PLC CONTROL IN INDUSTRIAL PROCESS

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CERTIFICATION OF APPROVAL

PLC Control in Industrial Process

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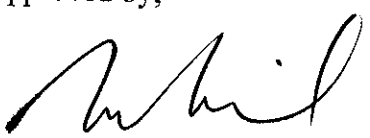

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June 2004

CERTIFICATION OF ORIGINALITY

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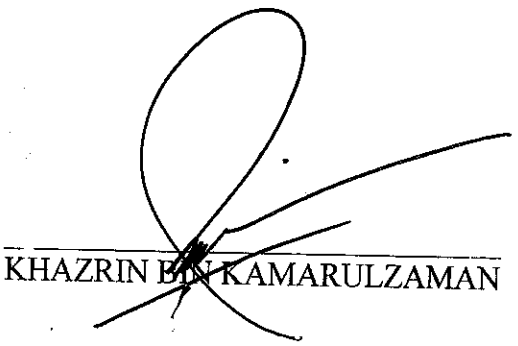

KHAZRIN BIN KAMARULZAMAN

ABSTRACT

Programmable Logic Controller (PLC) has been widely used in the industrial world. It ease of usage and minimal in size make it the best option to replace the function of the old analogue circuit which is spacious and very complicated. This project has been dedicated to study the PLC usage in KLIA Aviation Fuel terminal and to observe any room for improvement in PLC usage. Thus, throughout the details study, it was found out that the ability of the PLC is not fully utilized for the fuel terminal fast flushing operation. This project has been focusing in this area and a model of its implementation will be developed within the given timeframe.

This project is basically focusing on replicating or to imitate a PLC functions in a real industrial processes. Thus, a study was carried on the current system used in KLIA Aviation Fuel Terminal.

The main objective of this project is to establish a one click solution for KLIA Aviation Fuel Terminal Fast Flushing Operation using the available equipments in UTP. Thus, the operator will only have to click one single button in the Graphic user Interface (GUI) at the SCADA program screen which represents the different section. With just one click, the program will instruct the PLC to control the appropriate pumps and motorized operating valve (MOV). Moreover, this program is accessible thru any internet communication link. Thus, the operation can be carried out from other places with internet access instead of the Operation Control Room.

The scope of this project is divided into six major areas. The first part is to understand the whole system and then narrow down the scope toward a more focus area namely the Fast Flushing Operation (FFO). Secondly, it is necessary to understand the function of the available PLC and then focus on the programming works, by manipulating the particular software. The third phase focused on setting up the PC-based system. The main task of this step is focusing on linking the Computer and PLC to prepare the basic platform for the total system. Next, in the fourth phase, the focus is to

develop the Graphic User Interface (GUI). In the fifth phase, the GUI and the PLC will be integrated and tested as a system. Phase six will be focusing on setting up the web based structure of the system. In general, this project is a combination of hardware and software which is integrated to each other to become a complete system.

Various methods of research have been used to carry out this project. Basically, it may be classified into three main methods. The methods are Case Study or Field Study, Desk Study and Project Milestone. All the three methods were used throughout the project in order to collect relevance data, understanding the hardware and software etc. Project Milestone play the role as an indicator of the project achievement.

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ABBREVIATIONS AND NOMENCALTURES

1. PLC	: Programmable Logic Controller
2. PC	: Personal Computer
3. VB	: Visual Basic
4. GUI	: Graphic User Interface
5. KLIA	: Kuala Lumpur International Airport
6. KAFS	: Kuala Lumpur Aviation Fuelling System
7. MPP	: Multi Product Pipeline
8. JOS	: Joint Operating System
9. SCADA	: Supervisory Control and Data Acquisition
10. IATA	: International Air Transport Association
11. MOV	: Motorized Operating Valves
12. OS	: Operating System
13. IR	: Internal Relay

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

This project is basically focusing on replicating or to imitate a PLC functions in a real industrial processes. Thus, a study was carried on the current system used in KLIA Aviation Fuel Terminal.

KLIA Aviation Fuel Terminal is the biggest aviation fuel terminal in Malaysia. It is owned by Kuala Lumpur Aviation Fuelling System (KAFS), a joint venture company between PETRONAS Dagangan, Malaysia Airport Berhad, and Malaysia Airlines. As the expertise in fuel terminal operation in the country, PETRONAS Dagangan has been engaged to manage and operate this fuel terminal. KLIA Aviation Fuel Terminal is one of three airports in Malaysia which have underground fuel hydrant line system [3]. Another uniqueness of this fuel terminal is that, it is the only aviation fuel terminal which received fuel supply from the refineries via Multi Product Pipeline (MPP). This Aviation Fuel Terminal used the concept of Joint Operating System (JOS) whereby, the fuel supplied to this terminal is owned by three oil companies namely, PETRONAS, SHELL and EXXONMOBIL. Then, the into-plane operation of the three oil companies will distribute the fuel to their customers which is the airlines companies.

The main focus of this study is to observe the functions of PLC in the fuel terminal operation and try to construct a similar system using the available equipments in UTP, based on selected operations of the whole fuel terminal operations. Focus is also given to identify any improvement that can be made on the Supervisory Control and Data Acquisition (SCADA) System at this aviation depot. It is vital to understand the operation and the operational system used of this fuel terminal. Currently the SCADA system of this

depot is integration between FactoryLink Graphic User Interface (GUI), the PLC and the field instruments. The main PLC used is Siemens 155U. The link between the SCADA and the PLC are made thru SIEMENS H1 network, while the connection between PLC and the field instrument are either hardwire or using communication link.

Based on the study that have been done, one of the area that can be focused in from the whole fuel terminal operations is in the PLC and SCADA system of sequence control for Fast Flushing operation. Basically, Fast Flushing is a process of 'cleaning' the underground pipeline. The Fast Flushing operation will be describes in more detail, later in the following section.

1.2 PROBLEM STATEMENT

The KLIA Aviation Fuel Terminal has been recommended by International Air Transport Association (IATA) to carry out annual fast flushing operation. The purpose of the fast flushing operation is to ensure the underground fuel hydrant line system is free from dirt or any contamination agent which is trapped inside the pipeline.

For the operation purpose, the underground hydrant line system in KLIA has been divided into 10 sections (sequences) [4]. The fast flushing operation will be carried out at least once a year for each sequence. During the fast flushing operation, the selected sections (sequences) will be flushed with fuel at a specified flow rate, which is relatively high compared to normal operation. When the high flow rate of fuel pass through the sections (sequences), it will wash out all the dirt which was trapped on the bottom surface of the pipeline. Then all this 'dirty' fuel will be pumped back to a dedicated tank. Then, the fuel will be 'recycled' through the filtration system so that it can be used for distribution.

Thus in order to carry out the operation, the underground fuel hydrant line instruments which is consist of Motorized Operating valve (MOV), hydrant pumps etc. need to be set up according to the fast flushing/commissioning guideline for KLIA

Aviation Fuel Terminal prepared by AirBP one of the terminal, commissioning consultant. However, currently there is no one click system in the GUI to activate all the related instruments at once before each fast flushing operation. The operator has to select the instrument one-by-one from the user interface and set it in the correct status. So, with this project, a simulation of the same system with the improvement will be built using the sources available in UTP. Hope, it can be a model of implementation for the terminal in the future.

1.3 OBJECTIVE AND SCOPE OF STUDY

This whole project is intended to develop a simulation/model the real world PLC system based on the PLC system architecture at KLIA Aviation Fuel Terminal. The focus is to develop a system to control the Fast Flushing Operation processes. The components of this model will be the PLC programming, the Graphic User Interface (GUI) and for further enhancement planning, a module of web based GUI, whereby the operation can be done and monitored far away from the main control room via internet connection with restricted access level. The system will developed to depict the real industrial operations using the available equipments in UTP.

Basically the study can be divided into four major areas. The first part is to understand the whole system and then narrow down the scope toward a more focus area which is the Fast Flushing operation. Thus, at this stage, a lot of study and observation were done. Data and information about the available system were obtained. Understanding of the functionality of the existing system was also done in the first phase of the project.

Secondly, it is necessary to understand the function of the available PLC in UTP and then focus on programming the PLC. Currently, the available PLC in UTP was manufactured by OMRON PLC. There are several versions such as C, CS, and CQM

series. At this stage, the focus is on the method of programming the PLC. Basically, there are two softwares that can be used to construct the PLC ladder diagram. The softwares are SysWin and CX-Programmer. Due to more advance features available in CX-Programmer, it has been the platform for ladder diagram construction.

The third phase will focus on the building of Graphic User Interface panel. Understanding the necessary software is the essence of this phase. Basically, at this stage, the mechanism of communication between PLC and Computer must be understood. In general, it is a manipulation of several communication softwares which has the ability to build up communication link between PLC and Computer.

Last phase is to study the ability to integrate all the system to make it accessible via internet. Once again, good understanding in software and networking is vital. In order to set up a system which can be accessed from remote, it needs a combination of softwares and hardwares.

Generally, the project involves good understanding in PLC and all the related software as well as hardware configuration.

CHAPTER 2

THEORY / LITERATURE REVIEW

Programmable Logic Controller (PLC) has been widely used in the industrial world. It ease of usage and minimal in size make it the best choice to replace the function of old analogue circuit which is spacious and more complicated. This project has been dedicated to study the PLC usage in KLIA Aviation Fuel Terminal and to observe any room for improvement in PLC usage. Thus, KLIA Aviation Fuel Terminal Fast Flushing has been identified to be the main focused for this project.

Firstly it is important to understand what fast flushing operation is all about. Fast flushing operation is one of the exercises that have to be done during a commissioning of an aviation fuel terminal with underground fuel hydrant line system. Basically, the operation is carried out to clear the pipeline from dirt and any contamination which enter the pipeline during the construction process [1]. In aviation fuel business, it is very critical to ensure the cleanliness of the pipeline system [2]. The main reason is, any unexpected particles or dirt will damage the aircraft turbine engine and it will put the safety of the flight passengers and cabin crews at stake. The basic mechanism of the fast flushing operation is to pump certain volume of fuel into the pipeline on certain flow rate for a certain period. The fuel will push all the pipeline contents back to the fuel terminal dedicated tank. In order to make the operation more efficient, the 23km fuel hydrant line has been divided into 10 sections or sequences (refer appendix I for the arrangement of the sequence).

Since receiving quite a number of complain regarding filter clogging and dirt content in fuel from the into-plane operator, KLIA Aviation Fuel Terminal has seek opinion from IATA on how to address this issue. Hence, IATA recommended KLIA Aviation Fuel Terminal to set up annual Fast Flushing program. Starting from 2002, this

program has been successfully executed. Currently, KLIA Aviation Fuel Terminal is conducting the 2003/2004 Fast Flushing operation.

Based on all the facts, it is necessary to propose a modification in the PLC system set up in order to include the execution of this operation. Thus, the architecture of PLC must be fully comprehended. PLC programming technique, ladder diagram construction, methods of implementation and simulation have to be understood. Next, the architecture of good Graphic User Interface has to be figured out to ensure ease of operation. Final step is to realize the system which can be operated within remote access via data networking. The basic of all the work plans is on the understanding of various software and programming tools available.

As a whole, this project is designed to simulate the process in KLIA Aviation Fuel Terminal. Thus, with further enhancement it can be the simulation based for the development or amendment of the real process in the plant. In the real world, it is difficult to introduce any changes or amendment in a real system because the risk is too high especially to the whole industrial process. Thus, it is necessary to have a pilot simulation plant or system which will works as the test bed of the real system before the commissioning process into the real system. In general, this project should be able to fit the purpose as the test bed of the real system.

CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 METHODOLOGY

In order to workout with this project, several methods of study and research were carried out. The methods used are as listed below:

- Case Study
- Desk Study
- Project Milestone
- Tools and Equipments Used

3.1.1 Case Study

As a starting point, it is obligatory to carry out a case study on the system at the KLIA Aviation Fuel Terminal. All important data have to be collected and self initiated research has to be done to understand the system especially on the Fast Flushing operation.

3.1.2 Desk Study

Desk study plays significant impact to strengthen the basic knowledge about anything related to the project. Internet is the main source for the study, as well as to refer in books, journals, articles and reports. Any information related to the PLC programming and the software which will be used have to be gathered and study accordingly. A lot of time has been spent doing desk study especially to understand the working and programming method of the softwares that will be used in this project.

3.1.3 Project Milestone

The student as well as the supervisor can easily monitor the progress of the project. Since this project is for two semester project, the milestone should be planned in such a way that can fix the time for the two semesters.

3.1.4 Tools and Equipments Used

Since this project is a PLC based project, the main tool will be the PLC programming tool. The project will go on with the GUI software and if possible, the web based software to create the remote access portal. Generally, this project is a combination of hardware and software which is integrated together to become a complete system.

Understanding the correct software to be used during the initial stage is very imperative, so that the right knowledge can be obtained and focus can be given to the project as a whole. The software that has been identified can be referred in **Table 3.1**.

Table 3.1: Project software requirement

Items	**Software**
User Interface	Visual Basic 6.0
Application program	SYSMAC Compolet Version 2 (for OMRON PLC)
Communication software	FinsGateway
Programming software	CX Programming

3.2 PROJECT WORKS

In order to monitor the project planning and the progress made, it has been divided into 6 main stages. The stages are:

- Field study
- PLC programming
- PC-Based system set up
- Graphic User Interface (GUI) software programming
- Integrating GUI and PLC
- Set up a web based link for the integrated GUI and PLC system

3.2.1 Field Study

This is the initial stage. The main focus is to study the available system at KLIA Aviation Fuel Terminal and identify the improvement that can be made. Thus, Fast Flushing operation has been recognized as the topic of interest. Data related to this operation have been collected. Field trip to KLIA Aviation Fuel Terminal has been conducted and discussion with the personnel from KLIA Aviation Fuel Terminal has been held. Mainly, at this stage, data were gathered via establishing good communication with the appropriate person.

At the end of this stage, all the data have to be studied and summarized to get the essence which is needed for this project. The summarized data will be described in the later part of this report.

3.2.2 Programmable Logic Controller (PLC) Programming

This is the second stage for the project workflow. This particular stage starts with understanding of the architecture of the available PLC. For the sake of developing the understanding on Sequence Diagram, the focused initially is on Sequence 3 of the Fast Flushing section. After developing the proper Sequence Diagram, the basic logic equation can be obtained. Thus, the project can proceed with the PLC programming based on this basic logic equation. This will be the next planning for this ongoing project.

3.2.3 PC-based System Set-up

At this third stage, the focus area is to understand the mechanism of linking the PLC and the Computer. Computer acts as the source of controller and monitoring, while the PLC will execute it based on the programming which has been downloaded into the PLC Data Memory Area. Basically, at this stage, manipulation of PLC communication software is the man job scope. Architecture of communication software such as FinsGateway and Sysmac Compolet is important to be fully comprehended.

3.2.4 Graphic User Interface (GUI) Software Programming

The third stage of the project is to program the GUI software so that it can coordinate the PLC system. The proper software is yet to be selected. Most probably, this stage will be the initial focus for next semester progress. At this stage, understanding the software structure is important in order to build a comprehensive GUI for this system.

3.2.5 Integrating GUI and PLC

Basically, this stage will run concurrently with the previous stage. For the purpose of controlling the workflow, although this stage will be conducted concurrently with the previous stage, all the findings and error reporting will be collected as a report of a single stage. This part can be considered quit critical because adequate knowledge on software and hardware is needed here. Moreover, at this stage, the program can be considered as a working system. Thus, error should be eliminated or at least to be minimized to ensure smooth workflow of the working system.

3.2.6 Set-up a Web Based Link for the Integrated GUI and PLC System

This is one of the crucial stages. It will be the part which will give the biggest improvement for the whole system. Thus the system is controllable from remote area rather than at the plant it self. This stage is the last stage of the whole project. Once again it requires the understanding of hardware and software. At this stage, data communication gets into the picture. The utilization of Open Network Controller, Ethernet system and networking is the main focus.

The whole work flow is depicted in figure 3.1 in the following page.

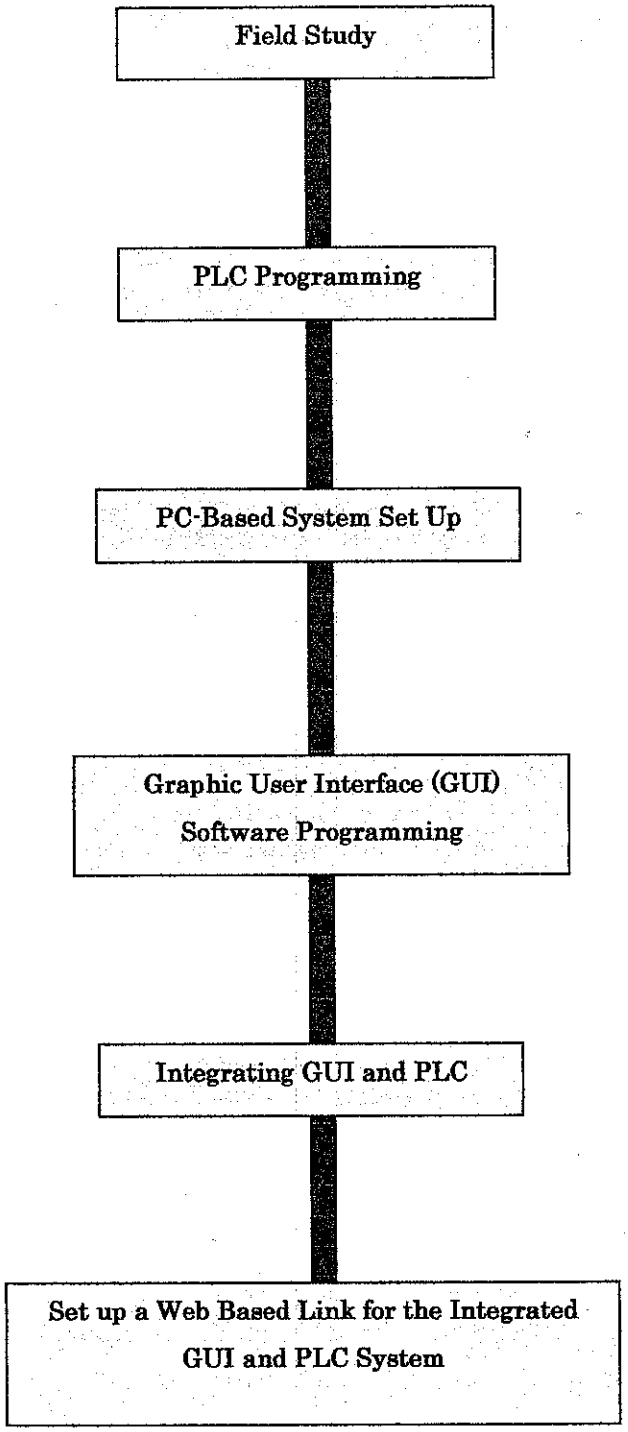

Figure 3.1: The Project Work Flow

CHAPTER 4

RESULTS AND DISCUSSION

4.1 THE CASE STUDY ON THE FAST FLUSHING OPERATIONS

First of all, it is appropriate to discuss about the case study itself to get the primary picture of this project. So, basically this section will discuss anything related to the case study that was carried out.

The case study of this project is based on the system KLIA Aviation Fuel Terminal Fast Flushing Operation. This terminal is the biggest aviation fuel depot in Malaysia and one of three airports in Malaysia which used underground fuelling system. The underground fuelling system is consisting of 23 kilometres of various diameter pipeline and 52 Motorized Operated Valves (MOV) which is located in the Valve Chamber. This underground fuelling system is the biggest system in the country [3]. Thus, it is necessary for it to be flushed flush annually to ensure that the pipeline is free from unexpected dirt.

As mentioned earlier, the basic mechanism of the fast flushing operation is to pump certain volume of fuel into the pipeline on certain flow rate for a certain period. The fuel will push all the pipeline contents, which including all the unexpected dirt, back to the fuel terminal dedicated tank. In order to make the operation more efficient, the 23km fuel hydrant line has been divided into 10 sections or sequences (refer appendix I for the arrangement of the sequence). All the section/sequence is isolated by manipulating the MOV status.

For example, for KLIA Flushing Sequence 1 (refer appendix II) the MOV that must be closed are 1E, 51A, 50A, 7A, 12B, 8A, 9B, 11A, 11C, 33A, 5B, 4A, 3B, 2C, and 6A. So, when the operation is carried on, the fuel will be flushed through the highlighted pipeline. Different Flushing Sequence has different MOV setting [4]. The pump setting differs for each sequence. This is to get the appropriate flue flow rate movement inside the pipeline that will create turbulent flow. If the fuel flow rate fail to reach the particular level, only laminar flow can be obtained. Thus, the operation is not valid. Flushing Sequence 1 needs eight pumps running for about 94 minutes with total flow rate of 2192 m^3/hr to complete the operation.

