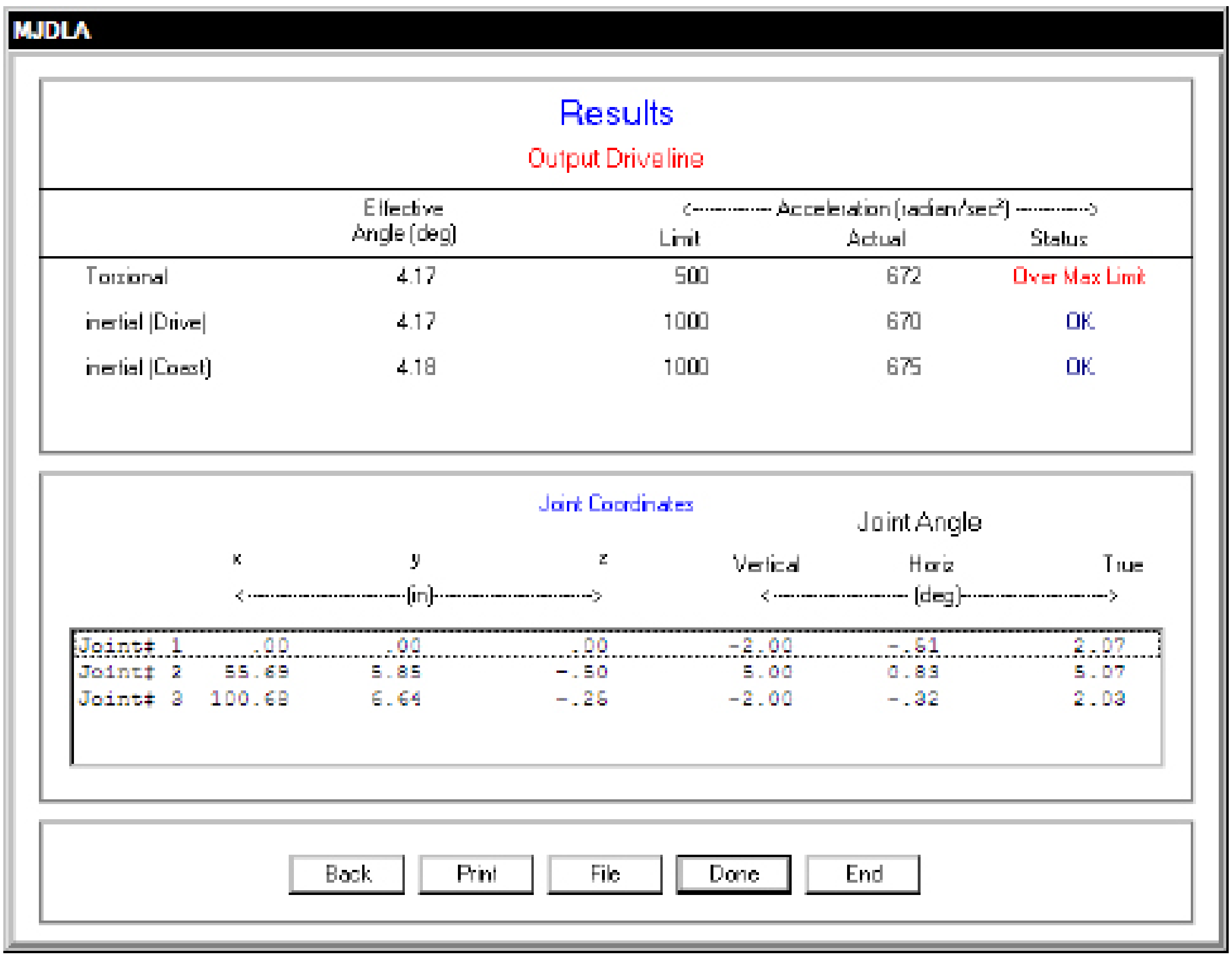


Figure 4-6b: Sample Driveline Output – Results Screen

• Overall driveline, transmission to axle
• Driveline from transmission to retarder
• Driveline from retarder to axle

Refer to *Driveline Design – Special Cases* for a discussion of this type of driveline. Allison Calc prompts the user for the necessary input for each of the three calculations. All of the input is basically the same as for the standard output driveline.

The torsional acceleration limits for the transmission to retarder and the retarder to axle sections are lower than for the overall driveline. Refer to Figure 4-3a. The lower limits ensure that the retarder or other large inertia source rotates nearly uniformly.

4.6 SPECIAL CASE: INPUT DRIVELINE

This driveline analysis is used when there is a driveline between the engine and the transmission. The input data for the input driveline is similar to the input data for the typical output driveline. Engine speed is entered instead of transmission output speed. The torsional and inertial acceleration limits are different for the input driveline, as shown in Figure 4-3b. Refer to *Driveline Design – Special Cases* for additional input driveline design considerations

5.0 COOLING ANALYSES

The cooling analyses cover the following transmission cooling systems:

- Oil-to-Water (OTW) Transmission Cooling
- Oil-to-Air (OTA) Transmission Cooling
- OTW + OTA Combinations, both Series and Parallel configurations

5.1 DESCRIPTION OF CALCULATIONS

For Oil-to-Water and Oil-to-Air transmission cooling the following calculations are available:

- **Estimate Stabilized Temperatures at a Given Condition.** Used to determine if cooling is adequate at a converter efficiency point or at some retarder mode point.

- **Estimate Heat Load Capacity at Maximum Oil Temperature.** Used to determine the heat load a cooler can remove if the oil temperature out of the transmission is at the maximum limit.

- **Estimate Required Cooler Capacity.** Used to determine the cooler capacity required to meet maximum transmission out and transmission sump temperature limits.

- **Estimate Maximum Heat Load Capacity to Meet All Limits.** For a given cooler, used to determine the maximum heat load that the cooler can remove and still be within both transmission and sump temperature limits.

For OTW and OTA Combination Cooling Analysis, the following calculations are available:

- Estimate Stabilized Temperatures at a Given Condition.
- Estimate Heat Load Capacity at Maximum Oil Temperature
- Required cooler capacity for combination systems can be determined by an iterative process. For example, to determine the what size OTA cooler is needed in series with an OTW cooler, assume a cooler capacity value for the OTA and estimate the heat load. Adjust the OTA cooler capacity until the required heat load capacity is obtained.

5.2 INPUT DATA

Data for input is obtained from the following sources:

- Heat loads and engine speed at the appropriate converter efficiency cooling point – *iSCAAN* output
- Oil flow and temperature limits
  - *1000/2000 Product Family Transmission Data*
  - *3000 Product Family Transmission Data*
  - *4000 Product Family Transmission Data*
- Engine water flow curve – engine manufacturer
- Oil cooler performance curve – cooler supplier

Delta Temperature – Sump minus Cooler Out: One of the input values required is the temperature difference between cooler out and transmission sump. In transmission models where cooler out oil returns into the lube circuit, the sump temperature is typically 5–10º F (2.8–5.6º C) higher than cooler out. A larger value results in a more conservative calculation.

5.3 UNITS

The input and output data can be in U.S. units or in SI Metric units. A summary of the parameters and their corresponding units are shown in Figure 5-1.

Parameter	SI Metric Units	U.S. Units
Temperature	ºC	ºF
Flow, Oil	liters/sec	gpm
Flow, Water	liters/sec	gpm
Flow, Air	meters/sec	feet/min
Heat Load	kW	Btu/min
Area	sq-meters	sq-feet
Cooler Performance Factor Q’	kW/ºC-ITD	Btu/min/ºF-ITD
Cooler Efficiency	%	%

ITD = Inlet Temperature Difference = $T_{oil\ in} - T_{water\ in}$ or $T_{oil\ in} - T_{air\ in}$

Figure 5-1: Parameters and Units for Cooling Analyses

5.4 OUTPUT DATA

The output of a calculation appears on the Results screen. The results may be printed or saved to a file as described in 3.2, Common Buttons. To rerun the calculation with modifications to the input data, use the **Back** button at the bottom of the results screen.

For the Estimate Required Cooling Capacity to Meet Maximum Transmission Out and Sump Temperature Limits calculations, the required cooler efficiency is an output. If the required efficiency is greater than 100 percent, the combination of heat load, oil flow and temperatures is impossible to cool.

5.5 OIL-TO-WATER ANALYSES

The Oil-to-Water (OTW) analyses are started by selecting the **Oil-to-Water (OTW) Analysis** button on the opening menu. Figure 5-2 illustrates the OTW temperature and flow parameters.

