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PIPELINE AND PUMP EVALUATION AND SELECTION PROGRAM
(PAPES)
PROGRAM MANUAL
ISSUE VERSION 1



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FLORIDA INSTITUTE OF PHOSPHATE RESEARCH



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Pipeline and Pump Evaluation and Selection Program

(PAPES)

Program Manual

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Before You Begin

This manual is your personal guide as you learn and use the Pipeline and Pump Evaluation and Selection Program PAPES. Your manual contains three sections: Getting Started, Understanding PAPES, and Using PAPES.

Getting Started -- helps you set up PAPES for your computer and printer.

Understanding PAPES -- is a description of the program, what it does, and how to use it.

Using PAPES -- is a step-by-step guide through the mechanical operation of the program.

Appendices -- contain information on error messages, pump design cards and references.

Getting Started

PAPES is a program that will aid in your design of a phosphate matrix slurry pumping system. You supply the operating conditions, and PAPES will tell you what pumping system will suit your needs. Furthermore, PAPES can help you evaluate your existing pumping system and predict pipeline pressures under different startup conditions.

Equipment You Will Need

PAPES is easy to use, and it doesn't require a lot of extra equipment. Here is a list of all you need:

- * Any MS-DOS Personal Computer with 640K, one hard disk drive and one floppy disk drive
- * Alternatively in lieu of the hard disk a 3-1/2" low density 720 K or a 5-1/4" low density 360K floppy disks may be used.
- * MS-DOS operating system, version 3 or later
- * EGA graphics card and compatible monitor (for graphical display of pump performance after editing or entry)
- * Printer (preferable but not essential)
- * Blank diskettes
- * Maths co-processor (optional)

NOTE: Depending on what equipment you have and how you plan to use it we will supply the program to you on suitably prepared floppy disks.

We need to know the following:

1. Do you have and intend to use a hard disk?
2. What size and density floppy drive do you have?

Installing PAPES

General Information about Installing

Your PAPES package comes with either two 5-1/4 inch, one 5-1/4 inch or one 3-1/2 inch diskettes depending on the equipment that you have told us you have.

If you have a hard disk you must have at least 800K space available.

In this case we will give you a floppy disk(s) that you can copy only twice to your hard drive, once initially and one if ever the hard drive gives a problem. The disk we give you will not be able to be executed nor will it be possible to copy the program from the hard drive to a floppy.

Procedure for two 5-1/4" disks (one product disk and one support disk)

1. Make the hard disk the default drive. Enter:

C: and press ENTER

2. Create a subdirectory named PGM on the hard disk. Enter:

MD \PGM and press ENTER

3. Make PGM the current subdirectory on the hard disk. Enter:

CD \PGM and press ENTER

4. Insert the support disk into drive A.

5. Make drive A the default drive. Enter

A:and press ENTER

6. To start the installation program, enter:

INSTALLH.COM and press ENTER

-
7. "Product diskette drive (input)". Enter A
 8. "Support diskette drive (input)". Enter A
 9. "Hard disk drive (output)". Enter C
 10. "Verify product diskette in drive A:"
Insert product disk in drive A: Hit Enter
 11. "Enter Y to continue:" Y Hit Enter
 12. "Insert support disk in drive A".
Insert support disk in drive A: Hit Enter
 13. Install program runs,
 14. "Installation completed".
 15. Make PGM the current subdirectory on the hard disk. Enter:
CD C:\PGM (Hit Enter)
c: (Hit Enter)
 16. Insert support disk in drive A.
 17. Give this command:
Copy A: *.DAT (Hit Enter)
 18. Give this command:
Copy A: Setup (Hit Enter)

All necessary data files are now on the hard disk in the directory where PAPES.EXE is located.

If you do not have a hard disk and have only a 3-1/2" or 5-1/4 inch low density drive we will supply you with a floppy that you can use in the active drive. The floppy disk will not be able to be copied.

PAPES uses ANSI screen controls. In order for these to work properly you will need the line Device = ANSI.SYS

in your CONFIG.SYS file. For more information on ANSI.SYS and CONFIG.SYS see., "Configuring your System" in your DOS manual.

2

Procedure for two 5-1/4" (one product disk and one data disk and one 3-1/2" (which is both product disk and data disk).

NOTE: Anything in "quotes" is output to screen by program.

1. Make the hard disk the default drive. ENTER:
C: and press ENTER
2. Create a subdirectory named PGM on the hard disk.
ENTER:
MD \PGM and Press ENTER
3. Make PGM the current subdirectory on the hard disk. ENTER:
CD \PGM and press ENTER
4. Insert the product disk into drive A.
5. Make drive A the default drive. ENTER:
A: and press ENTER
6. To start the installation program, ENTER:
INSTALLH.COM and press ENTER
7. "Product diskette drive (input)". Enter A and
press ENTER
8. "Hard disk drive (output)" Enter C and
press ENTER
9. "Verify product diskette in drive A:"
Insert product disk in drive A: Hit Enter
10. Enter Y to continue:" Hit Enter

11. Install program runs
12. "Installation completed"
13. Make PGM the current subdirectory on the hard disk. Enter:

CD C:\PGM (Hit Enter)

C: (Hit Enter)

For 5-1/4" disk:

14. Give Following command:
Copy A:setup (Hit <enter>)
15. Insert data disk in Drive A:
16. Give Following command:
Copy A:*.dat (Hit <enter>)

For 3-1/2" disk.

14. Insert data disk (which is also the product disk)
15. Give following command:
Copy A:*.DAT (Hit Enter)
16. Give following command:
Copy A:Setup (Hit Enter)

Also, the PRINT.COM or PRINT.EXE command needs to be run before PAPES so that the resident part of PRINT is installed in RAM. You can do this by adding the line PRINT /D:PRN to your AUTOEXEC.BAT file. PRINT should be available through the PATH or in the ROOT directory for this to work. See your DOS manual for more about PATH.

Note: If you do not have ANSI.SYS or PRINT.COM on your hard disk, they can be found on your original DOS diskettes.

UNINSTALLING PAPES FROM A HARD DISK

- (1) MAKE THE HARD DISK THE DEFAULT DRIVE.
TYPE: C: (PRESS <ENTER>)
- (2) MAKE PGM THE CURRENT SUBDIRECTORY ON THE HARD DISK.
TYPE: CD \PGM (PRESS <ENTER>)
- (3) MAKE DRIVE A: THE DEFAULT DRIVE.
TYPE: A: (PRESS <ENTER>)
- (4) INSERT PRODUCT DISK INTO DRIVE A:
- (5) TO START THE UNINSTALLATION PROCESS:
TYPE: INSTALLH /U (PRESS <ENTER>)
- (6) "DRIVE (INPUT)"
TYPE: A: (PRESS <ENTER>)
- (7) "HARD DISK DRIVE(OUTPUT)"
TYPE: C (PRESS <ENTER>)
- (8) "VERIFY PRODUCT DISKETTE IS IN DRIVE A:"
(PRESS <ENTER>)
- (9) "ENTER Y TO CONTINUE OR N TO QUIT"
TYPE: Y (PRESS <ENTER>)
- (10) "PROCESSING, PLEASE WAIT..."
- (11) "PRODUCT HAS BEEN SUCCESSFULLY UNINSTALLED"
- (12) REMOVE YOUR PRODUCT DISKETTE FROM DRIVE A:

The computer files that come on the diskettes are

PAPES.EXE
DBSINX.DAT
PMPSELDM.DAT
DBSCOF.DAT
DBSDIR.DAT
SETUP

The program was originally written in FORTRAN so the executable version of the program PAPES.EXE is in object form.

The other files are data files created by FORTRAN. File DBSINX.DAT carries index information, PMPSELD.DAT carries index data and curve coefficients. DBSCOF.DAT is for polynomial and other curve coefficients while DBSDIR.DAT contains the so called card data information. These files are automatically updated when you change data or add pumps when you exit the edit menu so you will need make backup copies of these from time to time. After you have run the program and saved a pipeline file to disk another file YOURNAME.PLN will appear also. Depending on the name and the available disk space. You can have any number of these.

It is planned at least initially to limit the life of program versions by date and usage. So that old program versions are not kept in circulation. New programs will be issued before this time. If the location or address of the registered user changes then G. R. Addie at GIW should be notified in writing so that the new software disk will reach the user. The usage counter has been set to two program loadings per day so one should limit the number of loading accordingly.

Understanding PAPES

This part of the manual is a complete description of the PAPES program. It will help in your knowledge about what the program does and how it works before you actually use the program.

* NOTE: The divisions of this program will be referred to in this way: Main Menu Items, Sections, and Sub-sections.

For example: Main Menu Item 1 has three sections, and Section 1-3 has two sub-sections.

Main Menu Item may be interchanged for Section in many cases.

General Overview of Program

The PAPES Program is user friendly and easy to use. It is a MS DOS PC based program that will help you design your phosphate matrix slurry pipeline systems.

PAPES allows you to identify a matrix type and then determine the specific energy consumption and head loss for different concentrations and pipe diameters. The program also checks particle settling and deposit velocities prior to pumping system design.

The PAPES program allows you to enter details of an existing piping system and

EVALUATE: that system against a given set of pumps in order to determine the resulting flow, pressure gradients and power consumption or, alternately determine the characteristics of a given system and then

SELECT: the best pump (or pumps) from a pump file selecting the speed and/or impeller diameter necessary to achieve a recommended operating transport rate or velocity.

The matrix pipe friction and pump performance calculations are carried out as a result of and as described in the work carried out in reference 1.

The pumps used in the analysis are stored in the computer file for easy access. The initial pumps where full scale performance test data was available. They may be added to or edited at any time.

After a pipeline system and pumps have been Evaluated or Selected, the pipeline pressure gradients can be calculated for steady flow and startup conditions. A summary of the system's energy requirements will also be generated.

The main menu shown on the following page allows entry into the main sections noted.

Main Menu

- 1.) Update Pump Data Files
- 2.) Calculate Slurry and Horizontal Friction
- 3.) Calculate Overall Pipeline System Resistance
- 4.) Select or Evaluate Pumps
- 5.) Evaluate Operational Factors
- 0.) Quit program

Main Menu Item 1

Update Pump Data Files

This Main Menu item allows pump additions and modifications to the stored data file. Also available are an index of pumps and pump data listings.

All Main Menu items have internal menus called Section Menus. The following is the Section Menu for Main Menu Item 1.

Section Menu 1

- 1.) Index of Pumps
- 2.) List Pump Data
- 3.) Edit and View Pump Data
- 0.) Return to Main Menu

Required pump information is descriptive. For example: title, impeller diameter, head quantity, and NPSH performance.

The head quantity and NPSH performance is entered as given numbers of test data points. This is derived from one constant speed set of characteristics such as on speed of a multiple speed sales curve.

Most of the entry here is self explanatory and prompted by suitable defaults.

New pumps may be added as copies of existing pumps modified as need be or as completely new pumps into blank records.

Some data is essential for the fits and other calculations so this must be entered before exiting. If any of this is missing an error message will appear and direct the operator back to enter that information.

A list of the data that has to be entered is listed below along with some comments.

CARD 1.

Discharge branch diameter (in)
 Suction branch diameter (in)
 Test curve basis in the format T999A-89

The pump type field on Card 1 is intended for the format as used in standard GIW nomenclature. The 26th character as shown in the example above the line must be a "/".

Card 2.

The drawing information is not checked for but should be wherever possible be entered as the best means of identifying the pump type.

Card 3.

Stores peak performance and other information such
 as
 Best efficiency flow (BEP Qty)
 Best efficiency head (BEP Head)
 Best efficiency value (%)
 Pump rotating speed (RPM)
 Test curve in the format T999A-89

The units field should always be U for American. If there is no test curve available then N/A will stop the computer flagging an error.

Test impeller diameter (ins)

Cards 4-8.

Contain the constant speed performance test information in the form of given data points of total developed head (ft), efficiency (%) rotational speed (rpm) and net positive suction head NPSH (ft) at different USGPM flows. Any number of points in ascending flow up to 15 may be entered. A minimum of three NPSH points are expected. These should correspond to some of the entered flows. A NPSH reference may also be entered.

Card 9.

Horsepower at zero flow or shut head horsepower (BHP). The performance basis should show T for test or E for estimate.

The pump casing throat area in square inches. This is used to calculate throat velocity during a selection. It must be entered for the program to be able to select pumps. If the throat area is not known then the discharge branch area should be used.

The pump casing type as either annular (A) or semi-volute (C) must be entered. This is used later in the calculation of head and efficiency effect due to solids.

As the user exits the program, polynomials and other curve coefficients needed in the program are generated. Also a plot of the entered data points and the generated curve is displayed to allow checking of the curve fit. If these are not within a few percent over the full range, the operator should consider checking the data or respacing the point locations.

Main Menu Item 2

Calculate Slurry and Horizontal Friction

Section Menu 2

- | |
|---|
| <ul style="list-style-type: none">1.) Horizontal Pipe Performance Evaluation2.) Solids Settling in Liquids3.) Particle Deposit Velocity Check0.) Return to Main Menu |
|---|

Section 2 allows the engineer operator to compare different alternatives; such as pumping concentrations and pipe diameters for a base unit of horizontal pipe.

Section 2-1 is mainly be used when no existing piping equipment is available and/or the concentration can be varied to carry out a preliminary analysis. This allows the user to check the stability of the system and minimize the energy usage before deciding on the details of the system and the pumps.

Details relating to matrix type input are described in Section 3.

Comparisons of constant solids throughput, constant concentration, and constant flow are possible. The output will include head loss, unit energy, volume flow rate, mass flow rate, and concentration in several forms.

Section 2-2 Solids Settling in Liquids

Section 2-2 calculates hindered and unhindered solids settling velocity (for different sized and shaped particles), the drag coefficients, and particle Reynolds Numbers. The calculations are carried out as described in references 4 and 5.

The values produced here are used for vertical pipelines and to get an idea of the mode of horizontal pipeline flow particle movement. Twice the unhindered settling velocity is recommended for vertical pipe flow.

Section 2-3 Particle Deposit Velocity Check

Section 2-3 calculates the deposit velocity of a given size particle in a given concentration of a settling slurry. This is only a check and is for an individual particle within a range of concentrations. It is not to be confused with the velocity at which the head loss is a minimum which in the case of heterogeneous slurries is considered to be the minimum stable operating flow. Some flow above this is usually chosen as the design or operating flow.

The particle deposit velocity check calculation is carried out according to reference 6.

When the particle deposit velocity is above the selected operating flow and the slurry is a settling type, the operator must consider that particles of the specified size (at the concentration used) may settle out in the pipe.

This in turn may require the pipeline design flow to be increased or the particles involved kept out of the pipeline.

Menu Item 3

Calculate Overall Pipeline System Resistance

```
Section Menu 3
1.) Get Pipeline Data From Disk File
2.) Store Pipeline Data to Disk File
3.) System Resistance for Single Flow
4.) System Resistance for Range of Flows
0.) Return to Main Menu
```

Main Menu Item 3 calculates the overall pipe friction for a complete piping system for a given specified matrix slurry including the effect of bends, valves, and static head.

Up to 5 pipe section diameters are allowed. The suction of the pit pump is considered one diameter. After the pit pump, up to four different discharge diameter pipe sections are allowed.

The system static head values relative to the pit pump impeller centerline are included for the suction and discharge. At this stage, the existence and location of other pumps in the line are ignored along with any internal pipeline level changes.

A matrix is identified by the percentage of pebble and the fines percentage. Pebble is defined as all screened material over 1200 micron in size and fines is defined as all solids below 100 micron in size,.

The pebble and fines concentration values entered should be based on geological or size data. The size multiplier and viscosity correction factor should be based on operator experience and/or the chart shown as Appendix C.

Sections 3-3 and 3-4 calculate system head loss for a specific flow or a range of flows. The difference between the two sections relates to whether an existing system and pump configuration is being evaluated and the flow is being determined or a flow and head is specified and the program has to find the pump(s) operating speed and/or diameter.

Pipe roughness equivalent to smooth pipe is set up for default entry through the enter key. The pipe diameter is also set at 17.25" diameter as the most common case. Both may be changed as necessary.

In both sections, a recommended minimum flow is shown on the screen.

The minimum flow is the flow at which the system head loss is at a minimum for the typical heterogeneous settling slurry inverted parabola, or it is the laminar to turbulent transition point, where the slurry is a non settling type.

In the given flow case the flow entered should be greater than the minimum to allow for stable operation at different operational changes in concentration and slurry type.

Section menu items 1 and 2 allow storing pipe systems and retrieving previously calculated systems. These may be given any 6 digit alphanumeric name.

Main Menu Item 4

Select or Evaluate Pumps

Section Menu 4

- | |
|---|
| <ol style="list-style-type: none">1.) Evaluate Existing Pumps (Finds flow)2.) Selects Pumps (Flow given)0.) Return to Main Menu |
|---|

Section 4-1 evaluates up to nine pumps in series at given speeds and impeller diameters (including turndowns) against the previously entered pipe system finding the flow at which the total pump head intersects the total system resistance.

The system head is recalculated inside Section 4 for both evaluation and selection to be sure the correct conditions are set and to avoid going back through Section 3. The previously entered individual flow or range of flows can be accepted or altered before this calculation.

After the number of pumps operating in series has been entered the pumps are entered by database file number. If this is not known zero enables a search routine based on branch, and/or impeller diameter to be used.

In the evaluate option the pump RPM, maximum horsepower, slurry SG, and actual impeller diameter are entered for each pump.

The pump solids effect is dependent on flow and shell type. Shell types of annular (A) and semi-volute (C) are taken into consideration. Before an evaluation the flow is not known. An expected estimate value is therefore requested. Being a small value any estimate is usually within 1-2%. If exact values are required the overall problem should be run a second time and the first solution flow entered.

In an unrestricted selection the shell type is not know, so an A or C is requested. Where the pump is given the program finds which type of shell exists from the pump data files.

A synchronous electric motor is assumed with no change in speed with power consumed. The flow at which the full motor power is absorbed is noted on the screen so the operator can check for overloads.

A table for total pump (series) head is produced in comparison to the system resistance at corresponding flows. The intersecting operation point for these two curves is noted at the bottom of the table.

Section 4-2 selects pumps for the system head previously calculated for a given flow. Selection may be forced to be for only a given pump, a pump of a given branch, a given type or, a given diameter or left unrestricted. If left-unrestricted selection is based on the highest efficiency pump found in the pump data file subject to limiting casing branch, and impeller tip speeds.

The selection limits which exclude pumps from selection are for the impeller peripheral speed in surface feet per minute (SFPM), the shell throat velocity and discharge branch velocity. Heavy medium or light duty service is allowed. The values used for rejection are shown the following table.

	Heavy	Medium	Light
SFPM	5500	7000	8500
Throat Vel	25 fps	32.5	50
Branch Vel	20 fps	26	40

If a pump is specified (forced) and one or more of the above limits is exceeded the pump details will still be calculated and displayed but warnings will show.

selection at a given head and flow may be for variable speed and/or a variable impeller diameter for a chosen pump.

When selecting more than one pump, all pumps must be identical or all but one must be specified by size, RPM, and impeller diameter.

Up to four fixed speeds may be chosen for selection.