Effort has also been carried out to study the architecture of the SCADA system of the aviation fuel terminal. The basic components of this particular system are the PLC, the SCADA Server, the communication link and the Control Workstation. Figure 4.1 in the following page shows the interconnection of all these components as implemented in the real industrial plant.

The main purpose of this project is to simulate this setting by using the PLC and other related equipments available in UTP to control all the processes. The system will be supported by workstation (PC) with Graphic User Interface (GUI) from where the operation will be triggered and controlled.

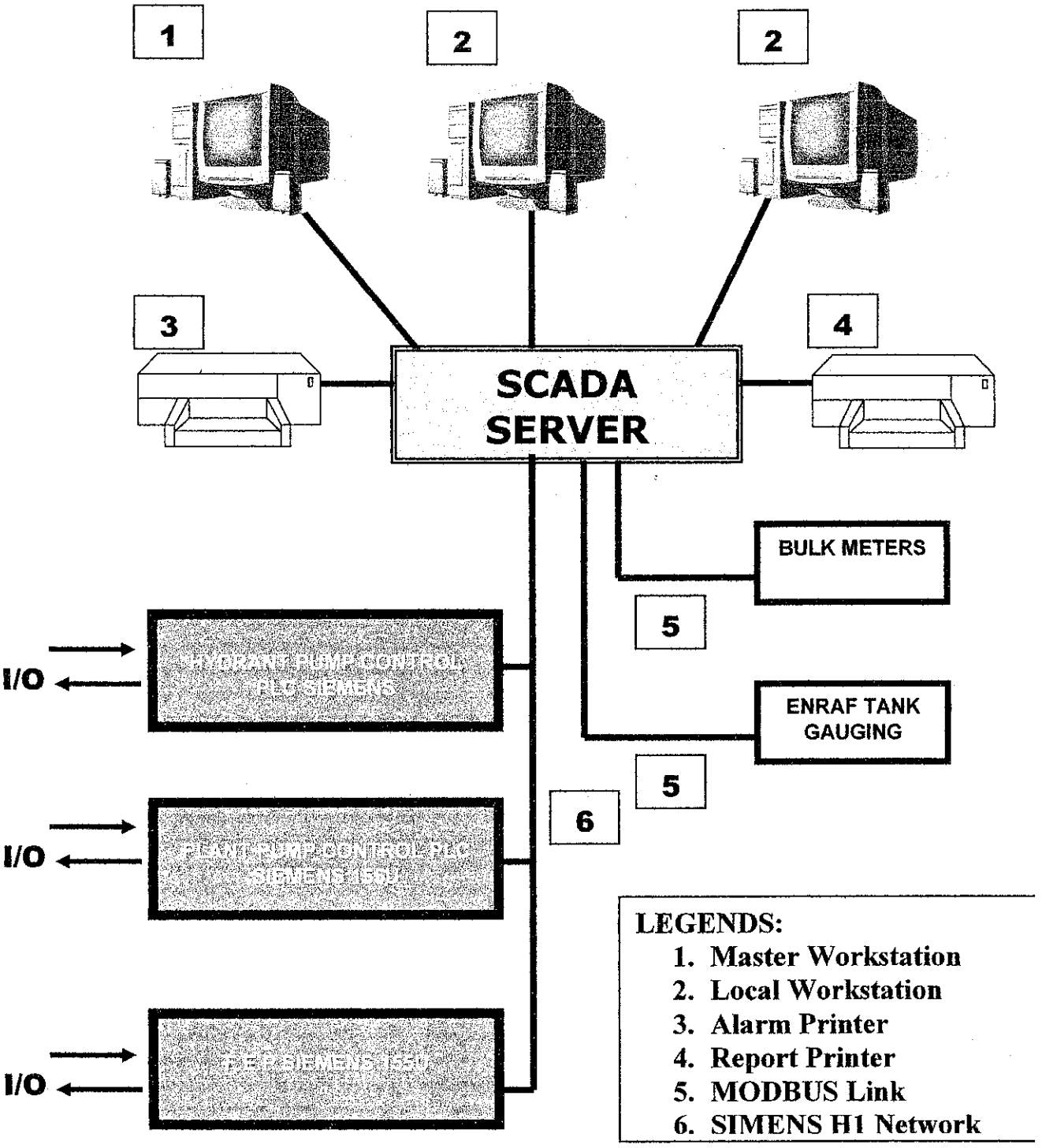

Figure 4.1: The PLC System Architecture in KLIA Aviation Fuel Terminal

4.2 THE PROGRAMMABLE LOGIC CONTROLLER (PLC) PROGRAMMING

Based on the project planning, this is the second stage that should be completed. This stage starts with understanding of the architecture of the available PLC. The PLC that available in UTP is manufactured by OMRON. There are from various series such as C, CS, and CQM series. For the second stage, the series of PLC is not very important as long as it is programmable via the selected PLC programming software. All the programming works will be conducted from the PC and then the program will be uploaded into the PLC. Figure 4.2 depicted the dataflow from the PC into the PLC.

Figure 4.2 Dataflow of the PLC Program

The PLC programming software used is the CX-Programmer Version 3. CX-Programmer is a very useful OMRON PLC programmer. It programs all types, from micro PLC's up to the new high-end CS series [8]. CX-Programmer supplies all the programming power needed to even construct complex, multi-device systems applying ladder and/or Statement List languages.

In addition to the comprehensive programming environment, CX-Programmer provides all tools necessary to engineer, test and debug any automation system. On-line capabilities are included like program up- and download, monitoring and multi-rung editing, up to three levels deep in the network.

The CX-Programmer Version 3 supported by CX-Server Version 1.7. This software main function is to assist the uploading of the program to the PLC memory

The PLC that available in UTP is manufactured by OMRON. There are from various series such as C, CS, and CQM series. For the second stage, the series of PLC is not very important as long it is programmable via the selected PLC programming software. The PLC programming software used is the CX-Programmer Version 3 supported by CX-Server Version 1.7. The latter software is the one which assist the uploading of the program to the PLC memory.

Throughout the previous semester, the data gathered from the field study have been translated into PLC ladder diagram. Generally, the PLC available can cater up to 16 external input and output. Thus it cannot accommodate the configuration of the real system in KLIA Aviation Fuel Terminal which required more than 60 outputs Thus, for the simulation purpose, the scale-down version has been developed with just a few external inputs and outputs which will suits the PLC specifications.

The scale-down version of the system specification is as follows:

No. of Tank : 2 (Tank A and Tank B)
No of MOV : 3 (MOV 1, 2, and 3)
No. of Pump : 3 (Pump 1, 2, and 3)

Table 4.1 Scale down Version Specification

	Flushing Sequence 1	**Flushing Sequence 2**
MOV Close	1, 2 and 3	1 and 2
Pumps Operating	3	3
Pumps Duration	20 seconds	10 seconds

The flow diagram of the system is as attached in Appendix III. Using the CX-Programmer, the ladder diagram for above configuration have been constructed (refer appendix VI). However, this is not the complete version of the scale-down version operation. A few improvements have to be done to several things on the ladder diagram. But, basically from the ladder diagram simulation test, it is proven working.

For this particular project, the ladder diagram is generally consisting of 27 rungs with 101 I/O modules. Based on the studies which have been done, only the basic feature of OMRON PLC is being utilized for this project [5]. For the purpose of verification, the ladder diagram which has been programmed was uploaded into the PLC. The inputs were depicted by assigning particular switches which will generate specific output that were represented by the output LED.

At first, as far as basic PLC ladder diagram programming is concern, this stage can be considered as successfully completed. But, when the project reaches the next step which is the GUI programming, this stage has to be reviewed to suit the GUI syntax especially in term of PLC addressing. There must be synchronization between PLC addressing and Visual Basic syntax to ensure that the GUI can access the PLC memory.

4.3 PC-BASED SYSTEM SET-UP

The stage three of the project is focusing on linking the Computer and PLC in order to prepare a PC-based system. Basically, the PC-based system consists of two mechanisms. The first mechanism is the system which will connects the PLC system with the PC, while the second mechanism is the system which will link the GUI and PLC so that the GUI can control the PLC from the PC.

First of all, it is necessary to understand the basic architecture of establishing the PC-based system using PC and OMRON PLC. Figure 4.3 below depicted the basic interconnection of the PC-bases system.

In general, there three main softwares involve. The softwares are SYSMAC Compolet, FINS Gateway and Visual Basic. Each of the software has its own function.

Visual Basic, a Microsoft Window based software is the software where the GUI will be constructed. The construction process will be explained in the later section of the report.

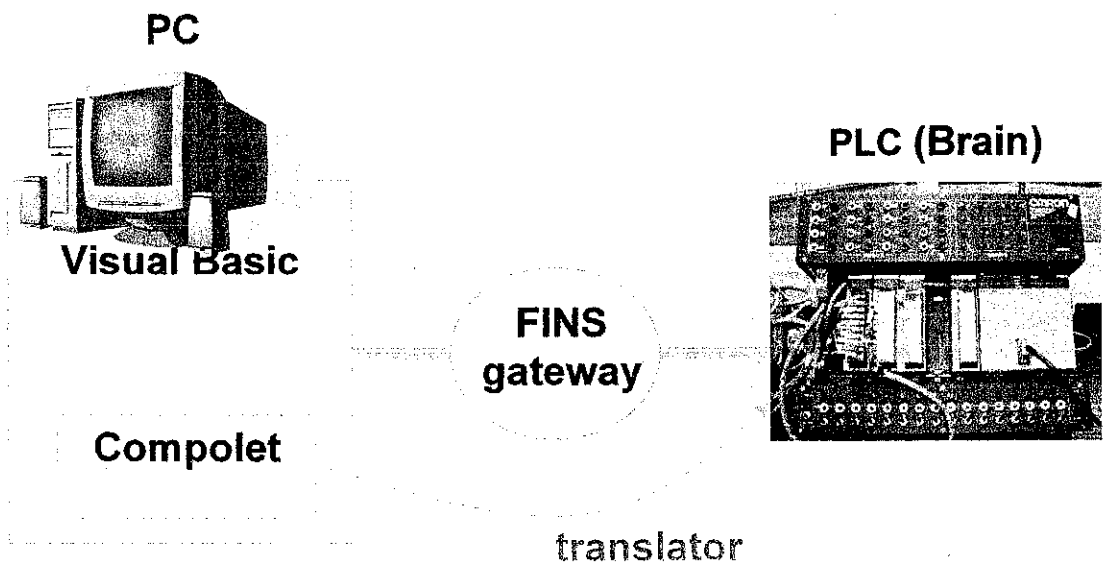

Figure 4.3: The PC-based Interconnectivity

FINS Gateway works as the communication software. It establishes the communication interface between PC and the PLC. This window based software is suitable for most OMRON PLC system [7]. Thus, it is applicable for this particular project.

The third software is the SYSMAC Compolet. This software plays the role as Communication Bridge or the translator. It establishes the Visual Basic GUI Interface communication with the PLC system. Without this software, the GUI cannot interact with the PLC memory area even though the correct programming syntax is used. SYSMAC Compolet utilizes the ActiveX control for Window to allow the user to read and write to the PLC freely.

In order to establish the PLC-PC connection, we need to follow the methods and settings as mentioned in this section.

The first thing to do is to activate the FINS Gateway Service Manager. This will enable the PC-to communicate with the PLC. At the **'Service Control Manager'**, activate the **CPU_UNIT** and **Serial Unit.** Upon activation, the status will indicate it is in 'Running' mode. The window display can be viewed as Figure 4.4.

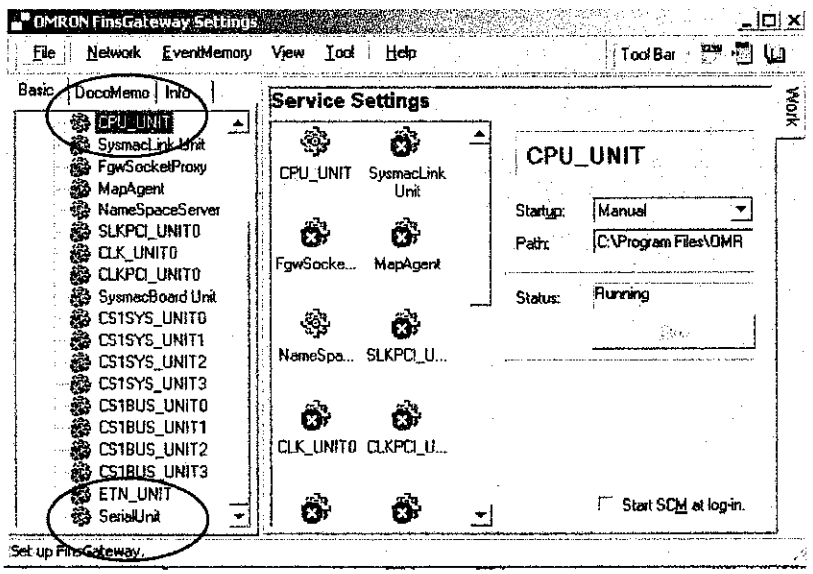

Figure 4.4: Service Control Manager

Next step, go to **Basic –Network – Networks and Units -Local Network 1**, to configure the serial communication port. Serial communication port is being use to communicate between PLC-PC as cable is being attached from the communication port of the PC to the RS232 port of the PLC. The communication port used is COM1.The parameters can be observed from Figure 4.5 and Figure 4.6 in the following page.

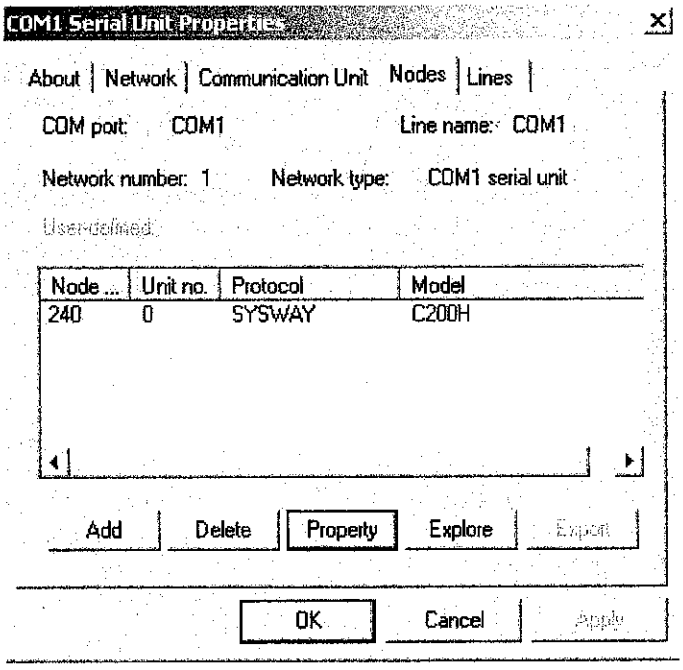

Figure 4.5: Node Setting Parameter for COM1 Serial Unit

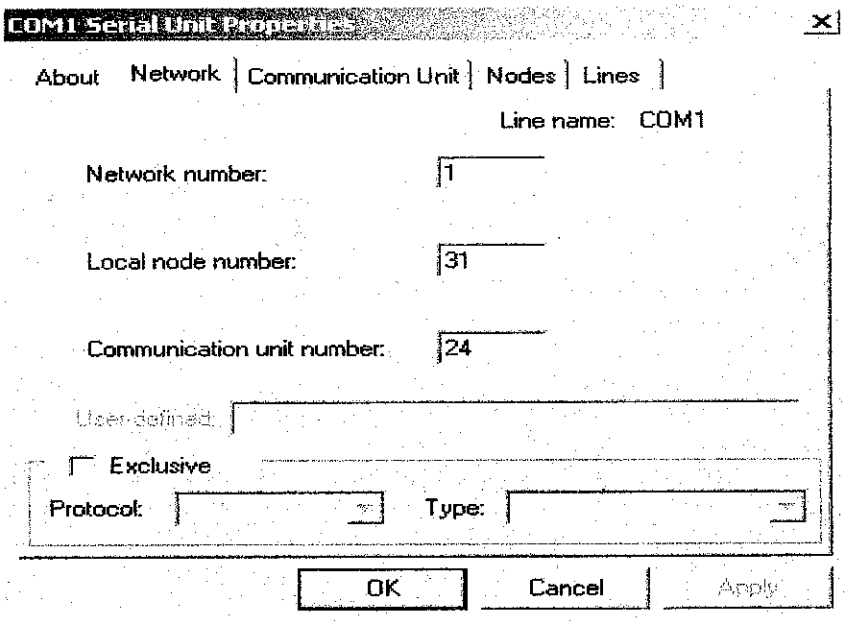

Figure 4.6: Network Setting Parameter for COM1 Serial Unit Properties

This setting is usually automatically configured by the system. But, it is important to validate the setting by manual checking.

All the steps, which have been followed, are basically to set up the PLC-PC communication. The end result of these steps can be verified by checking the *Properties* tab. From the configuration carried out, it has been proven that the link has been successfully established.

The components of the *Network* are PLC and PC; recognized by FINSGateway as C200HE and CPU_UNIT respectively. For PLC C200HE, its *Network address* would be '1' and as for CPU_UNIT, its *Network address* would be '0'. Both addresses are fixed by the *FINSGateway Configuration for Serial Unit*. Basically, once FINSGateway has detected both components, it will automatically provide the *Network* component description or *Controller Model*; upon the insertion of *Network, Node* and *Unit* address (refer to Figure 4.7 in the folloing page).

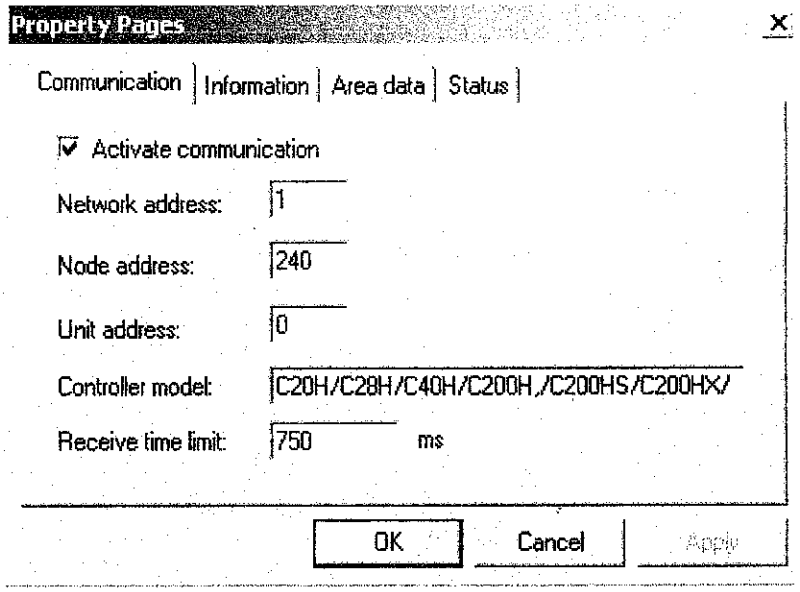

Figure 4.7: Network component descriptions

Based on Figure 4.7, Node Address which indicates the address 240 refers to Serial COM1, which is the PLC that is being used. Meanwhile, Unit Address which indicates 0 refers to the CPU_UNIT of the PC, which is the heart of the system.

4.4 GRAPHIC USER INTERFACE (GUI) SOFTWARE PROGRAMMING

As mentioned earlier, Graphic User Interface (GUI) software programming is the fourth stage of the project. Basically, the main focus of this stage is to set-up a GUI that will control the PLC from the PC. Visual Basic 6.0 is being used as the GUI development tool. In general, Visual Basic 6.0 is an object oriented programming tools [9]. It works in Window based operating system.

In essence, Visual Basic is an object oriented programming language that allows the creation of *customs programs*. *Custom programs* are usually designed for specific purposes. In this project, a program will be developed to control the Fast Flushing Operation.

The most important thing about Visual basic is, this software is widely accepted and compatible with many automation devices including the OMRON PLC. In order allows PLC to be controlled from Visual Basic, SYSMAC Compolet is required. SYSMAC Compolet is the intermediate software. For the purpose of this project, Compolet Version 2 is being used. This software contains the control utility for C/CS1/CV series of OMRON PLC.