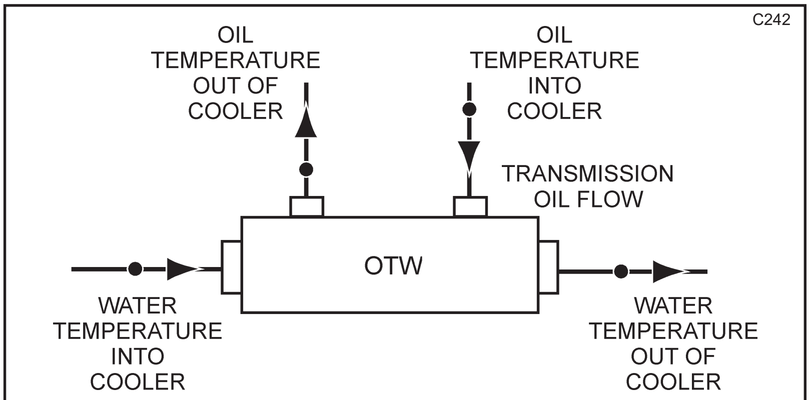


Figure 5-2: Oil-to-Water Cooler – Temperatures and Flow Parameters

Figure 5-3 illustrates a typical OTW cooler performance curve and the data required from the curve. If the heat rejection (Q’) units on the manufacturer’s cooler performance curve are not Btu/min/ºF or kW/ºC, convert the value to one of these units. Usually this can be done by dividing the Btu/min or the kW by the Inlet Temperature Difference (ITD), the difference between the oil inlet temperature and the water inlet temperature.

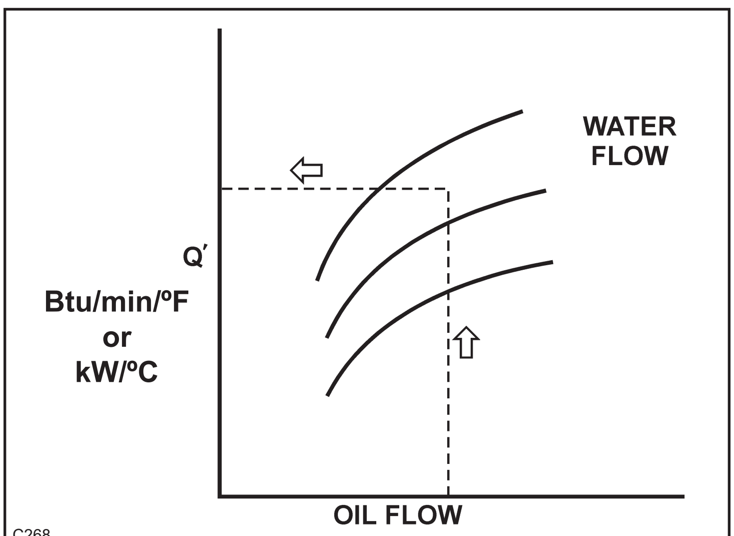


Figure 5-3: Typical Oil-to-Water Cooler Performance Curve

5.6 OIL-TO-AIR ANALYSES

Select the **Oil-to-Air (OTA) Cooling Analysis** button on the opening menu to start the OTA analyses. Figure 5-4 illustrates the OTA temperature and flow parameters.

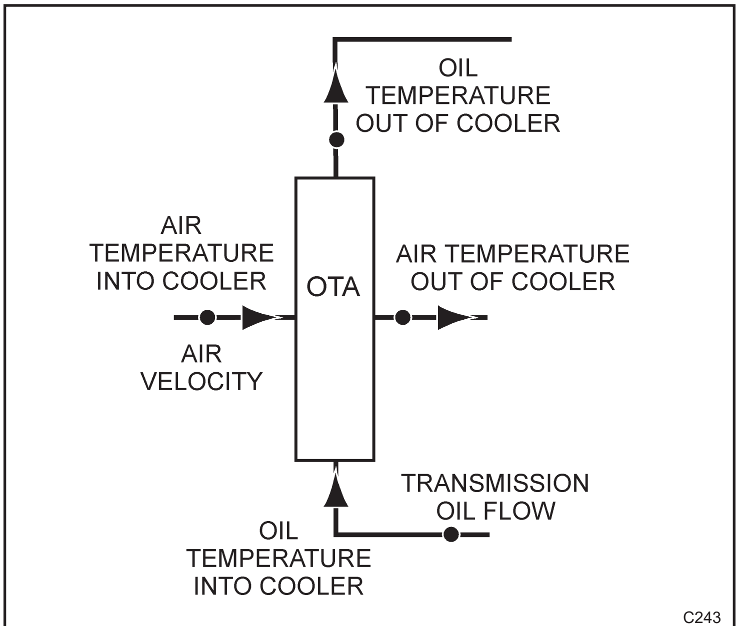


Figure 5-4: Oil-to-AIr Cooler Input & Output Parameters

Figure 5-5 illustrates a typical OTA cooler performance curve and the data required from the curve. If the heat rejection (Q') units on the manufacturer's cooler performance curve are not Btu/min/ºF or kW/ºC, convert the value to one of these units.

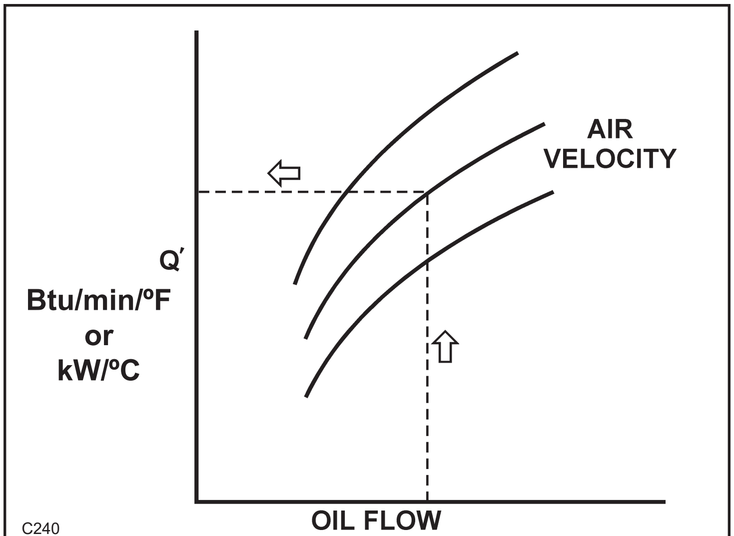


Figure 5-5: Typical Oil-to-Air Cooler Performance Curve

5.7 OTW AND OTA COMBINATION ANALYSES

Select the **OTW and OTA Combination Cooling Analysis** button on the opening screen to start the Oil-to-Water and Oil-to-Air cooler combination analyses. Combination cooler systems are used when higher capacity cooling is required for severe duty applications. Either series or parallel cooler configurations can be analyzed.

5.7.1 SERIES COOLER CONFIGURATION

Figures 5-6a and 5-6b illustrate the possible series cooler arrangements. In Figure 5-6a the oil flows through the OTW cooler before the OTA cooler. In Figure 5-6b the oil flows through the OTA cooler before the OTW cooler.

The input data for the OTW and OTA coolers in series is similar to the input for each of the separate calculations.