Menu Item 5

Evaluate Operational Factors

Section Menu 5

- | |
|---|
| <ol style="list-style-type: none"> 1.) Pump Spacing & Steady Head Distributions 2.) Evaluate Startup Alternatives 3.) Summarize Energy Requirements 4.) Return to Main Menu |
|---|

Information necessary for this section is as follows:

- * Location of pump along the pipeline
- * Height of pump with reference to the pit pump
- * Instantaneous level changes
- * Distance from pit pump at which diameter changes occur in the pipeline

Section 5.1 Pump Spacing and Steady Head Distributions

In this section the steady state head distributions are presented, in tabular form, at different pump locations, instantaneous elevation changes and pipe diameter changes for the specified operating conditions entered in the Main Menu items 3-3 and 4-2.

Section 5.2 Evaluate Startup Alternatives

This section presents, in tabular form, the head distributions along the pipeline for a specified startup sequence of pumps. The solution is based, on water only (S.G. = 1.0). The pipeline is assumed to be filled with water at the time of starting the first pump.

The transient solution is sought in a sequence of time steps, each 0.5 seconds in duration. At each time step, a force balance between water inertia, pressure force and head loss by friction, valves and bends are

used to compute the acceleration of the mass of water. The acceleration is assumed to be constant over each time step. Knowing the velocity at the beginning of each time step and the acceleration, the final velocity at the end of the time step is calculated. This final velocity is used to compute head loss due to wall friction, valves and bends. The friction factor is computed using the classical Colebrook-White equation. Calculations are repeated for successive intervals of time until the relative change in acceleration between consecutive time steps is negligibly small.

Section 5.3 Summarize Energy Requirements

For the specified system and steady operating conditions, this section presents, in tabular form, the solids transport rate, the energy requirement (in Hp-Hr/ton-mile) as well as the discharge and suction pressures at all of the pumps in the pipeline.

Using PAPES

The Using PAPES section is a step-by-step guide through the program. There are five major divisions of this chapter that correspond to the program's Main Menu Items.

Operation is menu driven and all input is to be entered at the keyboard and followed by the <ENTER> key. A special feature developed by GIW, Inc. allows you to just press <ENTER> if no change to the displayed value is required. Alternatively, any new value entered will replace the existing value after the <ENTER> key is pressed. Displayed values may be normally occurring conditions, information from a previous run, or calculated/recommended data from previous input. This feature will speed your progress through the program once you have worked with it.

- * NOTE: All data that is to be entered must be followed by the <ENTER> key.
- * NOTE: Use of CONTROL Z will return you to the current section menu.
- * NOTE: In most cases screen output will scroll a page at a time with "HIT ENTER" to continue. The screen output, however, can be stopped (and started) anytime by use of Control S.
- * NOTE: Separate printer output is provided for most answers displayed to the screen. If necessary, however, all screen output can be toggled to printer using Control P.

Main Menu

PAPES is a menu driven program that is easy to use. The Main Menu of this program is divided into six numeric divisions.

- ```

-----Main Menu-----
1.) Update Pump Performance Data Files
2.) Calculate Slurry and Horizontal Friction
3.) Calculate Overall Pipeline System Resistance
4.) Select or Evaluate Pumps
5.) Evaluate Operational Factors
0.) Quit program

```

When you are ready to start, just make your selection from the Main Menu and then press the <ENTER> key.

\* NOTE: All data should be followed by the <ENTER> key.

\* NOTE: Sub-sections of major divisions of this program will be referred to in this way: Major division number and then the sub-section number.  
(Example 1-1)

---

Main Menu Item 1Update Pump Performance Data Files

Main Menu Item 1 of the MAIN MENU has four sections which allow you to view and/or update the pump file that will be used later in the program. Here is a list of the sections. This list will be on the screen when you choose Section 1 of the MAIN MENU

```
Section Menu 1
1.) Index of Pumps
2.) List Pump Data
3.) Edit and View Pump Data
0.) Return to Main Menu
```

1-1 Index of Pumps

This section of the program will give you an index of pumps available to be evaluated or selected.

enter where you wish output to go, either 5 for Screen  
or 6 for Line printer

\* index will scroll if sent to screen or index will  
print if sent to printer

-- program will return to section menu

1-2 List Pump Data

This section will list data for a certain pump.

enter pump number, or enter 0 for pump search routine

Where do you wish to send output? enter 5=Screen or  
6 = line printer

-- program will display Pump Test and-other Data

-- if output is to screen it will stop for an enter  
to continue

-- program will return to section menu

---

1-3 Edit and View Pump Data

Section 1-3 allows you to change, add to, and view pump data. This section includes four smaller sections. They appear on screen like the list below.

| Section 1-3 |                           |
|-------------|---------------------------|
| 1.          | Modify Existing Pump Data |
| 2.          | Add a New Pump            |
| 3.          | List Raw Data             |
| 0.          | Return to Section Menu    |

Choose 1, 2, 3 or, 0 from section menu.

\* Note: Each choice above will ask you to enter different types of data and then will ask you for the type of modification you wish to make.

1. Choice 1 Modify Existing Pump Data

enter the pump number to be modified or  
0 for search routine

\* Note: If choice is 0. At least one of the following four entries must be entered.

enter discharge diameter in inches

enter suction diameter in inches

enter pump type (for example LSA, WBC, VERT...)

enter impeller diameter in inches

-- Matches will appear on screen

enter pump number from matches given on screen

-- Modification Menu appears on screen

|    |                                         |
|----|-----------------------------------------|
| 1. | List Raw Data                           |
| 2. | Modify Pump Data                        |
| 3. | Plot Data Curves                        |
| 4. | Save Changes and Return to Section Menu |
| 0. | Return Without Saving Changes           |

enter type of modification, 1, 2, 3, 4, or 0.

Choice 1 allows range 1 to 9 of so called card records to be listed.

\*Note: Where instructions include 2 as choice.

enter card number or 0 to exit

enter all modifications on card #1 through 9 as necessary.

\*Note: There are 9 cards. They are as listed:

- |                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"><li>1. Pump Title and Reference</li><li>2. Pump Drawing Numbers</li><li>3. BEP (Best Efficiency Point) and Duty Performances</li><li>4. H-Q and NPSH Performance</li><li>5. H-Q and NPSH Performance</li><li>6. H-Q and NPSH Performance</li><li>7. H-Q and NPSH Performance</li><li>8. H-Q and NPSH Performance</li><li>9. Comments zero flow (Shut Head) power and throat area in square inches.</li></ol> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

\* Note: Choice 3 of the modification menu will plot the previously entered pump on the screen as verification of the fit of the data to the curve.

after all modifications on the following cards have been made, program will return to the Modification Menu

enter 0 to return to section menu without saving modifications or enter 4 to save modifications

-- program returns to section menu

## 2. Choice 2 Add a New Pump

The next database position for the new pump will be found and noted. If you wish to copy an existing pump (and modify it later), enter the pump number or enter 0 for search routine. Enter the number noted for the new pump if you do not wish to copy another pump.

---

\* Note: Instructions' choice is 0. At least one of the following four entries must be entered.

enter discharge diameter in inches

enter suction diameter in inches

enter pump type (Ex. LSA, WBC, VERT...)

enter impeller diameter in inches

-- program lists matches of pumps

enter pump number (#) from matches on screen

-- Modification Menu will appear on screen

enter #2 from Modification Menu (to Modify Rump Data)

enter card #1 through 9 pump for modifications

\* Note: There are 9 cards as listed in the Choice 1 section that are also appended. See Appendix A for more information about cards.

after all card modifications have been made, program will return to the Modification Menu

enter 0 to return to section menu without saving or  
enter 4 to save changes and return to section menu.

### 3. Choice 3 List Raw Data

enter range of pumps to be listed , Start # and End #

enter range of cards to be listed, Start # and End #

enter 5 or 6 to send output to 5= screen or 6= printer

-- program lists data requested  
(in scroll format if on screen)

-- program returns to section menu

---

Main Menu Item 2

Calculate Slurry and Horizontal Friction

Section 2 of the MAIN MENU has four sub-sections. They are as follows:

|                                                                                                                                                                                                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Section Menu 2</p> <ol style="list-style-type: none"><li>1.) Horizontal Pipe Performance Evaluation</li><li>2.) Solids Settling in Liquids</li><li>3.) Particle Deposit Velocity Check</li><li>0.) Return to Main Menu</li></ol> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

2-1 Horizontal Pipe Performance Evaluation

Section 2-1 evaluates the unit length horizontal pipe performance of transportation cases calculating the pipe friction and unit energy.

enter temperature in degrees F  
enter viscosity of fluid in lb sec/ft sq  
enter fluid S.G.  
enter value for G in ft/set sq  
enter inside diameter of pipe in inches  
enter % of pebble  
enter % of fines  
enter feed size multiplier  
enter carrier viscosity correction



---

Type of problem menu appears on screen.

- |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"><li>1. Constant slurry flow with different concentrations</li><li>2. Constant slurry flow with different solids throughput</li><li>3. Constant solids throughput with different flows</li><li>4. Constant solids throughput with different concentrations</li><li>5. Constant concentration with different flows</li><li>6. Constant concentration with different solids throughput</li><li>0. RETURN TO SELECTION MENU</li></ol> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

enter type of modification

input is similar for all choices so example will show only one case.

operators choice is taken to be 5.

enter any one of the following three variables  
mean specific gravity of slurry = .000  
will show on the screen.

enter specific gravity of slurry or leave blank  
and hit enter

enter weight concentration of solids or leave blank,  
hit enter

enter volume concentration of solids.

screen displays concentrations.

enter slurry flow in USGPM

screen displays head loss specific energy and other  
values

enter next flow or zero to exit.

assuming operator enters zero.

program asks to print data or not and returns to  
Section 2 menu.

---

2-2 Solids Settling in Liquids

This section calculates the velocity at which solids settle out of the slurry being pumped.

enter temperature in degrees Farenheit

enter absolute viscosity of fluid in (LB/ FT SQ)

enter specific gravity (S.G.) of fluid

enter value for G in (FT/SEC SQ)

enter specific gravity (S.G.) of solids

enter particle shape factor, use screen table for reference

enter volume concentration of slurry in percent (%)

enter next particle diameter in microns

or 0

if 0 is entered, answer Y or N to the question about a hardcopy

\* Note: DO NOT USE KEYBOARD WHEN PRINTER IS IN USE

-- program will return to section menu

2-3 Particle Deposit Velocity Check

This section calculates the velocity at which solids settle out of the slurry being pumped in a pipe.

enter temperature in degrees Farenheit

enter absolute viscosity of fluid in (LB SEC/ FT SQ)

enter specific gravity (S.G.) of fluid

enter value for G in (FT/ SEC SQ)

enter specific gravity (S.G.) of solids

enter particle diameter in microns

---

enter pipeline diameter in inches

enter angle of pipe incline in degrees

table of particle deposit velocities and different delivered concentrations will appear on screen

enter Y or N for a hardcopy

\* Note: DO NOT USE KEYBOARD WHEN PRINTER IS IN USE

-- program returns to section menu

### Main Menu Item 3

#### Calculate Overall Pipeline System Resistance

##### Section Menu 3

- 1.) Get Pipeline Data From Disk File
- 2.) Store Pipeline Data to Disk File
- 3.) System Resistance for Single Flow
- 4.) System Resistance for Range of Flows
- 0.) Return to Main Menu

#### 3-1 Get Pipeline Data from Disk File

This section allows you to get data from disk files for use in the program. Keep in mind that there must be files saved in order to use this section.

enter file name, use no more than 8 characters

wait for prompt that file has been found

-- program returns to section menu

#### 3-2 Store Pipeline Data to Disk File

This section allows you to store data to disk file format if you have not saved data in sections 3-3 or 3-4. Keep in mind that there must be data available to be stored in order to use this section.

enter file name, use no more than 8 characters

-- program returns to section menu

---

### 3-3 System Resistance for Single Flow

This section is divided into four areas, 1. Matrix Description, 2. Conduit Description, 3. Static Head Information, and 4. Operating Parameters.

#### 1. Matrix Description

enter pebble concentration in percent (%)

enter fines concentration in percent (%)

enter feed size multiplier

enter carrier viscosity correction

enter concentration of solids by weight in percent (%)

-- note calculated S.G.

press <ENTER> to continue

#### 2. Conduit Description

enter number of different diameter discharge sections

Note: Ignore at this stage existence of pumps other than pit pump and any level changes within pipeline.

\* When you enter suction values and discharge values in the next section there will be 7 variables for each suction and discharge.

| Roughness | Dia  | Length | Number | Bend   | Valve |
|-----------|------|--------|--------|--------|-------|
|           | ins. | feet   | bends  | valves | K     |

enter suction values

enter roughness in inches

enter diameter pipe in inches

enter length of pipe in feet

enter number of bends

enter number of valves

---

enter bend resistance coefficients

enter valve resistance coefficients

enter discharge values i.e. as noted above for each  
diameter discharge

press <ENTER> to continue

### 3. Static Head Information

enter suction head from pit or tank to pit pump  
centerline in vertical feet

enter discharge head from pit pump to end of pipeline  
in vertical feet

enter Y or N to save pipeline data to disk

### 4. Operating Parameters

enter temperature in degrees Fahrenheit

enter elevation of suction in feet

enter desired operating flow, "Head Loss for what  
flow?" in gallons per minute (GPM)

-- table of Head Loss particulars will appear on screen

enter Y or N to question "Try another flow?"

enter Y or N to question "Print a hardcopy?"

\* Note: DO NOT USE KEYBOARD WHEN PRINTER IS IN USE

-- program returns to section menu

### 3-4 System Resistance for Range of Flows

This section is divided into three basic sections;  
1. Matrix Description, 2. Conduit Description,  
3. Static Head Information and, 4. Operating  
Parameters.

#### 1. Matrix Description

enter pebble concentration in percent (%)

---

enter fines concentration in percent (%)  
enter feed size multiplier  
enter carrier viscosity correction  
enter concentration of solids by weight in percent (%)  
-- note: calculated slurry S.G. on screen  
press <ENTER> to continue

## 2. Conduit Description

enter number of different diameter discharge sections

Note: Ignore at this stage pumps other than pit pump  
and any level changes within pipeline.

When you enter suction and discharge values, keep in  
mind that there are 7 values for each suction and  
discharge.

| Roughness<br>"E" | Dia<br>ins. | Length<br>feet | Number<br>bends | Valves | Bend<br>K | Valve<br>K |
|------------------|-------------|----------------|-----------------|--------|-----------|------------|
|------------------|-------------|----------------|-----------------|--------|-----------|------------|

enter all suction values  
enter roughness in inches  
enter diameter pipe in inches  
enter length of pipe in feet  
enter number of bends  
enter number of valves  
enter bend resistance coefficients  
enter valve resistance coefficients  
enter discharge values as noted above for each diameter  
discharge.  
Press <ENTER> to continue

---

3. Static Head Information

enter suction head from pit or tank to pit pump centerline.

enter discharge head from pit pump to end of pipeline in vertical feet.

enter Y or N to save to disk

4. Operating Parameters

enter temperature in degrees Farenheit

enter suction elevation in feet

enter minimum flow of range in GPM

enter maximum flow of range in GPM

Note: Where system is to be evaluated against a pump configuration the range should be made sufficiently broad to ensure intersection with the total pump head.

-- program gives a table of Head Losses for Range

enter Y or N for a hardcopy

\* Note: DO NOT USE KEYBOARD WHEN PRINTER IS IN USE

-- program returns to section menu

Main Menu Item 4

Select or Evaluate Pumps

\* NOTE: Main Menu Item 3 (sub sections 1,3 or 4) must be performed before you can operate Main Menu Item 4.1

There are three sections in this division of the Main Menu. They are as follows:

- |                                          |
|------------------------------------------|
| Section Menu 4                           |
| 1.) Evaluate Existing Pumps (Finds flow) |
| 2.) Selects Pumps (Flow given)           |
| 0.) Return to Main Menu                  |

---

4-1 Evaluate Existing Pumps

\* NOTE: This repeats calculation done in Section 3 ensuring particulars are entered correctly.

enter temperature in degrees Farenheit

enter suction evaluation in feet

enter minimum flow for range in GPM

enter maximum flow in range in GPM

\* NOTE: Where system is to be evaluated against a pump configuration it should be made sufficiently broad to ensure intersection with the total pump head.

-- table for Range of Head Losses will appear on screen

enter number (how many) pumps in series to evaluate  
(1-9)

\* Note: Program will ask for information about each pump. Instructions include information on only one pump.

enter database number for pump #1 or 0 for search routine

\* Note: Instructions choice is 0

enter at least 1 of the next 4 measurements if you are in the search routine

enter discharge diameter in inches

enter suction diameter in inches

enter pump type

enter impeller diameter in inches

-- program will give matches

choose a pump number or enter 0 to try again

enter desired RPM of pump

enter maximum limit of horsepower



---

enter desired S.G.

enter actual impeller diameter in inches

enter estimated pump flow for solids effect estimation  
if want to override flow above enter % of BEPQ  
flow in decimal form

enter 1, 2 or 3 for closest slurry type. Program will  
calculate and display solids effect values from  
head and efficiency. If you want to override  
calculated values you can do so using CRTIO.

enter depreciation of head curves in percent (%)

enter depreciation of efficiency curves in percent (%)

enter Y or N to question "Details OK?"

enter all other pumps

-- program gives an evaluation table of total pump  
head against total resistance of a given system

-- recommended operating point will appear on screen or  
no operating point found will be flagged

enter Y or N for a hardcopy

\* Note: DO NOT USE KEYBOARD WHEN PRINTER IS IN USE

-- program returns to section, menu

#### 4-2 Select Pumps

\* Note: Section 3-1 or Section 3-3 must have been  
performed before using this section. If a  
system resistance for a given flow is  
required.

1. System Head Information

enter Y or N to question "Calculate System Bead Loss?"

\* Note: This should be performed if all values set in  
Section 3 were not identical. If N is  
selected any flow or head values may be  
entered.

---

\* Note: Instruction's choice is Y.

enter temperature in degrees Fahrenheit

enter suction elevation in feet

enter GPM for operational flow required. Program  
calculates and displays head particulars at flow  
noted

enter if 'Y' or 'NO' for question another flow required

enter Y or N to "Is NPSH to be considered?"

enter NPSH available if different from that calculated

enter how many pumps to be used in series in the  
pipeline (up to 9 allowed)

enter pump to be selected (chosen and varied): 0 for  
all pumps, 1 for the pit pump, 2 for the first booster  
pump pump, 3 for the second booster pump, etc ...

\* Note: A choice of 0 indicates all pumps are identical

\* Note: READ SCREEN NOTE ON WHAT SELECTION IS CAREFULLY

\* Note: Instructions immediately below are for  
choice 0. See further down for non identical  
case.

enter motor speed Variable or Fixed (V\F)

\* Note: If variable speed is chosen, then enter  
minimum speed and maximum speed for range

\* Note: If a fixed motor speed is nominated enter up to  
4 fixed speeds in RPM terminating with a zero.

enter estimated % of BEPQ flow for solids effect  
estimation calculation

enter semi-volute (C) or annular (A) type of shell

enter 1, 2, or 3 for closest matrix type

enter depreciation of head curves in percent (%)  
where desire different from calculated value

---

enter depreciation of efficiency curves in percent (%)  
where desire different from calculated value

enter database number of a pump or enter 0 to leave  
unrestricted

\* Note: Instructions' choice is 0.

enter any or none of the following measurements,  
DISCHARGE DIAMETER, SUCTION DIAMETER, and IMPELLER  
DIAMETER if the selection is to be restricted to  
any of these.