In order to have a better job coordination, the fourth stage of the project can be divided into five minor stages. The stages are: -

- Self Study on Visual Basic 6.0
- Graphic User Interface (GUI) Sketching
- Graphic User Interface (GUI) Construction
- Graphic User Interface (GUI) Programming
- Graphic User Interface (GUI) Programming for PLC System

4.4.1 Self Study on Visual Basic 6.0

This stage started with self study on Visual Basic 6.0. Reference books and colleagues with the related knowledge were the main focus to gauge the proper understanding on this subject matter. It is quite difficult to fully comprehend the working concept of this software without proper courses on this software. Moreover, the time frame to do the self study is quite short and the subject to be covered is quite a lot. Thus, the concept of trial and error was put into practice throughout the learning stages. The learning process was done by exercising the lesson learnt with the project implementation.

First of all it is vital to understand the basic window of Visual Basic 6.0. The basic window is depicted in Figure 4.8 in the following page.

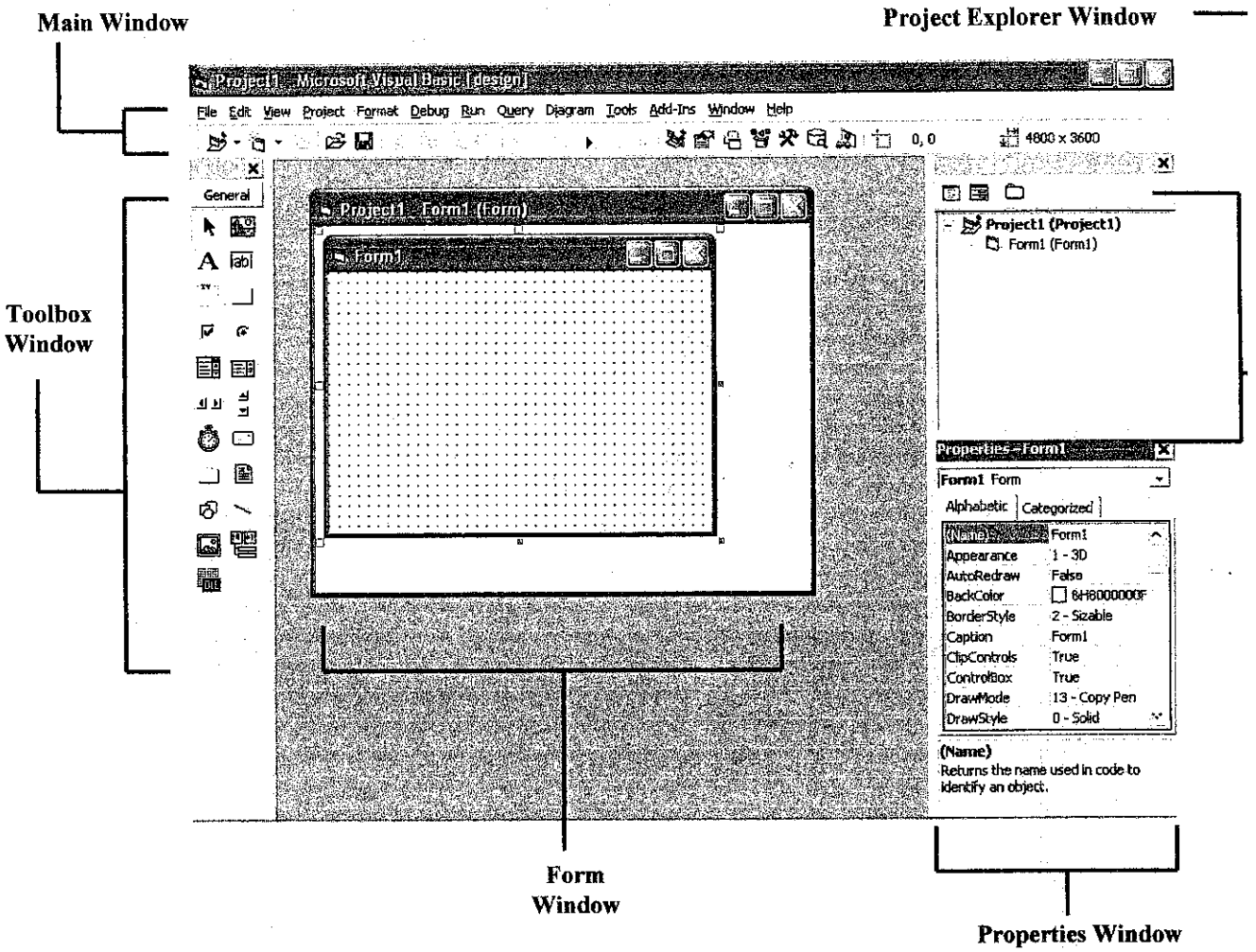

Figure 4.8: Main Window of Visual Basic

As shown in Figure 4.8 above, the start-up screen of Visual Basic contains five separate windows: the Visual Basic main window, the Toolbox window, the Form window, the Properties window, and the Project Explorer window.

The main window, at the top of the screen, contains the title bar, the menu bar, and the standard toolbar.

A Visual Basic Form window is a window which the interface of the application is designed. This is where the programmer will arrange the outlook of the Graphic User Interface.

On the left on the screen is the Toolbox Window. This window contains the set of tool that will be used in the GUI designing process. This window allows the designer to place objects such as button, boxes, and scroll box on the form. This window also allows the designer to place the related control component on the interface.

Next is the Project Explorer window. The Project Explorer window or often called the Project Window, displays a hierarchical list of the projects included in the currently created application. It also display all the items contained in the project.

The properties window is located below the Project Explorer window. Each object in Visual Basic has a set of characteristic, called properties. All these properties, listed in he Properties window, control the object's appearance and behaviour.

After gaining all the related understanding on the main start up window of Visual Basic, the focus of the project can now be directed on applying the knowledge on the GUI design.

4.4.2 Graphic User Interface (GUI) Sketching

In the design step, first off all, the GUI designer must come out with the basic outlook of the interface. The initial design must be created based on the requirement of the application that will be designed. Thus, for this particular project, the requirement will be based on the Fast Flushing Operation and the PLC control requirements.

By referring back to the objective of the project, it is clearly stated that the purpose of this project is to develop a simulation/model of the fast flushing process of the hydrant line system. The components of this model will be the PLC programming, the Graphic User Interface (GUI) and for further enhancement planning, a module of web based GUI, whereby the operation can be done and monitored far away from the main control room via internet connection with restricted access level.

The main component which is related to this stage is the constructing of GUI that will control the operation. Since that the stage three of the project is to develop the PLC ladder diagram, thus, the design of the GUI has to comply with it. This is to ensure there is connectivity between the two designs.

Principally, there are six main interfaces that are needed for this design. All these six interfaces are for the main control purpose. But the number might change to suit current alteration as the project goes on.

The GUI sketching is a process whereby the designer spends some time with pencil and paper, creating the rough draft of the interface arrangement and appearance. This is basically a short process if the designer has understood all the requirements of the process especially the PLC ladder diagram design.

4.4.3 Graphic User Interface (GUI) Construction

The third stage of this phase is to construct the interface based on the sketches made earlier. At this level, knowledge on how to operate and use all the control features of Visual Basic is an essence. At this phase also, all the requirements must be defined properly to ensure the design meet the expectation of the system.

The six GUI sketches will then, be implemented into a real application. Thus, this section will be dedicated to display all the basic design of the interfaces.

Figure 4.9 below shows the first interface of the application. This is basically the welcoming screen. It displays the name of the software. And the bottom right of the interface, the user will finds two command buttons. If the user clicks on the 'ENTER' button, the following screen will pop up. But if the user clicks on the 'QUIT' button, the software will be closed. Similar to other common window based user interface, at the top right there are three command buttons for minimize, maximize and close. Each of the GUI for this project also inherits the same features.

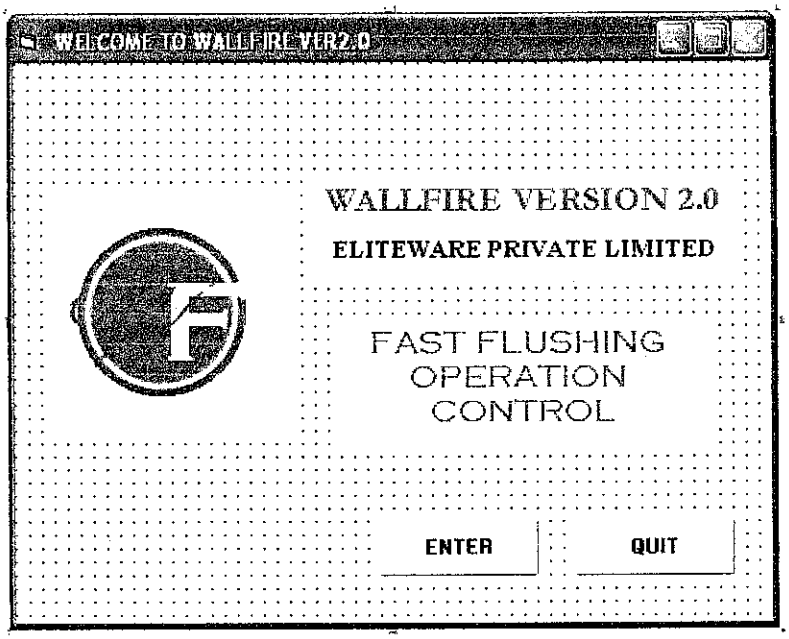

Figure 4.9: First Interface

Once the user click 'ENTER' in the welcoming screen, the interface as shown in Figure 4.10 below will appear. This second interface is basically the log in interface. In this interface, there are two text input features (normally known as text box) and three command buttons.

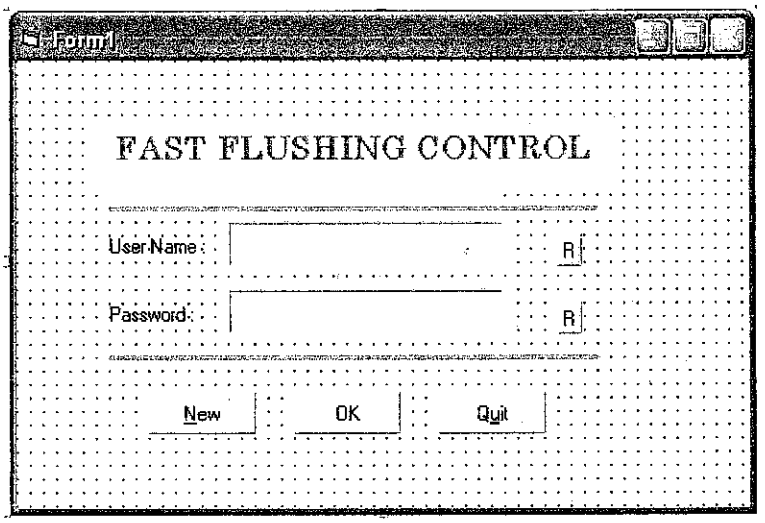

Figure 4.10: Second Interface

The user will enter his/her user name and key in the password. The program will accept the user request to log in to the system if both user name and password are correct. This interface works like a common log in interface. But the main challenge at this stage is to do the database linking process.

Basically, a database must be developed. This database will keep the entire user name and the password. Only the administrator has the access to this database. This is to ensure the integrity of the system.

In order to link the database system and the Visual Basic interface, it is important to understand the mechanism of Visual Data Manager and Universal Data Access (UDA). Generally, Visual Data Manager is the features of Visual Basic that allow the designer to create a database system. Using this feature, the designer can design a database system based in various system including Microsoft Access, Dbase, FoxPro, Paradox and Microsoft Excel. Then, the UDA features will

be used to link the Visual Basic interface under construction, with the database created.

The UDA approach used a set of complex interfaces, called Object Linking and Embedding Database (OLE BD) that provides access to data stored in a database. Due to its complexity, OLE DB was not designed to be accessed directly from Visual Basic, Rather, the Visual Basic programmer gain access to the OLE DB through ActiveX Data Objects (ADO).

But, for this project, this part has been simplified. The approached used for this GUI is, the program will compare a default user name and password which have been saved. Thus, if both name and password entered are correct, the user will be allowed to proceed to the next window. If the user name and password entered are not correct, a message box will pop up. It will prompt the user to re-enter the correct user name and password.

Once the log in interface requirements have been completed the next interface will pop-up. The third interface is shown in figure 4.11 below.

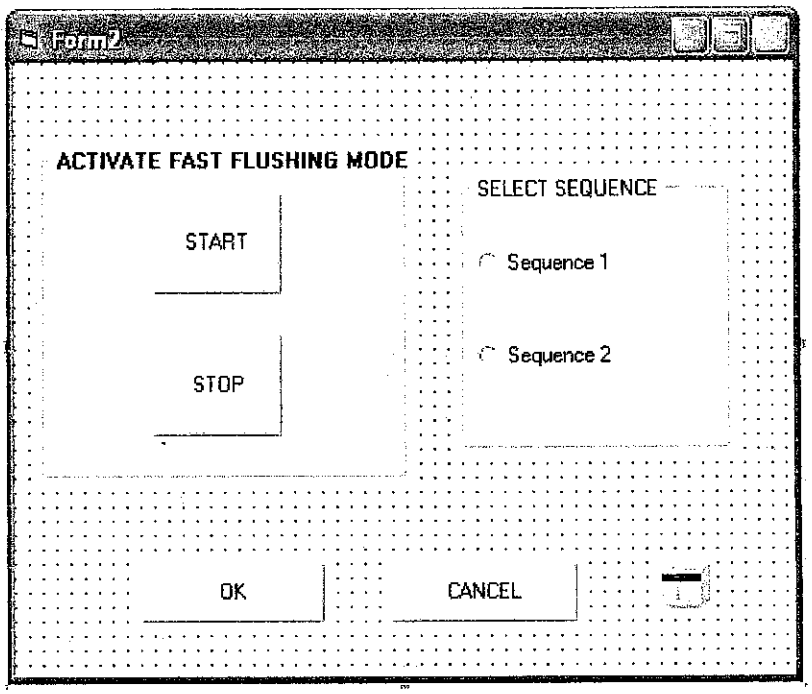

Figure 4.11: Third Interface

Based on the figure above, the third interface is consisting of four command buttons and two option buttons. In this interface, the user will activate the Fast Flushing mode by clicking the start button. That particular button is linked with the PLC system. Then, the user will have to select the Fast Flushing sequence to be operated from the two option buttons. Since we designed the PLC system to cater only for two sequences, thus only Sequence 1 and Sequence 2 are available. Thus, by clicking the sequence selection option button, the selected sequence will be activated. The PLC setting for that particular sequence will be in active mode. The user must click OK to proceed to the next interface. If the user clicks CANCEL, all the selection will be reset and first interface will pop-up.

Next, will be the fourth interface. Figure 4.12, below display the fourth interface of this application.

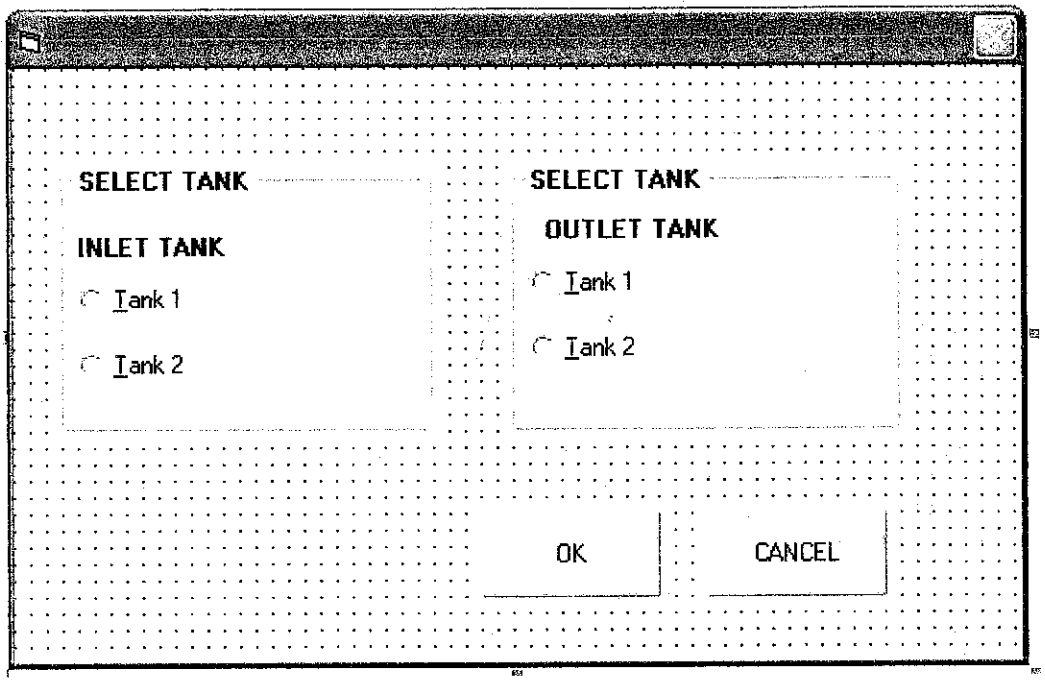

Figure 4.12: Fourth Interface

As in the previous interface, the fourth interface also contains command buttons and option buttons. There are two command buttons and four option buttons in this interface. The option buttons function is to select the tank that will be used as the inlet and outlet tank, based on the PLC system design.

In general, the user has to select the inlet tank that will be used. Once the tank has been selected to be the inlet tank, it cannot be selected to be the outlet tank. This is a part of the safety system that is implemented in the PLC ladder diagram design.

Once the tanks have been selected, clicking OK will bring the user to the next interface. If the user clicks CANCEL, the fourth interface will disappear and the previous interface then pop-up.

Next, the focus is on the fifth interface of this application. Once the user clicks 'OK' button in the fourth interface, the fifth interface will appear. The fifth interface is depicted in the Figure 4.13 below.

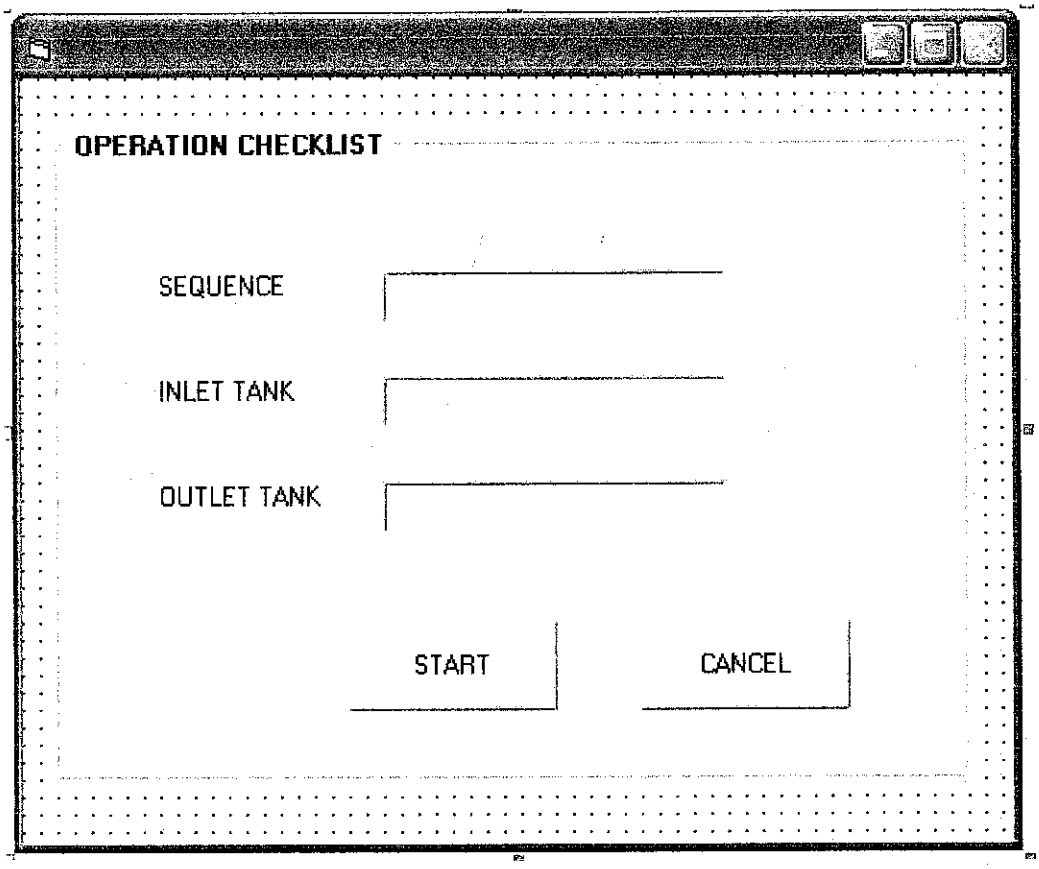

Figure 4.13: Fifth Interface

The fifth interface is quite unique. It contains two command button and three text box. Basically, the fifth interface works as the operation check list. All the sequence and tanks that have been selected in the previous interface will appear. Thus, the user will check the correctness. If the user satisfied with the selection, the user can click START to start the operation. By clicking CANCEL the user will return back to the previous interface. This interface indirectly works as safety features of the application, whereby, the user will have to check the selections made before starting the operation.