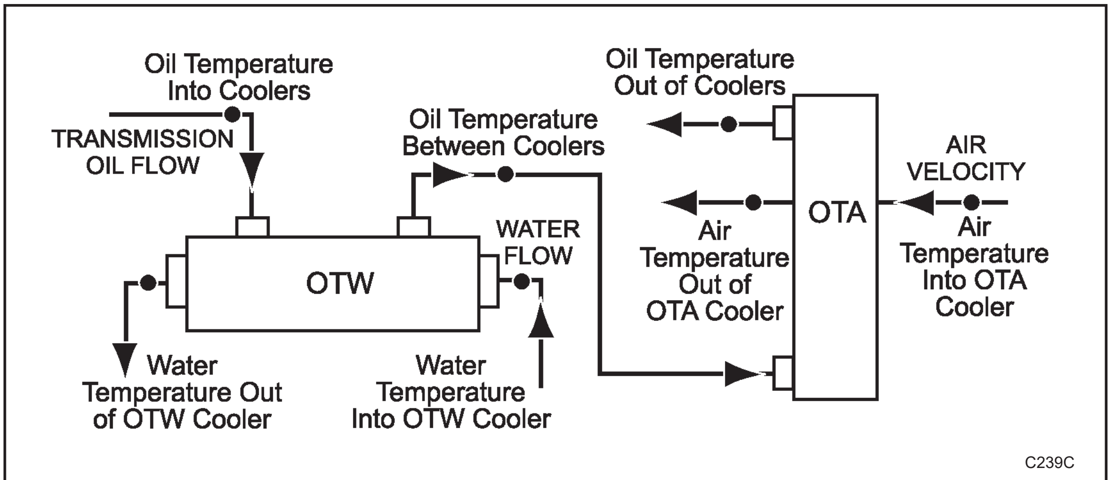


Figure 5-6a: Coolers in Series – OTW before OTA

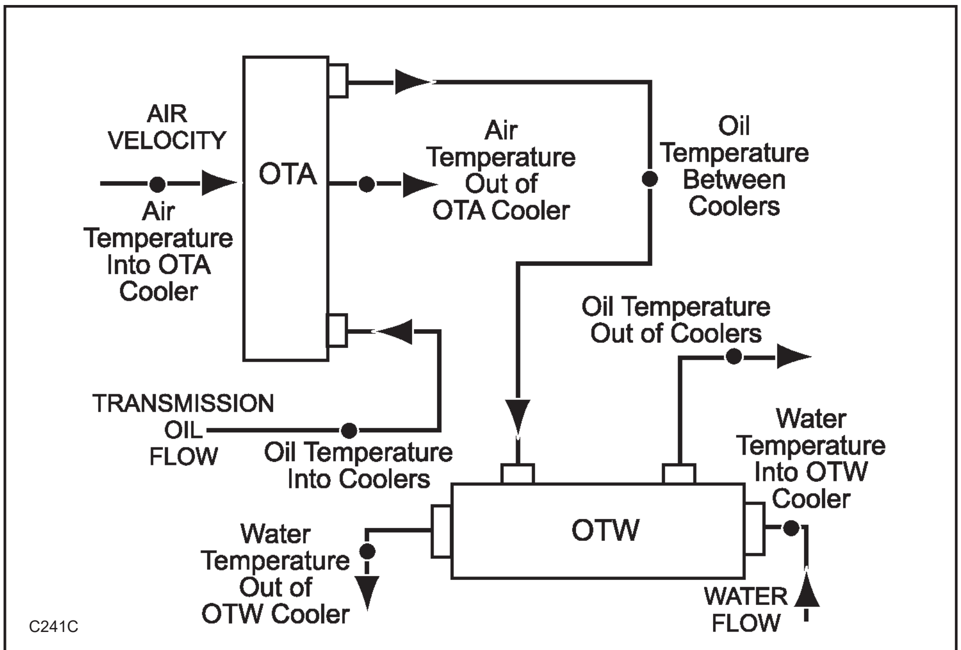


Figure 5-6b: Coolers in Series – OTA before OTW

5.7.2 PARALLEL COOLER CONFIGURATION

Figure 5-7 illustrates the parallel cooler configuration. The input data for the OTW and OTA coolers in parallel is similar to the input for each of the separate calculations. In addition, it is necessary to estimate how the flow is split between the two coolers. The Hose and Fitting Pressure Drop Analysis can be used to help estimate how the flow is split.

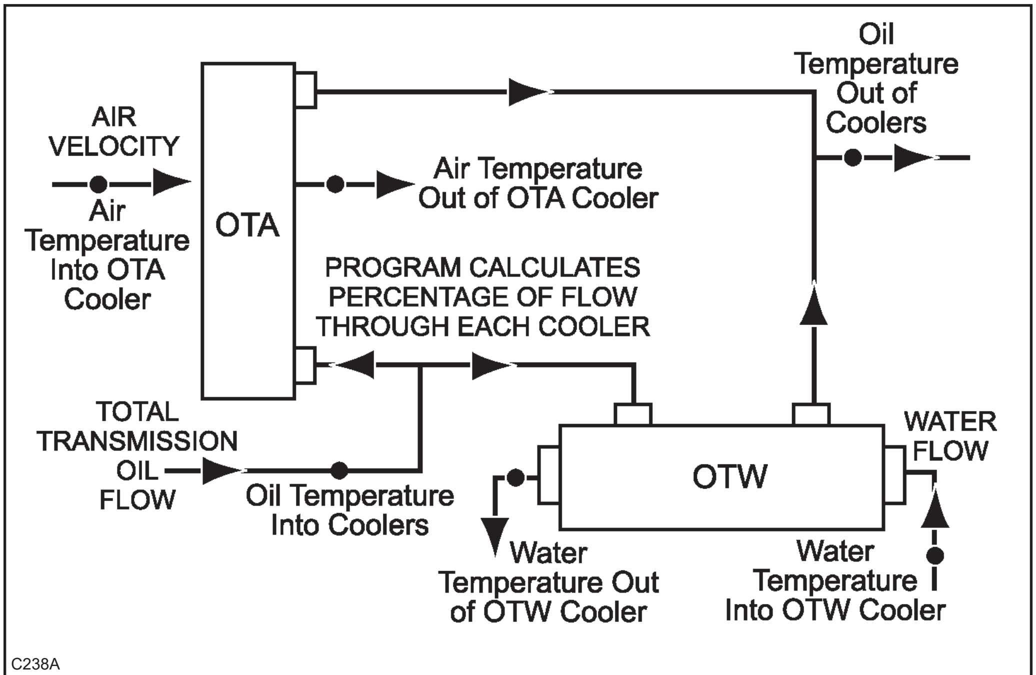


Figure 5-7: Parallel Cooler Configuration

5.8 SAMPLE COOLING SYSTEM EVALUATION

The following example illustrates how the cooling analyses work. The primary cooler is an OTW. An optional OTA cooler can be added in series if the OTW capacity is insufficient to meet the transmission cooling requirements. Stabilized temperatures will be calculated.

System Description	SI Metric Units	U.S. Units
Typical Medium Duty Diesel Engine		
Typical Transmission in the 2000 Product Family		
OTW Cooler – 8 plates, in bottom tank of radiator	75x460 mm	3x18 inch
OTW Cooler Q'	0.57 kW/ºC-ITD	17.9 Btu/min/ºF-ITD
OTW Cooler Pressure Drop	49 kPa	7.1 psi
Optional OTA – 2 pass cooler in front of radiator	610x510x30.5 mm	24x20x1.5 inch
OTA Core Area	0.25 sq-m	2.74 sq-ft
OTA Cooler Q'	0.23 kW/ºC-ITD	7.3 Btu/min/ºF-ITD
OTA Cooler Pressure Drop	62 kPa	9.0 psi
Cooling Requirement – 80% Converter Efficiency		
Engine Speed	2113 rpm	2113 rpm
Transmission Heat Rejection	32.8 kW	1868 Btu/min
Temperature Limits		
Max Converter Out/Cooler In	149º C	300º F
Maximum Sump	121º C	250º F
Delta Sump - Cooler Out	5.6º C	10º F
Conditions at 80% CE		
Oil Flow at 2113 rpm	0.5 l/s	8.1 gpm
Water Flow at 2113 rpm	4.3 l/s	68 gpm
Air Flow at 24 km/hr (15 mph)	6.7 m/s	1320 ft/min
Water Temperature in Bottom Tank of Radiator	99º C	210º F
Air Temperature into Radiator	38º C	100º F

Sample Calculations: The OTW input screen is shown below. This example is in U.S. units. The process for metric units is similar.

In this sample the stabilized temperatures will be estimated, so the **Estimate Stabilized Temperature** radio button is selected under Select Calculation.

After all the data has been entered, select the **Calculate** button to see the results screen.