-- program will give a table with particulars of a  
selected pump(s) and performance

program will ask you to Reselect or End (R\E)

-- if there is no match, a reason will be given on  
screen

enter Y or N for a hardcopy

\* Note: DO NOT USE KEYBOARD WHEN PRINTER IS IN USE

-- program will return to section menu

Where more than one pump is to be used and they are not  
identical selections

enter location along line of pump too be selected

program will now ask to specify all other pumps,  
starting with number 1

enter database number or zero to get search routine,  
assuming enter pump number

program shows pump and impeller diameter

enter impeller diameter if different than that shown

enter speed

enter estimated % of BEPQ flow for solids effect  
estimation calculation

---

enter 1, 2, or 3 for matrix type

enter depreciation of head curves in percent (%)  
where desire different from calculated value

enter depreciation of efficiency curves in percent (%)  
where desire different from calculated value

This is then repeated for all remaining pumps  
except the pump to be selected

When all the fixed particular pumps have been entered  
the program will then ask is speed variable or fixed  
and select the last pump as described earlier.

#### Main Menu Item 5

##### 5.1 Evaluate Operational Factors

\* NOTE: Main Menu Item 3 and then Main Menu Item 4  
(subsection 2) must be performed before you can operate  
Main Menu Item 5.

There are 4 subdivisions of this Main Menu Item.

##### Section Menu 5

- 1.) Pump Spacing & Steady Head Distributions
- 2.) Evaluate Startup Alternatives
- 3.) Summarize Energy Requirements
- 4.) Return to Main Menu

##### 5.2 Read User Input from Keyboard for Main Menu Item 5

Upon choosing this section, you have to type in the  
common input for all subsections of Main Menu Item 5.  
There are 3 divisions of the information you must  
enter; 1. Pump Information, 2. Elevation Changes and 3.  
Pipeline Data.

\* Note: In all cases, the values that appear on screen  
(default values) are the values entered during the use  
of Main Menu Item 3 and/or 4.

---

1. Pump Information

enter the number of pumps along pipeline (Maximum 9)

\*Note: Program will ask for information about each pump in the pipeline, starting with the pit pump. Instructions are only given for pump #1.

enter distance in feet from the pit to pump #1

enter height in feet of pit above pit pump centerline (C.L.). Enter negative value if pit is below pump centerline.

enter height in feet of plant discharge above pit pump centerline (C.L.)

enter head added to system by pump #1 in (feet-slurry)

enter data for all other pumps in pipeline

2. Elevation Changes

\* Caution: Static Head at suction and plant discharge are separately accounted for. These should not be entered as elevation changes. The program will ask for information about each elevation change along pipeline. Instructions only include elevation change #1.

enter length (feet) along pipe from pit to first elevation change

enter Rise (+) or Decrease(-) (feet) in elevation

enter data for all other elevation changes

3. Pipeline Data

enter number of pipe sections, different diameter pipes in the pipeline

\*Note: Program will ask for information about each pipe section. A minimum of two pipe sections -- exactly one for the suction conduit and at least one for the discharge -- must be included. Instructions only include pipe section #1.

enter length (ft) of section #1

---

enter inside diameter in inches of section #1

enter friction head loss (including valves & fittings)  
in Ft. -Slurry for section #1

enter data for all sections of pipeline

enter Y or N for hardcopy of input

\* Note: DO NOT USE KEYBOARD WHEN PRINTER IS IN USE

-- program returns to section menu

#### 5-2 Pump Spacing & Steady Head Distribution

This subsection of the Main Menu Item 5 will give a table of pump locations and the steady state head values at the suction and the discharge of each pump. When head is negative, a warning will be given to check for local cavitation. The suction and discharge pressures in PSI also appear in the table.

#### 5-4 Evaluate Startup Alternatives

This subsection will give the transient head distribution in the pipeline for any startup sequence of the pumps. The transient solution is valid for water alone, with the pipeline initially full of water.

-- program asks for the startup order of pumps

enter the number of the pump (along the pipeline) that will be started first, second and so forth  
(Maximum of 9)

enter the time intervals between adjacent startups.  
The minimum time interval is 1.0 seconds.

tabular results will appear on screen after every five seconds of operation of the system. The output includes the time after the first startup, flow rate (USGPM), transient head in feet and warnings for cavitation.

enter Y or N to get a hardcopy of results

---

\* Note: DO NOT USE KEYBOARD WHEN PRINTER IS IN USE

5-5 Summary of Energy Requirements

This subsection of Main Menu Item 5 will give the energy requirements for the chosen steady operating point.

enter Y or N to get a hardcopy of the results from this section

## Glossary

This section of the manual is a reference guide to terms, abbreviations, and functions used in the program.



This section of the manual is divided into three smaller divisions. They are 1. Terms, 2. Abbreviations, and 3. Functions.

1. Terms

Absolute viscosity of fluids -- the resistance of the fluid being pumped, often in (LB SEC\ FT SQ).

C.L. or Centerline -- the shaft and suction branch center on a pump.

Card Number -- the number given to a test card, used in modifying or adding information about a pump's test.

Discharge Diameter -- the inside size of a discharge pipe coming out of a pump.

Discharge head -- the amount of pressure at the pump discharge.

E value -- (roughness) average height of the asperity

Friction Head Loss -- amount of pressure loss along a length of pipe.

G value -- Acceleration due to gravity, G: gravity = 32.17 ft/sec<sup>2</sup>

Hardcopy -- a printout of data.

Head - the pressure in units of feet of specified liquid.

Head Loss -- a loss of pressure in a piping system due to friction of pipe, valves or bends.

Inside Diameter of Pipe -- the maximum width in inches of the inside of a pipe perpendicular to its axis.

Impeller Diameter -- the maximum length in inches across an impeller shroud.

K value -- resistance coefficient for valve, bend or fitting

Matrix -- a mixture of solids and water (liquids) being pumped.

Microns -- a particle size that measures one millionth of a meter.

NPSH or Net Positive Suction Head -- absolute pressure usually at pit pump suction. If NPSH available is not greater than NPSH needed, cavitation will occur.

Particle Volumetric Shape Factors -- volume of particle over diameter of circle having the same maximum projected area.

Pebble Content -- the percentage of pebble in a matrix where pebble is particles of diameter greater than 1200 micron.

Pipe Sections -- the length of pipe of a certain diameter. The suction section is the suction pipe for the pit pump. Discharge Section #1 starts at the pit pump discharge and continues to the first pipe diameter change. If there is no diameter change, there is only one discharge section.

Pump Number -- the number assigned to a pump in the database.

Pump Types -- the class, style or model of a pump. (Ex. LSA, WBC, VERT...).

Search Routine -- a method that allows user to find a pump number when one is not known.

Slug -- unit of mass determined this way  $\text{lb} \cdot \text{sec}^2 \div \text{ft}$

S.G. or Specific Gravity -- the density relative to water. The S.G. of water is 1.0.

Static Head Loss -- head loss or gain due to elevation change.

Suction Diameter -- the size of the pipe going into the pump.

---

Suction Head -- the pressure in feet of liquid at a given pump suction.

## 2. Abbreviations

|             |                                                   |
|-------------|---------------------------------------------------|
| BEPQ        | pump best efficiency flow quantity at a given rpm |
| C.L.        | centerline                                        |
| disch. dia. | discharge diameter                                |
| ft.         | feet                                              |
| GPM         | gallons per minute                                |
| in.         | inches                                            |
| I\DIA       | inside diameter                                   |
| imp.dia.    | impeller diameter                                 |
| lb.         | pound                                             |
| NPSHA       | net positive suction head available               |
| S.G.        | specific gravity                                  |
| sec.        | seconds                                           |
| suct. dia.  | suction diameter                                  |
| sq.         | squared                                           |
| vel         | velocity                                          |

## 3. Functions

|                          |                                                 |
|--------------------------|-------------------------------------------------|
| <u>&lt;ENTER&gt; key</u> | -- must be used after each data entry           |
| <u>CONTROL S</u>         | -- stops and restarts screen printing           |
| <u>CONTROL P</u>         | -- toggles screen output to printer as well     |
| <u>CONTROL Z</u>         | -- will return you to the current section menu. |



---

-----Card 7:-----H & Q Performance-----

| Readg No. | Qty | Head | Eff | RPM | NPSH | Sigma | Test |
|-----------|-----|------|-----|-----|------|-------|------|
| 10.       |     |      |     |     |      |       |      |
| 11.       |     |      |     |     |      |       |      |
| 12.       |     |      |     |     |      |       |      |

-----Card 8:-----H & Q Performance-----

| Readg No. | Qty | Head | Eff | RPM | NPSH | Sigma | Test |
|-----------|-----|------|-----|-----|------|-------|------|
| 13.       |     |      |     |     |      |       |      |
| 14.       |     |      |     |     |      |       |      |
| 15.       |     |      |     |     |      |       |      |

-----Card 9:-----H-Q Performance-----

Shut Head Horsepower  
 Performance Basis  
 Throat Area  
 Units.  
 Shell type Semi-volute (C) or Annular (A)

## Appendix B Error Messages

F indicates "fatal". Program will terminate after this error.

W indicates "warning". Program will continue but results are unpredictable.

I indicates "informative". Program will continue as indicated by the error.

### General Error Messages

F The resident part of PRINT must be loaded before you run PAPES.

Because this program tries to print files using the print spooler, the PRINT program must be run before PAPES. For more information on PRINT see your DOS manual.

See also: Installing PAPES

W INVALID PARAMETER:> text <

The parameter text typed on the command line is not a valid parameter.

### Section 1

No error messages

### Section 2

No error messages

### Section 3

F Iterative solution error in "CLAY" subroutine

F Iterative solution error in "NOCLAY" subroutine

An error occurred calculating the head loss at a particular velocity. Check your velocity and try again.

---

I The file name already exists. Do you wish to overwrite it?

You tried to save a data file with the name of an existing file. If you want to replace the existing file answer "Y" to the question. If you wish to give the new information another name answer "N" and then save the information using Section item 2 of Section 3.

W There was an error opening the file

W There was an error closing the file

W There was an error reading the file

W There was an error writing the file

While trying to open, close, write to, or read from a file an error occurred. This usually indicates a hardware error. Hardware errors which could occur include but are not limited to: write protected disk, not enough available space on disk, hardware parity, and directory not found errors.

When one of these errors occurs when trying to write information to disk, that information is NOT written. When trying to read information, the information to be read is undefined.

#### Section 4-1

I BHP needed exceeds maximum available BHP at the flow. Operation beyond this flow overloads and (if applicable) reduces speed according to motor characteristics.

The power needed to drive the pump is greater than the available power. The speed of the pump is reduced according to the characteristics of the motor.  
See also: Understanding PAPES Section 4-1

I Overloading beyond xxx GPM has caused head reductions! This pump will be considered as adding no additional head beyond this point.

The speed reductions at this flow caused by overloading the motor are large enough to keep the pump from adding head to the system.

---

Section 4-2

Rejection messages from Select:

If the pump that you chose to be selected does not meet certain requirements it will be rejected. The reason the pump is rejected will be one of the following:

I Rejected due to excessive impeller turn up

The impeller needed is more than 2% larger than the standard impeller.

I Rejected due to excessive impeller turn down

The impeller needed is more than 30% smaller than the standard impeller.

I Rejected: throat velocity exceeds limit

The calculated throat velocity is larger than the limit at the chosen duty.

I Rejected: branch velocity exceeds limit

The calculated branch velocity is larger than the limit at the chosen duty.

I Rejected: Impeller peripheral speed exceeds limit

At the speed (RPM) chosen the impeller surface feet per minute exceeds a safe limit.

I Rejected: Duty flow is less than 10% of BEP flow

The chosen flow rate is less than 10% of the BEP flow. In other words, the flow is not near enough the BEP to be operating efficiently.

I Rejected: Duty flow is over 150% of BEP flow

The chosen flow rate exceeds the BEP enough to cause a significant decrease in efficiency.



Appendix C Correlation Accuracy and Correction

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Chart

Appendix D References

1. Final Report FIPR Doe Contract #87-04-037R, "Phosphate Matrix Pipeline Design Data and Tools for Efficiency Improvement", GIW Industries, Inc., 5000 Wrightsboro Road, Grovetown, GA 30813
2. Duckworth, R. A., Addie, G.R. and Maffett, J.R., "Full Scale Experimental Study of the Pipeline Transport of Phosphate Matrix Slurries", (Noralyln Phase Only), 11th Annual Hydrotransport Conference at Stratford-upon-Avon in England.
3. Duckworth, R. A., Addie, G.R. and Maffett, J.R., "Experimental Study of the Fullscale Pipeline Transport Phosphate Matrix Slurries", the AIME Regional Conference 1988, Lakeland Civic Center, October 28-29,1988.
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5. Transportation of Solids Using Centrifugal Pumps Seminar Course Notes, Sponsored by GIW Hydraulic Laboratory, 1988.
6. Wilson, K. C., Dept. Civil Engineers, Queen's University Kingston, Canada, Algorithn for Coarse Particle Transport in Horizontal and Inclined Pipes", 1988

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Example Output

Additional Information

Program Support

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**Portions of this report are not legible. However, it is the best reproduction available.**

# CORRELATION ACCURACY AND CORRECTIONS

| MINE                   |                                        | NORALYN                                                                                                                                                                                                                                                  | SUWANNEE                                                                                                                                                                                                                | HOOKERS PRAIRIE                                                                                                                                                                                                   |                                                                                   |
|------------------------|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| % PEBBLE               |                                        | APPROX 46                                                                                                                                                                                                                                                | APPROX 1                                                                                                                                                                                                                | APPROX 12                                                                                                                                                                                                         |                                                                                   |
| % FINES                |                                        | APPROX 28                                                                                                                                                                                                                                                | APPROX 12                                                                                                                                                                                                               | APPROX 28                                                                                                                                                                                                         |                                                                                   |
| COMMENTS               |                                        | COARSE AND DIFFICULT TO PUMP                                                                                                                                                                                                                             | EASY PUMPING (FINES < 20%)                                                                                                                                                                                              | MEDIUM                                                                                                                                                                                                            |                                                                                   |
| 15 1/4"<br>PIPE<br>DIA | ACCURACY OF CURVES WITH<br>① AND ② = 1 | % FIT AT 15 FT/S                                                                                                                                                                                                                                         | 1% FOR Cw=50%<br>5% FOR Cw=35%                                                                                                                                                                                          | 5%                                                                                                                                                                                                                | 2%                                                                                |
|                        |                                        | FORM                                                                                                                                                                                                                                                     | GOOD                                                                                                                                                                                                                    | GOOD                                                                                                                                                                                                              | ERROR IS GREATER FOR HIGH CONCENTRATION CURVE ( 50%) AT LOW VELOCITIES (<15 FT/S) |
|                        | SUGGESTED OPTIMUM VALUES               | ① FEED SIZE MULTIPLIER                                                                                                                                                                                                                                   | 1 FOR Cw=50%<br>.92 FOR Cw=35%                                                                                                                                                                                          | 1                                                                                                                                                                                                                 | 1                                                                                 |
|                        |                                        | ② VISCOSITY CORRECTION FACTOR                                                                                                                                                                                                                            | 1                                                                                                                                                                                                                       | .73                                                                                                                                                                                                               | 1                                                                                 |
| 17 1/4"<br>PIPE<br>DIA | ACCURACY OF CURVES WITH<br>① AND ② = 1 | % FIT AT 15 FT/S                                                                                                                                                                                                                                         | 2% FOR Cw=50%<br>5% FOR Cw=35%                                                                                                                                                                                          | 5%                                                                                                                                                                                                                | 2%                                                                                |
|                        |                                        | FORM                                                                                                                                                                                                                                                     | GOOD                                                                                                                                                                                                                    | GOOD                                                                                                                                                                                                              | ERROR IS GREATER FOR HIGH CONCENTRATION CURVE ( 50%) AT LOW VELOCITIES (<15 FT/S) |
|                        | SUGGESTED OPTIMUM VALUES               | ① FEED SIZE MULTIPLIER                                                                                                                                                                                                                                   | .95                                                                                                                                                                                                                     | 1                                                                                                                                                                                                                 | 1                                                                                 |
|                        |                                        | ② VISCOSITY CORRECTION FACTOR                                                                                                                                                                                                                            | 1                                                                                                                                                                                                                       | .73                                                                                                                                                                                                               | 1                                                                                 |
| 19 1/4"<br>PIPE<br>DIA | ACCURACY OF CURVES WITH<br>① AND ② = 1 | % FIT AT 15 FT/S                                                                                                                                                                                                                                         | 5% FOR Cw=50%<br>8% FOR Cw=35%                                                                                                                                                                                          | 5%                                                                                                                                                                                                                | 2%                                                                                |
|                        |                                        | FORM                                                                                                                                                                                                                                                     | GOOD                                                                                                                                                                                                                    | GOOD                                                                                                                                                                                                              | ERROR IS GREATER FOR HIGH CONCENTRATION CURVE ( 50%) AT LOW VELOCITIES (<15 FT/S) |
|                        | SUGGESTED OPTIMUM VALUES               | ① FEED SIZE MULTIPLIER                                                                                                                                                                                                                                   | .90                                                                                                                                                                                                                     | 1                                                                                                                                                                                                                 | 1                                                                                 |
|                        |                                        | ② VISCOSITY CORRECTION FACTOR                                                                                                                                                                                                                            | 1                                                                                                                                                                                                                       | .73                                                                                                                                                                                                               | 1                                                                                 |
| GENERAL COMMENTS       |                                        | DUE TO THE LARGE PEBBLE X, THE FEED SIZE MULTIPLIER HAS A GREATER EFFECT THAN THE VISCOSITY CORRECTION FACTOR. FEED SIZE MULTIPLIER AND VISCOSITY CORRECTION FACTOR VALUES LESS THAN 1 PRODUCE A DECREASE IN THE MAGNITUDE OF HEAD LOSS, AND VICE-VERSA. | IN GENERAL, BOTH THE FEED SIZE MULTIPLIER AND THE VISCOSITY CORRECTION FACTORS HAVE ONLY A SLIGHT EFFECT ON THE MAGNITUDE OF HEAD LOSS. AGAIN, THE DIRECTION OF THE EFFECT IS SIMILAR TO THAT OF THE NORALYN PHOSPHATE. | EFFECTS ARE SIMILAR TO THOSE FOR SUWANEE RIVER PHOSPHATE, EXCEPT AT HIGH CONCENTRATIONS AND/OR AFTER A LOT OF MOVEMENT THRU PUMPS SUCH AS IN LAB TESTS. TENDENCY FOR INCREASES IN VISCOUS HEAD LOSS DUE TO CLAYS. |                                                                                   |