Once the user click the START button, a message box will pop up which prompt the user for further confirmation. The message box is shown in the figure 4.14.

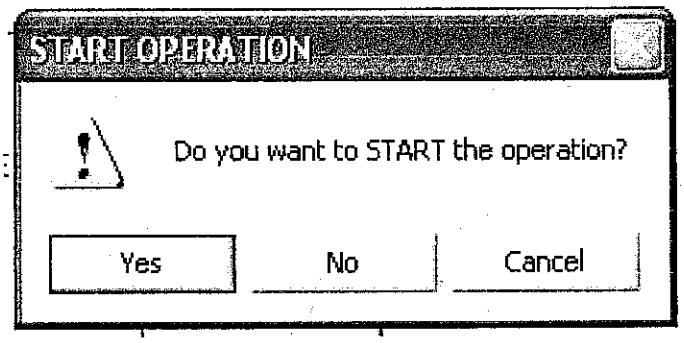

Figure 4.14: Message Box

This message box is basically used a method which interact with user to fulfil a condition. In this case, once the user clicks the START button from the fourth interface the message box above appear. The message box contains three command buttons which the user has to click in order to answer the question in the message box. In this particular message box, the question is 'Do you want to START the operation?' If the users click YES, the GUI will go to the next interface.

The next interface will be the monitoring interface. It is shown in figure 4.15 below.

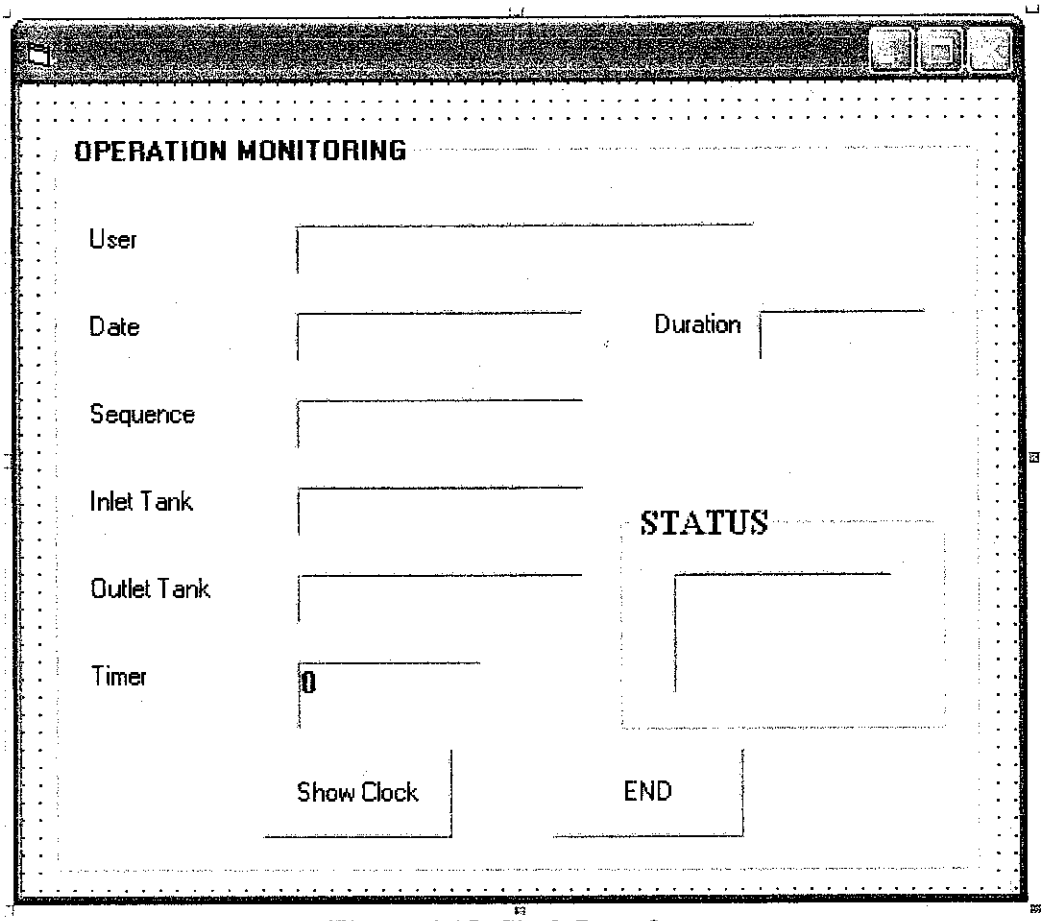

Figure 4.15: Sixth Interface

The main purpose of the sixth interface is as the user monitoring board. The user can monitor the operation from the data given in this interface. Basically, this interface is consisting of six text boxes, two label and two command buttons. All the data which have been entered in the previous interfaces will appear in this interface. The user will also be updated with the current time and the elapse time of the operation. A text box which shows the date is also available in this interface. There is also an operation status text box. This text box will show the current status of the operation. It will indicate FINISH once the operation has ended. Then the user must click END to reset the whole system.

This sixth interface might as well be linked with a database system that will collect all the information of the operation that has been carried out. This database will works for historical reference. All the data of the operation can be retrieved back by the user.

While the sixth interface appears, another interface will become visible. This interface is basically shows the current time. Figure 4.16 below shows the particular interface.

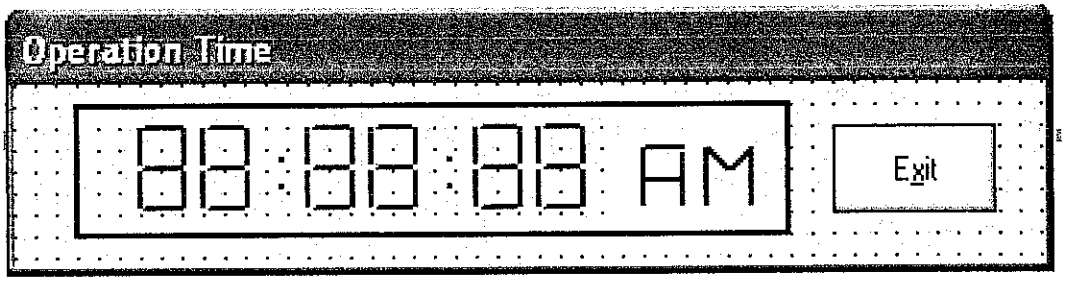

Figure 4.16: Digital Clock

This interface basically depicted a digital clock display. It shows the hour, minute and second. This interface is scrutinized to show the same time as shown by the clock of the PC. This interface can be closed by clicking the EXIT button on the right side of the interface.

Based on the discussion in this section, there are basically six main interfaces plus one message box. However, the number might change based on the improvement process that will be carried out later to enhance this application. Moreover, one interface which is dedicated for administration usage may be constructed. In general, the five main interfaces are good enough to cater all the basic needs of the project objectives.

4.4.4 Graphic User Interface (GUI) Programming

Based on this stage job distribution, is has been decided that Graphic User Interface (GUI) Programming will be done once all the basic GUIs have been constructed. At this phase, the main concern is to write the proper coding techniques use in Visual Basic programming.

Basically, Visual Basic is an object oriented programming tool. It is considered as one of the best programming tool. Visual Basic is considered as one of the fastest and easiest way to create application for Window. It has the Real Time capability which acts as multimedia interface for data acquisition. In this project, the Real Time is utilized for data acquisition to and fro PLC.

At this stage, initially it is necessary to define the function that will be implemented for each control features. In general, an assignment statement that will assign a value to the property of an object must follow this syntax: -

[*form.*]*object.property* = *value*

Form is the name of the form or interface in which the object is located, *object* is the name of the object, and *property* is the name of the property to which the value that will be assigned. Besides, using that general syntax, Visual also has its own predefine syntax which is called **method**. For example, there is method to execute a print job. The syntax is: -

[*form.*]**PrintForm**

Form is the name of the form while **PrintForm** is the name of the method.

In order to construct the coding for the interface, the programmer must know the functionality of each of the object that will be used in the interface. There are more than eight types of object that can be manipulated for GUI construction. In this GUI programming stage, generally we will play around with various Visual Basic programming techniques, such as utilizing *if else loop* and *GoTo Command.*

Full focus on this stage is essential in order to obtain a working GUI. All the six main interfaces have to be programmed accordingly to achieve a workable GUI. Moreover, this part will be followed by the implementing of the syntax that will make the GUI communicate with the PLC. To view the complete coding, please refer to Appendix V.

4.4.5 Graphic User Interface (GUI) Programming for PLC System

The programming job for this system does not end at the Visual Basic programming technique only. We should realize that the project will be implemented with the PLC system. Thus, a proper addressing should be done to suit the Visual Basic mechanism so that it can instruct the PLC.

Therefore, in order to complete this level, two essential skills that must be acquired are the Visual Basic Programming method and the PLC addressing technique so that it will suit with the GUI syntax.

Currently, the work at this stage is directed on understanding the PLC addressing mode. Basically, in order to execute the PLC program using Visual Basic, the PLC Internal Relay (IR) will be utilized. The range of PLC Internal Relay address depends on the type of PLC. In the ladder diagram design, to turn on each command, one IR address must be turned ON. For example, for a particular operation, IR address 246.06 must be turned ON. In order to turn on this address, CIO will be manipulated. For example, in order to turn IR address 246.06, the Compolet code or the syntax that will be programmed in the GUI is as follows:

SYSMAC_C1.writeArea plcAreaCIO, 246, 1, "0040"

The syntax above is the basic technique for writing a code in Visual Basic to control an OMROM PLC which uses SYSMAC as the bridging medium.

At this stage, *Event Memory*, is very helpful. It allows data from the PLC *I/O Memory Area* to be read and write from the PC. It also allows programmer to set event condition to send and receive event. This feature can be accessed by activating *COMPOLET-PLCDatafile*. There are two types of data area; which are the CIO and DM. An example of a window showing a data area can be viewed as Figure 4.17. The numbers in circle depicts the data that the DM of the PLC is

currently storing. The usage of Event Memory will be more obvious when we go in depth on the GUI programming.

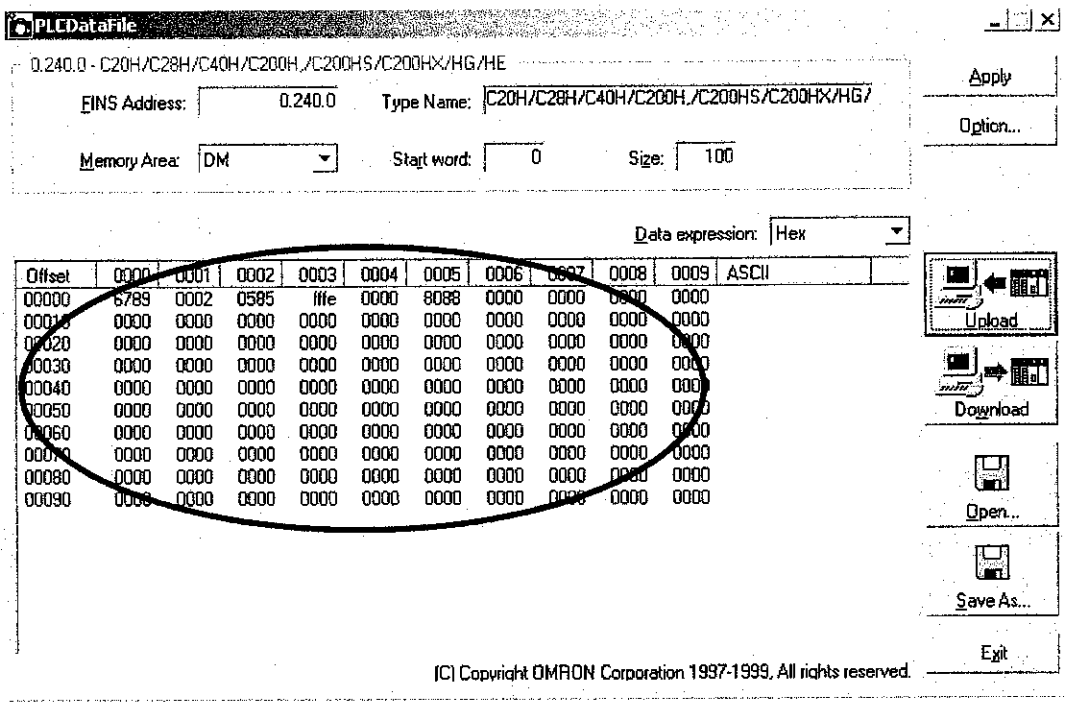

Figure 4.17: PLC Data

In order to create the PLC-VB GUI connection, it is compulsory to add in *OMRON SYSMAC C Control* under 'Project Component', on the GUI form. Figure 4.18 shows the example of this step.

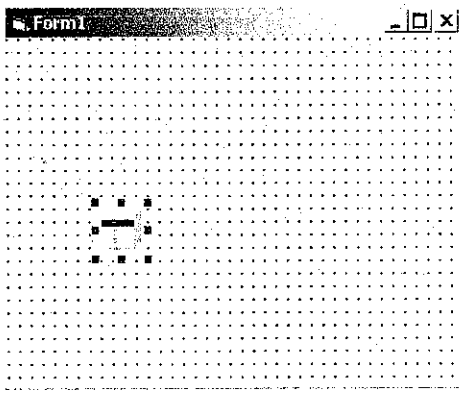

Figure 4.18: SYSMAC C icon for C Series

On the *PropertyPages*, under *Communication*, set the *Network, Node* and *Unit* address according to the setting fixed by *FINSGateway Configuration for*

Serial Unit; which is 1.240.0. If PLC- PC communication is established, the 'Controller Model' will indicates the PLC model attached to the system, as shown in Figure 4.19.

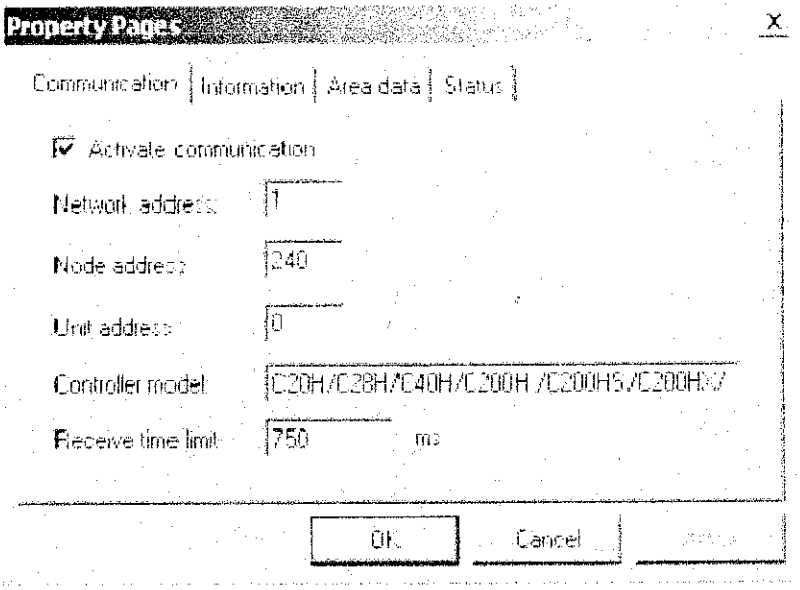

Figure 4.19: SYSMAC C Property settings

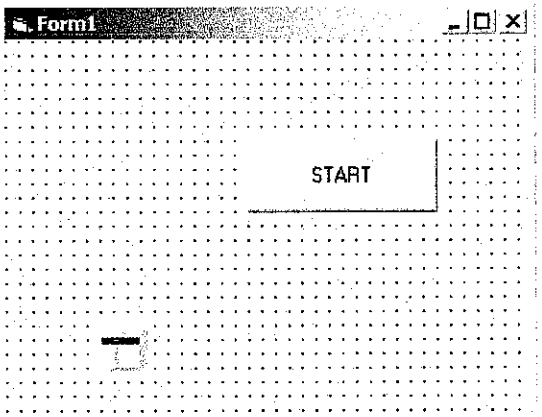

Figure 4.20: Visual Basic Interface program to start a PLC program

For the purpose of testing, a simple instruction is being entered. The instruction is just to activate an LED by controlling from the VB. First of all, *CommandButton* is selected and labelled with START (Refer Figure 4.20 in the previous page). Basically, by clicking this button, it will activate the LED.

The instruction for this process is as follows:

```
Private Sub startbutton_Click()
  SYSMAC_C1.writeArea plcAreaCIO, 246, 1, "0040"
End Sub
```

Figure 4.21: Compolet Coding

Briefly, the example above in Figure 4.21, which has been downloaded into the PLC CIO Memory, will switch ON the address 246.06 when the START button is press.

Another important element is how to access the right address which is the utilization of the Internal Relay (IR). IR allows PLC to be controlled from SYSMAC C control in Visual Basic. This is because IR addresses lets the program in PLC to be invoked internally (through communication link) instead of hardwire (physical input such as switches). So, the right IR address must be used during ladder diagram construction using the CX-Programmer. For this trial process, address 246 has been used and it was called by the VB program to activate that Address.

Table 4.2: Compolet Series Table

0				0								0			
15	14	13	12	11	10	09	08	07		05	04	03	02	01	00
2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3		2^1	2^0	2^3	2^2	2^1	2^0

The number 246 represent the IR 246 and number 1 indicates the offset. The "0040" is obtained from the last two digits (246.06) .This value is obtainable from the Compolet Series Table as shown in Table 4.2.

After understanding the addressing mode, it will be easier to apply the correct address for all the PLC Internal Relay inside the Visual Basic programming syntax. The sample of the programming syntax which integrates the coding for GUI and the PLC control for this project can be referred in Appendix V. The ladder diagram which has been amended to integrate the PLC with the GUI can be referred in Appendix VI.

4.5 INTEGRATING GUI AND PLC

This is the fifth stage of the project. At this stage, the main concern is to integrate the completed GUI which is created using Visual Basic, with the PLC. This part can be considered quite critical because adequate knowledge on software and hardware is needed here.

In order to link the GUI and PLC, SYSMAC CompoletVersion 2 will be utilized. This software is responsible to create a working bridge between Visual Basic, as the GUI and the PLC. In other words; it allows PLC to be controlled from the GUI program, which is a VB-based program, through this working bridge. Basically, it refers back to the basic architecture of the PC-based system as mentioned in the earlier section. SYSMAC Compolet Version 2 utilizes the ActiveX control for Window to allow the user to give read/write command freely to the PLC. This software supports most of the OMRON network type PLC system.

This stage can be considered as the trial phase of the project. Only at this phase, the workability of the system can be checked. Thus, at this stage, all the defects can be verified. Although it can be quite late in term of a design process, but that is the fact that must be faced in executing this project.

4.6 WEB-BASED SYSTEM

This is one of the crucial stages. It will be the part which will give the biggest improvement for the whole system. Thus the system is controllable from remote area rather than at the plant it self. This stage is the last stage of the whole project. Once again it requires the understanding of hardware and software. At this stage, data communication gets into the picture. The utilization of Open Network Controller, Ethernet system and networking is the main focus.

Basically, the web based system consists of four major components which are the PLC which control the industrial process, a server, internet/intranet system; and client/end user workstation. In order to set up this system, the equipments needed are two set of PC which will represent the workstation, two set of PLC – one set will connected with the Ethernet system, and the other one which control the industrial process; and one set of open network controller (ONC)

In this set up, the open network controller acts as the server. The industrial process is controlled by the server which is located locally or nearby the industry area. This server must be connected to the internet. The end user workstation must be connected to the internet as well. The idea is, when the authorized personnel need to monitor the industrial process, he/she just need to log on to the server website. The set up of this system is shown in Figure 4.18 in the following page.

Even though it seem that the basic set up is just a simple connection, in reality, it is not as easy as expected. Based on the configuration manual, a lot of things have to be scrutinized before the web-based system can work. That the main reason why this stage is considered as on of the most difficult stage. Thus, a lot of efforts have to be put to ensure the success of this step.