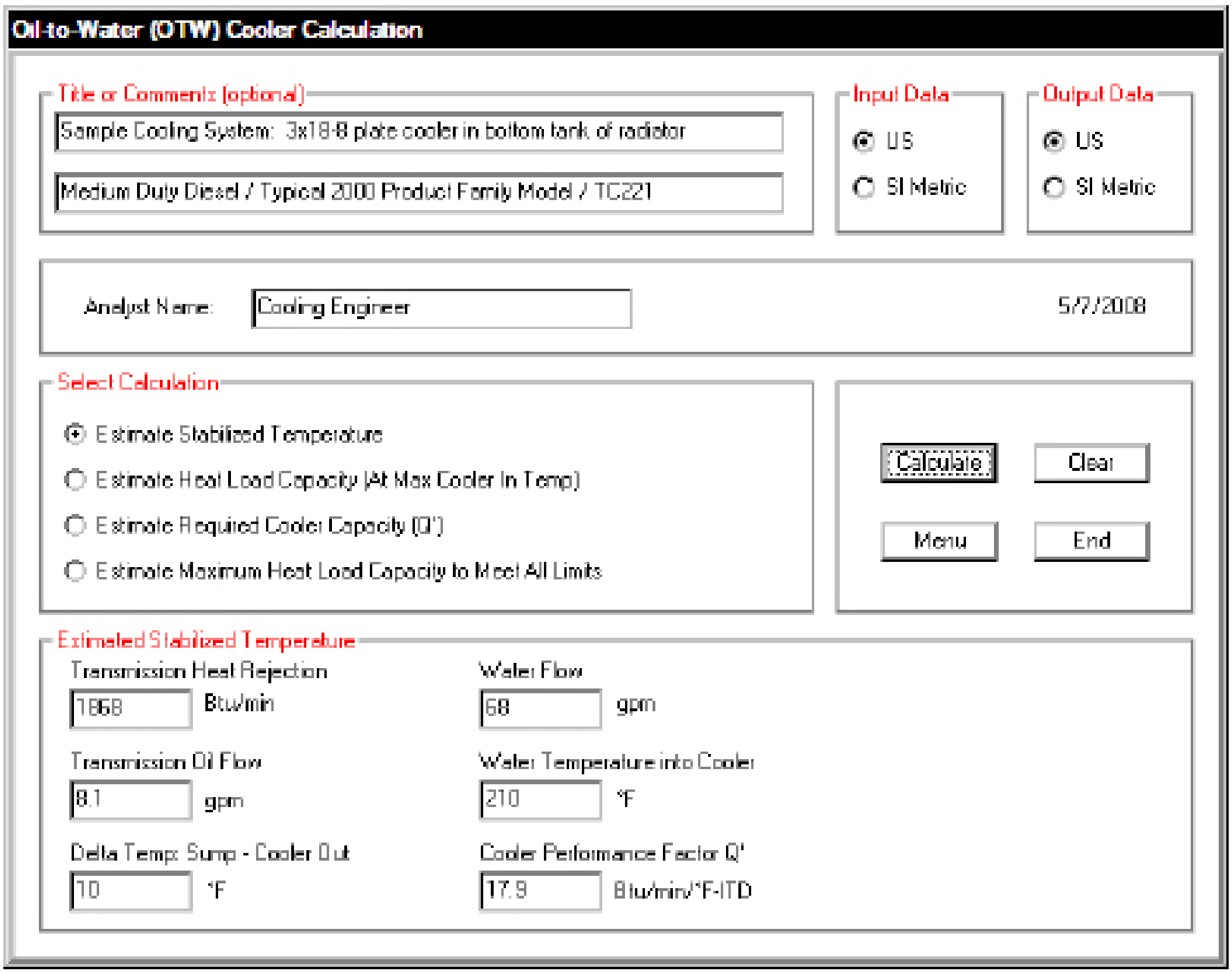


Figure 5-8: Input Screen – OTW Cooling Analysis

The results screen for the OTW calculation is shown in Figure 5-9. The input data is listed on the left and the estimated temperatures are listed on the right.

The estimated temperatures exceed the following transmission temperature limits:

- converter out (cooler in) limit of 300º F (149º C) and the transmission
- sump limit of 250º F (121º C)

Therefore, the OTW cooler is not adequate.

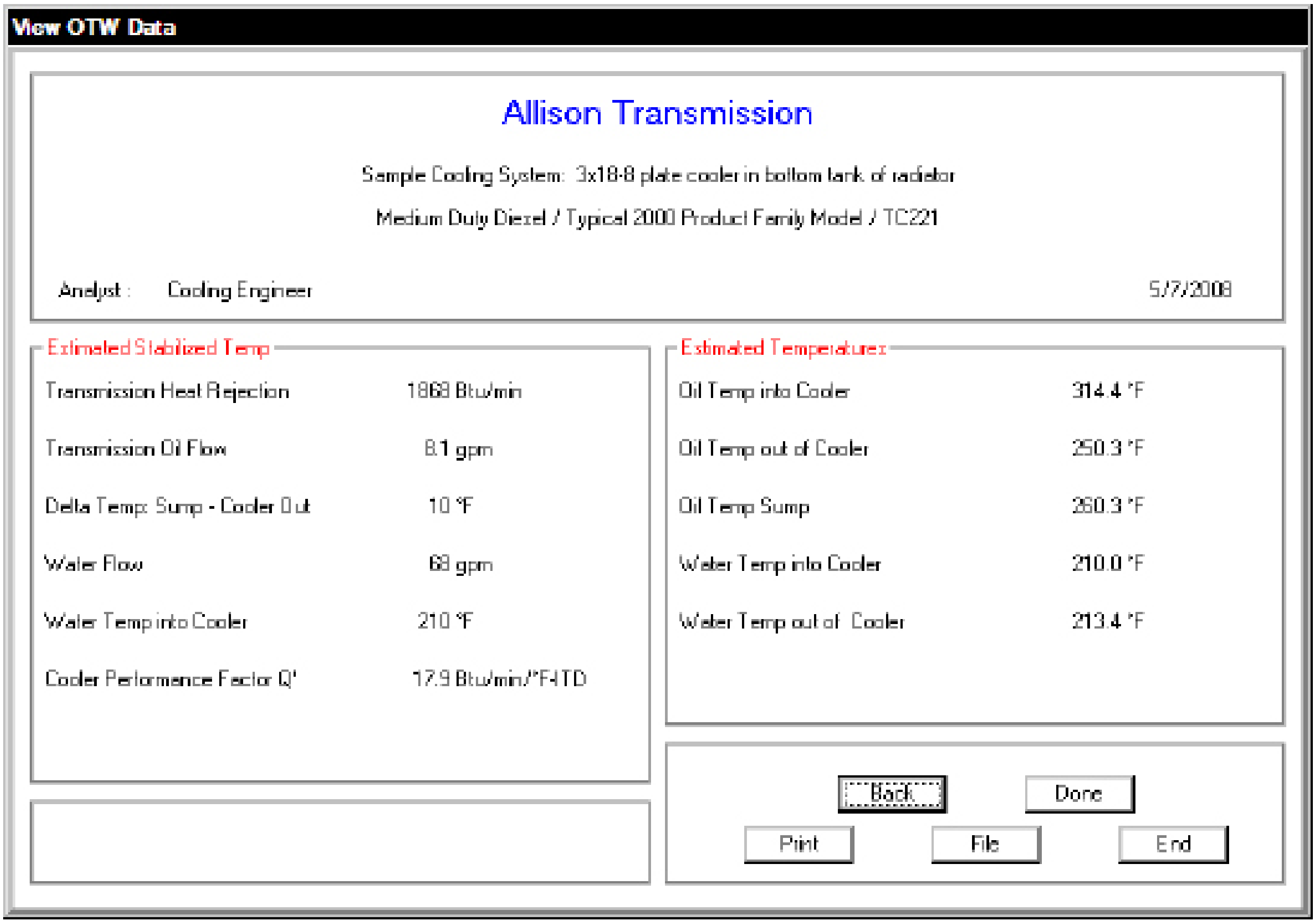


Figure 5-9: Results Screen – OTW Cooler Only

One solution is to add an oil-to-air cooler to the system. Select **OTW and OTA Combination Cooling Analysis** from the opening menu. The input screen for an OTW and OTA Combination Cooling Analysis is shown in Figure 5-10. Note the following:

- the coolers are in series – as indicated by the radio button under Calculation Type
- the oil flows through the OTW cooler first – as indicated by the radio button under Select First

Again, the stabilized temperatures will be estimated.

After entering the data, select the **Calculate** button to see the results screen.