FIGURE 28

SECTION 1.1

27/JAN/89

20:06:58

SUMMARY OF PUMP DATA BASE FILE

| No. | DSCH | SUCT | PUMP       | TYPE         | ASSEMBLY | SHELL    | IMPLR    | TEST CURV |
|-----|------|------|------------|--------------|----------|----------|----------|-----------|
| 1   | 16   | /18  | WSO 40     | (39)HP A 4RV | 1768D    | 1740D    | 667C     | T172A-81  |
| 2   | 16   | /18  | WSO 40     | HP A 3ME     | 2262D    | 1740D    | 2037D    | T177A-81  |
| 3   | 18   | /18  | WSO 44     | A 4RV        | 1591D    | 1590D    | 889C     | T202 -80  |
| 4   | 18   | /18  | LSA 44     | C H3ME       | 2070D    | 2067D    | 3016D    | T 71 -85  |
| 5   | 18   | /20  | LSA 48     | (46) A H3ME  | *1125D   | 1124D    | 2198D T/ | T244 -81  |
| 6   | 18   | /20  | LSA 48     | A H4RV       | 1322D    | 1321D    | 1145C    | T233 -81  |
| 7   | 18   | /18  | LSA 44     | C H3ME       | 2086D    | 2072D    | 2016D    | T 86 -81  |
| 8   | 18   | /18  | WBC 46     | C H3ME       | -        | 3164D    | 3162D    | E 32B-85  |
| 9   | 18   | /20  | WBC 54     | C H3ME       | 3461D    | 3454D    | 3456D    | T118 -85  |
| 10  | 18   | /18  | WSO 44     | A 3ME        | 1635D    | 1590D    | 2016D-00 | T173 -80  |
| 11  | 16   | /18  | TOM 40     | C H3RV       | P16316-1 | P16387-4 |          | T100 -82  |
| 12  | 20   | /20  | TOM 52(50) | C H3RV       |          | T-20208  |          | T 84 -81  |
| 13  | 16   | /18  | TOM 46     | C H4RV       |          | P-1601-7 |          | T 66 -80  |



## ----- PUMP-TEST DATABASE INFORMATION LISTING -----

## TITLE AND REFERENCE INFORMATION

## DRAWINGS

18 /20 WBC 54  
C H11- 1/ 2/3ME11- 1/ 4

ASSEMBLY  
CASING  
IMPELLER

3461D  
3454D  
56D

SALES CURVE# T 87 -863

## BEP PERFORMANCE

QUANTITY (GPM) 18406.9  
HEAD (feet) 191.4  
EFFICIENCY 83.8  
RPM 450.0  
TEST CURVE NO T 87 -86  
Impeller Diameter (inches) 54.000  
BEP PERF NOTED IS EST/TEST/STAND (E/T/S)=T

## PUMP RATED PERFORMANCE

| RDG NO | QUANTITY<br>( GPM) | HEAD<br>(ft) | EFF  | RPM   | NPSH<br>(ft) | SIGMA TESTS |
|--------|--------------------|--------------|------|-------|--------------|-------------|
| 1      | 41.2               | 233.6        | .9   | 450.0 | .0           | -----       |
| 2      | 2156.6             | 232.3        | 33.2 | 450.0 | .0           | -----       |
| 3      | 4074.8             | 230.6        | 49.9 | 450.0 | .0           | -----       |
| 4      | 6189.0             | 228.3        | 61.3 | 450.0 | .0           | -----       |
| 5      | 7881.4             | 227.0        | 67.8 | 450.0 | .0           | -----       |
| 6      | 10055.3            | 219.2        | 75.7 | 450.0 | 6.5          | S 86 -86    |
| 7      | 12414.5            | 211.6        | 80.3 | 450.0 | .0           | -----       |
| 8      | 14373.8            | 204.2        | 82.4 | 450.0 | .0           | -----       |
| 9      | 16293.1            | 197.9        | 83.5 | 450.0 | .0           | -----       |
| 10     | 18005.8            | 192.2        | 84.0 | 450.0 | 12.0         | S85-86      |
| 11     | 19024.4            | 188.8        | 83.9 | 450.0 | .0           | -----       |
| 12     | 20166.4            | 184.7        | 83.7 | 450.0 | .0           | -----       |
| 13     | 22386.7            | 175.9        | 82.4 | 450.0 | .0           | -----       |
| 14     | 23739.5            | 170.7        | 81.8 | 450.0 | 20.0         | S84-86      |
| 15     | 24933.5            | 166.8        | 81.4 | 450.0 | .0           | -----       |

PERF ABOVE IS EST/TEST/STANDARD (E/T/S) NOTED

HYDRO TEST PRESSURE 1.00 psi

SHUT HEAD POWER IS 330.3

CT COLLECTOR TYPE S/D/A/C: S ACTUAL THROAT AREA (AAT) 155.200 BASIS 1.174

DIA RATIO .98 EFF RATIO WBC46

SECTION 1.3.3

\*\*\*\*\* LISTING PUMP DATA BASE \*\*\*\*\*

PUMP # 9 18 /20 WBC 54 C H11- 1/ 2/3ME11- 1/ 4

----- CARD 1: ----- PUMP TITLE & REFERENCE -----  
 Pump Type: WBC 54 C H11- 1/ 2/3ME11- 1/ 4  
 Pump Serial No: -  
 Discharge Dia: 18 Suction Dia: 20  
 Salescurve #: E 07E-86 Hydr basis # T11B -85

----- CARD 2: ----- PUMP DRAWING NO's -----  
 Assembly: 3461D  
 Casing: 3454D  
 Impeller: 3456D

----- CARD 3: ----- REF & DUTY PERFORMANCE -----  
 Test Curve No: T 87 -86 B.E.P. Qty: 18406.9 B.E.P. Head: 191.4  
 Best Efficiency: 83.8 Rotat. Speed: 450.0 Test Imp. Dia: 54.000  
 Metric/Brit/US M/B/U U  
 Performance Basis noted above is Estimate/Test/Standard E/T/S: T  
 Comments on Performance Basis: 1.174 DIA RA

----- CARD 4: ----- H & Q PERFORMANCE -----

| Readg No. | Qty    | Head  | Eff. | RPM   | NPSH | Sigma Test |
|-----------|--------|-------|------|-------|------|------------|
| 1         | 41.2   | 233.6 | .9   | 450.0 | .0   | -----      |
| 2         | 2156.6 | 232.3 | 33.2 | 450.0 | .0   | -----      |
| 3         | 4074.8 | 230.6 | 49.9 | 450.0 | .0   | -----      |

----- CARD 5: -----

|   |         |       |      |       |     |          |
|---|---------|-------|------|-------|-----|----------|
| 4 | 6189.0  | 228.3 | 61.3 | 450.0 | .0  | -----    |
| 5 | 7881.4  | 227.0 | 67.8 | 450.0 | .0  | -----    |
| 6 | 10055.3 | 219.2 | 75.7 | 450.0 | 6.5 | S 86 -86 |

----- CARD 6: -----

|   |         |       |      |       |    |       |
|---|---------|-------|------|-------|----|-------|
| 7 | 12414.5 | 211.6 | 80.3 | 450.0 | .0 | ----- |
| 8 | 14373.8 | 204.2 | 82.4 | 450.0 | .0 | ----- |
| 9 | 16293.1 | 197.9 | 83.5 | 450.0 | .0 | ----- |

----- CARD 7: -----

|    |         |       |      |       |      |        |
|----|---------|-------|------|-------|------|--------|
| 10 | 18005.8 | 192.2 | 84.0 | 450.0 | 12.0 | S85-86 |
| 11 | 19024.4 | 188.8 | 83.9 | 450.0 | .0   | -----  |
| 12 | 20166.4 | 184.7 | 83.7 | 450.0 | .0   | -----  |

----- CARD 8: -----

|    |         |       |      |       |      |        |
|----|---------|-------|------|-------|------|--------|
| 13 | 22386.7 | 175.9 | 82.4 | 450.0 | .0   | -----  |
| 14 | 23739.5 | 170.7 | 81.8 | 450.0 | 20.0 | S84-86 |
| 15 | 24933.5 | 166.8 | 81.4 | 450.0 | .0   | -----  |

----- CARD 9: ----- COMMENTS -----

Comments: BASIS 1.174 DIA RATIO .98 EFF RATIO WBC46  
 Shut Head Horsepower: 330.3 Perf Basis: E Units M/B/U: U  
 Actual Throat Area (AA<sub>t</sub>) 155.200 CT Collector Type S/D/A/C: S

## SECTION 2.1

### Environmental Data:

Temperature ..... 70.000 deg. Farenheit  
 Dynamic viscosity of fluid ... .000020 lb set/ft^2  
 Specific Gravity of fluid .... .998  
 Gravity ..... 32.170 ft/sec^2  
 Pipe inside diameter ..... 17.250 inches  
 Pipe Roughness ..... .000050 feet

### Matrix Data:

Specific Gravity of Solids ..... 2.650  
 Pebble Concentration (%) ..... 46.000  
 Fines Concentration (%) ..... 28.000  
 Feed Size Multiplier ..... .950  
 Carrier Viscosity Correction ... 1.000

| VELOCITY       | FRICITION      | ENERGY | FLOW   | RATE                 | TRANSPORT RATE | SLURRY | CONCENTRATION |                |                |
|----------------|----------------|--------|--------|----------------------|----------------|--------|---------------|----------------|----------------|
| V <sub>m</sub> | J <sub>m</sub> | HP-HR  | Q      | Q                    | TON/HR         | LB/SEC | SG            | C <sub>v</sub> | C <sub>w</sub> |
| (FT/SEC)       | FT SLY/FT      | TON MI | GPM    | FT <sup>3</sup> /SEC |                |        |               | %              | %              |
| 29.794         | .0963          | 1.394  | 21703. | 48.35                | 2000.0         | 1111.1 | 1.23          | 13.9           | 30.0           |
| 24.558         | .0718          | .858   | 17889. | 39.86                | 2000.0         | 1111.1 | 1.28          | 16.9           | 35.0           |
| 20.632         | .0576          | .578   | 15029. | 33.48                | 2000.0         | 1111.1 | 1.33          | 20.1           | 40.0           |
| 17.578         | .0490          | .419   | 12804. | 28.53                | 2000.0         | 1111.1 | 1.39          | 23.6           | 45.0           |
| 15.135         | .0437          | .321   | 11025. | 24.56                | 2000.0         | 1111.1 | 1.45          | 27.4           | 50.0           |

SECTION 2.2

Settling of solids particles in a liquid

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Solids particle S.G. ... 2.650 Carrier liquid S.G. = 1.000  
 Shape factor K ..... .260 Absolute viscosity (LB SEC/FT SQ)= .0000205  
 Value of G (FT/SEC SQ).. 32.170 Specific weight of fluid (LB/FT SQ) = 62.2  
 ?  
 Slurry concentration by VOL (%) 20.000

| PARTIC<br>DIA<br>MICRONS | DIMENS<br>GROUP<br>ND | PARTIC<br>RENO NO<br>RE | DRAG<br>COEFF<br>CD | SPHERE<br>TER VEL<br>FT/SEC | SHAPE<br>FACT<br>K | SHAPE<br>COR<br>KA | TERMIN<br>VEL<br>FT/SEC | HIND S<br>INDEX<br>N | HINDERED<br>SET VEL<br>FT/SEC |
|--------------------------|-----------------------|-------------------------|---------------------|-----------------------------|--------------------|--------------------|-------------------------|----------------------|-------------------------------|
| 100.                     | 22.                   | .822                    | 33.04               | .0265                       | .260               | .520               | .0138                   | 4.426                | .0051                         |
| 250.                     | 348.                  | 8.724                   | 4.58                | .1126                       | .260               | .562               | .0633                   | 3.543                | .0287                         |
| 500.                     | 2788.                 | 40.112                  | 1.73                | .2588                       | .260               | .581               | .1504                   | 3.042                | .0763                         |
| 750.                     | 9409.                 | 90.655                  | 1.14                | .3900                       | .260               | .567               | .2211                   | 2.804                | .1183                         |
| 1000.                    | 22302.                | 157.988                 | .89                 | .5097                       | .260               | .546               | .2783                   | 2.652                | .1540                         |
| 2000.                    | 178420.               | 568.806                 | .55                 | .9176                       | .260               | .517               | .4747                   | 2.400                | .2779                         |

SECTION 2.3

PARTICLE DEPOSIT VELOCITY CHECK

|                                              |               |
|----------------------------------------------|---------------|
| Fluid Specific Gravity .....                 | .99792        |
| Viscosity ..... (lb sec/ft <sup>2</sup> )    | .2048948E-04  |
| Fluid friction factor .....                  | .01300        |
| Solids Specific Gravity .....                | 2.6500        |
| Coefficient of mechanical-sliding friction . | .35000        |
| Volumetric fraction of solids .....          | .60000        |
| Particle diameter .....                      | 500.0 microns |

Pipe diameter = 17.250 inches SLOPE = 0. deg

CALCULATED RESULTS:

V<sub>sm</sub> = 11.64 ft/s C<sub>sm</sub> = .126

| Cvd  | Vs (ft/s) |
|------|-----------|
| .050 | 9.30      |
| .100 | 11.43     |
| .150 | 11.50     |
| .200 | 10.53     |
| .250 | 8.99      |
| .300 | 7.20      |
| .350 | 5.37      |
| .400 | 3.65      |

SECTION 3.3

Pipeline Information

Matrix Description:

Pebble Fraction(%) is 46.000  
 Fines Fraction(%) is 28.000  
 Feed size multiplier is .950  
 Carrier viscosity correction is 1.000

Solids Concentration by WEIGHT (%) = 40.000  
 Slurry S.G. = 1.332

| Section | Roughness<br>"E" | Dia.<br>in. | Length<br>ft. | NUMBER<br>BENDS | VALVES | BEND<br>K | VALVE<br>K |
|---------|------------------|-------------|---------------|-----------------|--------|-----------|------------|
| Suction | .000050          | 17.250      | 60.0          | 0               | 0      | .300      | .100       |
| Disch#1 | .000050          | 17.250      | 23700.0       | 0               | 0      | .300      | .100       |

Static Head Information:

Vertical distances from Pit Pump Center Line  
 A negative number indicates a position below Center Line.

Suction (vertical ft) ..... -5.000  
 Final Discharge (vertical ft) .. 5.000

\*\*\*\*\* SYSTEM HEAD EVALUATION \*\*\*\*\*

DISCHARGE #1 MINIMUM FRICTION VELOCITY = 8.2 ft/s @ 5993.GPM  
 Minimum Flow (GPM) ..... 5993.  
 Temperature Farenheit ..... 70.0  
 VAPOR PRESSURE (feet Slurry). .63  
 Suction Elevation (feet) ..... 0.

HEAD LOSSES EVALUATED AT 15390. GPM

NOTE: Inlet and Outlet Losses neglected. Standard Atmospheric Pressure assumed.

| PIPE<br>SECTION | VELOCITY<br>FT/S | REYNOLDS<br>NO. | FRICTION<br>FACTOR | RESISTANCE IN<br>CONDUIT | BENDS | VALVES | TOTAL  |
|-----------------|------------------|-----------------|--------------------|--------------------------|-------|--------|--------|
| Suction         | 21.1             | .8375E+06       | .01201             | 3.57                     | .00   | .00    | 3.6    |
| Disch#1         | 21.1             | .8375E+06       | .01201             | 1410.55                  | .00   | .00    | 1410.5 |

TOTAL SYSTEM RESISTANCE (including static) is 1424.1 ft Slurry  
 NPSH AVAILABLE is 16.3 ft Slurry

SECTION 3.4

Pipeline Information

Matrix Description:

Pebble Fraction(%) is 46.000  
 Fines Fraction(%) is 28.000  
 Feed size multiplier is .950  
 Carrier viscosity correction is 1.000

Solids Concentration by WEIGHT (%) = 40.000  
 Slurry S.G. = 1.332

| Section | Roughness<br>"E" | Dia.<br>in. | Length<br>ft. | NUMBER<br>BENDS VALVES | BEND<br>K | VALVE<br>K |
|---------|------------------|-------------|---------------|------------------------|-----------|------------|
| Suction | .000050          | 17.250      | 60.0          | 0 0                    | .300      | .100       |
| Disch#1 | .000050          | 17.250      | 23700.0       | 0 0                    | .300      | .100       |

Static Head Information:

Vertical distances from Pit Pump Center Line  
 A negative number indicates a position below Center Line.

Suction (vertical ft) ..... -5.000  
 Final Discharge (vertical ft) .. 5.000

\*\*\*\*\* SYSTEM HEAD EVALUATION \*\*\*\*\*

DISCHARGE #1 MINIMUM FRICTION VELOCITY = 8.2 ft/s @ 5993.GPM  
 Minimum Flow (GPM) ..... 5993.  
 Temperature (Farenheit) ..... 70.0  
 Suction Elevation (feet) ..... 0.

HEAD LOSSES EVALUATED FOR FLOW RANGE  
 5993. to 20000. GPM

NOTE: Inlet and Outlet Losses neglected. Standard Atmospheric Pressure assumed.

| FLOW<br>GPM | SUCT<br>ft liq | DSCH 1<br>ft liq | STATIC<br>ft liq | TOTAL RES<br>ft liq | NPSHA<br>ft liq |
|-------------|----------------|------------------|------------------|---------------------|-----------------|
| 5993.       | 2.0            | 781.4            | 10.0             | 793.4               | 17.9            |
| 6476.       | 2.0            | 781.7            | 10.0             | 793.7               | 17.9            |
| 6959.       | 2.0            | 787.3            | 10.0             | 799.3               | 17.9            |
| 7442.       | 2.0            | 797.5            | 10.0             | 809.5               | 17.9            |
| 7925.       | 2.1            | 811.8            | 10.0             | 823.9               | 17.8            |
| 8408.       | 2.1            | 830.0            | 10.0             | 842.1               | 17.8            |
| 8891.       | 2.2            | 851.7            | 10.0             | 863.9               | 17.7            |
| 9374.       | 2.2            | 876.7            | 10.0             | 888.9               | 17.7            |
| 9857.       | 2.3            | 904.8            | 10.0             | 917.1               | 17.6            |
| 10340.      | 2.4            | 935.8            | 10.0             | 948.2               | 17.5            |
| 10823.      | 2.5            | 969.6            | 10.0             | 982.0               | 17.4            |
| 11306.      | 2.5            | 1006.0           | 10.0             | 1018.6              | 17.3            |
| 11789.      | 2.6            | 1045.1           | 10.0             | 1057.7              | 17.2            |
| 12272.      | 2.8            | 1086.6           | 10.0             | 1099.4              | 17.1            |
| 12755.      | 2.9            | 1130.6           | 10.0             | 1143.5              | 17.0            |
| 13238.      | 3.0            | 1176.9           | 10.0             | 1189.9              | 16.9            |
| 13721.      | 3.1            | 1225.5           | 10.0             | 1238.6              | 16.8            |
| 14204.      | 3.2            | 1276.4           | 10.0             | 1289.6              | 16.6            |
| 14687.      | 3.4            | 1329.5           | 10.0             | 1342.8              | 16.5            |
| 15170.      | 3.5            | 1384.7           | 10.0             | 1398.2              | 16.4            |
| 15653.      | 3.7            | 1442.1           | 10.0             | 1455.7              | 16.2            |
| 16136.      | 3.8            | 1501.5           | 10.0             | 1515.3              | 16.1            |
| 16619.      | 4.0            | 1563.1           | 10.0             | 1577.0              | 15.9            |

|        |     |        |      |        |      |
|--------|-----|--------|------|--------|------|
| 17102. | 4.1 | 1626.7 | 10.0 | 1640.8 | 15.8 |
| 17585. | 4.3 | 1692.3 | 10.0 | 1706.6 | 15.6 |
| 18068. | 4.5 | 1759.9 | 10.0 | 1774.4 | 15.4 |
| 18551. | 4.6 | 1829.5 | 10.0 | 1844.1 | 15.2 |
| 19034. | 4.8 | 1901.1 | 10.0 | 1915.9 | 15.1 |
| 19517. | 5.0 | 1974.6 | 10.0 | 1989.6 | 14.9 |
| 20000. | 5.2 | 2050.1 | 10.0 | 2065.2 | 14.7 |

SECTION 3.4 Continued



## SECTION 4-1

### EVALUATION OF PUMPS AGAINST GIVEN SYSTEM

DATAPASE # 10 18 x 18 WSO 44  
PUMP TYPE: A 16- / /3ME15- 5/ 8 TEST BASIS: T173 -80  
MOTOR CHAR. = ELECTRIC SYNCHRONOUS MAX AVAILABLE BHP: 1500. RPM: 590.  
TEST IMP DIA 44.000 SLURRY S. G. 1.332 SOLIDS EFFECT FOR HEAD 5.%  
ACTUAL IMP DIA 44.000

#### NOTE:

BHP needed exceeds the maximum available BHP at 13793.1 GPM.  
Operation beyond this flow overloads and (if applicable) reduces speed according to motor characteristics.