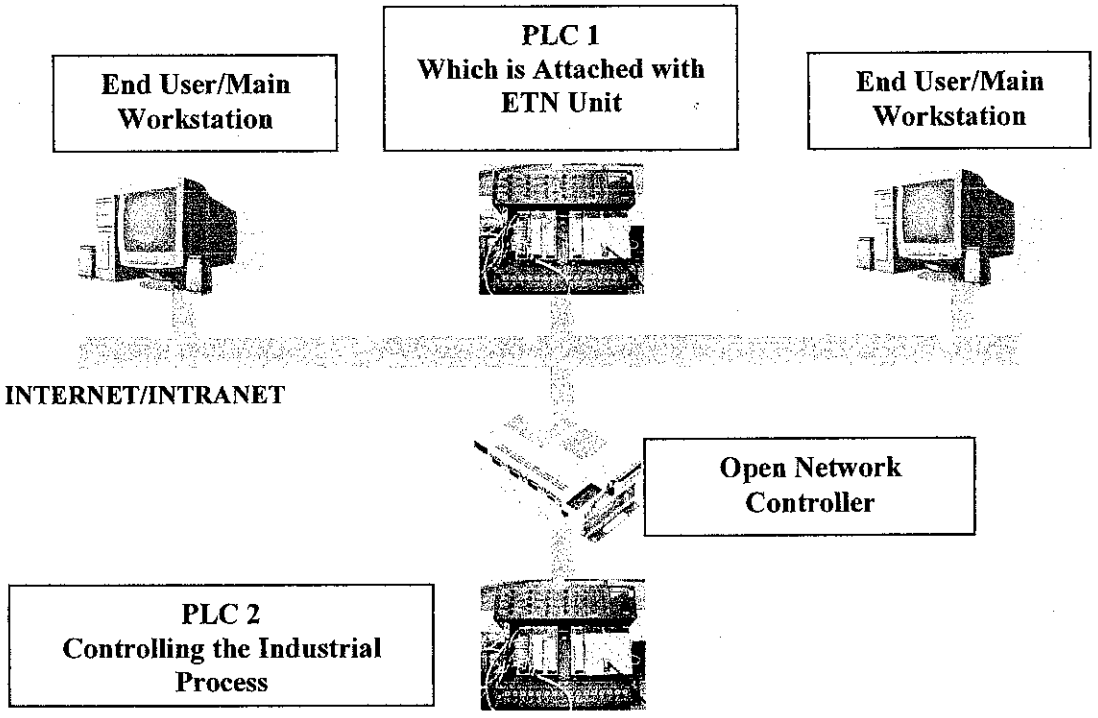

Figure 4.22: Web-based system diagrams

At this stage, first of all, it is important to understand basic element of data communication system. Components such as Local Area Network and concept of Network Protocol such as TCP/IP should be well understood.

The principle of LAN operation can be described as follows. Basically, Local Area Network (LAN) consists of a shared transmission medium and a set of hardware and software for interfacing devices to the medium. It allows devices to exchange data over the

shared transmission medium but imposes certain rule in regulating the orderly access to the medium.

LAN system is extremely utilized various organization because it provides easy data exchange. It includes data exchange between personal workstations and data interchange to a centralized facility as well. The existence of LAN granted data exchanging capability which is one of the challenges of the borderless world.

The common protocol architecture would be the IEEE 802 reference model. Protocol architecture cites how blocks data is transmitted over the network. Important features of LAN would be its topologies and Medium Access Control (MAC) technique. LAN Topology describes the physical layout of the interconnecting devices while MAC technique describes the method of determining which device in the network has access to the transmission medium at any given time.

In order for computers, terminal or other devices which is connected to each other through a network to communicate, it must agree to one protocol which is supported by the whole system. Protocol is a convection or set of rules use for communication between entities in different system. Protocol architecture is a structured set of modules that implements the communication functions. For example, each data frame transmitted (data is transmitted in frame) or file transferred is unique; such as transmitting password, file command and records. .To ensure its sound transmission, there is a certain kind of reliability required. The same sort of reliability requirement can be used by variety of applications such as e-mail and document transfer. Therefore these requirements are met by a separate communication service module that can be use by a variety of application.

The most popular architecture protocol would be TCP/IP models. Internet Protocol (IP) is a layer of TCP/IP suite. It is the most widely used internetworking protocol. Basically, IP manages data that is being send between two systems over the internet. The most important matter when discussing IP would be the IP addresses. As internet involve multiple networks, the source and destination address in IP header appends at a data frame must consist of a network identifier and a host identifier as well.

As the Web-based system is being developed using OMRON Factory Automation devices; namely the Ethernet Unit CS1W-ETN 11 (ETN Unit) module and Open Network Controller ITNC-EIX01 (ONC), understanding on FINS addressing system and UNIX are required.

In order to allow communication between ONC and C200HE PLC, a Finslink file needs to be edited. Familiarization with UNIX vi editor command is needed to edit the file. UNIX is an operating system (OS); which controls and coordinates the activities of the computer. Like other operating system, the UNIX OS is a collection of programs that include text editors, language compilers and other system utility program. It was written using the C language.

UNIX utility programs can be able to perform varieties of functions required by the users including the following functions:

- Text editing and text formatting utilities
- File manipulation utilities
- Electronic mail (e-mail) utilities
- Programmers tools

UNIX used vi editor to do the editing jobs. Vi is a type of screen editor. The knowledge pertaining the editor source code and syntax are needed in editing a file. Basic editing operations would be creating a new file or modifying an existing file, entering text, deleting text, searching text, changing text, saving the file and editing the session.

Problem with insufficient and malfunction equipment is really a set back at this stage. Thus, this stage could not be carried out as planned. But, the basic understanding on the execution of this stage has been obtained based on the research made.

4.7 AUTOMGEN SIMULATION – AN ADDITIONAL STEP

Based on the initial plan, a hardware system which consists of circuitry and electrical components will be built to simulate the PLC process. However, new idea arises, whereby the Project Supervisor suggested the usage of AUTOMGEN simulation software to simulate the real operation.

In general, AUTOMGEN is a workshop for automation, SCADA and 2D/3D process simulation that functions on a PC, under the WINDOWS operating system. Once again, knowledge on software is needed.

Currently, only Automgen 7 Starter Kit, trial edition available. The AUTOMGEN STARTER KIT is a software-learning package that deals with the basic notions of automation. It is an extraordinarily, user-friendly interface allows students who are new to the science of automation to learn basic concepts regarding sensors, actuators, and algorithmic, numerical and sequential sequencing.

The ASK language (an original language invented by IRAI), allows for the descriptions of automatic behaviors to be defined in a combination of textual and graphical terms.

In general, AUTOMGEN is just basic education software that is used to apply instrumentation controlling processes.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 REVIEW

This whole project is intended to develop a simulation/model the real world PLC system based on the PLC system architecture at KLIA Aviation Fuel Terminal. The focus is to develop a system to control the Fast Flushing Operation processes. The main components of this model are the PLC programming and the Graphic User Interface (GUI). The enhancement factor of this project is the web-based system. In general, this project is a combination of hardware and software which is integrated to each other to become a complete system.

5.2 THE PROJECT STEPS

Based on the project progress, by dividing the project into six major phases really gives a better control on the project flow. The phases are:

- Field study – Focusing on collecting relevance data and information from the real operating unit.

- PLC programming – Concentrating on programming the PLC to simulate the real system.

- PC-Based system set up – Linking the PLC and the PC to establish the platform that will be used once the GUI is completed.

- Graphic User Interface (GUI) software programming – Focusing on understanding the method of programming the GUI using related software and constructs the GUI.

- Integrating GUI and PLC – Establish the PC-GUI-PLC integration based on the platform connection which have been establish earlier.

- Set up a web based link for the integrated GUI and PLC system – Enhance the accessibility of the program, whereby it can be reached from remote area by manipulating the internet/intranet capability.

5.3 RECOMMENDATIONS

Although this project has partially achieved its objectives which include constructing the proper PLC programming, GUI construction and PC-based system platform, it still has along way to go. This project can be a good starting point for a SCADA system development. There are a lot of things that can be improved.

First of all, good understanding on all the software and hardware is the essence of this project. The project is mainly about integrated various PLC which is the hardware with the PC, using relevance software which act as the connection platform.

The GUI that has been developed is not a finalized version. It can be enhanced from time to time based on the industrial requirement. Among of the area that can be focused for the GUI improvement is the safety and integrity of the GUI. It is important that the GUI only permit limited access especially if it is used to control critical operations. Besides, the GUI must be able to cope up with the operation system changes. Thus, it is important that the GUI system source code can be easily altered to suit the field equipments changes.

The major achievement of the project is to implement the system into the real industrial process. Thus, in the future, focus on such project should be headed to understand the real world SCADA system and how the integration were done especially with the various field equipment which used difference mode – digital or analogue. But to achieve this level, a lot of effort must be done. The relevance software must be fully comprehended and the hardware especially the PLC must be able to compromise with the real industrial standard.

5.4 CONCLUSION

Several conclusions can be made from the project works. Below are the conclusions that can be distinguished:

- The main objective of this project is to design a model of PLC implementation for fast flushing operation based on KLIA Aviation Fuel Terminal operation. Thus, understanding the PLC architecture and programming method is vital.

- The essence of this project is the ability to grasp the knowledge on related hardware and software. This is followed by the integration process of the hardware and software. Thus, it is important to have good understanding on the structure of the software and hardware.

- CX-Programmer is the tools to develop the ladder diagram. Correct addressing mode is an essential factor. Moreover, the address must suit the syntax that is used in Visual Basic which is the GUI programming software.

- In order to set-up a PC-based system, the communication mechanism between PLC-PC must be fully understood. FinsGateway is the software that is used to establish the PLC-PC communication.

- SYSMAC Compolet is the software which integrates the Visual Basic command which is the GUI and the PLC program. The operation of SYSMAC Compolet and the correct setting must be fully comprehended.

- A SCADA system is important in an industrial operating unit. Thus, the SCADA system human interface must have a users-friendly features and easy to be operated. The integrity of the system is also important to ensure safe and smooth industrial operation.

- The main contribution of the works done are:
    - It can be a platform for SCADA or PC-based PLC system, for educational purpose.
    - The idea of controlling the Fast Flushing Operation using the PC-based PLC system can be implemented in the real industrial plant if proper study and research were done.

- As the time goes by, the technology keeps on moving forward, SCADA system move along with the technology improvement as well. Thus, the introduction of web-based SCADA system really changes the method of operation in the industrial operating units.

- There are further problem to be addressed in the design and development of the SCADA system model of an industrial process. Based on this project, future works should include:

- It is important to have a good understanding on the PLC utilization in the real industrial process. Moreover, it will be an advantage if the study includes a research on various PLC system or model currently available in the real industrial world.
- A good understanding on software and GUI programming will be very helpful. Actually, there are various softwares that can be manipulated for GUI development purpose. Thus, it is important to have appropriate skill on the various softwares.
- Programming skill is very crucial. Different software or PLC systems have different style of programming. Thus, it is vital to have basic programming skill in order to cope up with the programming requirements.

- PLC system will face bigger challenge from time to time to coup up with the industrial world which moving forward rapidly. Thus, more people who have good knowledge in PLC system will be needed.

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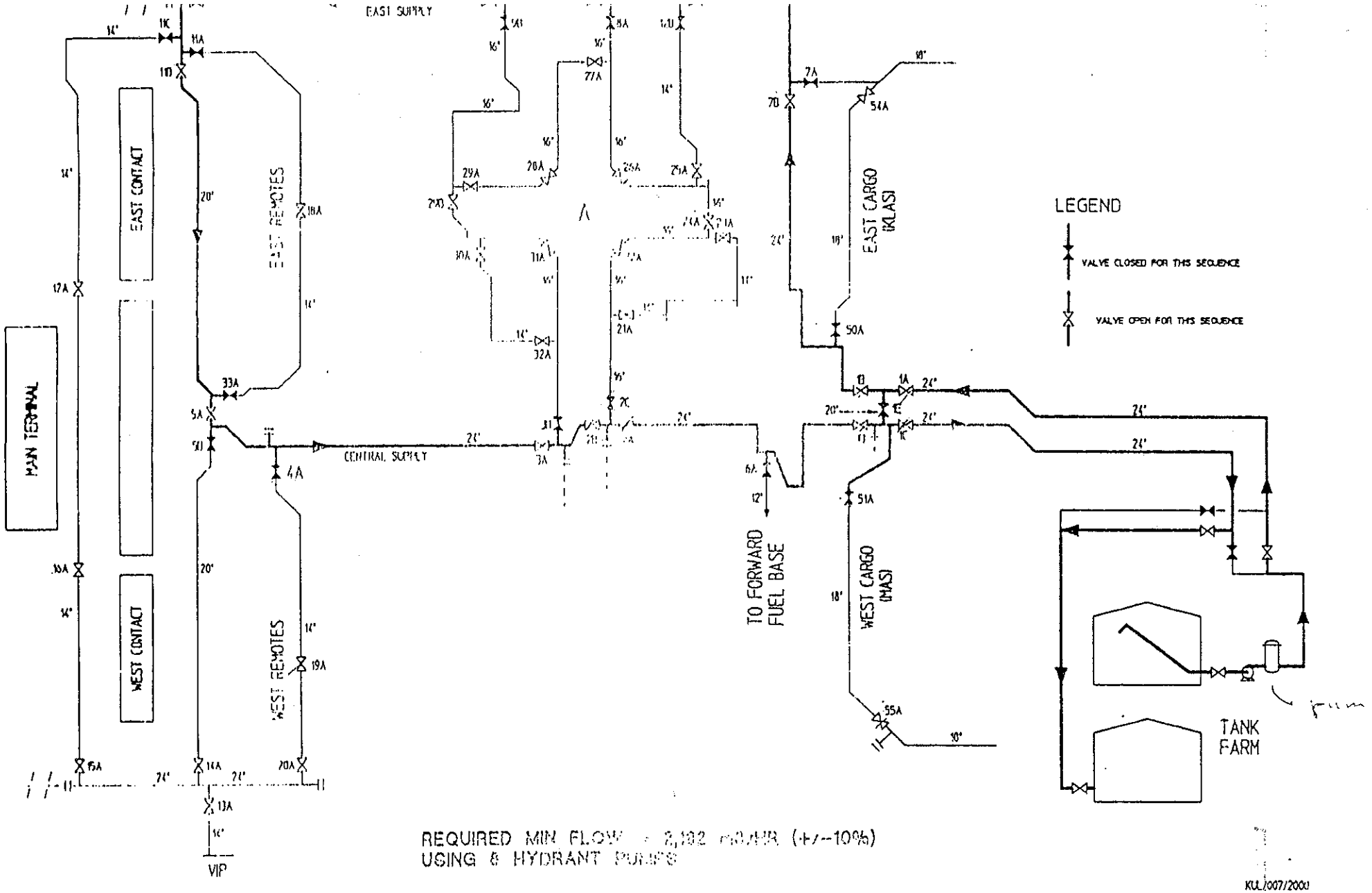
APPENDIX I

KLIA AVIATION FUEL TERMINAL FAST FLUSHING SEQUENCES ARRANGEMENT

'AST FLUSHING SEQUENCE No.1-East Supply & Main Contact East

Date:-

	Action	Checked	Time
.ll hydrant pressure testing is to be completed prior to commencement			
nsure all construction works in area are complete			
nsure entire hydrant has been opened and pressurised to stall pressure (150 psi)prior to commencement			
sue Works Permit			
ll hydrant DBB Valves are to be closed Electrically (if practical)			
FF DBB Block Valves are to be closed			
he following DBB Valves are to be opened ready for flushing operations			
C1A			
C1B			
C1C			
C1D			
C7B			
C12A			
C8B			
C9A			
C10A			
C11B			
C5A			
C3A			
C2B			
C2A			
FF valves from Issuing tank to Hydrant to be opened			
FF valves to Receiving tank from Hydrant to be opened			
vels in Issuing & Receiving tanks to be taken & recorded on Flushing Sheet			
ntrol Gate Valve on Return Line in AFF to be closed			
drant Pumps are to be prepared for start up (manual or remote)			
ll personnel are to be informed that flushing is about to commence			
tronas Comcen are to be informed that flushing is about to commence			
adually open Control Valve (CV) keeping pressure to below 3.5 Bar			
onitor flowrate until 274 Cu.M/hr achieved. Hold flowrate for 1 minute.			
ntinue opening CV to start Pumps 2 - 8, holding flow for 1 min for each pump before further opening CV			
quired flowrate with 8 pumps running = 2,192 m3/hr (8,000 igpm)			
onitor Samples Visually every 15 mins from sampling point in AFF			
onitor fuel quality with Colorimetrics from sampling point in AFF			
nfirm pipeline clean with Gravimetrics taken at end of circulation from sampling point in AFF			
n completion of desired flush slowly close Control Valve to stop pumps and cease circulation			
ssess results of flushing operation			
flush successful close all valves on hydrant			
ose tank side valves in AFF			
form all personnel Flushing operations are complete			
form Petronas Comcen all works are complete			


EAST SUPPLY
EAST CONTACT
WEST CONTACT
MAIN TERMINAL
EAST REMOTES
WEST REMOTES
CENTRAL SUPPLY
EAST CARGO (KLASI)
WEST CARGO (MAS)
TO FORWARD FUEL BASE
TANK FARM
VIP
LEGEND
VALVE CLOSED FOR THIS SEQUENCE
VALVE OPEN FOR THIS SEQUENCE
REQUIRED MIN FLOW = 2,182 m3/HR (+/-10%)
USING 6 HYDRANT PUMPS
KU/007/2000

CIRCULATION FLUSHING

ENCE 2 - Main Contacts - N and W Remotes, KLAS Cargo
im Flowrate = 6 pumps @274m3/hr = 1,644 m3/hr (6,,000 igpm)

ENCE 2	from	to	volume m3	pipe dia"	vel ft/sec
ction being flushed	VC50	VC54	99	18	9.9
ction being flushed	VC54	VC7	36	18	9.9
	VC7	VC12	175	24	5.4
	VC12	VC8	48	24	5.4
	VC8	VC9	91	24	5.4
	VC9	VC10	179	24	5.4
	VC10	VC11	9	20	7.9
ction being flushed	VC11	VC17	71	14	16.8
ction being flushed	VC17	VC16	40	14	16.8
ction being flushed	VC16	VC15	37	14	16.8
ction being flushed	VC15	VC20	85	24	5.4
ction being flushed	VC20	VC19	14	14	16.8
ction being flushed	VC19	VC4	42	14	16.8
	VC5	VC3	211	24	5.4
	VC3	VC2	42	24	5.4
	VC2	VC1	331	24	5.4
	VC1	AFF	585	24	5.4

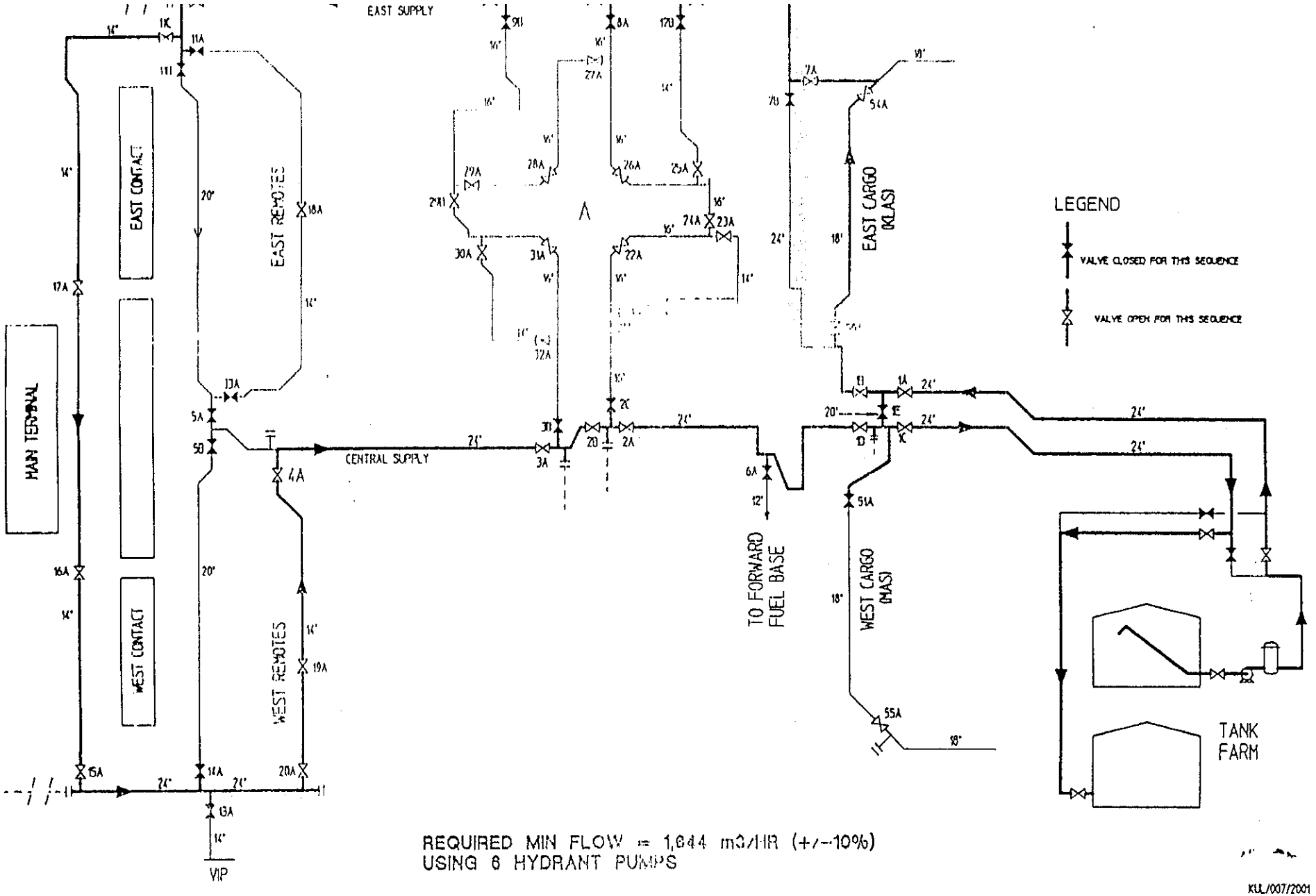
ntents of section being flushed	2,095
m flushing volume = Contents x 2	4,190
am	31.5
rop for minimum flush (one tank)	5.377