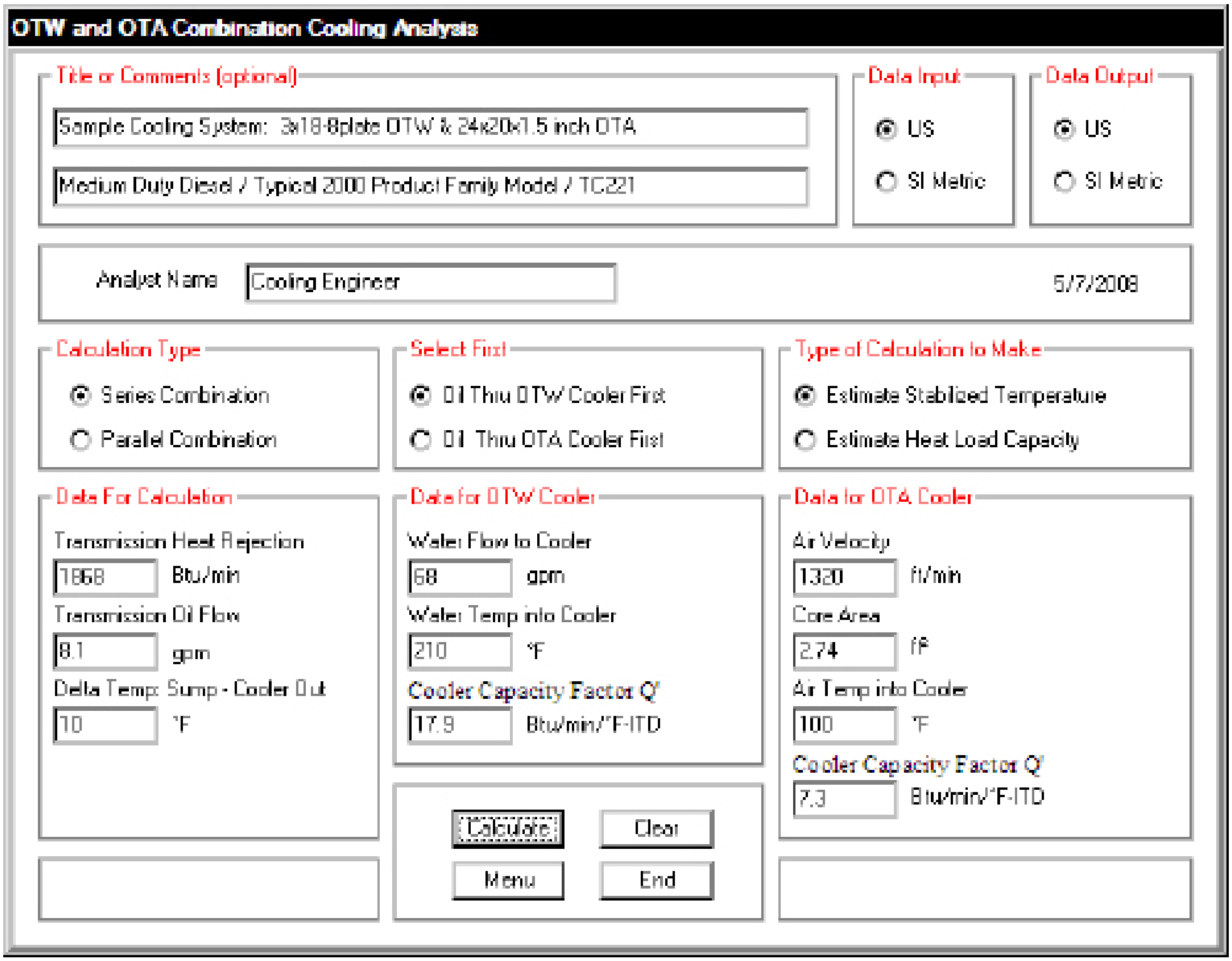


Figure 5-10: Input Screen – OTW Before OTA in Series

Figure 5-11 shows the results screen for the OTW and OTA combination system with the OTW first. Input data is displayed on the left and the calculated results are on the right.

The transmission temperatures are well below Allison's transmission temperature limits of 300º F (149º C) converter out and 250º F (121º C) sump.

The data can be printed or saved to a file by using the appropriate buttons at the bottom of the screen.

Return to the input screen by selecting the **Back** button at the bottom of the screen.

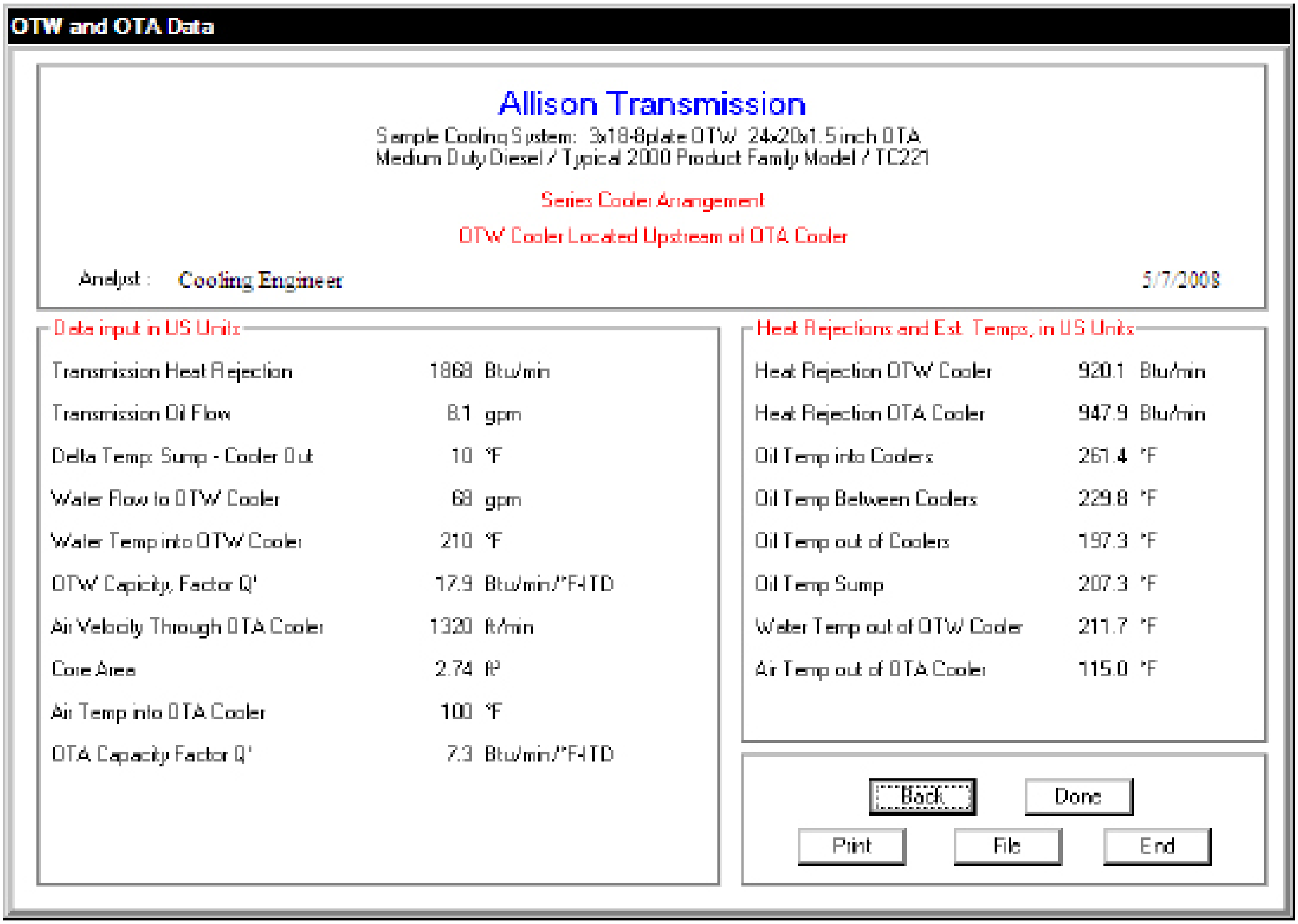


Figure 5-11: Results Screen – OTW Before OTA in Series

Back at the input screen (Figure 5-12), change the order of the coolers by selecting **Oil Thru OTA Cooler First**.

Then select **Calculate** to go to the Results screen.

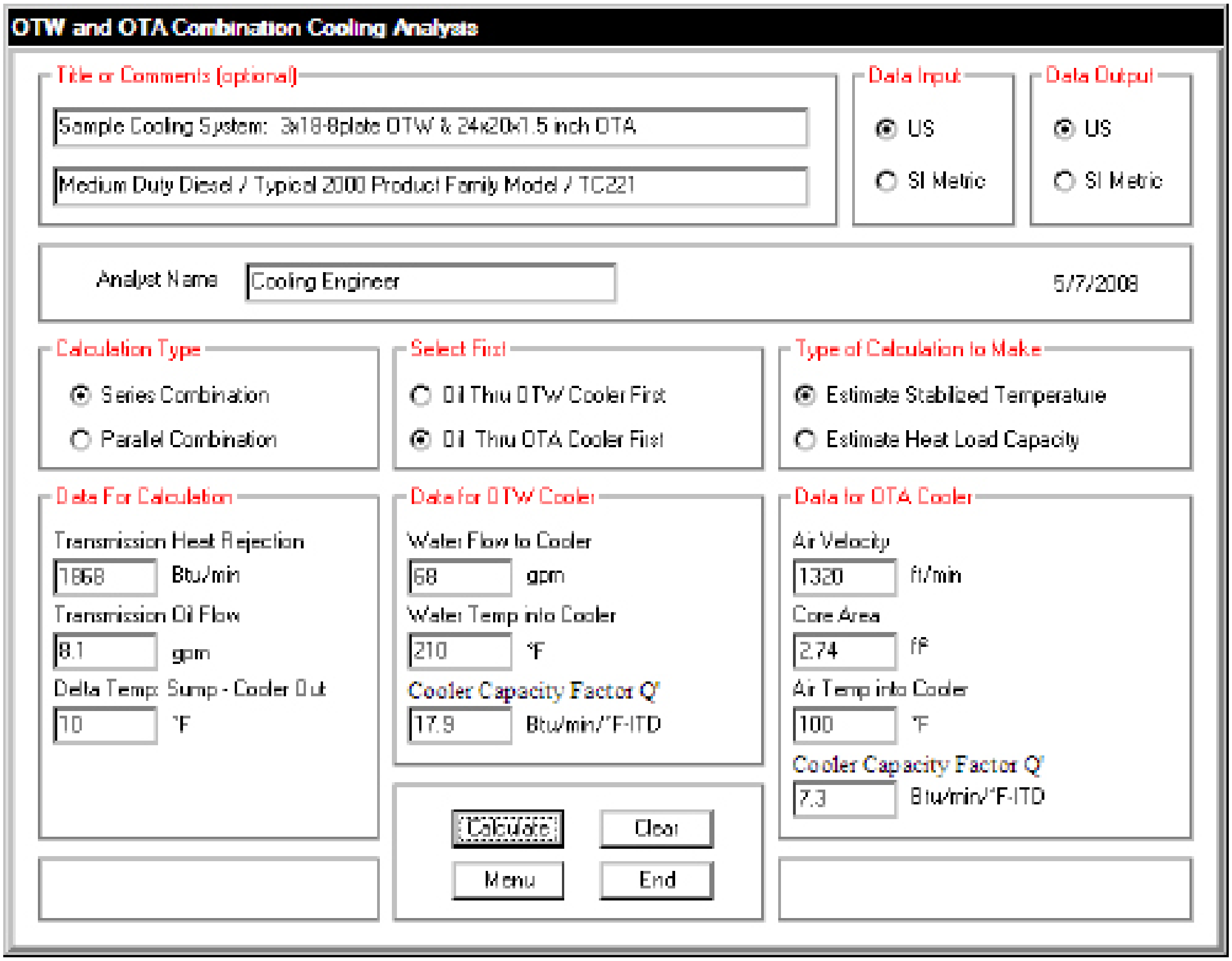


Figure 5-12: Input Screen – OTA Before OTW in Series

The results for the OTA and OTW combination system with the OTA first is shown in Figure 5-13. The transmission temperatures are still below the transmission limits when the OTA cooler is located before the OTW cooler. When the oil flows through the OTA cooler first, the temperatures are higher than when the oil flows through the OTW cooler first.