DATABASE # 8 18 x 18 WBC 46  
PUMP TYPE: C H11- 1/ 2/3ME11- 1/ 4 TEST BASIS : E 32B-85  
MOTOR CHAR. = ELECTRIC SYNCHRONOUS MAX AVAILABLE BHP: 1500. RPM: 505.  
TEST IMP DIA 46.000 SLURRY S.G. 1.332 SOLIDS EFFECT FOR HEAD 4.%  
ACTUAL IMP DIA 46.000

#### NOTE:

BHP needed exceeds the maximum available BHP at 25615.8 GPM.  
Operation beyond this flow overloads and (if applicable) reduces speed according to motor characteristics.

DATABASE # 10 18 X 18 WSO 44  
PUMP TYPE: A 16- / /3ME15- 5/ 8 TEST BASIS: T173 -80  
MOTOR CHAR. = ELECTRIC SYNCHRONOUS MAX AVAILABLE BHP: 1500. RPM: 505.  
TEST IMP DIA 44.000 SLURRY S. G. 1.332 SOLIDS EFFECT FOR HEAD 4.%  
ACTUAL IMP DIA 44.000

#### NOTE:

BHP needed exceeds the maximum available BHP at 23645.3 GPM.  
Operation beyond this flow overloads and (if applicable) reduces speed according to motor characteristics.

DATABASE # 10 18 X 18 WSO 44  
PUMP TYPE: A 16- / /3ME15- 5/ 8 TEST BASIS: T173 -80  
MOTOR CHAR. = ELECTRIC SYNCHRONOUS MAX AVAILABLE BHP: 1500. RPM: 505.  
TEST IMP DIA 44.000 SLURRY S.G. 1.332 SOLIDS EFFECT FOR HEAD 4.%  
ACTUAL IMP DIA 44.000

#### NOTE:

BHP needed exceeds the maximum available BHP at 23645.3 GPM.  
Operation beyond this flow overloads and (if applicable) reduces speed according to motor characteristics.

DATABASE # 10 18 X 18 WSO 44  
PUMP TYPE: A 16- / /3ME15- 5/ 8 TEST BASIS: T173 -80  
MOTOR CHAR. = ELECTRIC SYNCHRONOUS MAX AVAILABLE BHP: 1500. RPM: 585.  
TEST IMP DIA 44.000 SLURRY S.G. 1.332 SOLIDS EFFECT FOR HEAD 5.%  
ACTUAL IMP DIA 44.000

BHP needed exceeds the maximum available BHP at 13793.1 GPM.  
 Operation beyond this flow overloads and (if applicable) reduces speed  
 4.1 according to motor characteristics.

Cont'd

DATABASE # 6 18 X 18 WBC 46  
 PUMP TYPE: C H11- 1/ 2/3ME11- 1/ 4 TEST BASIS: E 32E-25  
 MOTOR CHAR. = ELECTRIC SYNCHRONOUS MAX AVAILABLE BHP: 1500. RPM: 505.  
 TEST IMP DIA 46.000 SLURRY S.G. 1.332 SOLIDS EFFECT FOR HEAD 4.%  
 ACTUAL IMP DIA 46.000

NOTE:

BHP needed exceeds the maximum available BHP at 25615.8 GPM.  
 Operation beyond this flow overloads and (if applicable) reduces speed  
 according to motor characteristics.

DATABASE # 10 18 X 18 WSO 44  
 PUMP TYPE: A 16- / /3ME15- 5/ 8 TEST BASIS: T173 -80  
 MOTOR CHAR. = ELECTRIC SYNCHRONOUS MAX AVAILABLE BHP: 1500. RPM: 585.  
 TEST IMP DIA 44.000 SLURRY S.G. 1.332 SOLIDS EFFECT FOR HEAD 5.%  
 ACTUAL IMP DIA 42.000

NOTE:

BHP needed exceeds the maximum available BHP at 16748.8 GPM.  
 Operation beyond this flow overloads and (if applicable) reduces speed  
 according to motor characteristics.

| FLOW<br>GPM | TOTAL SYSTEM<br>RESISTANCE<br>ft slurry | HEAD PRODUCED<br>BY PUMP(S)<br>ft slurry |
|-------------|-----------------------------------------|------------------------------------------|
| 5992.8      | 793.4                                   | 1471.0                                   |
| 6475.8      | 793.7                                   | 1464.1                                   |
| 6958.8      | 799.3                                   | 1457.0                                   |
| 7441.8      | 809.5                                   | 1449.6                                   |
| 7924.9      | 823.9                                   | 1441.9                                   |
| 8407.9      | 842.1                                   | 1433.9                                   |
| 8890.9      | 863.9                                   | 1425.6                                   |
| 9373.9      | 888.9                                   | 1417.1                                   |
| 9856.9      | 917.1                                   | 1408.3                                   |
| 10339.9     | 948.2                                   | 1399.2                                   |
| 10822.9     | 982.0                                   | 1389.8                                   |
| 11305.9     | 1018.6                                  | 1380.1                                   |
| 11788.9     | 1057.7                                  | 1370.2                                   |
| 12271.9     | 1099.4                                  | 1360.0                                   |
| 12754.9     | 1143.5                                  | 1349.5                                   |
| 13237.9     | 1189.9                                  | 1338.7                                   |
| 13720.9     | 1238.6                                  | 1327.7                                   |
| 14203.9     | 1289.6                                  | 1316.4                                   |
| 14686.9     | 1342.8                                  | 1304.8                                   |
| 15169.9     | 1398.2                                  | 1292.9                                   |
| 15652.9     | 1455.7                                  | 1280.7                                   |
| 16136.0     | 1515.3                                  | 1268.3                                   |
| 16619.0     | 1577.0                                  | 1255.6                                   |
| 17102.0     | 1640.8                                  | 1242.6                                   |
| 17585.0     | 1706.6                                  | 1229.3                                   |
| 18068.0     | 1774.4                                  | 1215.7                                   |
| 18551.0     | 1844.1                                  | 1201.9                                   |
| 19034.0     | 1915.9                                  | 1187.8                                   |
| 19517.0     | 1989.6                                  | 1173.4                                   |
| 20000.0     | 2065.2                                  | 1158.8                                   |

RECOMMENDED OPERATING POINT : 14446.75 GPM

HEAD= 1310.6 FT SLURRY

4.1 Cont'd.

PUMP DATA AT OPERATING POINT FOUND

| <u>PUMP #</u> | <u>HEAD</u> | <u>EFF</u> | <u>POWER</u> |
|---------------|-------------|------------|--------------|
| 1             | 218.4       | 70.8       | 1500.0       |
| 2             | 171.3       | 81.5       | 1022.0       |
| 3             | 164.8       | 72.9       | 1099.0       |
| 4             | 164.8       | 72.9       | 1099.0       |
| 5             | 218.6       | 70.8       | 1500.6       |
| 6             | 171.3       | 81.5       | 1022.0       |
| 7             | 201.9       | 71.1       | 1380.0       |

## SECTION 4.2

\*\*\*\*\* SYSTEM HEAD EVALUATION \*\*\*\*\*

DISCHARGE #1 MINIMUM FRICTION VELOCITY = 8.2 ft/s @ 5993.6PM  
 Minimum Flow (GPM) ..... 5993.  
 Temperature Farenheit ..... 70.0  
 VAPOR PRESSURE (feet Slurry). .63  
 Suction Elevation (feet) ..... 0.

HEAD LOSSES EVALUATED AT 14447. GPM

NOTE: Inlet and Outlet Losses neglected. Standard Atmospheric Pressure assumed.

| PIPE SECTION | VELOCITY FT/S | REYNOLDS NO. | FRICTION FACTOR | RESISTANCE IN CONDUIT | BENDS | VALVES | TOTAL  |
|--------------|---------------|--------------|-----------------|-----------------------|-------|--------|--------|
| Suction      | 19.8          | .7861E+06    | .01215          | 3.30                  | .00   | .00    | 3.3    |
| Disch#1      | 19.8          | .7861E+06    | .01215          | 1302.79               | .00   | .00    | 1302.8 |

TOTAL SYSTEM RESISTANCE (including static) is 1316.1 ft Slurry  
 NPSH AVAILABLE is 16.6 ft Slurry

SECTION 4.2 Cont'd.

Duty Details: 14447.GPM 1316.1 ft slurry required 1.33 Slurry S.G.  
 NPSH Available = 14.7 ft of slurry

NUMBER OF PUMPS IN SERIES : 7

GIVEN PUMPS :

|                                   | PUMP TITLE                          | DBS# | RPM  | ImpDia | HEAD                                |
|-----------------------------------|-------------------------------------|------|------|--------|-------------------------------------|
| 1                                 | 18X18WSO 44 A 16- / /3ME15- 5/ 8    | 10   | 590. | 44.00  | 230.6                               |
| 2                                 | 18X18WBC 46 C H11- 1/ 2/3ME11- 1/ 4 | 8    | 505. | 46.00  | 170.3                               |
| 3                                 | 18X18WSO 44 A 16- / /3ME15- 5/ 8    | 10   | 505. | 44.00  | 165.1                               |
| 4                                 | 18X18WSO 44 A 16- / /3ME15- 5/ 8    | 10   | 505. | 44.00  | 165.1                               |
| 5                                 | 18X18WSO 44 A 16- / /3ME15- 5/ 8    | 10   | 585. | 44.00  | 227.8                               |
| 6                                 | 18X18WBC 46 C H11- 1/ 2/3ME11- 1/ 4 | 8    | 505. | 46.00  | 170.3                               |
| HEAD PRODUCED BY 6 PUMPS = 1129.4 |                                     |      |      |        | HEAD REQUIRED OF FINAL PUMP = 186.7 |

----- SELECTED PUMP with ALL VALUES SCALED to NEW SPEED & TURNDOWN -- DBS 10  
 18X18WSO 44 A 16- / /3ME15- 5/ 8 E 17 -87 T173 -80

|            |                          |                   |     |             |
|------------|--------------------------|-------------------|-----|-------------|
| RPM        | 585.0 ! T/D RATIO (THEO) | .913 ! PERIPHERAL | VEL | 6210.17 SFM |
| EFF.       | 71.5 ! FULL IMP DIA      | 44.00 ! THROAT    | VEL | 19.83 ft/   |
| NPSH RQD   | 9.4 ! THEORET IMP DIA    | 40.17 ! BRANCH    | VEL | 19.83       |
| BASE PRICE | ! ACTUAL IMP DIA         | 40.55 ! SUCTION   | VEL | 19.83       |

PERFORMANCE CURVES for the pump selected at the nominated duty:

| Flow             | HEAD  | Eff. | BHP W/ Slurry S.G.CORR |
|------------------|-------|------|------------------------|
| .0               | 215.7 | .0   | 387.3                  |
| 3975.2           | 209.2 | 43.3 | 646.7                  |
| 7950.4           | 201.6 | 59.5 | 906.2                  |
| 11925.6          | 192.9 | 68.3 | 1133.3                 |
| @ Duty 14446.7   | 186.7 | 71.5 | 1270.2                 |
| 120% Dty 17336.0 | 179.2 | 73.4 | 1423.6                 |
| @ BEP 19876.0    | 172.0 | 73.9 | 1556.3                 |
| 23851.3          | 159.9 | 72.9 | 1761.8                 |
| 27826.5          | 146.6 | 69.9 | 1965.1                 |
| 31801.7          | 132.3 | 65.4 | 2166.0                 |
| 35776.9          | 116.8 | 59.5 | 2363.0                 |

SECTION 5  
Input Data

-----  
| PUMP LOCATION DATA |  
-----

TOTAL NUMBER OF PUMPS ALONG PIPELINE= 7

DATA FOR PUMP# 1 [PIT PUMP]  
 DISTANCE (FT.) FROM THE PIT TO PUMP# 1 = 60.0  
 HEIGHT (FT.) OF PIT ABOVE PIT PUMP CENTERLINE -5.0  
 HEIGHT (FT.) OF PLANT DISCH. ABOVE PIT PUMP C. 5.0  
 HEAD (FT-SLURRY) ADDED BY PUMP# 1 = 230.6  
 DATA FOR PUMP# 2

PIPE LENGTH (FT.) FROM PUMP#1 TO PUMP#2= 3385.0  
 HEIGHT (FT.) OF PUMP# 2 CL ABOVEPIT PUMP CL= .0  
 HEAD (FT-SLURRY) ADDED BY PUMP#2= 170.9  
 DATA FOR PUMP# 3

PIPE LENGTH (FT.) FROM PUMP#2 TO PUMP#3= 3385.0  
 HEIGHT (FT.) OF PUMP# 3 CL ABOVEPIT PUMP CL= .0  
 HEAD (FT-SLURRY) ADDED BY PUMP#3= 165.7  
 DATA FOR PUMP# 4

PIPE LENGTH (FT.) FROM PUMP#3 TO PUMP#4= 3385.0  
 HEIGHT (FT.) OF PUMP# 4 CL ABOVEPIT PUMP CL= .0  
 HEAD (FT-SLURRY) ADDED BY PUMP#4= 165.7  
 DATA FOR PUMP# 5

PIPE LENGTH (FT.) FROM PUMP#4 TO PUMP#5= 3385.0  
 HEIGHT (FT.) OF PUMP# 5 CL ABOVEPIT PUMP CL= .0  
 HEAD (FT-SLURRY) ADDED BY PUMP#5= 226.4  
 DATA FOR PUMP# 6

PIPE LENGTH (FT.) FROM PUMP#5 TO PUMP#6= 3385.0  
 HEIGHT (FT.) OF PUMP# 6 CL ABOVEPIT PUMP CL= .0  
 HEAD (FT-SLURRY) ADDED BY PUMP#6= 170.9  
 DATA FOR PUMP# 7

PIPE LENGTH (FT.) FROM PUMP#6 TO PUMP#7= 3385.0  
 PIPE LENGTH (FT.) FROM PUMP#7 TO DISCH.= 3385.0

HEIGHT (FT.) OF PUMP# 7 CL ABOVEPIT PUMP CL= 5.0  
 HEAD (FT-SLURRY) ADDED BY PUMP#7= 185.9

-----  
| INSTANT CHANGES IN ELEVATIONS |  
-----

NUMBER OF INSTANT CHANGES IN  
 ELEVATION OF PIPELINE (MAX 20) = 0

-----  
| PIPELINE DATA |  
-----

ENTER THE NUMBER OF PIPE SECTIONS (MIN 2)= 2

DATA FOR PIPE SECTION NUMBER 1  
 ENTER LENGTH (FT) OF SECTION # 1 = 60.0  
 ENTER I/DIA (IN) OF SECTION # 1 = 17.3  
 FRICTION HEAD LOSS (FT-SLURRY) FOR SECTION # 1 3.3

DATA FOR PIPE SECTION NUMBER 2  
 ENTER LENGTH (FT) OF SECTION # 2 = 23700.0  
 ENTER I/DIA (IN) OF SECTION # 2 = 17.3  
 FRICTION HEAD LOSS (FT-SLURRY) FOR SECTION # 2 1302.8

-----  
 - PUMP SPACING AND STEADY HEAD DISTRIBUTIONS -  
 -----

| LENGTH ALONG PIPE (FT) | DESCRIPTION          | HEAD (FT-SLURRY) | CAVITATIO |
|------------------------|----------------------|------------------|-----------|
| 60.0                   | SUCTION OF PUMP # 1  | -8.3             | CHECK     |
| 60.0                   | DISCHARGE OF PUMP# 1 | 222.3            | NO        |
| 3445.0                 | SUCTION OF PUMP # 2  | 36.3             | NO        |
| 3445.0                 | DISCHARGE OF PUMP# 2 | 207.2            | NO        |
| 6830.0                 | SUCTION OF PUMP # 3  | 21.1             | NO        |
| 6830.0                 | DISCHARGE OF PUMP# 3 | 186.8            | NO        |
| 10215.0                | SUCTION OF PUMP # 4  | .7               | NO        |
| 10215.0                | DISCHARGE OF PUMP# 4 | 166.3            | NO        |
| 13600.0                | SUCTION OF PUMP # 5  | -19.7            | CHECK     |
| 13600.0                | DISCHARGE OF PUMP# 5 | 206.7            | NO        |
| 16985.0                | SUCTION OF PUMP # 6  | 20.6             | NO        |
| 16985.0                | DISCHARGE OF PUMP# 6 | 191.5            | NO        |
| 20370.0                | SUCTION OF PUMP # 7  | .4               | NO        |
| 20370.0                | DISCHARGE OF PUMP# 7 | 186.4            | NO        |
| 23755.0                | PLANT DISCHARGE      | .3               | NO        |

| PUMP # | SUCTION PR. (PSI) | DISCHARGE PR. (PSI) |
|--------|-------------------|---------------------|
| 1      | -4.78             | 128.17              |
| 2      | 20.90             | 119.44              |
| 3      | 12.17             | 107.66              |
| 4      | .39               | 95.89               |
| 5      | -11.38            | 119.14              |
| 6      | 11.87             | 110.41              |
| 7      | .25               | 107.43              |

-----  
 ! EVALUATE STARTUP ALTERNATIVES !  
 -----

## STARTUP ORDER OF PUMPS

START-UP #1 : ENTER PUMP NUMBER = 1  
 START-UP #2 : ENTER PUMP NUMBER = 2  
 START-UP #3 : ENTER PUMP NUMBER = 3  
 START-UP #4 : ENTER PUMP NUMBER = 4  
 START-UP #5 : ENTER PUMP NUMBER = 5  
 START-UP #6 : ENTER PUMP NUMBER = 6  
 START-UP #7 : ENTER PUMP NUMBER = 7

TIME INTERVAL BETWEEN STARTUP #1 AND #2 = 15.0  
 TIME INTERVAL BETWEEN STARTUP #2 AND #3 = 20.0  
 TIME INTERVAL BETWEEN STARTUP #3 AND #4 = 15.0  
 TIME INTERVAL BETWEEN STARTUP #4 AND #5 = 20.0  
 TIME INTERVAL BETWEEN STARTUP #5 AND #6 = 15.0  
 TIME INTERVAL BETWEEN STARTUP #6 AND #7 = 20.0