ATE	No pumps	flow/ pump	flowrate
m flow rate for 2 x contents m3/hr	6	274	1644
m duration at max flow (mins)			153

ING SUMMARY

lume flushed m3 - ENTER	
ent to number times sequence capacity	0.0
lour millipore result	
avimetric millipore result	

h speed circulation flushing of this section has been satisfactorily completed for Air BP:-



REQUIRED MIN FLOW = 1,644 m3/HR (+/-10%)
USING 6 HYDRANT PUMPS

KUL/007/2001

A - CIRCULATION FLUSHING

UENCE 3 - West Contacts

imum Flowrate (+/- 10%) = 1,644 m3/hr (6,,000 igpm), 6 pumps

UENCE 3	from	to	volume m3	pipe dia"	vel ft/sec
n section being flushed	VC14	VC5	117	20	7.9
	VC5	VC3	211	24	5.4
	VC3	VC2	42	24	5.4
	VC2	VC1	331	24	5.4
	VC1	AFF	585	24	5.4

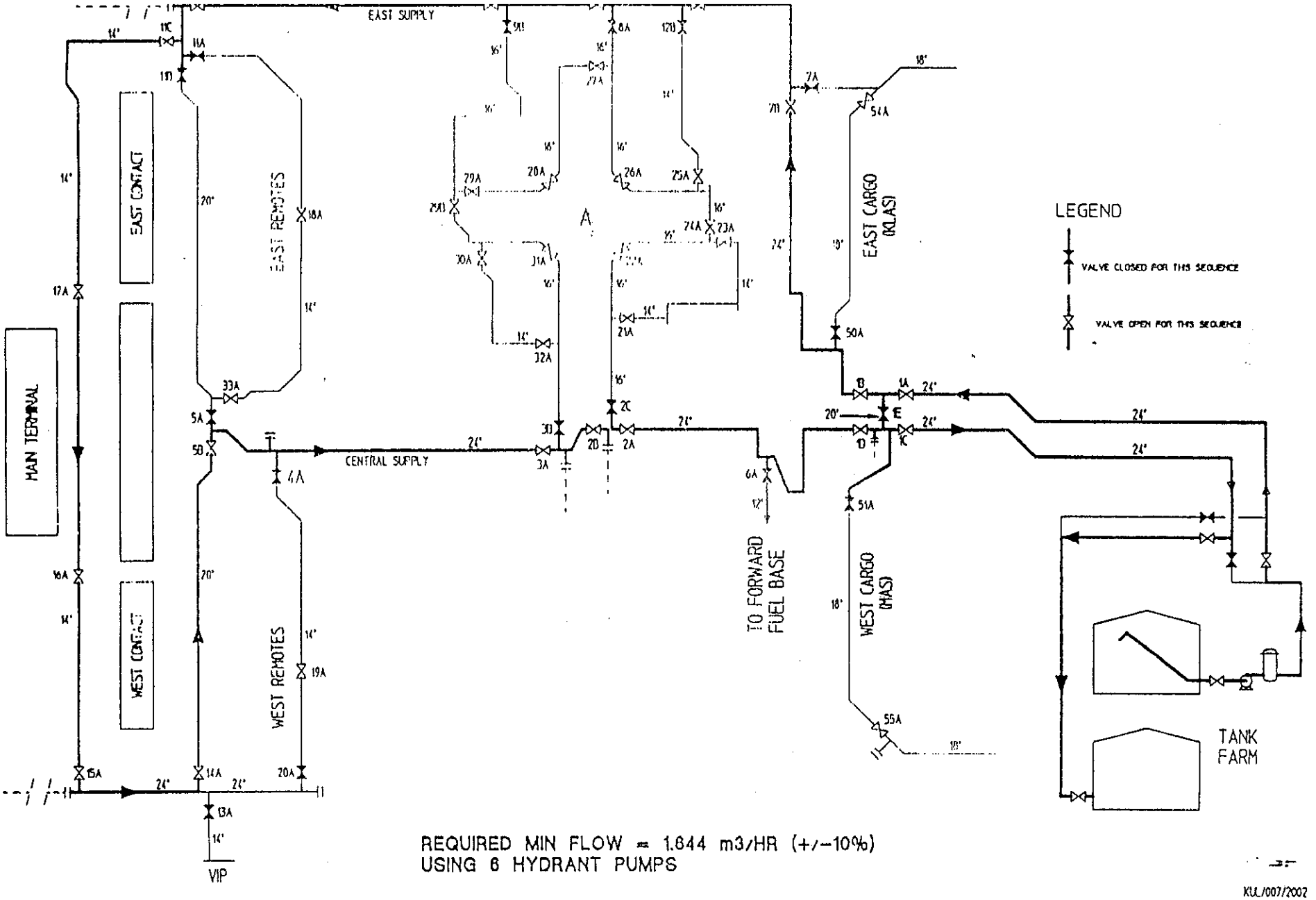
l contents of section being flushed			1,286		
mum flushing volume = Contents x 2			2,572		
diam			31.5		
l drop for minimum flush (one tank)			3.300		

WRATE	No pumps	flow/ pump	flowrate
mum flow rate for 2 x contents m3/hr	6	274	1644
mum duration at peak flow (mins)			94

SHING SUMMARY

volume flushed m3 - ENTER	
valent to number times sequence capacity	0.0
colour millipore result	
gravimetric millipore result	

iigh speed circulation flushing of this section has been satisfactorily completed
d for Air BP:-


EAST SUPPLY
EAST CONTACT
EAST REMOTES
EAST CARGO (KLAS)
MAIN TERMINAL
WEST CONTACT
WEST REMOTES
CENTRAL SUPPLY
TO FORWARD FUEL BASE
WEST CARGO (HAS)
TANK FARM
VIP
A
LEGEND
VALVE CLOSED FOR THIS SEQUENCE
VALVE OPEN FOR THIS SEQUENCE
REQUIRED MIN FLOW = 1.644 m3/HR (+/-10%)
USING 6 HYDRANT PUMPS
KUL/007/2002

A - CIRCULATION FLUSHING

UENCE 4 - East Remotes

mum Flowrate (+/- 10%) = 1,096 m3/hr (4,000 igpm), 4 pumps

UENCE 4	from	to	volume m3	pipe dia"	vel ft/sec
section being flushed	VC11	VC18	47	14	11.2
section being flushed	VC18	VC33	48	14	11.2
	VC5	VC3	211	24	3.6
	VC3	VC2	42	24	3.6
	VC2	VC1	331	24	3.6
	VC1	AFF	585	24	3.6

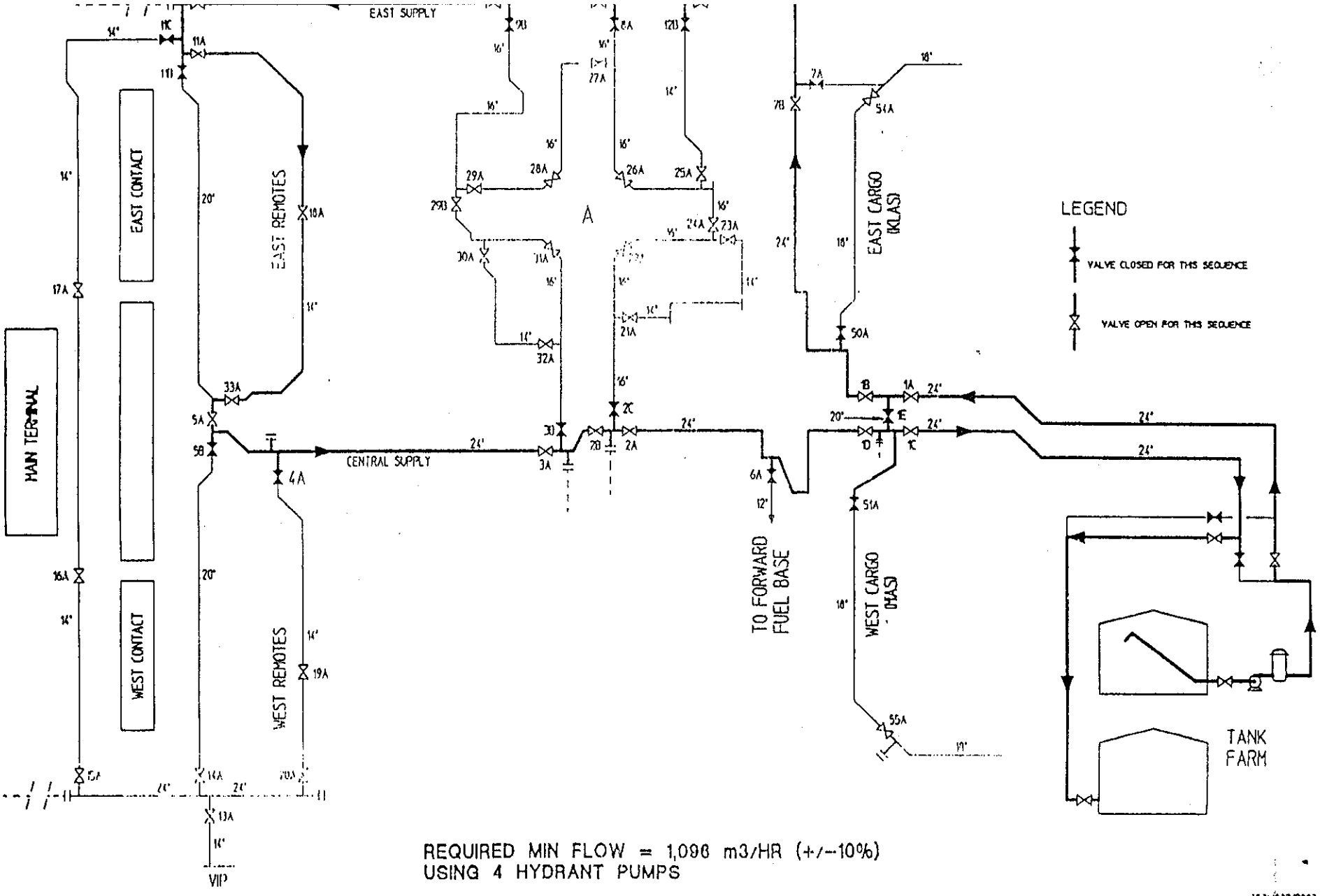
contents of section being flushed	1,264
num flushing volume = Contents x 2	2,528
diam	31.5
l drop for minimum flush (one tank)	3.244

VRATE	No pumps	flow/ pump	flowrate
num flow rate for 2 x contents m3/hr	4	274	1096
num duration at peak flow (mins)			138

SHING SUMMARY

volume flushed m3 - ENTER	
valent to number times sequence capacity	0.0
colour millipore result	
gravimetric millipore result	

igh speed circulation flushing of this section has been satisfactorily completed
d for Air BP:-



REQUIRED MIN FLOW = 1,096 m3/HR (+/-10%)
USING 4 HYDRANT PUMPS

KU/007/2003

IA - CIRCULATION FLUSHING

)UENCE 5 - Satellite A - North East Contacts & North West Remotes

imum Flowrate (+/- 10%) = 1.096 m3/hr (4.000 igpm). 4 pumps

)UENCE 5	from	to	volume m3	pipe dia"	vel ft/sec
n section being flushed	VC8	VC27	0	16	8.4
n section being flushed	VC27	VC28	52	16	8.4
n section being flushed	VC28	VC29	38	16	8.4
n section being flushed	VC29	VC30	7	16	8.4
n section being flushed	VC30	VC32	42	14	11.2
n section being flushed	VC32	VC3	19	16	8.4
	VC3	VC2	42	24	3.6
	VC2	VC1	331	24	3.6
	VC1	AFF	585	24	3.6

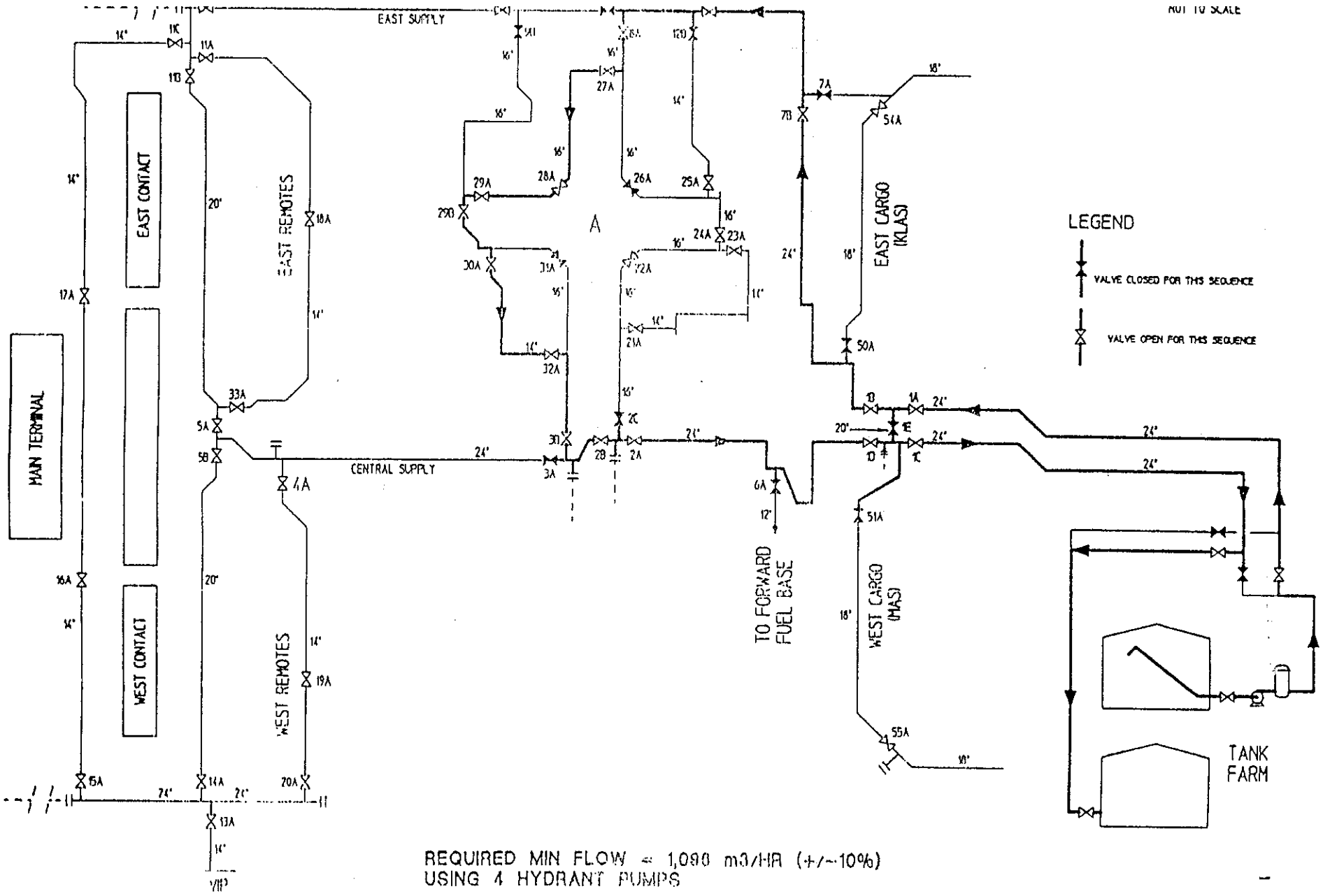
l contents of section being flushed	1,116
imum flushing volume = Contents x 2	2,232
x diam	31.5
el drop for minimum flush (one tank)	2.864

WRATE	No pumps	flow pump	flowrate
imum flow rate for 2 x contents m3/hr	4	274	1096
imum duration at peak flow (mins)			122

ISHING SUMMARY

l volume flushed m3 - ENTER	
valent to number times sequence capacity	9.0
l colour millipore result	
l gravimetric millipore result	

high speed circulation flushing of this section has been satisfactorily completed
ed for Air BP:-
:-


NOT TO SCALE
EAST SUPPLY
CENTRAL SUPPLY
EAST CONTACT
WEST CONTACT
MAIN TERMINAL
EAST REMOTES
WEST REMOTES
EAST CARGO (KLAS)
WEST CARGO (MAS)
TO FORWARD FUEL BASE
TANK FARM
A
LEGEND
VALVE CLOSED FOR THIS SEQUENCE
VALVE OPEN FOR THIS SEQUENCE
REQUIRED MIN FLOW = 1,090 m3/HR (+/-10%)
USING 4 HYDRANT PUMPS
KL/007/2001

A - CIRCULATION FLUSHING

UENCE 6 - Satellite A - North East Remotes & North West Contacts

imum Flowrate (+/- 10%) = 1,096m3/hr (4,000 igpm), 4 pumps

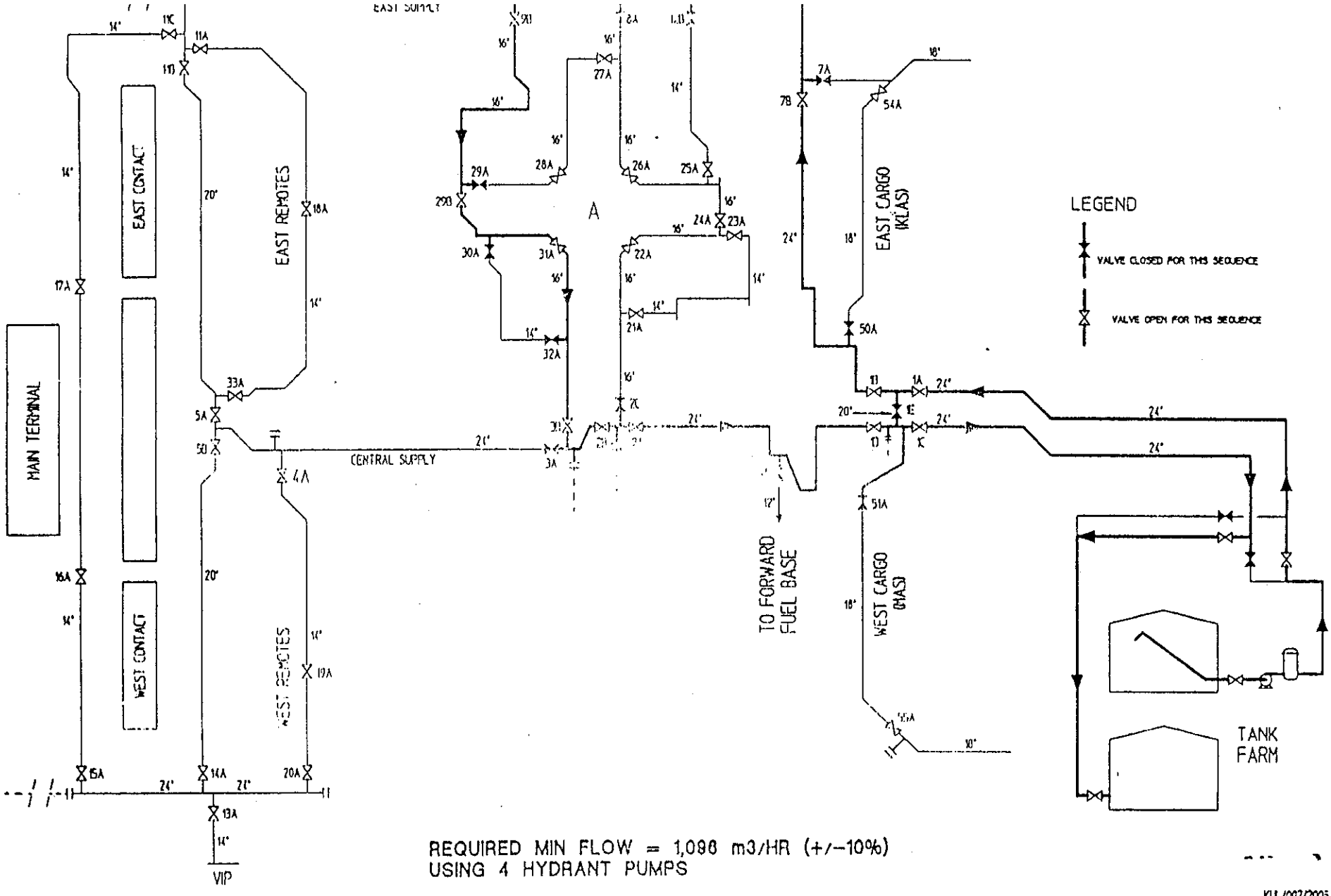
UENCE 6	from	to	volume m3	pipe dia"	vel ft/sec
n section being flushed	VC9	VC29	67	16	8.4
n section being flushed	VC29	VC31	53	16	8.4
n section being flushed	VC31	VC3	50	16	8.4
	VC3	VC2	42	24	3.6
	VC2	VC1	331	24	3.6
	VC1	AFF	585	24	3.6

l contents of section being flushed			1,128		
imum flushing volume = Contents x 2			2,256		
e diam			31.5		
el drop for minimum flush (one tank)			2.895		
WRATE	No pumps	flow pump	flow rate		
mum flow rate for 2 x contents m3 hr	4	274	1096		
mum duration at peak flow (mins)			124		