Parallel Cooler Configuration: OTW and OTA coolers are seldom used in parallel configurations.

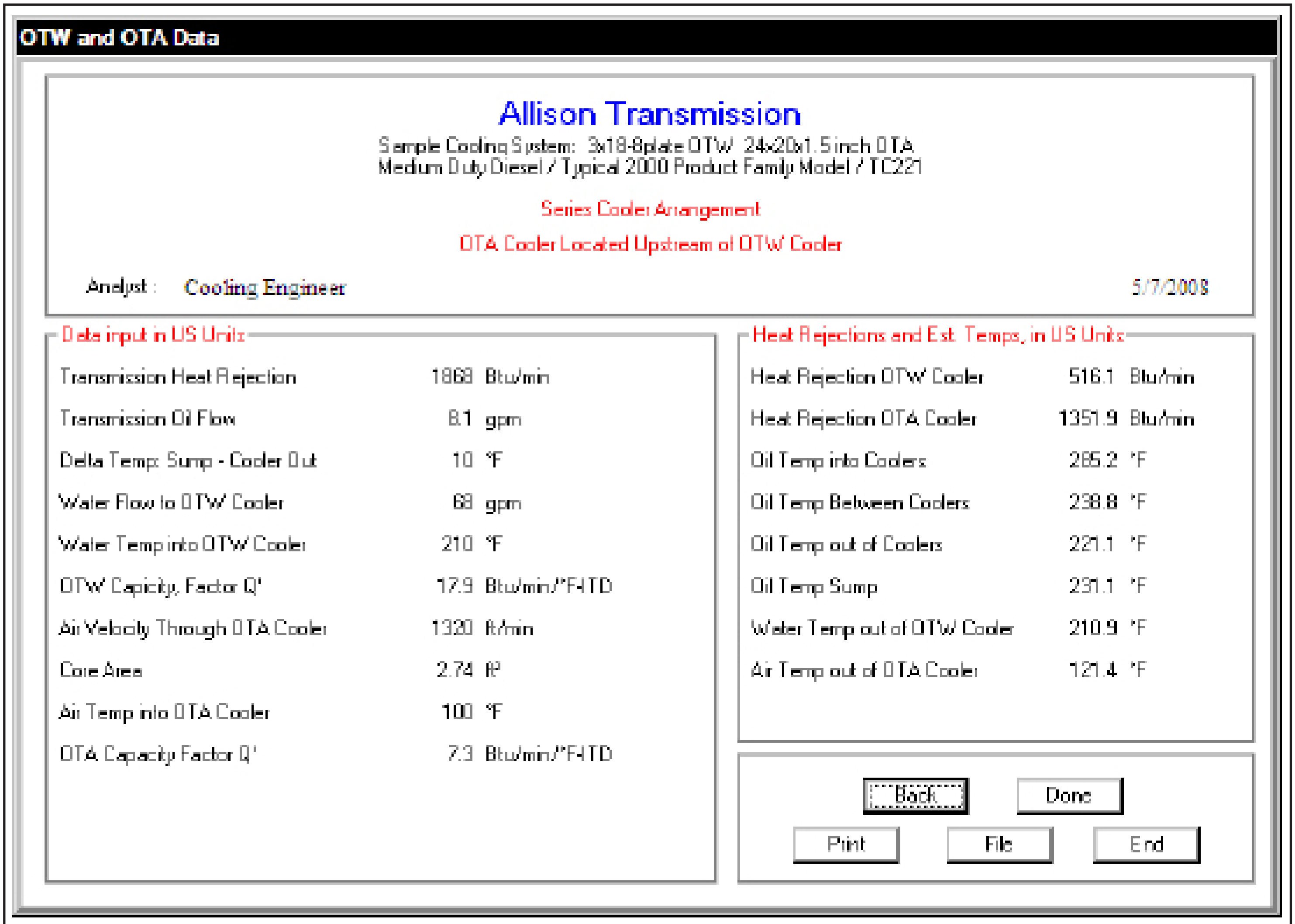


Figure 5-13: Results Screen – OTA Before OTW in Series

Therefore, a sample calculation will not be shown. Input for the parallel system is similar to the input for the series system. One important difference is the estimate of transmission oil flow split between the coolers. The oil flow split is entered as a percentage of the transmission oil flow. Allison Calc calculates the flow into each of the two coolers.

6.0 HOSE AND FITTING PRESSURE DROP ANALYSIS

The total external circuit pressure drop is the sum of the pressure drops of the following components:

- Hose or tube
- Fittings
- Cooler
- External filter, where used

This set of calculations is used to estimate the hose and fitting portion of the external circuit. Cooler and filter pressure drop data is obtained from the manufacturers.

6.1 DATA SOURCES

Cooler circuit data is obtained from the following sources:

- External circuit description –
  - vehicle manufacturer's installation design drawing
  - or, measurements in an actual vehicle
- Transmission oil flow – *Transmission Data* for the *1000/2000*, the *3000* or the *4000* Product Family
- Oil temperature – assume on the low side of the expected transmission operating band
- Cooler pressure drop – cooler manufacturer, usually part of cooler performance data
- Filter pressure drop (where applicable) – filter manufacturer's specifications or assume that the filter meets Allison Transmission requirements in *Transmission Data*
- Allison's limits for the cooler circuit restriction – *Transmission Data*

6.2 UNITS

Input and output can be in U.S. or SI Metric units. The units are summarized in Figure 6-1.

Parameter	SI Metric Units	U.S. Units
Temperature	ºC	ºF
Flow, Oil	liters/sec	gpm
Pressure Drop	kPa	psi
Hose / Fitting ID	mm	inches
Hose Length	meters	feet
Bend Radius	mm	inches
Bend Angle	degrees	degrees

Figure 6-1: Parameters and Units

6.3 INPUT PARAMETERS

Hose Size: Common hose inside diameters (ID's) are built into the program. In addition, the user can input a hose ID by selecting **Input Hose Dia**. under Hose Size. An input box for the hose size will appear on the screen.

Straight Hose Length: Straight hose pressure drop is based on the total length of straight hose sections as shown in Figure 6-2.

Figure 6-2: Straight Hose Length

45º and 90º Sharp Elbow Fittings: The program estimates pressure drop for 45º and 90º sharp elbow fittings. Enter the total number of each type of fitting. Figure 6-3 shows the types of fittings covered by this calculation.

The calculations do not cover fittings used to convert from one hose size to another, called expansion or contraction connections. Expansion and contraction connections can be conservatively estimated by assuming an extra 90º fitting for each such connection.

Oil Flow and Temperature: Pressure drop estimates can be made at any oil flow rate or oil temperature. Calculations assume a uniform temperature throughout the circuit.

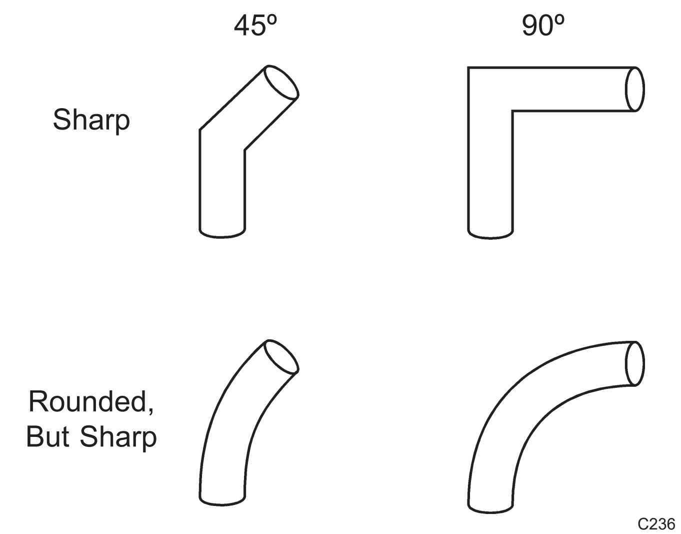


Figure 6-3: Elbow Fittings

Smooth Hose Bends: The program will calculate the pressure drop for smooth hose bends of any radius and included angle. See Figure 6-4. To enter data for smooth hose bends, select **Yes** under Smooth Hose Bends on the input screen. A dialog box will appear asking for the number of different smooth hose bends. Up to 10 differently sized bends may be entered. After the number of smooth hose bends is entered, select the **OK** button. A second input screen will appear. Enter the radius and angle for each smooth hose bend, as well as the number of bends with this radius and angle. Select **OK** to return to the first input screen.