+-----+  
 ! TRANSIENT HEAD DISTRIBUTION ALONG SYSTEM !  
 +-----+

| TIME<br>SEC | FLOW<br>USGPM | LENGTH ALONG<br>PIPELINE (FT.) | DESCRIPTION<br>OF LOCATION | HEAD<br>FT-WATER | CAVITATION<br>WARNING |
|-------------|---------------|--------------------------------|----------------------------|------------------|-----------------------|
| .0          | 0.            | 60.                            | SUCTION OF PUMP# 1         | -5.0             | CHECK                 |
| .0          | 0.            | 60.                            | DISCHARGE OF PUMP#1        | 267.8            | NO                    |
| .0          | 0.            | 3445.                          | SUCTION OF PUMP# 2         | 267.8            | NO                    |
| .0          | 0.            | 3445.                          | DISCHARGE OF PUMP#2        | 267.8            | NO                    |
| .0          | 0.            | 6830.                          | SUCTION OF PUMP# 3         | 267.8            | NO                    |
| .0          | 0.            | 6830.                          | DISCHARGE OF PUMP#3        | 267.8            | NO                    |
| .0          | 0.            | 10215.                         | SUCTION OF PUMP# 4         | 267.8            | NO                    |
| .0          | 0.            | 10215.                         | DISCHARGE OF PUMP#4        | 267.8            | NO                    |
| .0          | 0.            | 13600.                         | SUCTION OF PUMP# 5         | 267.8            | NO                    |
| .0          | 0.            | 13600.                         | DISCHARGE OF PUMP#5        | 267.8            | NO                    |
| .0          | 0.            | 16985.                         | SUCTION OF PUMP# 6         | 267.8            | NO                    |
| .0          | 0.            | 16985.                         | DISCHARGE OF PUMP#6        | 267.8            | NO                    |
| .0          | 0.            | 20370.                         | SUCTION OF PUMP# 7         | 262.8            | NO                    |
| .0          | 0.            | 20370.                         | DISCHARGE OF PUMP#7        | 262.8            | NO                    |
| .0          | 0.            | 23755.                         | PLANT DISCHARGE HEAD       | 262.8            | NO                    |
| 5.0         | 1273.         | 60.                            | SUCTION OF PUMP# 1         | -5.0             | CHECK                 |
| 5.0         | 1273.         | 60.                            | DISCHARGE OF PUMP#1        | 265.6            | NO                    |
| 5.0         | 1273.         | 3445.                          | SUCTION OF PUMP# 2         | 263.9            | NO                    |
| 5.0         | 1273.         | 3445.                          | DISCHARGE OF PUMP#2        | 263.9            | NO                    |
| 5.0         | 1273.         | 6830.                          | SUCTION OF PUMP# 3         | 262.2            | NO                    |
| 5.0         | 1273.         | 6830.                          | DISCHARGE OF PUMP#3        | 262.2            | NO                    |
| 5.0         | 1273.         | 10215.                         | SUCTION OF PUMP# 4         | 260.5            | NO                    |
| 5.0         | 1273.         | 10215.                         | DISCHARGE OF PUMP#4        | 260.5            | NO                    |
| 5.0         | 1273.         | 13600.                         | SUCTION OF PUMP# 5         | 258.8            | NO                    |
| 5.0         | 1273.         | 13600.                         | DISCHARGE OF PUMP#5        | 258.8            | NO                    |
| 5.0         | 1273.         | 16985.                         | SUCTION OF PUMP# 6         | 257.1            | NO                    |
| 5.0         | 1273.         | 16985.                         | DISCHARGE OF PUMP#6        | 257.1            | NO                    |
| 5.0         | 1273.         | 20370.                         | SUCTION OF PUMP# 7         | 250.4            | NO                    |
| 5.0         | 1273.         | 20370.                         | DISCHARGE OF PUMP#7        | 250.4            | NO                    |
| 5.0         | 1273.         | 23755.                         | PLANT DISCHARGE HEAD       | 248.7            | NO                    |
| 10.0        | 2438.         | 60.                            | SUCTION OF PUMP# 1         | -5.1             | CHECK                 |
| 10.0        | 2438.         | 60.                            | DISCHARGE OF PUMP#1        | 263.5            | NO                    |
| 10.0        | 2438.         | 3445.                          | SUCTION OF PUMP# 2         | 257.9            | NO                    |



|      |       |        |                      |       |       |
|------|-------|--------|----------------------|-------|-------|
| 10.0 | 2438. | 3445.  | DISCHARGE OF PUMP#2  | 257.9 | NO    |
| 10.0 | 2438. | 6830.  | SUCTION OF PUMP# 3   | 252.9 | NO    |
| 10.0 | 2438. | 6830.  | DISCHARGE OF PUMP#3  | 252.9 | NO    |
| 10.0 | 2438. | 10215. | SUCTION OF PUMP# 4   | 246.7 | NO    |
| 10.0 | 2438. | 10215. | DISCHARGE OF PUMP#4  | 246.7 | NO    |
| 10.0 | 2438. | 13600. | SUCTION OF PUMP# 5   | 241.1 | NO    |
| 10.0 | 2438. | 13600. | DISCHARGE OF PUMP#5  | 241.1 | NO    |
| 10.0 | 2438. | 16985. | SUCTION OF PUMP# 6   | 235.4 | NO    |
| 10.0 | 2438. | 16985. | DISCHARGE OF PUMP#6  | 235.4 | NO    |
| 10.0 | 2438. | 20370. | SUCTION OF PUMP# 7   | 224.8 | NO    |
| 10.0 | 2438. | 20370. | DISCHARGE OF PUMP#7  | 224.8 | NO    |
| 10.0 | 2438. | 23755. | PLANT DISCHARGE HEAD | 219.2 | NO    |
| 15.0 | 3439. | 60.    | SUCTION OF PUMP# 1   | -5.2  | CHECK |
| 15.0 | 3439. | 60.    | DISCHARGE OF PUMP#1  | 261.6 | NO    |
| 15.0 | 3439. | 3445.  | SUCTION OF PUMP# 2   | 250.9 | NO    |
| 15.0 | 3439. | 3445.  | DISCHARGE OF PUMP#2  | 458.2 | NO    |
| 15.0 | 3439. | 6830.  | SUCTION OF PUMP# 3   | 447.6 | NO    |
| 15.0 | 3439. | 6830.  | DISCHARGE OF PUMP#3  | 447.6 | NO    |
| 15.0 | 3439. | 10215. | SUCTION OF PUMP# 4   | 437.0 | NO    |
| 15.0 | 3439. | 10215. | DISCHARGE OF PUMP#4  | 437.0 | NO    |
| 15.0 | 3439. | 13600. | SUCTION OF PUMP# 5   | 426.4 | NO    |
| 15.0 | 3439. | 13600. | DISCHARGE OF PUMP#5  | 426.4 | NO    |
| 15.0 | 3439. | 16985. | SUCTION OF PUMP# 6   | 415.8 | NO    |
| 15.0 | 3439. | 16985. | DISCHARGE OF PUMP#6  | 415.8 | NO    |
| 15.0 | 3439. | 20370. | SUCTION OF PUMP# 7   | 400.1 | NO    |
| 15.0 | 3439. | 20370. | DISCHARGE OF PUMP#7  | 400.1 | NO    |
| 15.0 | 3439. | 23755. | PLANT DISCHARGE HEAD | 389.5 | NO    |
| 20.0 | 5159. | 60.    | SUCTION OF PUMP# 1   | -5.4  | CHECK |
| 20.0 | 5159. | 60.    | DISCHARGE OF PUMP#1  | 258.0 | NO    |
| 20.0 | 5159. | 3445.  | SUCTION OF PUMP# 2   | 235.4 | NO    |
| 20.0 | 5159. | 3445.  | DISCHARGE OF PUMP#2  | 438.8 | NO    |
| 20.0 | 5159. | 6830.  | SUCTION OF PUMP# 3   | 416.2 | NO    |
| 20.0 | 5159. | 6830.  | DISCHARGE OF PUMP#3  | 416.2 | NO    |
| 20.0 | 5159. | 10215. | SUCTION OF PUMP# 4   | 393.5 | NO    |
| 20.0 | 5159. | 10215. | DISCHARGE OF PUMP#4  | 393.5 | NO    |
| 20.0 | 5159. | 13600. | SUCTION OF PUMP# 5   | 370.9 | NO    |
| 20.0 | 5159. | 13600. | DISCHARGE OF PUMP#5  | 370.9 | NO    |
| 20.0 | 5159. | 16985. | SUCTION OF PUMP# 6   | 348.3 | NO    |
| 20.0 | 5159. | 16985. | DISCHARGE OF PUMP#6  | 348.3 | NO    |
| 20.0 | 5159. | 20370. | SUCTION OF PUMP# 7   | 320.7 | NO    |
| 20.0 | 5159. | 20370. | DISCHARGE OF PUMP#7  | 320.7 | NO    |
| 20.0 | 5159. | 23755. | PLANT DISCHARGE HEAD | 298.0 | NO    |
| 25.0 | 6430. | 60.    | SUCTION OF PUMP# 1   | -5.6  | CHECK |
| 25.0 | 6430. | 60.    | DISCHARGE OF PUMP#1  | 255.2 | NO    |
| 25.0 | 6430. | 3445.  | SUCTION OF PUMP# 2   | 220.9 | NO    |
| 25.0 | 6430. | 3445.  | DISCHARGE OF PUMP#2  | 421.4 | NO    |
| 25.0 | 6430. | 6830.  | SUCTION OF PUMP# 3   | 387.2 | NO    |
| 25.0 | 6430. | 6830.  | DISCHARGE OF PUMP#3  | 387.2 | NO    |
| 25.0 | 6430. | 10215. | SUCTION OF PUMP# 4   | 352.9 | NO    |
| 25.0 | 6430. | 10215. | DISCHARGE OF PUMP#4  | 352.9 | NO    |
| 25.0 | 6430. | 13600. | SUCTION OF PUMP# 5   | 318.7 | NO    |
| 25.0 | 6430. | 13600. | DISCHARGE OF PUMP#5  | 318.7 | NO    |
| 25.0 | 6430. | 16985. | SUCTION OF PUMP# 6   | 284.5 | NO    |
| 25.0 | 6430. | 16985. | DISCHARGE OF PUMP#6  | 284.5 | NO    |
| 25.0 | 6430. | 20370. | SUCTION OF PUMP# 7   | 245.3 | NO    |
| 25.0 | 6430. | 20370. | DISCHARGE OF PUMP#7  | 245.3 | NO    |
| 25.0 | 6430. | 23755. | PLANT DISCHARGE HEAD | 211.1 | NO    |
| 30.0 | 7309. | 60.    | SUCTION OF PUMP# 1   | -5.8  | CHECK |
| 30.0 | 7309. | 60.    | DISCHARGE OF PUMP#1  | 253.1 | NO    |
| 30.0 | 7309. | 3445.  | SUCTION OF PUMP# 2   | 209.6 | NO    |
| 30.0 | 7309. | 3445.  | DISCHARGE OF PUMP#2  | 407.8 | NO    |
| 30.0 | 7309. | 6830.  | SUCTION OF PUMP# 3   | 364.3 | NO    |

|      |        |        |                      |       |       |
|------|--------|--------|----------------------|-------|-------|
| 30.0 | 7309.  | 6830.  | DISCHARGE OF PUMP#3  | 364.3 | NO    |
| 30.0 | 7309.  | 10215. | SUCTION OF PUMP# 4   | 320.7 | NO    |
| 30.0 | 7309.  | 10215. | DISCHARGE OF PUMP#4  | 320.7 | NO    |
| 30.0 | 7309.  | 13600. | SUCTION OF PUMP# 5   | 277.1 | NO    |
| 30.0 | 7309.  | 13600. | DISCHARGE OF PUMP#5  | 277.1 | NO    |
| 30.0 | 7309.  | 16985. | SUCTION OF PUMP# 6   | 233.6 | NO    |
| 30.0 | 7309.  | 16985. | DISCHARGE OF PUMP#6  | 233.6 | NO    |
| 30.0 | 7309.  | 20370. | SUCTION OF PUMP# 7   | 185.0 | NO    |
| 30.0 | 7309.  | 20370. | DISCHARGE OF PUMP#7  | 185.0 | NO    |
| 30.0 | 7309.  | 23755. | PLANT DISCHARGE HEAD | 141.4 | NO    |
| 35.0 | 7887.  | 60.    | SUCTION OF PUMP# 1   | -5.9  | CHECK |
| 35.0 | 7887.  | 60.    | DISCHARGE OF PUMP#1  | 251.7 | NO    |
| 35.0 | 7887.  | 3445.  | SUCTION OF PUMP# 2   | 201.4 | NO    |
| 35.0 | 7887.  | 3445.  | DISCHARGE OF PUMP#2  | 398.2 | NO    |
| 35.0 | 7887.  | 6830.  | SUCTION OF PUMP# 3   | 347.9 | NO    |
| 35.0 | 7887.  | 6830.  | DISCHARGE OF PUMP#3  | 534.5 | NO    |
| 35.0 | 7887.  | 10215. | SUCTION OF PUMP# 4   | 484.1 | NO    |
| 35.0 | 7887.  | 10215. | DISCHARGE OF PUMP#4  | 484.1 | NO    |
| 35.0 | 7887.  | 13600. | SUCTION OF PUMP# 5   | 433.8 | NO    |
| 35.0 | 7887.  | 13600. | DISCHARGE OF PUMP#5  | 433.8 | NO    |
| 35.0 | 7887.  | 16985. | SUCTION OF PUMP# 6   | 383.5 | NO    |
| 35.0 | 7887.  | 16985. | DISCHARGE OF PUMP#6  | 383.5 | NO    |
| 35.0 | 7887.  | 20370. | SUCTION OF PUMP# 7   | 328.2 | NO    |
| 35.0 | 7887.  | 20370. | DISCHARGE OF PUMP#7  | 328.2 | NO    |
| 35.0 | 7887.  | 23755. | PLANT DISCHARGE HEAD | 277.9 | NO    |
| 40.0 | 9002.  | 60.    | SUCTION OF PUMP# 1   | -6.1  | CHECK |
| 40.0 | 9002.  | 60.    | DISCHARGE OF PUMP#1  | 249.0 | NO    |
| 40.0 | 9002.  | 3445.  | SUCTION OF PUMP# 2   | 184.4 | NO    |
| 40.0 | 9002.  | 3445.  | DISCHARGE OF PUMP#2  | 378.2 | NO    |
| 40.0 | 9002.  | 6830.  | SUCTION OF PUMP# 3   | 313.6 | NO    |
| 40.0 | 9002.  | 6830.  | DISCHARGE OF PUMP#3  | 497.9 | NO    |
| 40.0 | 9002.  | 10215. | SUCTION OF PUMP# 4   | 433.3 | NO    |
| 40.0 | 9002.  | 10215. | DISCHARGE OF PUMP#4  | 433.3 | NO    |
| 40.0 | 9002.  | 13600. | SUCTION OF PUMP# 5   | 368.7 | NO    |
| 40.0 | 9002.  | 13600. | DISCHARGE OF PUMP#5  | 368.7 | NO    |
| 40.0 | 9002.  | 16985. | SUCTION OF PUMP# 6   | 304.1 | NO    |
| 40.0 | 9002.  | 16985. | DISCHARGE OF PUMP#6  | 304.1 | NO    |
| 40.0 | 9002.  | 20370. | SUCTION OF PUMP# 7   | 234.4 | NO    |
| 40.0 | 9002.  | 20370. | DISCHARGE OF PUMP#7  | 234.4 | NO    |
| 40.0 | 9002.  | 23755. | PLANT DISCHARGE HEAD | 169.8 | NO    |
| 45.0 | 9669.  | 60.    | SUCTION OF PUMP# 1   | -6.3  | CHECK |
| 45.0 | 9669.  | 60.    | DISCHARGE OF PUMP#1  | 247.3 | NO    |
| 45.0 | 9669.  | 3445.  | SUCTION OF PUMP# 2   | 173.3 | NO    |
| 45.0 | 9669.  | 3445.  | DISCHARGE OF PUMP#2  | 365.3 | NO    |
| 45.0 | 9669.  | 6830.  | SUCTION OF PUMP# 3   | 291.3 | NO    |
| 45.0 | 9669.  | 6830.  | DISCHARGE OF PUMP#3  | 474.2 | NO    |
| 45.0 | 9669.  | 10215. | SUCTION OF PUMP# 4   | 400.2 | NO    |
| 45.0 | 9669.  | 10215. | DISCHARGE OF PUMP#4  | 400.2 | NO    |
| 45.0 | 9669.  | 13600. | SUCTION OF PUMP# 5   | 326.2 | NO    |
| 45.0 | 9669.  | 13600. | DISCHARGE OF PUMP#5  | 326.2 | NO    |
| 45.0 | 9669.  | 16985. | SUCTION OF PUMP# 6   | 252.2 | NO    |
| 45.0 | 9669.  | 16985. | DISCHARGE OF PUMP#6  | 252.2 | NO    |
| 45.0 | 9669.  | 20370. | SUCTION OF PUMP# 7   | 173.2 | NO    |
| 45.0 | 9669.  | 20370. | DISCHARGE OF PUMP#7  | 173.2 | NO    |
| 45.0 | 9669.  | 23755. | PLANT DISCHARGE HEAD | 99.2  | NO    |
| 50.0 | 10053. | 60.    | SUCTION OF PUMP# 1   | -6.4  | CHECK |
| 50.0 | 10053. | 60.    | DISCHARGE OF PUMP#1  | 246.3 | NO    |
| 50.0 | 10053. | 3445.  | SUCTION OF PUMP# 2   | 166.6 | NO    |
| 50.0 | 10053. | 3445.  | DISCHARGE OF PUMP#2  | 357.5 | NO    |
| 50.0 | 10053. | 6830.  | SUCTION OF PUMP# 3   | 277.8 | NO    |
| 50.0 | 10053. | 6830.  | DISCHARGE OF PUMP#3  | 459.9 | NO    |
| 50.0 | 10053. | 10215. | SUCTION OF PUMP# 4   | 380.2 | NO    |