SHING SUMMARY

l volume flushed m3 - ENTER	
valent to number times sequence capacity	0.0
colour millipore result	
gravimetric millipore result	

high speed circulation flushing of this section has been satisfactorily completed
ed for Air BP:-
:-



REQUIRED MIN FLOW = 1,086 m3/HR (+/-10%)
USING 4 HYDRANT PUMPS

KUJ/007/2005

- CIRCULATION FLUSHING

JENCE 7 - Satellite A - South East & South West Remotes
num Flowrate (+/- 10%) = 1,096m3/hr (4,000 igpm), 4 pumps

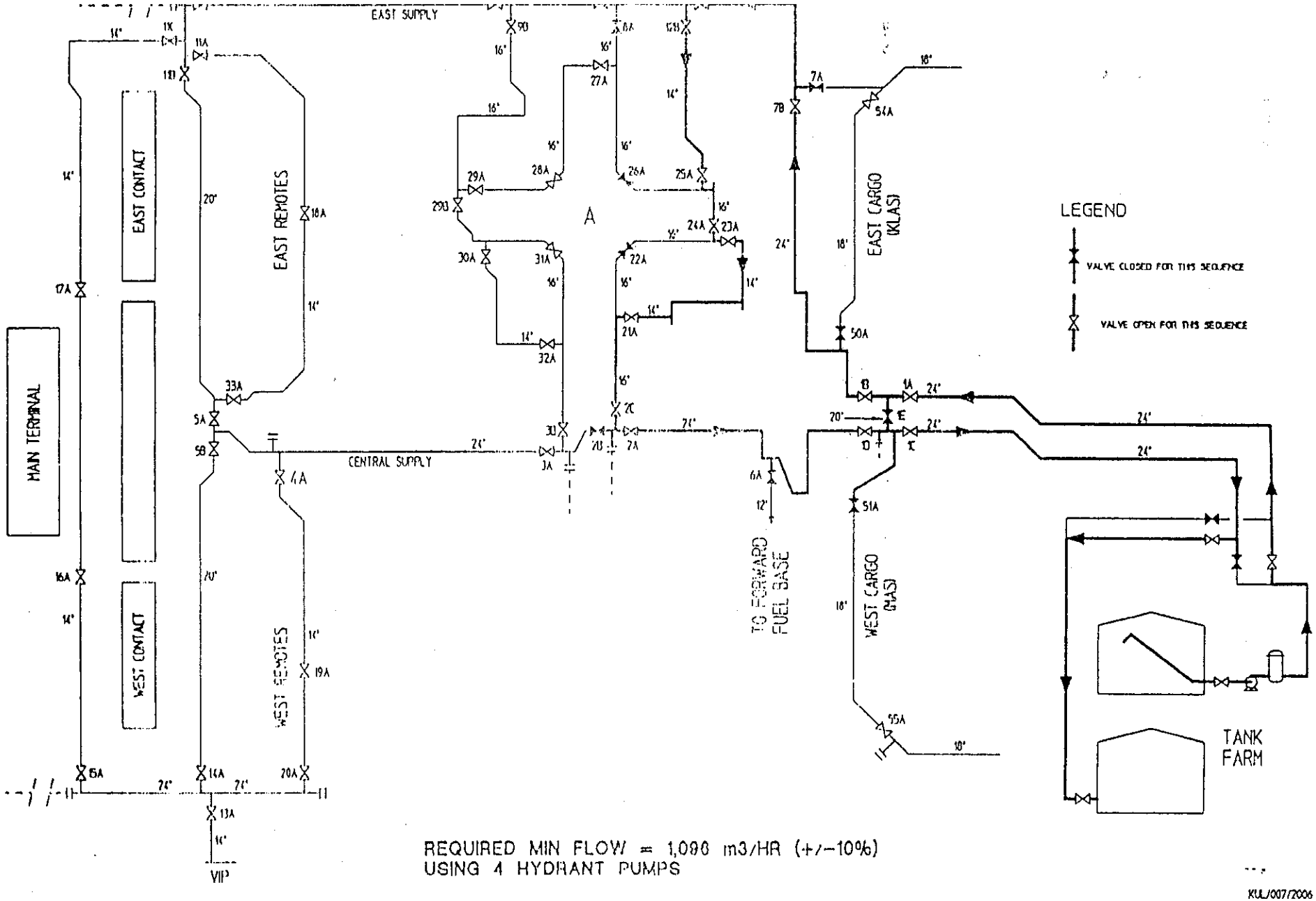
JENCE 7	from	to	volume m3	pipe dia"	vel ft/sec
section being flushed	VC12	VC25	34	14	11.2
section being flushed	VC25	VC24	26	16	8.4
section being flushed	VC24	VC23	4	16	8.4
section being flushed	VC23	VC21	48	14	11.2
section being flushed	VC21	16" tee	3	14	11.2
section being flushed	16" tee	VC2	27	16	8.4
	VC2	VC1	331	24	3.6
	VC1	AFF	585	24	3.6

contents of section being flushed			1,058		
num flushing volume = Contents x 2			2,116		
diam			31.5		
drop for minimum flush (one tank)			2.715		

VRATE	No pumps	flow/ pump	flowrate		
num flow rate for 2 x contents m3/hr	4	274	1096		
num duration at peak flow (mins)			116		

HING SUMMARY					
volume flushed m3 - ENTER					
alent to number times sequence capacity			0.0		
colour millipore result					
gravimetric millipore result					

igh speed circulation flushing of this section has been satisfactorily completed
d for Air BP:-
-


EAST SUPPLY
EAST CONTACT
EAST REMOTES
MAIN TERMINAL
WEST CONTACT
WEST REMOTES
CENTRAL SUPPLY
A
EAST CARGO (KLAS)
WEST CARGO (KLAS)
TO FORWARD FUEL BASE
TANK FARM
LEGEND
VALVE CLOSED FOR THIS SEQUENCE
VALVE OPEN FOR THIS SEQUENCE
REQUIRED MIN FLOW = 1,090 m3/HR (+/-10%)
USING 4 HYDRANT PUMPS
KUL/007/2006

A - CIRCULATION FLUSHING

UENCE 8 - Satellite A - South East & South West Contacts

num Flowrate (+/- 10%) = 1.096m3/hr (4.000 igpm). 4 pumps

UENCE 8	from	to	volume m3	pipe dia"	vel ft/sec
section being flushed	VC8	VC26	41	16	8.4
section being flushed	VC26	VC24	52	16	8.4
section being flushed	VC24	VC22	36	16	8.4
section being flushed	VC22	VC2	49	16	8.4
	VC2	VC1	331	24	3.6
	VC1	AFF	585	24	3.6
contents of section being flushed			1,094		
num flushing volume = Contents x 2			2,188		
diam			31.5		
drop for minimum flush (one tank)			2.808		

VRATE	No pumps	flow/ pump	flowrate
num flow rate for 2 x contents m3/hr	4	274	1096
num duration at peak flow (mins)			120

SHING SUMMARY

volume flushed m3 - ENTER

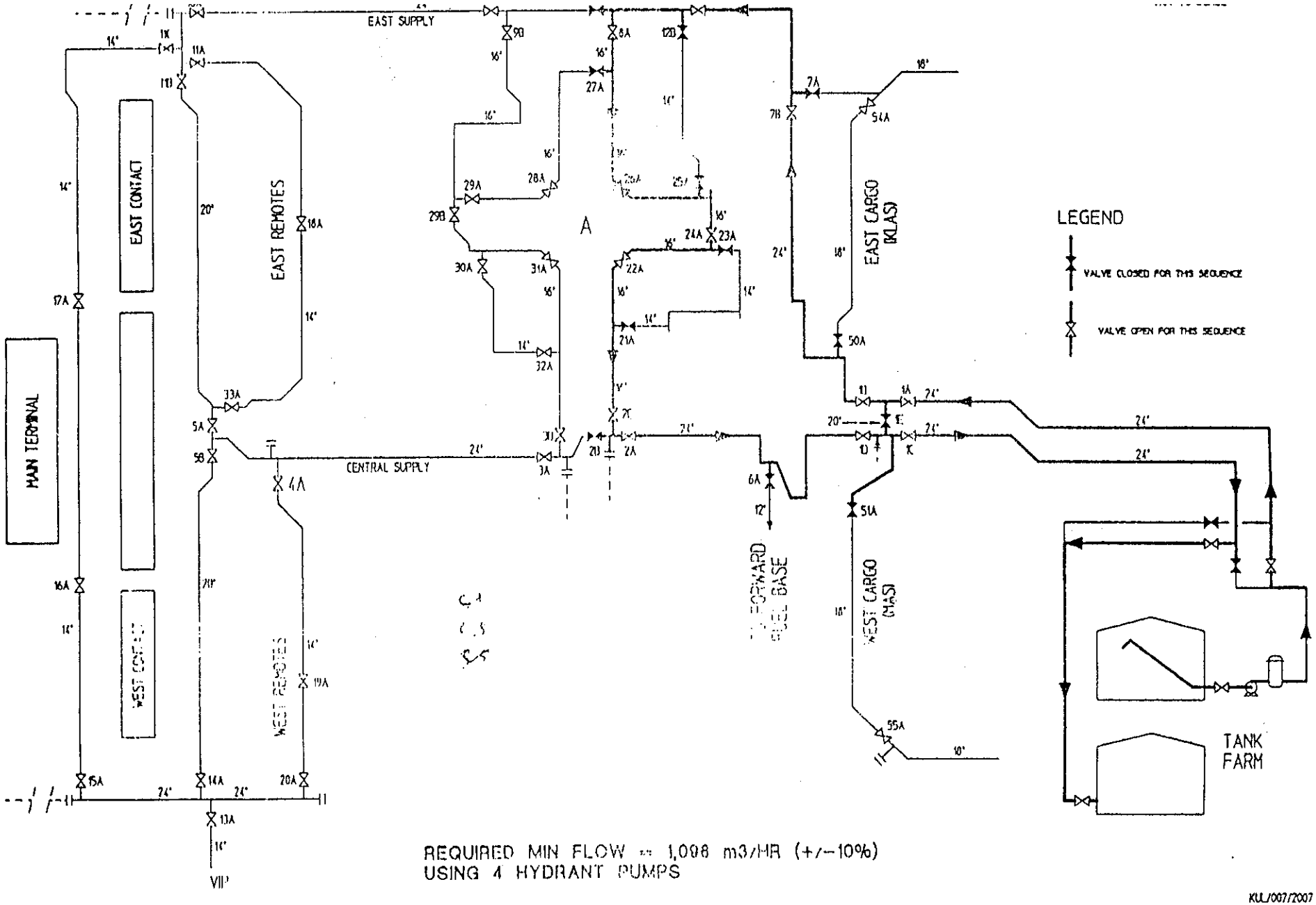
valent to number times sequence capacity 0.0

colour millipore result

gravimetric millipore result

high speed circulation flushing of this section has been satisfactorily completed

d for Air BP:-


EAST SUPPLY
EAST CONTACT
EAST REMOTES
MAIN TERMINAL
WEST CONTACT
WEST REMOTES
CENTRAL SUPPLY
EAST CARGO (KLAS)
WEST CARGO (MAS)
TO FORWARD FUEL BASE
TANK FARM
A
LEGEND
VALVE CLOSED FOR THIS SEQUENCE
VALVE OPEN FOR THIS SEQUENCE
REQUIRED MIN FLOW = 1,098 m3/HR (+/-10%)
USING 4 HYDRANT PUMPS
KUL/007/2007

- CIRCULATION FLUSHING

JENCE 9 - East Cargo (VC 54 to end)

ium Flowrate (+/- 10%) = 822 m3/hr (3,000 igpm), 3 pumps

JENCE 9	from	to	volume m3	pipe dia"	vel ft/sec
section being flushed	VC54	End	45	18	4.9
contents of section being flushed			45		
ium flushing volume = Contents x 2			90		
diam			31.5		
drop for minimum flush (one tank)			0.115		

/RATE	No pumps	flow/ pump	flowrate
ium flow rate for 2 x contents m3/hr	3	274	822
ium duration at peak flow (mins)			7

HING SUMMARY

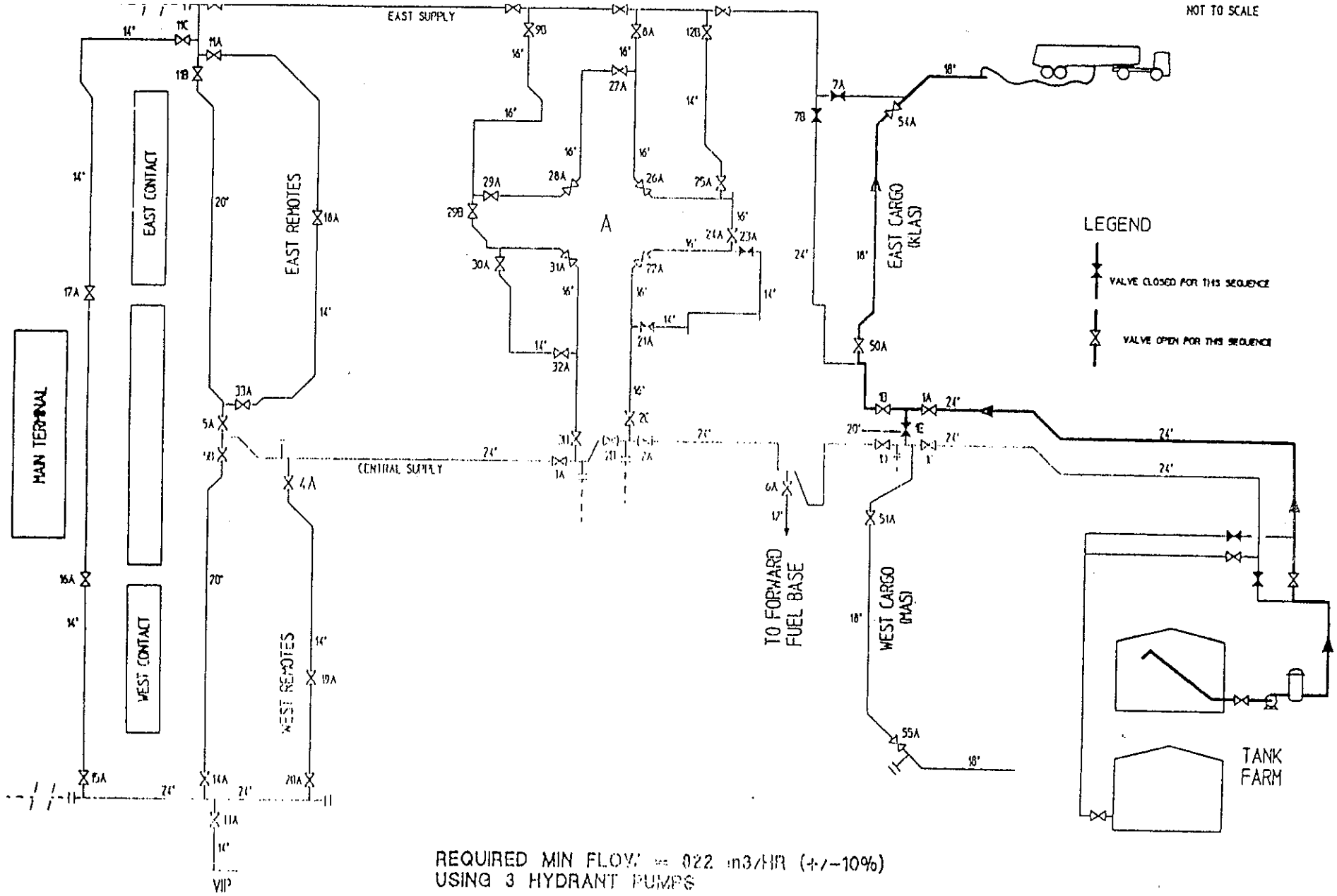
volume flushed m3 - ENTER

alent to number times sequence capacity 0.0

colour millipore result

gravimetric millipore result

igh speed circulation flushing of this section has been satisfactorily completed
d for Air BP:-


NOT TO SCALE
EAST SUPPLY
EAST CONTACT
EAST REMOTES
MAIN TERMINAL
WEST CONTACT
WEST REMOTES
CENTRAL SUPPLY
A
EAST CARGO (KLAS)
WEST CARGO (MAS)
TO FORWARD FUEL BASE
TANK FARM
LEGEND
VALVE CLOSED FOR THIS SEQUENCE
VALVE OPEN FOR THIS SEQUENCE
VIP
REQUIRED MIN FLOW = 022 m3/HR (+/-10%)
USING 3 HYDRANT PUMPS
KUL/007/2006

- CIRCULATION FLUSHING

JENCE 10 -West Cargo

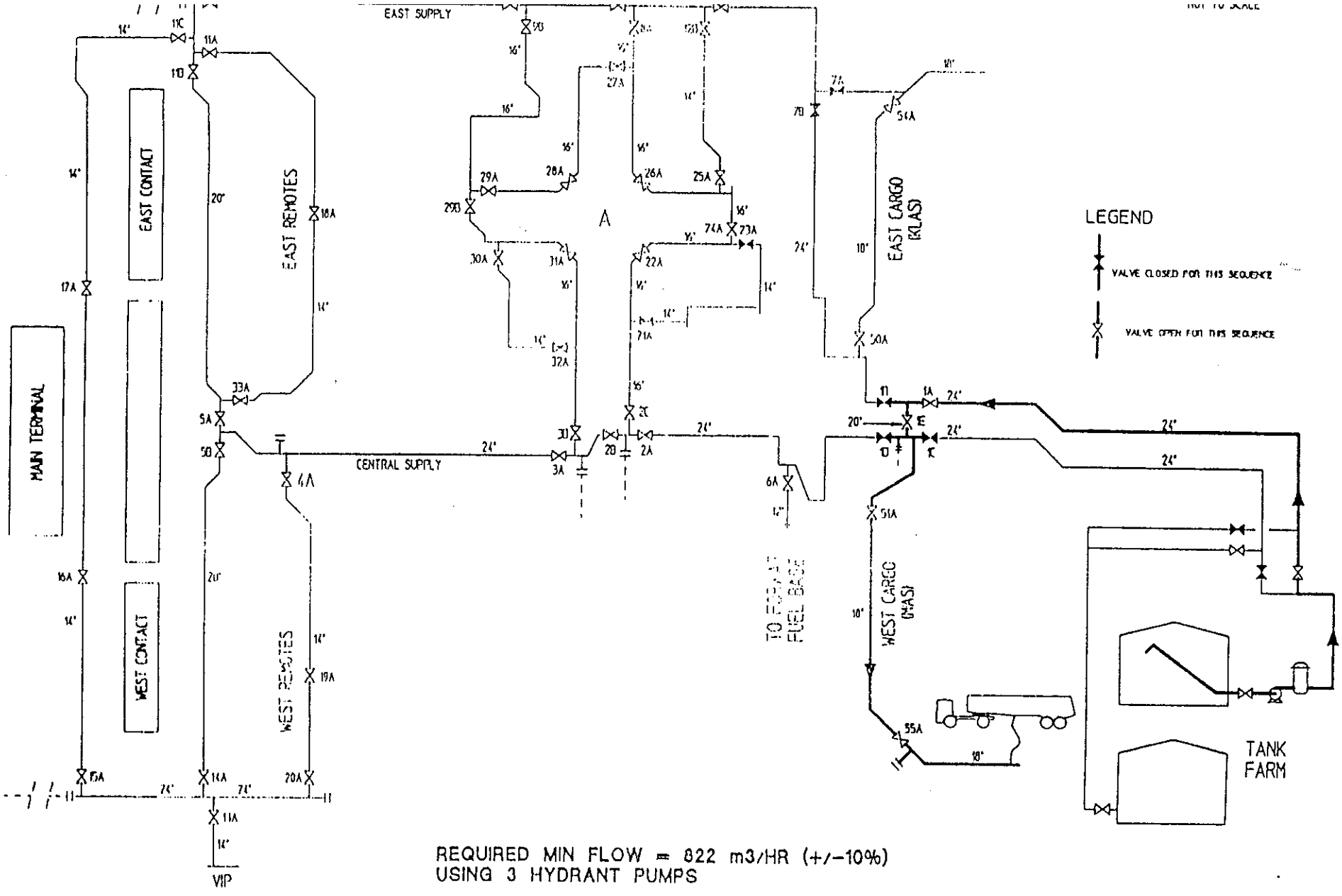
ıum Flowrate (+/- 10%) = 822 m3/hr (3,000 igpm), 3 pumps