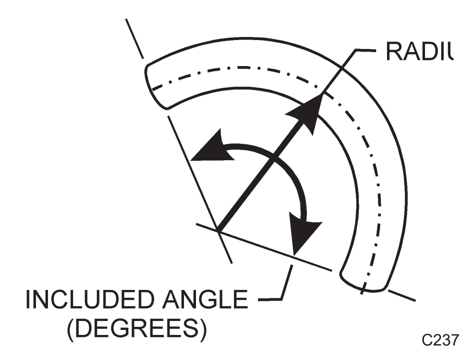


Figure 6-4: Smooth Hose Bends

Oil Type: Use the radio buttons to select oil type:

- select SAE 10 weight oil for
  - TES-295 licensed fluids
  - TES-389 Schedule One licensed fluids
  - DEXRON®
  - some C-4 fluids
- select SAE 30 weight oil for most C-4 fluids

Oil type can be quickly changed for comparison.

6.4 OUTPUT DATA

Once all of the input data has been entered, select the **Calculate** button at the bottom of the input screen. The results screen will appear. The input data is summarized on the right side of the screen. The resulting pressure drops are listed on the left side of the screen. The results may be printed or saved to a file using the **Print** or **File** buttons at the bottom of the screen.

6.5 TOTAL EXTERNAL CIRCUIT PRESSURE DROP

To estimate the total pressure drop for the complete external circuit, the pressure drop of the cooler must be added to the hose and fitting pressure drop. If the installation of a 1000 or 2000 transmission includes a filter in the cooler circuit, the pressure drop of the filter must also be added.

6.6 INTERPRETATION OF RESULTS

Although the pressure drop calculations are accurate, it is nearly impossible to describe and evaluate the exact external circuit as installed in a vehicle. Therefore, some judgement is required in interpreting the results.

If the calculated pressure drop of the complete circuit, including cooler and filter, is well below or well above the transmission's external circuit pressure drop limit, the pressure drop in the vehicle will probably be well above or well below the limit. If the calculated pressure drop is close to the limit, it can not be determined from the calculation alone if the pressure drop of the installed circuit is below the limit. A test is required to verify that the pressure drop is within the transmission's limit.

Use the pressure drop calculations to design a low restriction circuit, then test an actual installation to verify.

6.7 SAMPLE SYSTEM EVALUATION

To illustrate how the pressure drop calculations work, the systems described in the cooling example will be evaluated. The external cooler circuit is described below:

System Description	SI Metric Units	U.S. Units
Hose		
Inside Diameter (ID)	16 mm	0.625 inch
Length of Straight Hose	6 m	20 ft
Smooth Bend #1		
Radius	510 mm	12 inch
Angle	75º	75º
Number of Bends	3	3
Smooth Bend #2		
Radius	460 mm	18 inches
Angle	90º	90º
Number of Bends	1	2
Number of 90º Elbow Fittings	2	2
Number of 45º Elbow Fittings	2	2
Oil Flow	0.5 l/s	8.1 gpm
Pressure Drops for Cooler Circuit Components		
OTW Cooler Pressure Drop	49 kPa at 0.5 l/s	7.1 psi at 8.1 gpm
OTA Cooler Pressure Drop	62 kPa at 0.5 l/s	9.0 psi at 8.1 gpm
Optional Cooler Circuit Filter	26 kPa at 0.5 l/s	3.8 psi at 8.1 gpm
(Allowed Only for 1000/2000 Product Family)		
Cooler Circuit Pressure Drop Limit	350 kPa at 0.5 l/s	51 psi at 8.1 gpm

To start the pressure drop analysis, select **Hose and Fitting Pressure Drop Analysis** from the opening menu.

Enter the data on the input screen as shown in Figure 6-5. This example is in U.S. units. The process is the same for metric units.

After selecting **Yes** for Smooth Hose Bends and entering 2 for the number of different smooth hose bends, select **OK**. The input screen for the smooth hose bends appears.

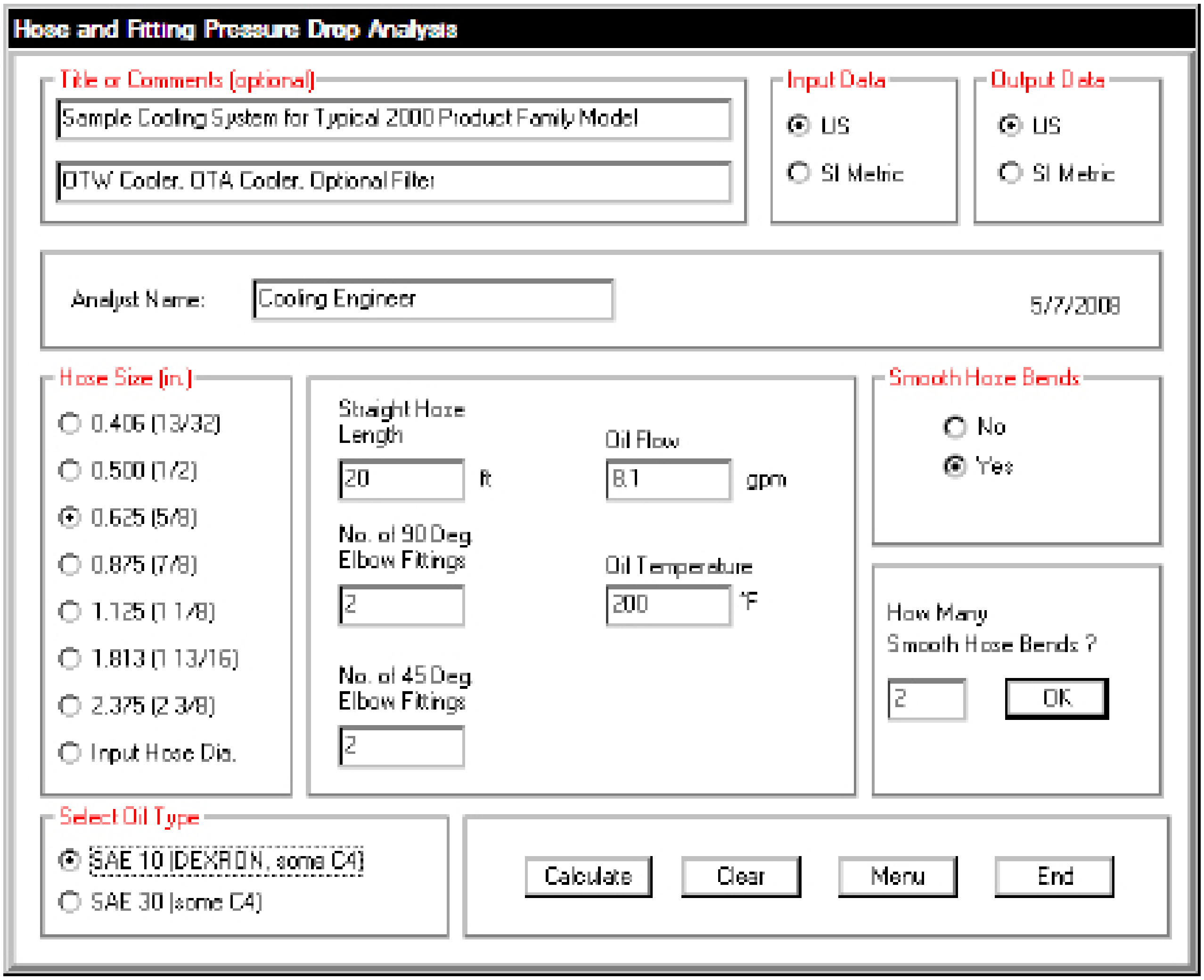


Figure 6-5: Input Screen – Hose and Fitting Pressure Drop Analysis

Enter the data describing the smooth hose bends as shown below in Figure 6-6. When the smooth hose bend data has been entered, select **OK** to return to the first input screen (Figure 6-5).

After all the data has been entered and the desired fluid type selected, select **Calculate** to see the results screen.