|      |        |        |                      |       |       |
|------|--------|--------|----------------------|-------|-------|
| 50.0 | 10053. | 10215. | DISCHARGE OF PUMP#4  | 562.3 | NO    |
| 50.0 | 10053. | 13600. | SUCTION OF PUMP# 5   | 482.6 | NO    |
| 50.0 | 10053. | 13600. | DISCHARGE OF PUMP#5  | 482.6 | NO    |
| 50.0 | 10053. | 16985. | SUCTION OF PUMP# 6   | 402.9 | NO    |
| 50.0 | 10053. | 16985. | DISCHARGE OF PUMP#6  | 402.9 | NO    |
| 50.0 | 10053. | 20370. | SUCTION OF PUMP# 7   | 318.2 | NO    |
| 50.0 | 10053. | 20370. | DISCHARGE OF PUMP#7  | 318.2 | NO    |
| 50.0 | 10053. | 23755. | PLANT DISCHARGE HEAD | 238.5 | NO    |
| 55.0 | 10964. | 60.    | SUCTION OF PUMP# 1   | -6.7  | CHECK |
| 55.0 | 10964. | 60.    | DISCHARGE OF PUMP#1  | 243.8 | NO    |
| 55.0 | 10964. | 3445.  | SUCTION OF PUMP# 2   | 149.8 | NO    |
| 55.0 | 10964. | 3445.  | DISCHARGE OF PUMP#2  | 338.2 | NO    |
| 55.0 | 10964. | 6830.  | SUCTION OF PUMP# 3   | 244.2 | NO    |
| 55.0 | 10964. | 6830.  | DISCHARGE OF PUMP#3  | 424.4 | NO    |
| 55.0 | 10964. | 10215. | SUCTION OF PUMP# 4   | 330.3 | NO    |
| 55.0 | 10964. | 10215. | DISCHARGE OF PUMP#4  | 510.5 | NO    |
| 55.0 | 10964. | 13600. | SUCTION OF PUMP# 5   | 416.5 | NO    |
| 55.0 | 10964. | 13600. | DISCHARGE OF PUMP#5  | 416.5 | NO    |
| 55.0 | 10964. | 16985. | SUCTION OF PUMP# 6   | 322.5 | NO    |
| 55.0 | 10964. | 16985. | DISCHARGE OF PUMP#6  | 322.5 | NO    |
| 55.0 | 10964. | 20370. | SUCTION OF PUMP# 7   | 223.4 | NO    |
| 55.0 | 10964. | 20370. | DISCHARGE OF PUMP#7  | 223.4 | NO    |
| 55.0 | 10964. | 23755. | PLANT DISCHARGE HEAD | 129.4 | NO    |
| 60.0 | 11450. | 60.    | SUCTION OF PUMP# 1   | -6.8  | CHECK |
| 60.0 | 11450. | 60.    | DISCHARGE OF PUMP#1  | 242.5 | NO    |
| 60.0 | 11450. | 3445.  | SUCTION OF PUMP# 2   | 140.4 | NO    |
| 60.0 | 11450. | 3445.  | DISCHARGE OF PUMP#2  | 327.4 | NO    |
| 60.0 | 11450. | 6830.  | SUCTION OF PUMP# 3   | 225.2 | NO    |
| 60.0 | 11450. | 6830.  | DISCHARGE OF PUMP#3  | 404.3 | NO    |
| 60.0 | 11450. | 10215. | SUCTION OF PUMP# 4   | 302.2 | NO    |
| 60.0 | 11450. | 10215. | DISCHARGE OF PUMP#4  | 481.3 | NO    |
| 60.0 | 11450. | 13600. | SUCTION OF PUMP# 5   | 379.1 | NO    |
| 60.0 | 11450. | 13600. | DISCHARGE OF PUMP#5  | 379.1 | NO    |
| 60.0 | 11450. | 16985. | SUCTION OF PUMP# 6   | 277.0 | NO    |
| 60.0 | 11450. | 16985. | DISCHARGE OF PUMP#6  | 277.0 | NO    |
| 60.0 | 11450. | 20370. | SUCTION OF PUMP# 7   | 169.9 | NO    |
| 60.0 | 11450. | 20370. | DISCHARGE OF PUMP#7  | 169.9 | NO    |
| 60.0 | 11450. | 23755. | PLANT DISCHARGE HEAD | 67.8  | NO    |
| 65.0 | 11702. | 60.    | SUCTION OF PUMP# 1   | -6.9  | CHECK |
| 65.0 | 11702. | 60.    | DISCHARGE OF PUMP#1  | 241.8 | NO    |
| 65.0 | 11702. | 3445.  | SUCTION OF PUMP# 2   | 135.3 | NO    |
| 65.0 | 11702. | 3445.  | DISCHARGE OF PUMP#2  | 321.6 | NO    |
| 65.0 | 11702. | 6830.  | SUCTION OF PUMP# 3   | 215.1 | NO    |
| 65.0 | 11702. | 6830.  | DISCHARGE OF PUMP#3  | 393.6 | NO    |
| 65.0 | 11702. | 10215. | SUCTION OF PUMP# 4   | 287.2 | NO    |
| 65.0 | 11702. | 10215. | DISCHARGE OF PUMP#4  | 465.7 | NO    |
| 65.0 | 11702. | 13600. | SUCTION OF PUMP# 5   | 359.2 | NO    |
| 65.0 | 11702. | 13600. | DISCHARGE OF PUMP#5  | 359.2 | NO    |
| 65.0 | 11702. | 16985. | SUCTION OF PUMP# 6   | 252.8 | NO    |
| 65.0 | 11702. | 16985. | DISCHARGE OF PUMP#6  | 252.8 | NO    |
| 65.0 | 11702. | 20370. | SUCTION OF PUMP# 7   | 141.3 | NO    |
| 65.0 | 11702. | 20370. | DISCHARGE OF PUMP#7  | 141.3 | NO    |
| 65.0 | 11702. | 23755. | PLANT DISCHARGE HEAD | 34.8  | NO    |
| 70.0 | 11832. | 60.    | SUCTION OF PUMP# 1   | -6.9  | CHECK |
| 70.0 | 11832. | 60.    | DISCHARGE OF PUMP#1  | 241.4 | NO    |
| 70.0 | 11832. | 3445.  | SUCTION OF PUMP# 2   | 132.7 | NO    |
| 70.0 | 11832. | 3445.  | DISCHARGE OF PUMP#2  | 318.6 | NO    |
| 70.0 | 11832. | 6830.  | SUCTION OF PUMP# 3   | 209.9 | NO    |
| 70.0 | 11832. | 6830.  | DISCHARGE OF PUMP#3  | 388.1 | NO    |
| 70.0 | 11832. | 10215. | SUCTION OF PUMP# 4   | 279.4 | NO    |
| 70.0 | 11832. | 10215. | DISCHARGE OF PUMP#4  | 457.6 | NO    |
| 70.0 | 11832. | 13600. | SUCTION OF PUMP# 5   | 348.9 | NO    |

|      |        |        |                      |       |       |
|------|--------|--------|----------------------|-------|-------|
| 70.0 | 11832. | 13600. | DISCHARGE OF PUMP#5  | 592.8 | NO    |
| 70.0 | 11832. | 16985. | SUCTION OF PUMP# 6   | 484.1 | NO    |
| 70.0 | 11832. | 16985. | DISCHARGE OF PUMP#6  | 484.1 | NO    |
| 70.0 | 11832. | 20370. | SUCTION OF PUMP# 7   | 370.4 | NO    |
| 70.0 | 11832. | 20370. | DISCHARGE OF PUMP#7  | 370.4 | NO    |
| 70.0 | 11832. | 23755. | PLANT DISCHARGE HEAD | 261.6 | NO    |
| 75.0 | 12789. | 60.    | SUCTION OF PUMP# 1   | -7.2  | CHECK |
| 75.0 | 12789. | 60.    | DISCHARGE OF PUMP#1  | 238.7 | NO    |
| 75.0 | 12789. | 3445.  | SUCTION OF PUMP# 2   | 112.6 | NO    |
| 75.0 | 12789. | 3445.  | DISCHARGE OF PUMP#2  | 295.6 | NO    |
| 75.0 | 12789. | 6830.  | SUCTION OF PUMP# 3   | 169.4 | NO    |
| 75.0 | 12789. | 6830.  | DISCHARGE OF PUMP#3  | 345.5 | NO    |
| 75.0 | 12789. | 10215. | SUCTION OF PUMP# 4   | 219.3 | NO    |
| 75.0 | 12789. | 10215. | DISCHARGE OF PUMP#4  | 395.4 | NO    |
| 75.0 | 12789. | 13600. | SUCTION OF PUMP# 5   | 269.2 | NO    |
| 75.0 | 12789. | 13600. | DISCHARGE OF PUMP#5  | 510.7 | NO    |
| 75.0 | 12789. | 16985. | SUCTION OF PUMP# 6   | 384.6 | NO    |
| 75.0 | 12789. | 16985. | DISCHARGE OF PUMP#6  | 384.6 | NO    |
| 75.0 | 12789. | 20370. | SUCTION OF PUMP# 7   | 253.5 | NO    |
| 75.0 | 12789. | 20370. | DISCHARGE OF PUMP#7  | 253.5 | NO    |
| 75.0 | 12789. | 23755. | PLANT DISCHARGE HEAD | 127.3 | NO    |
| 80.0 | 13247. | 60.    | SUCTION OF PUMP# 1   | -7.4  | CHECK |
| 80.0 | 13247. | 60.    | DISCHARGE OF PUMP#1  | 237.4 | NO    |
| 80.0 | 13247. | 3445.  | SUCTION OF PUMP# 2   | 102.5 | NO    |
| 80.0 | 13247. | 3445.  | DISCHARGE OF PUMP#2  | 284.0 | NO    |
| 80.0 | 13247. | 6830.  | SUCTION OF PUMP# 3   | 149.1 | NO    |
| 80.0 | 13247. | 6830.  | DISCHARGE OF PUMP#3  | 324.1 | NO    |
| 80.0 | 13247. | 10215. | SUCTION OF PUMP# 4   | 189.2 | NO    |
| 80.0 | 13247. | 10215. | DISCHARGE OF PUMP#4  | 364.1 | NO    |
| 80.0 | 13247. | 13600. | SUCTION OF PUMP# 5   | 229.2 | NO    |
| 80.0 | 13247. | 13600. | DISCHARGE OF PUMP#5  | 469.5 | NO    |
| 80.0 | 13247. | 16985. | SUCTION OF PUMP# 6   | 334.6 | NO    |
| 80.0 | 13247. | 16985. | DISCHARGE OF PUMP#6  | 334.6 | NO    |
| 80.0 | 13247. | 20370. | SUCTION OF PUMP# 7   | 194.7 | NO    |
| 80.0 | 13247. | 20370. | DISCHARGE OF PUMP#7  | 194.7 | NO    |
| 80.0 | 13247. | 23755. | PLANT DISCHARGE HEAD | 59.8  | NO    |
| 85.0 | 13460. | 60.    | SUCTION OF PUMP# 1   | -7.5  | CHECK |
| 85.0 | 13460. | 60.    | DISCHARGE OF PUMP#1  | 236.7 | NO    |
| 85.0 | 13460. | 3445.  | SUCTION OF PUMP# 2   | 97.6  | NO    |
| 85.0 | 13460. | 3445.  | DISCHARGE OF PUMP#2  | 278.6 | NO    |
| 85.0 | 13460. | 6830.  | SUCTION OF PUMP# 3   | 139.4 | NO    |
| 85.0 | 13460. | 6830.  | DISCHARGE OF PUMP#3  | 313.9 | NO    |
| 85.0 | 13460. | 10215. | SUCTION OF PUMP# 4   | 174.8 | NO    |
| 85.0 | 13460. | 10215. | DISCHARGE OF PUMP#4  | 349.2 | NO    |
| 85.0 | 13460. | 13600. | SUCTION OF PUMP# 5   | 210.1 | NO    |
| 85.0 | 13460. | 13600. | DISCHARGE OF PUMP#5  | 449.9 | NO    |
| 85.0 | 13460. | 16985. | SUCTION OF PUMP# 6   | 310.8 | NO    |
| 85.0 | 13460. | 16985. | DISCHARGE OF PUMP#6  | 491.7 | NO    |
| 85.0 | 13460. | 20370. | SUCTION OF PUMP# 7   | 347.6 | NO    |
| 85.0 | 13460. | 20370. | DISCHARGE OF PUMP#7  | 347.6 | NO    |
| 85.0 | 13460. | 23755. | PLANT DISCHARGE HEAD | 208.5 | NO    |
| 90.0 | 14194. | 60.    | SUCTION OF PUMP# 1   | -7.7  | CHECK |
| 90.0 | 14194. | 60.    | DISCHARGE OF PUMP#1  | 234.6 | NO    |
| 90.0 | 14194. | 3445.  | SUCTION OF PUMP# 2   | 80.5  | NO    |
| 90.0 | 14194. | 3445.  | DISCHARGE OF PUMP#2  | 259.2 | NO    |
| 90.0 | 14194. | 6830.  | SUCTION OF PUMP# 3   | 105.2 | NO    |
| 90.0 | 14194. | 6830.  | DISCHARGE OF PUMP#3  | 277.9 | NO    |
| 90.0 | 14194. | 10215. | SUCTION OF PUMP# 4   | 123.9 | NO    |
| 90.0 | 14194. | 10215. | DISCHARGE OF PUMP#4  | 296.6 | NO    |
| 90.0 | 14194. | 13600. | SUCTION OF PUMP# 5   | 142.6 | NO    |
| 90.0 | 14194. | 13600. | DISCHARGE OF PUMP#5  | 380.4 | NO    |
| 90.0 | 14194. | 16985. | SUCTION OF PUMP# 6   | 226.4 | NO    |

|       |        |        |                      |       |       |
|-------|--------|--------|----------------------|-------|-------|
| 90.0  | 14194. | 16985. | DISCHARGE OF PUMP#6  | 408.0 | NO    |
| 90.0  | 14194. | 20370. | SUCTION OF PUMP# 7   | 246.0 | NO    |
| 90.0  | 14194. | 20370. | DISCHARGE OF PUMP#7  | 246.0 | NO    |
| 90.0  | 14194. | 23755. | PLANT DISCHARGE HEAD | 92.0  | NO    |
| 95.0  | 14514. | 60.    | SUCTION OF PUMP# 1   | -7.8  | CHECK |
| 95.0  | 14514. | 60.    | DISCHARGE OF PUMP#1  | 233.6 | NO    |
| 95.0  | 14514. | 3445.  | SUCTION OF PUMP# 2   | 72.9  | NO    |
| 95.0  | 14514. | 3445.  | DISCHARGE OF PUMP#2  | 250.4 | NO    |
| 95.0  | 14514. | 6830.  | SUCTION OF PUMP# 3   | 89.7  | NO    |
| 95.0  | 14514. | 6830.  | DISCHARGE OF PUMP#3  | 261.6 | NO    |
| 95.0  | 14514. | 10215. | SUCTION OF PUMP# 4   | 100.3 | NO    |
| 95.0  | 14514. | 10215. | DISCHARGE OF PUMP#4  | 272.8 | NO    |
| 95.0  | 14514. | 13600. | SUCTION OF PUMP# 5   | 112.1 | NO    |
| 95.0  | 14514. | 13600. | DISCHARGE OF PUMP#5  | 349.1 | NO    |
| 95.0  | 14514. | 16985. | SUCTION OF PUMP# 6   | 188.4 | NO    |
| 95.0  | 14514. | 16985. | DISCHARGE OF PUMP#6  | 366.0 | NO    |
| 95.0  | 14514. | 20370. | SUCTION OF PUMP# 7   | 200.3 | NO    |
| 95.0  | 14514. | 20370. | DISCHARGE OF PUMP#7  | 200.3 | NO    |
| 95.0  | 14514. | 23755. | PLANT DISCHARGE HEAD | 39.5  | NO    |
| 100.0 | 14651. | 60.    | SUCTION OF PUMP# 1   | -7.9  | CHECK |
| 100.0 | 14651. | 60.    | DISCHARGE OF PUMP#1  | 233.2 | NO    |
| 100.0 | 14651. | 3445.  | SUCTION OF PUMP# 2   | 69.5  | NO    |
| 100.0 | 14651. | 3445.  | DISCHARGE OF PUMP#2  | 246.7 | NO    |
| 100.0 | 14651. | 6830.  | SUCTION OF PUMP# 3   | 83.0  | NO    |
| 100.0 | 14651. | 6830.  | DISCHARGE OF PUMP#3  | 254.6 | NO    |
| 100.0 | 14651. | 10215. | SUCTION OF PUMP# 4   | 91.0  | NO    |
| 100.0 | 14651. | 10215. | DISCHARGE OF PUMP#4  | 262.6 | NO    |
| 100.0 | 14651. | 13600. | SUCTION OF PUMP# 5   | 98.9  | NO    |
| 100.0 | 14651. | 13600. | DISCHARGE OF PUMP#5  | 335.6 | NO    |
| 100.0 | 14651. | 16985. | SUCTION OF PUMP# 6   | 171.9 | NO    |
| 100.0 | 14651. | 16985. | DISCHARGE OF PUMP#6  | 349.1 | NO    |
| 100.0 | 14651. | 20370. | SUCTION OF PUMP# 7   | 180.4 | NO    |
| 100.0 | 14651. | 20370. | DISCHARGE OF PUMP#7  | 180.4 | NO    |
| 100.0 | 14651. | 23755. | PLANT DISCHARGE HEAD | 16.8  | NO    |
| 105.0 | 14708. | 60.    | SUCTION OF PUMP# 1   | -7.9  | CHECK |
| 105.0 | 14708. | 60.    | DISCHARGE OF PUMP#1  | 233.0 | NO    |
| 105.0 | 14708. | 3445.  | SUCTION OF PUMP# 2   | 68.1  | NO    |
| 105.0 | 14708. | 3445.  | DISCHARGE OF PUMP#2  | 245.1 | NO    |
| 105.0 | 14708. | 6830.  | SUCTION OF PUMP# 3   | 80.2  | NO    |
| 105.0 | 14708. | 6830.  | DISCHARGE OF PUMP#3  | 251.6 | NO    |
| 105.0 | 14708. | 10215. | SUCTION OF PUMP# 4   | 86.7  | NO    |
| 105.0 | 14708. | 10215. | DISCHARGE OF PUMP#4  | 258.2 | NO    |
| 105.0 | 14708. | 13600. | SUCTION OF PUMP# 5   | 93.3  | NO    |
| 105.0 | 14708. | 13600. | DISCHARGE OF PUMP#5  | 329.8 | NO    |
| 105.0 | 14708. | 16985. | SUCTION OF PUMP# 6   | 164.9 | NO    |
| 105.0 | 14708. | 16985. | DISCHARGE OF PUMP#6  | 341.9 | NO    |
| 105.0 | 14708. | 20370. | SUCTION OF PUMP# 7   | 172.0 | NO    |
| 105.0 | 14708. | 20370. | DISCHARGE OF PUMP#7  | 445.9 | NO    |
| 105.0 | 14708. | 23755. | PLANT DISCHARGE HEAD | 281.0 | NO    |
| 110.0 | 15665. | 60.    | SUCTION OF PUMP# 1   | -8.3  | CHECK |
| 110.0 | 15665. | 60.    | DISCHARGE OF PUMP#1  | 230.0 | NO    |
| 110.0 | 15665. | 3445.  | SUCTION OF PUMP# 2   | 43.9  | NO    |
| 110.0 | 15665. | 3445.  | DISCHARGE OF PUMP#2  | 217.7 | NO    |
| 110.0 | 15665. | 6830.  | SUCTION OF PUMP# 3   | 31.7  | NO    |
| 110.0 | 15665. | 6830.  | DISCHARGE OF PUMP#3  | 200.7 | NO    |
| 110.0 | 15665. | 10215. | SUCTION OF PUMP# 4   | 14.6  | NO    |
| 110.0 | 15665. | 10215. | DISCHARGE OF PUMP#4  | 183.7 | NO    |
| 110.0 | 15665. | 13600. | SUCTION OF PUMP# 5   | -2.4  | CHECK |
| 110.0 | 15665. | 13600. | DISCHARGE OF PUMP#5  | 231.5 | NO    |
| 110.0 | 15665. | 16985. | SUCTION OF PUMP# 6   | 45.4  | NO    |
| 110.0 | 15665. | 16985. | DISCHARGE OF PUMP#6  | 219.3 | NO    |
| 110.0 | 15665. | 20370. | SUCTION OF PUMP# 7   | 28.2  | NO    |

|       |        |        |                      |       |       |
|-------|--------|--------|----------------------|-------|-------|
| 110.0 | 15665. | 20370. | DISCHARGE OF PUMP#7  | 239.4 | NO    |
| 110.0 | 15665. | 23755. | PLANT DISCHARGE HEAD | 113.3 | NO    |
| 115.0 | 16044. | 60.    | SUCTION OF PUMP# 1   | -8.5  | CHECK |
| 115.0 | 16044. | 60.    | DISCHARGE OF PUMP#1  | 228.8 | NO    |
| 115.0 | 16044. | 3445.  | SUCTION OF PUMP# 2   | 33.9  | NO    |
| 115.0 | 16044. | 3445.  | DISCHARGE OF PUMP#2  | 208.5 | NO    |
| 115.0 | 16044. | 6830.  | SUCTION OF PUMP# 3   | 11.6  | NO    |
| 115.0 | 16044. | 6830.  | DISCHARGE OF PUMP#3  | 179.7 | NO    |
| 115.0 | 16044. | 10215. | SUCTION OF PUMP# 4   | -15.1 | CHECK |
| 115.0 | 16044. | 10215. | DISCHARGE OF PUMP#4  | 153.0 | NO    |
| 115.0 | 16044. | 13600. | SUCTION OF PUMP# 5   | -41.8 | CHECK |
| 115.0 | 16044. | 13600. | DISCHARGE OF PUMP#5  | 191.0 | NO    |
| 115.0 | 16044. | 16985. | SUCTION OF PUMP# 6   | -3.8  | CHECK |
| 115.0 | 16044. | 16985. | DISCHARGE OF PUMP#6  | 168.7 | NO    |
| 115.0 | 16044. | 20370. | SUCTION OF PUMP# 7   | -31.1 | CHECK |
| 115.0 | 16044. | 20370. | DISCHARGE OF PUMP#7  | 239.0 | NO    |
| 115.0 | 16044. | 23755. | PLANT DISCHARGE HEAD | 44.1  | NO    |
| 120.0 | 16191. | 60.    | SUCTION OF PUMP# 1   | -8.5  | CHECK |
| 120.0 | 16191. | 60.    | DISCHARGE OF PUMP#1  | 228.3 | NO    |
| 120.0 | 16191. | 3445.  | SUCTION OF PUMP# 2   | 30.0  | NO    |
| 120.0 | 16191. | 3445.  | DISCHARGE OF PUMP#2  | 202.1 | NO    |
| 120.0 | 16191. | 6830.  | SUCTION OF PUMP# 3   | 3.8   | NO    |
| 120.0 | 16191. | 6830.  | DISCHARGE OF PUMP#3  | 171.5 | NO    |
| 120.0 | 16191. | 10215. | SUCTION OF PUMP# 4   | -26.8 | CHECK |
| 120.0 | 16191. | 10215. | DISCHARGE OF PUMP#4  | 140.9 | NO    |
| 120.0 | 16191. | 13600. | SUCTION OF PUMP# 5   | -57.3 | CHECK |
| 120.0 | 16191. | 13600. | DISCHARGE OF PUMP#5  | 175.1 | NO    |
| 120.0 | 16191. | 16985. | SUCTION OF PUMP# 6   | -23.2 | CHECK |
| 120.0 | 16191. | 16985. | DISCHARGE OF PUMP#6  | 148.9 | NO    |
| 120.0 | 16191. | 20370. | SUCTION OF PUMP# 7   | -54.4 | CHECK |
| 120.0 | 16191. | 20370. | DISCHARGE OF PUMP#7  | 215.2 | NO    |
| 120.0 | 16191. | 23755. | PLANT DISCHARGE HEAD | 16.9  | NO    |
| 125.0 | 16248. | 60.    | SUCTION OF PUMP# 1   | -8.5  | CHECK |
| 125.0 | 16248. | 60.    | DISCHARGE OF PUMP#1  | 228.1 | NO    |
| 125.0 | 16248. | 3445.  | SUCTION OF PUMP# 2   | 28.5  | NO    |
| 125.0 | 16248. | 3445.  | DISCHARGE OF PUMP#2  | 200.4 | NO    |
| 125.0 | 16248. | 6830.  | SUCTION OF PUMP# 3   | .8    | NO    |
| 125.0 | 16248. | 6830.  | DISCHARGE OF PUMP#3  | 168.3 | NO    |
| 125.0 | 16248. | 10215. | SUCTION OF PUMP# 4   | -31.3 | CHECK |
| 125.0 | 16248. | 10215. | DISCHARGE OF PUMP#4  | 136.3 | NO    |
| 125.0 | 16248. | 13600. | SUCTION OF PUMP# 5   | -63.3 | CHECK |
| 125.0 | 16248. | 13600. | DISCHARGE OF PUMP#5  | 169.0 | NO    |
| 125.0 | 16248. | 16985. | SUCTION OF PUMP# 6   | -30.6 | CHECK |
| 125.0 | 16248. | 16985. | DISCHARGE OF PUMP#6  | 141.2 | NO    |
| 125.0 | 16248. | 20370. | SUCTION OF PUMP# 7   | -63.4 | CHECK |
| 125.0 | 16248. | 20370. | DISCHARGE OF PUMP#7  | 206.1 | NO    |
| 125.0 | 16248. | 23755. | PLANT DISCHARGE HEAD | 6.5   | NO    |
| 130.0 | 16269. | 60.    | SUCTION OF PUMP# 1   | -8.5  | CHECK |
| 130.0 | 16269. | 60.    | DISCHARGE OF PUMP#1  | 228.1 | NO    |
| 130.0 | 16269. | 3445.  | SUCTION OF PUMP# 2   | 27.9  | NO    |
| 130.0 | 16269. | 3445.  | DISCHARGE OF PUMP#2  | 199.7 | NO    |
| 130.0 | 16269. | 6830.  | SUCTION OF PUMP# 3   | -.4   | CHECK |
| 130.0 | 16269. | 6830.  | DISCHARGE OF PUMP#3  | 167.1 | NO    |
| 130.0 | 16269. | 10215. | SUCTION OF PUMP# 4   | -33.0 | CHECK |
| 130.0 | 16269. | 10215. | DISCHARGE OF PUMP#4  | 134.5 | NO    |
| 130.0 | 16269. | 13600. | SUCTION OF PUMP# 5   | -65.6 | CHECK |
| 130.0 | 16269. | 13600. | DISCHARGE OF PUMP#5  | 166.6 | NO    |
| 130.0 | 16269. | 16985. | SUCTION OF PUMP# 6   | -33.5 | CHECK |
| 130.0 | 16269. | 16985. | DISCHARGE OF PUMP#6  | 138.3 | NO    |
| 130.0 | 16269. | 20370. | SUCTION OF PUMP# 7   | -66.8 | CHECK |
| 130.0 | 16269. | 20370. | DISCHARGE OF PUMP#7  | 202.6 | NO    |
| 130.0 | 16269. | 23755. | PLANT DISCHARGE HEAD | 2.5   | NO    |

|       |        |        |                      |       |       |
|-------|--------|--------|----------------------|-------|-------|
| 135.0 | 16277. | 60.    | SUCTION OF PUMP# 1   | -8.6  | CHECK |
| 135.0 | 16277. | 60.    | DISCHARGE OF PUMP#1  | 228.0 | NO    |
| 135.0 | 16277. | 3445.  | SUCTION OF PUMP# 2   | 27.7  | NO    |
| 135.0 | 16277. | 3445.  | DISCHARGE OF PUMP#2  | 199.5 | NO    |
| 135.0 | 16277. | 6830.  | SUCTION OF PUMP# 3   | -1.8  | CHECK |
| 135.0 | 16277. | 6830.  | DISCHARGE OF PUMP#3  | 166.7 | NO    |
| 135.0 | 16277. | 10215. | SUCTION OF PUMP# 4   | -33.7 | CHECK |
| 135.0 | 16277. | 10215. | DISCHARGE OF PUMP#4  | 133.8 | NO    |
| 135.0 | 16277. | 13600. | SUCTION OF PUMP# 5   | -55.5 | CHECK |
| 135.0 | 16277. | 13600. | DISCHARGE OF PUMP#5  | 165.7 | NO    |
| 135.0 | 16277. | 16985. | SUCTION OF PUMP# 6   | -34.6 | CHECK |
| 135.0 | 16277. | 16985. | DISCHARGE OF PUMP#6  | 137.2 | NO    |
| 135.0 | 16277. | 20370. | SUCTION OF PUMP# 7   | -68.1 | CHECK |
| 135.0 | 16277. | 20370. | DISCHARGE OF PUMP#7  | 201.3 | NO    |
| 135.0 | 16277. | 23755. | PLANT DISCHARGE HEAD | .9    | NO    |
|       |        |        |                      |       |       |
| 140.0 | 16280. | 60.    | SUCTION OF PUMP# 1   | -8.6  | CHECK |
| 140.0 | 16280. | 60.    | DISCHARGE OF PUMP#1  | 228.0 | NO    |
| 140.0 | 16280. | 3445.  | SUCTION OF PUMP# 2   | 27.6  | NO    |
| 140.0 | 16280. | 3445.  | DISCHARGE OF PUMP#2  | 199.4 | NO    |
| 140.0 | 16280. | 6830.  | SUCTION OF PUMP# 3   | -1.0  | CHECK |
| 140.0 | 16280. | 6830.  | DISCHARGE OF PUMP#3  | 166.5 | NO    |
| 140.0 | 16280. | 10215. | SUCTION OF PUMP# 4   | -33.9 | CHECK |
| 140.0 | 16280. | 10215. | DISCHARGE OF PUMP#4  | 133.6 | NO    |
| 140.0 | 16280. | 13600. | SUCTION OF PUMP# 5   | -66.8 | CHECK |
| 140.0 | 16280. | 13600. | DISCHARGE OF PUMP#5  | 165.4 | NO    |
| 140.0 | 16280. | 16985. | SUCTION OF PUMP# 6   | -35.0 | CHECK |
| 140.0 | 16280. | 16985. | DISCHARGE OF PUMP#6  | 136.8 | NO    |
| 140.0 | 16280. | 20370. | SUCTION OF PUMP# 7   | -68.6 | CHECK |
| 140.0 | 16280. | 20370. | DISCHARGE OF PUMP#7  | 200.7 | NO    |
| 140.0 | 16280. | 23755. | PLANT DISCHARGE HEAD | .4    | NO    |
|       |        |        |                      |       |       |
| 145.0 | 16282. | 60.    | SUCTION OF PUMP# 1   | -8.6  | CHECK |
| 145.0 | 16282. | 60.    | DISCHARGE OF PUMP#1  | 228.0 | NO    |
| 145.0 | 16282. | 3445.  | SUCTION OF PUMP# 2   | 27.6  | NO    |
| 145.0 | 16282. | 3445.  | DISCHARGE OF PUMP#2  | 199.3 | NO    |
| 145.0 | 16282. | 6830.  | SUCTION OF PUMP# 3   | -1.1  | CHECK |
| 145.0 | 16282. | 6830.  | DISCHARGE OF PUMP#3  | 166.4 | NO    |
| 145.0 | 16282. | 10215. | SUCTION OF PUMP# 4   | -34.0 | CHECK |
| 145.0 | 16282. | 10215. | DISCHARGE OF PUMP#4  | 133.5 | NO    |
| 145.0 | 16282. | 13600. | SUCTION OF PUMP# 5   | -66.9 | CHECK |
| 145.0 | 16282. | 13600. | DISCHARGE OF PUMP#5  | 165.3 | NO    |
| 145.0 | 16282. | 16985. | SUCTION OF PUMP# 6   | -35.1 | CHECK |
| 145.0 | 16282. | 16985. | DISCHARGE OF PUMP#6  | 136.6 | NO    |
| 145.0 | 16282. | 20370. | SUCTION OF PUMP# 7   | -68.8 | CHECK |
| 145.0 | 16282. | 20370. | DISCHARGE OF PUMP#7  | 200.6 | NO    |
| 145.0 | 16282. | 23755. | PLANT DISCHARGE HEAD | .1    | NO    |
|       |        |        |                      |       |       |
| 147.5 | 16282. | 60.    | SUCTION OF PUMP# 1   | -8.6  | CHECK |
| 147.5 | 16282. | 60.    | DISCHARGE OF PUMP#1  | 228.0 | NO    |
| 147.5 | 16282. | 3445.  | SUCTION OF PUMP# 2   | 27.6  | NO    |
| 147.5 | 16282. | 3445.  | DISCHARGE OF PUMP#2  | 199.3 | NO    |
| 147.5 | 16282. | 6830.  | SUCTION OF PUMP# 3   | -1.1  | CHECK |
| 147.5 | 16282. | 6830.  | DISCHARGE OF PUMP#3  | 166.4 | NO    |
| 147.5 | 16282. | 10215. | SUCTION OF PUMP# 4   | -34.0 | CHECK |
| 147.5 | 16282. | 10215. | DISCHARGE OF PUMP#4  | 133.5 | NO    |
| 147.5 | 16282. | 13600. | SUCTION OF PUMP# 5   | -67.0 | CHECK |
| 147.5 | 16282. | 13600. | DISCHARGE OF PUMP#5  | 165.2 | NO    |
| 147.5 | 16282. | 16985. | SUCTION OF PUMP# 6   | -35.2 | CHECK |
| 147.5 | 16282. | 16985. | DISCHARGE OF PUMP#6  | 136.6 | NO    |
| 147.5 | 16282. | 20370. | SUCTION OF PUMP# 7   | -68.3 | CHECK |
| 147.5 | 16282. | 20370. | DISCHARGE OF PUMP#7  | 200.5 | NO    |
| 147.5 | 16282. | 23755. | PLANT DISCHARGE HEAD | .1    | NO    |
|       |        |        |                      |       |       |
| 148.0 | 16282. | 60.    | SUCTION OF PUMP# 1   | -8.6  | CHECK |
| 148.0 | 16282. | 60.    | DISCHARGE OF PUMP#1  | 228.0 | NO    |

|       |        |        |                      |       |       |
|-------|--------|--------|----------------------|-------|-------|
| 148.0 | 16282. | 3445.  | DISCHARGE OF PUMP#1  | 229.0 | NO    |
| 148.0 | 16282. | 3445.  | SUCTION OF PUMP# 2   | 27.6  | NO    |
| 148.0 | 16282. | 3445.  | DISCHARGE OF PUMP#2  | 199.3 | NO    |
| 148.0 | 16282. | 6830.  | SUCTION OF PUMP# 3   | -1.1  | CHECK |
| 148.0 | 16282. | 6830.  | DISCHARGE OF PUMP#3  | 166.4 | NO    |
| 148.0 | 16282. | 10215. | SUCTION OF PUMP# 4   | -34.0 | CHECK |
| 148.0 | 16282. | 10215. | DISCHARGE OF PUMP#4  | 133.5 | NO    |
| 148.0 | 16282. | 13600. | SUCTION OF PUMP# 5   | -67.0 | CHECK |
| 148.0 | 16282. | 13600. | DISCHARGE OF PUMP#5  | 165.2 | NO    |
| 148.0 | 16282. | 16985. | SUCTION OF PUMP# 6   | -35.2 | CHECK |
| 148.0 | 16282. | 16985. | DISCHARGE OF PUMP#6  | 136.5 | NO    |
| 148.0 | 16282. | 20370. | SUCTION OF PUMP# 7   | -68.9 | CHECK |
| 148.0 | 16282. | 20370. | DISCHARGE OF PUMP#7  | 200.5 | NO    |
| 148.0 | 16282. | 23755. | PLANT DISCHARGE HEAD | .1    | NO    |



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 | SUMMARY OF ENERGY REQUIREMENTS |  
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DATE: 31/JAN/89

| PIPELINE<br>PUMP # | PUMP<br>ID # | PUMP NAME |    |   |                       |       |
|--------------------|--------------|-----------|----|---|-----------------------|-------|
| 1                  | 10           | 18X18WSO  | 44 | A | 16- / /3ME15- 5/ 8    | 1635D |
| 2                  | 8            | 18X18WBC  | 46 | C | H11- 1/ 2/3ME11- 1/ 4 | -     |
| 3                  | 10           | 18X18WSO  | 44 | A | 16- / /3ME15- 5/ 8    | 1635D |
| 4                  | 10           | 18X18WSO  | 44 | A | 16- / /3ME15- 5/ 8    | 1635D |
| 5                  | 10           | 18X18WSO  | 44 | A | 16- / /3ME15- 5/ 8    | 1635D |
| 6                  | 8            | 18X18WBC  | 46 | C | H11- 1/ 2/3ME11- 1/ 4 | -     |
| 7                  | 10           | 18X18WSO  | 44 | A | 16- / /3ME15- 5/ 8    |       |

| PIPELINE<br>PUMP # | IMPELLER<br>DIAM(IN) | RPM  | PUMP<br>ELEV(FT) | DIST(FT)<br>ALONG PIPE | MOTOR(*)<br>KW | EFFICIENCY<br>OF PUMP(%) |
|--------------------|----------------------|------|------------------|------------------------|----------------|--------------------------|
| 1                  | 44.0                 | 590. | 0.               | 60.                    | 695.           | 69.0                     |
| 2                  | 46.0                 | 505. | 0.               | 3445.                  | 840.           | 80.2                     |
| 3                  | 44.0                 | 505. | 0.               | 6830.                  | 559.           | 71.9                     |
| 4                  | 44.0                 | 505. | 0.               | 10215.                 | 559.           | 71.9                     |
| 5                  | 44.0                 | 585. | 0.               | 13600.                 | 686.           | 69.1                     |
| 6                  | 46.0                 | 505. | 0.               | 16985.                 | 840.           | 80.2                     |
| 7                  | 40.6                 | 585. | 5.               | 20370.                 | 1208.          | 69.8                     |

| PIPE<br>SECTION #                  | LENGTH<br>(FT) | DIAMETER<br>(IN) | FRICITION<br>FT-SLURRY | VELOCITY<br>(FT/S) |
|------------------------------------|----------------|------------------|------------------------|--------------------|
| 1                                  | 60.            | 17.25            | 3.3                    | 19.83              |
| 2                                  | 23700.         | 17.25            | 1302.8                 | 19.83              |
| SLURRY FLOW RATE (GPM) =           |                |                  |                        | 14447.0            |
| SOLIDS TRANSPORT RATE (TON/HR) =   |                |                  |                        | 1924.8             |
| SLURRY SPECIFIC GRAVITY =          |                |                  |                        | 1.3                |
| CONCENTRATION BY WEIGHT =          |                |                  |                        | 40.0%              |
| DISCHARGE ELEVATION (FT) =         |                |                  |                        | 5.0                |
| PIT TO WASHER (HP-HR)/(TON-MILE) = |                |                  |                        | .66685             |

\* MOTOR KW BASED ON 80% MOTOR EFFICIENCY