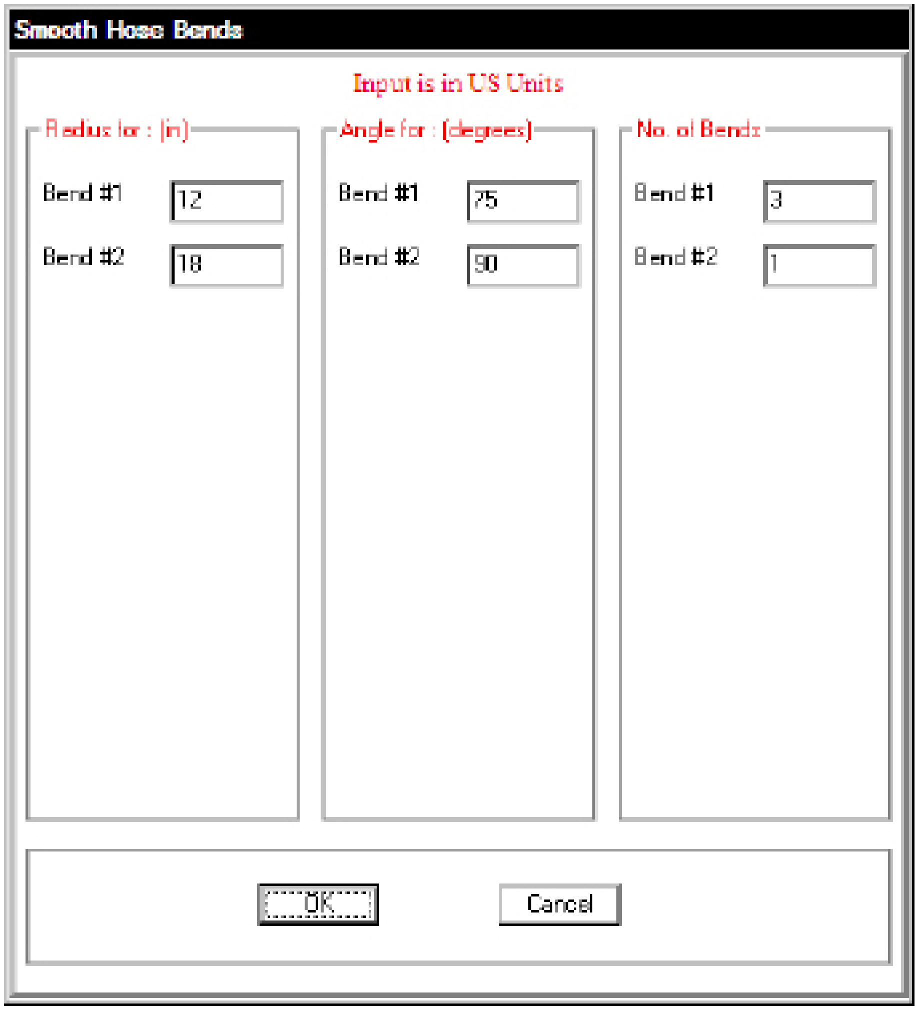


Figure 6-6: Input Screen – Smooth Hose Bends

The Hose and Fitting Pressure Drop results screen is shown in Figure 6-7.

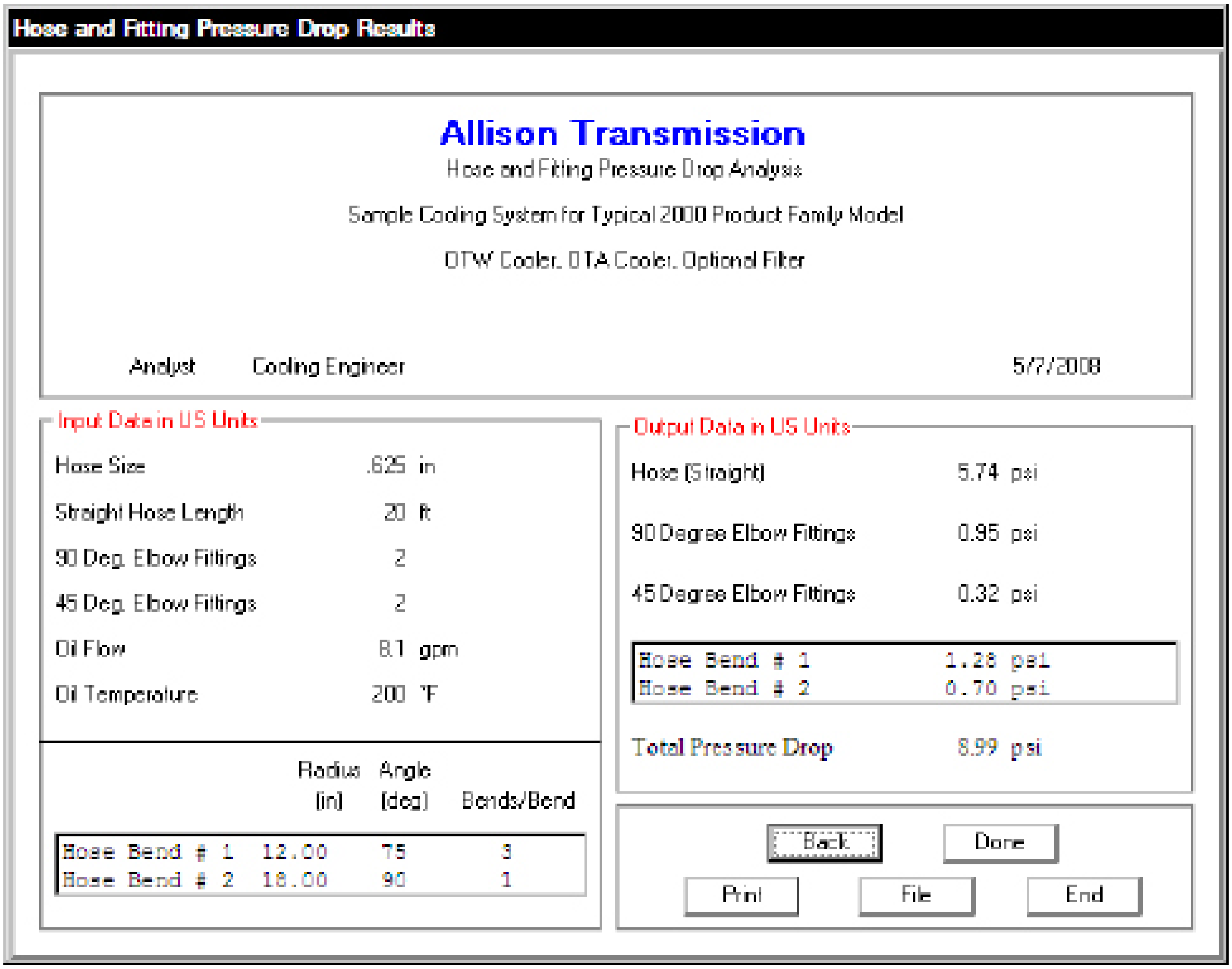


Figure 6-7: Results Screen – Hose and Fitting Pressure Drop

Total Circuit Pressure Drop. Note that the Total Pressure Drop shown in Figure 6-7 only accounts for the hoses and the fittings. In order to estimate the complete cooler circuit restriction, the cooler and the optional cooler circuit filter must be added as shown below.

OTW Cooler Only:	Hose & Fittings	9.0 psi
	OTW Cooler	7.1 psi
	Cooler Circuit Filter	3.8 psi
	Total Pressure Drop	19.9 psi
OTW & OTA Coolers:	Hose & Fittings	9.0 psi
	OTW Cooler	7.1 psi
	OTA Cooler	9.0 psi
	Cooler Circuit Filter	3.8 psi
	Total Pressure Drop	28.9 psi

Since the cooler circuit pressure drop limit is 51 psi at 8.1 gpm, both systems are acceptable by calculation. Cooler circuit requirements can be found in *Transmission Data* for the *1000/2000*, the *3000*, or the *4000* Product Family.

LIST OF REFERENCED DOCUMENTS

- *Basic Driveline Design*
- *Driveline Design – Special Cases*
- *Installation Design Calculations* (Allison Calc)
- *iSCAAN*, Allison's vehicle performance calculation program
- *Transmission Cooling – Basic*
- *Transmission Cooling – Retarder*
- *Transmission Data*
  - *1000/2000 Product Family Transmission Data*
  - *3000 Product Family Transmission Data*
  - *4000 Product Family Transmission Data*
- *Transmission Installation Checklists*

Technical Documents (TD's)

- *TD-157, Transmission Cooling Tests*

REVISION HISTORY

MAY 25, 2018
- Corrected hyperlink for Allison Design Calculations (Allison Calc.)

MAY 6, 2008
- Refreshed document and updated screens
- Added 2.0, Referenced Documents, and List of Referenced Documents

AUGUST 31, 2004
- Changed ATD Calc to Allison Calc. Added Revision History.