JENCE 10	from	to	volume m3	pipe dia"	vel ft/sec
section being flushed	VC1	VC51	4	18	4.9
	VC51	VC55	98	18	4.9
	VC55	End	61	18	4.9
contents of section being flushed			163		
um flushing volume = Contents x 2			326		
liam			31.5		
drop for minimum flush (one tank)			0.418		

RATE	No pumps	flow/ pump	flow rate
um flow rate for 2 x contents m3/hr	3	274	822
um duration at peak flow (mins)			24

HNG SUMMARY	
olume flushed m3 - ENTER	
lent to number times sequence capacity	0.0
olour millipore result	
ravimetric millipore result	

gh speed circulation flushing of this section has been satisfactorily completed for Air BP:-


EAST SUPPLY
EAST CONTACT
EAST REMOTES
MAIN TERMINAL
WEST CONTACT
WEST REMOTES
CENTRAL SUPPLY
EAST CARGO (KLIA2)
WEST CARGO (KLIA2)
TO FUEL FARM
TANK FARM
VIP
A
LEGEND
VALVE CLOSED FOR THIS SEQUENCE
VALVE OPEN FOR THIS SEQUENCE
REQUIRED MIN FLOW = 822 m3/HR (+/-10%)
USING 3 HYDRANT PUMPS
KUL/007/2009

FLUSHING SEQUENCE	MINIMUM FLOWRATE (m^3/hr)	NO. OF PUMP USED	MIN FLUSHING VOLUME (m^3)	ESTIMATED DURATION (minutes)	MOV TO BE CLOSED
1	2,192	8	5,366	147	1E, 2C, 3B, 4A, 5B, 6A, 7A, 9B, 8A, 11A, 11 12B, 33A, 50A & 51A
2	1,644	6	4,190	153	1E, 2C, 3B, 5A, 5B, 6A, 7B, 9B, 8A, 11A, 11 13A, 14A, 12B, 33A, 51A
3	1,644	6	2,572	94	1E, 2C, 3B, 5A, 4A, 6A, 7A, 9B, 8A, 11A, 11 12B, 13A, 20A, 51A
4✓	1,096	4	2,528	138	1E, 2C, 3B, 4A, 5B, 6A, 7A, 9B, 8A, 11B, 11 12B, 50A, 51A
5	1,096	4	2,232	122	1E, 51A, 6A, 2C, 3A, 31A, 9B, 8B, 26A, 12E 7A, 50A
6	1,096	4	2,256	124	1E, 51A, 2C, 3A, 32A, 30A, 29A, 9A, 8A, 12I 7A, 50A
7 ✓	1,096	4	2,116	116	1E, 51A, 6A, 2B, 22A, 26A, 8A, 8B, 7A, 50A
8	1,096	4	2,118	120	1E, 51A, 6A, 2B, 21A, 23A, 25A, 27A, 8B, 12 7A, 50A
9	822	3	90	7	1E, 7A, 7B
10	822	3	326	24	1B, 1C, 1D

APPENDIX II

KLIA AVIATION FUEL TERMINAL FAST FLUSHING FLOW DIAGRAM AND INSTRUCTIONS

The operation sequence for Fast Flushing Operation of Sequence 1

1. **Select Sequence**
   - Sequence 1

2. **Select Issuing Tank**
   - Select either one of the 10 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 10 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - **1E**
   - **50A**
   - **7A**
   - **12B**
   - **8A**
   - **9B**
   - **11A**
   - **11C**
   - **33A**
   - **5B**
   - **4A**
   - **3B**
   - **2C**
   - **6A**
   - **51A**

5. **Select Numbers of Pump**
   - Eight pump

   Start pumps operation. The duration of the operation for this sequence is 94 minutes

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**

   - **1E**
   - **50A**
   - **7A**
   - **12B**
   - **8A**
   - **9B**
   - **11A**
   - **11C**
   - **33A**
   - **5B**
   - **4A**
   - **3B**
   - **2C**
   - **6A**
   - **51A**

8. **Reset Tanks Back to Normal Operation**
   Close the receiving tank

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 2

1. **Select Sequence**
   - Sequence 2

2. **Select Issuing Tank**
   - Select either one of the 10 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 10 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - **1E**
   - **7B**
   - **12B**
   - **8A**
   - **9B**
   - **11A**
   - **11B**
   - **14A**
   - **13A**
   - **5A**
   - **5B**
   - **33A**
   - **3B**
   - **2C**
   - **6A**
   - **51A**

5. **Select Numbers of Pump**
   - Six pump

   Start pumps operation. The duration of the operation for this sequence is 94 minutes

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - **1E**
   - **7B**
   - **12B**
   - **8A**
   - **9B**
   - **11A**
   - **11B**
   - **14A**
   - **13A**
   - **5A**
   - **5B**
   - **33A**
   - **3B**
   - **2C**
   - **6A**
   - **51A**

8. **Reset Tanks Back to Normal Operation**
   Close the receiving tank

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 3

1. **Select Sequence**
   - Sequence 3

2. **Select Issuing Tank**
   - Select either one of the 10 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 10 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - **1E**
   - **50A**
   - **7A**
   - **12B**
   - **8A**
   - **9B**
   - **11A**
   - **11B**
   - **13A**
   - **20A**
   - **4A**
   - **5A**
   - **3B**
   - **2C**
   - **51A**

5. **Select Numbers of Pump**
   - Six pump

   Start pumps operation. The duration of the operation for this sequence is 94 minutes

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - **1E**
   - **50A**
   - **7A**
   - **12B**
   - **8A**
   - **9B**
   - **11A**
   - **11B**
   - **13A**
   - **20A**
   - **4A**
   - **5A**
   - **3B**
   - **2C**
   - **51A**

8. **Reset Tanks Back to Normal Operation**

   Close the receiving tank

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 4

1. **Select Sequence**
   - Sequence 4

2. **Select Issuing Tank**
   - Select either one of the 10 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 10 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - **1E**
   - **50A**
   - **7A**
   - **8A**
   - **12B**
   - **9B**
   - **11C**
   - **11B**
   - **5B**
   - **4A**
   - **3B**
   - **2C**
   - **6A**
   - **51A**

5. **Select Numbers of Pump**
   - Four pump

   Start pumps operation. The duration of the operation for this sequence is 138 minutes

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - **1E**
   - **50A**
   - **7A**
   - **8A**
   - **12B**
   - **9B**
   - **11C**
   - **11B**
   - **5B**
   - **4A**
   - **3B**
   - **2C**
   - **6A**
   - **51A**

8. **Reset Tanks Back to Normal Operation**

   Close the receiving tank

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 6

1. **Select Sequence**
   - Sequence 6

2. **Select Issuing Tank**
   - Select either one of the 10 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 10 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - 1E
   - 50A
   - 7A
   - 12B
   - 8A
   - 9A
   - 29A
   - 30A
   - 32A
   - 3A
   - 2C
   - 6A
   - 51A

5. **Select Numbers of Pump**
   - Four pump

   Start pumps operation. The duration of the operation for this sequence is 124 minutes

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - 1E
   - 50A
   - 7A
   - 12B
   - 8A
   - 9A
   - 29A
   - 30A
   - 32A
   - 3A
   - 2C
   - 6A
   - 51A

8. **Reset Tanks Back to Normal Operation**

   Close the receiving tank

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 7

1. **Select Sequence**
   - Sequence 7

2. **Select Issuing Tank**
   - Select either one of the 10 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 10 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - **1E**
   - **50A**
   - **7A**
   - **8A**
   - **8B**
   - **26A**
   - **22A**
   - **2B**
   - **6A**
   - **51A**

5. **Select Numbers of Pump**
   - Four pump

   Start pumps operation. The duration of the operation for this sequence is 116 minutes

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - **1E**
   - **50A**
   - **7A**
   - **8A**
   - **8B**
   - **26A**
   - **22A**
   - **2B**
   - **6A**
   - **51A**

8. **Reset Tanks Back to Normal Operation**

   Close the receiving tank

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 8

1. **Select Sequence**
   - Sequence 8

2. **Select Issuing Tank**
   - Select either one of the 10 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 10 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - **1E**
   - **50A**
   - **7A**
   - **12B**
   - **8B**
   - **27A**
   - **25A**
   - **23A**
   - **21A**
   - **2B**
   - **6A**
   - **51A**

5. **Select Numbers of Pump**
   - Four pump

   Start pumps operation. The duration of the operation for this sequence is 120 minutes

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - **1E**
   - **50A**
   - **7A**
   - **12B**
   - **8B**
   - **27A**
   - **25A**
   - **23A**
   - **21A**
   - **2B**
   - **6A**
   - **51A**

8. **Reset Tanks Back to Normal Operation**

   Close the receiving tank

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 9

The pipeline content for this operation will not be pumped back to the fuel farm because the pipeline route sequence is not a loop but it ended with dead leg. Thus, road tankers need to be used at the dead leg to pump out the fuel. The Fast Flushing Operation for this sequence is usually referred as Line Purging Operation.

1. **Select Sequence**
   - Sequence 9

2. **Select Issuing Tank**
   - Select either one of the 10 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Not necessary for this sequence. Road tanker and appropriate connection need to be deployed at the end of the pipeline for this sequence which is at FHP51.

4. **Close Selected Valve**
   - 1E
   - 7A
   - 7B

5. **Select Numbers of Pump**
   - Four pump

   Start pumps operation. The duration of the operation for this sequence is 116 minutes

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - 1E
   - 7A
   - 7B

8. **Reset Tanks Back to Normal Operation**

   Not necessary for this sequence

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 10

The pipeline content for this operation will not be pumped back to the fuel farm because the pipeline route sequence is not a loop but it ended with dead leg. Thus. road tankers need to be used at the dead leg to pump out the fuel. The Fast Flushing Operation for this sequence is usually referred as Line Purging Operation.

1. Select Sequence
   - Sequence 10

2. Select Issuing Tank
   - Select either one of the 10 tank which ever is ready for issuing

3. Select Receiving Tank
   - Not necessary for this sequence. Road tanker and appropriate connection need to be deployed at the end of the pipeline for this sequence which is at FHP1.

4. Close Selected Valve
   - 1B
   - 1C
   - 1D

5. Select Numbers of Pump
   - Four pump

   Start pumps operation. The duration of the operation for this sequence is 116 minutes

6. Operation Ended

   Stop pumps operation

7. Set Valves Back to Normal Status
   - 1B
   - 1C
   - 1D

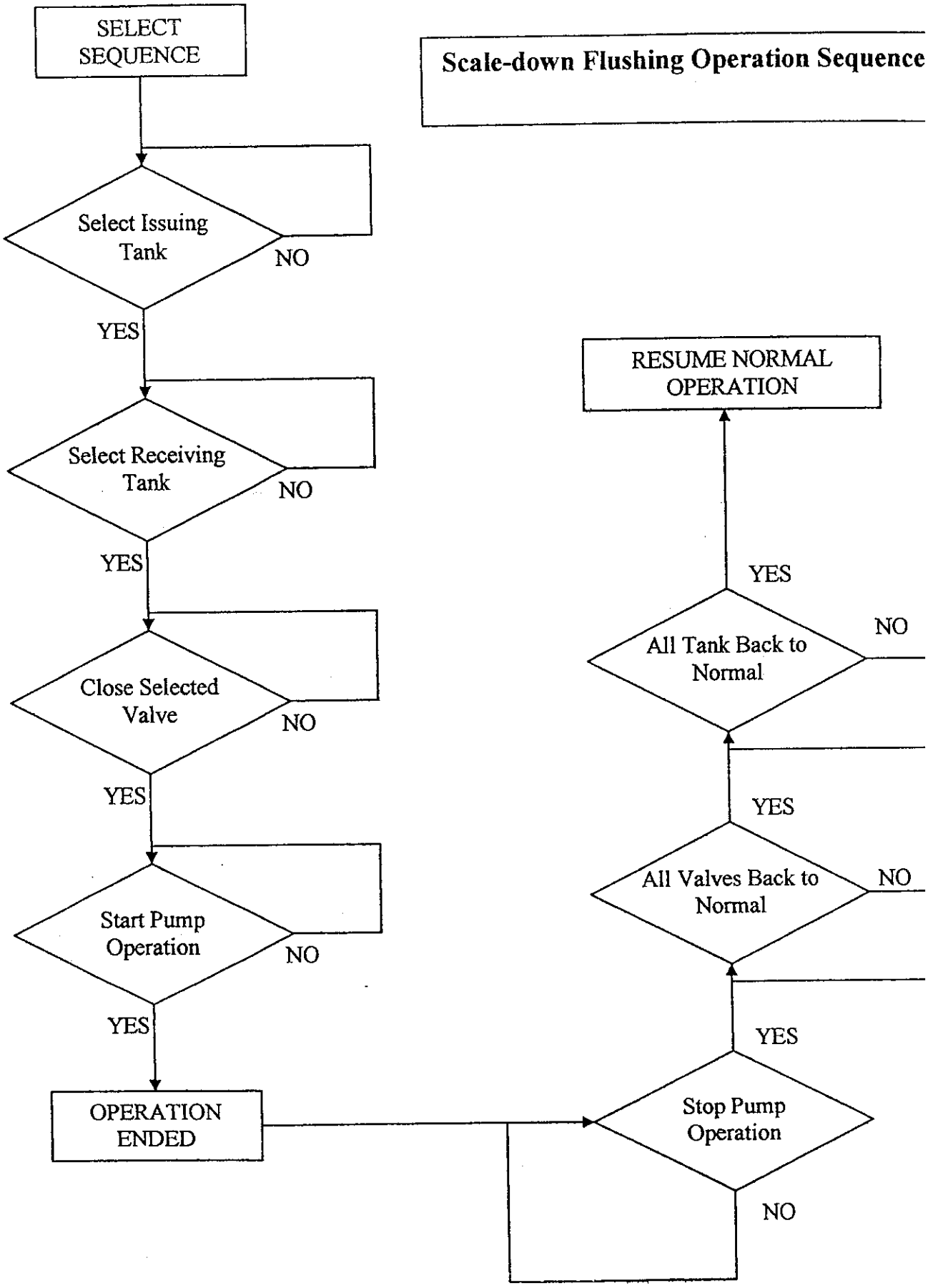
8. Reset Tanks Back to Normal Operation

   Not necessary for this sequence

9. Resume with Normal Operation

APPENDIX III
SCALED DOWN SYSTEM
FLOW DIAGRAM AND INSTRUCTIONS

Scale-down Flushing Operation Sequence



The operation sequence for Fast Flushing Operation of Sequence 1

1. **Select Sequence**
   - Sequence 1

2. **Select Issuing Tank**
   - Select either one of the 2 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 2 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - **1**
   - **2**
   - **3**

5. **Select Numbers of Pump**
   - Three pump

   Start pumps operation. The duration of the operation for this sequence is 20 seconds

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - **1**
   - **2**
   - **3**

8. **Reset Tanks Back to Normal Operation**

   Close the receiving tank

9. **Resume with Normal Operation**

The operation sequence for Fast Flushing Operation of Sequence 2

1. **Select Sequence**
   - Sequence 2

2. **Select Issuing Tank**
   - Select either one of the 2 tank which ever is ready for issuing

3. **Select Receiving Tank**
   - Select either one of the 2 tanks, but the receiving tank cannot be the same tank as the issuing tank.

4. **Close Selected Valve**
   - **1**
   - **3**

5. **Select Numbers of Pump**
   - Three pump

   Start pumps operation. The duration of the operation for this sequence is 10 seconds

6. **Operation Ended**

   Stop pumps operation

7. **Set Valves Back to Normal Status**
   - **1**
   - **3**

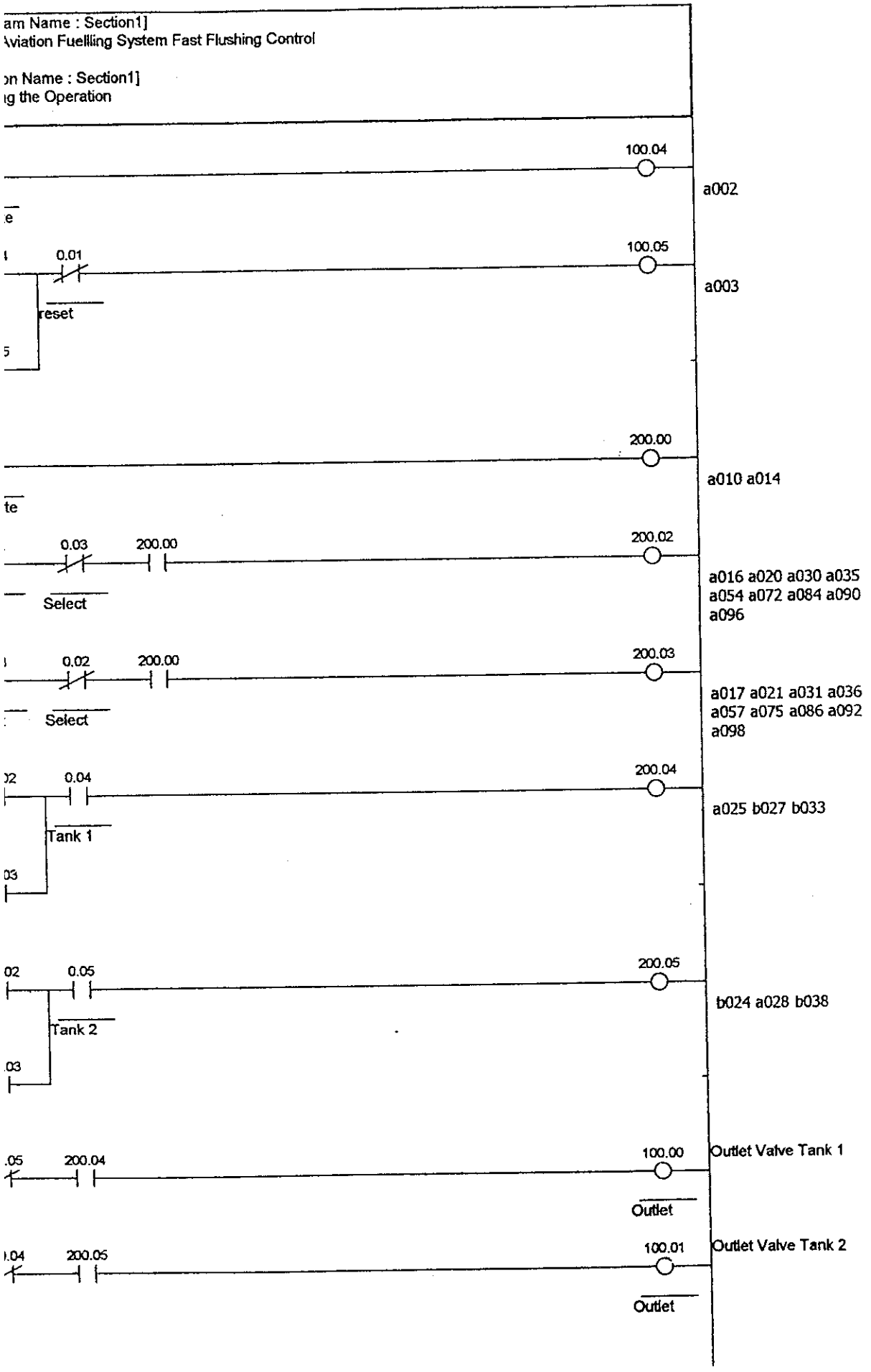
8. **Reset Tanks Back to Normal Operation**

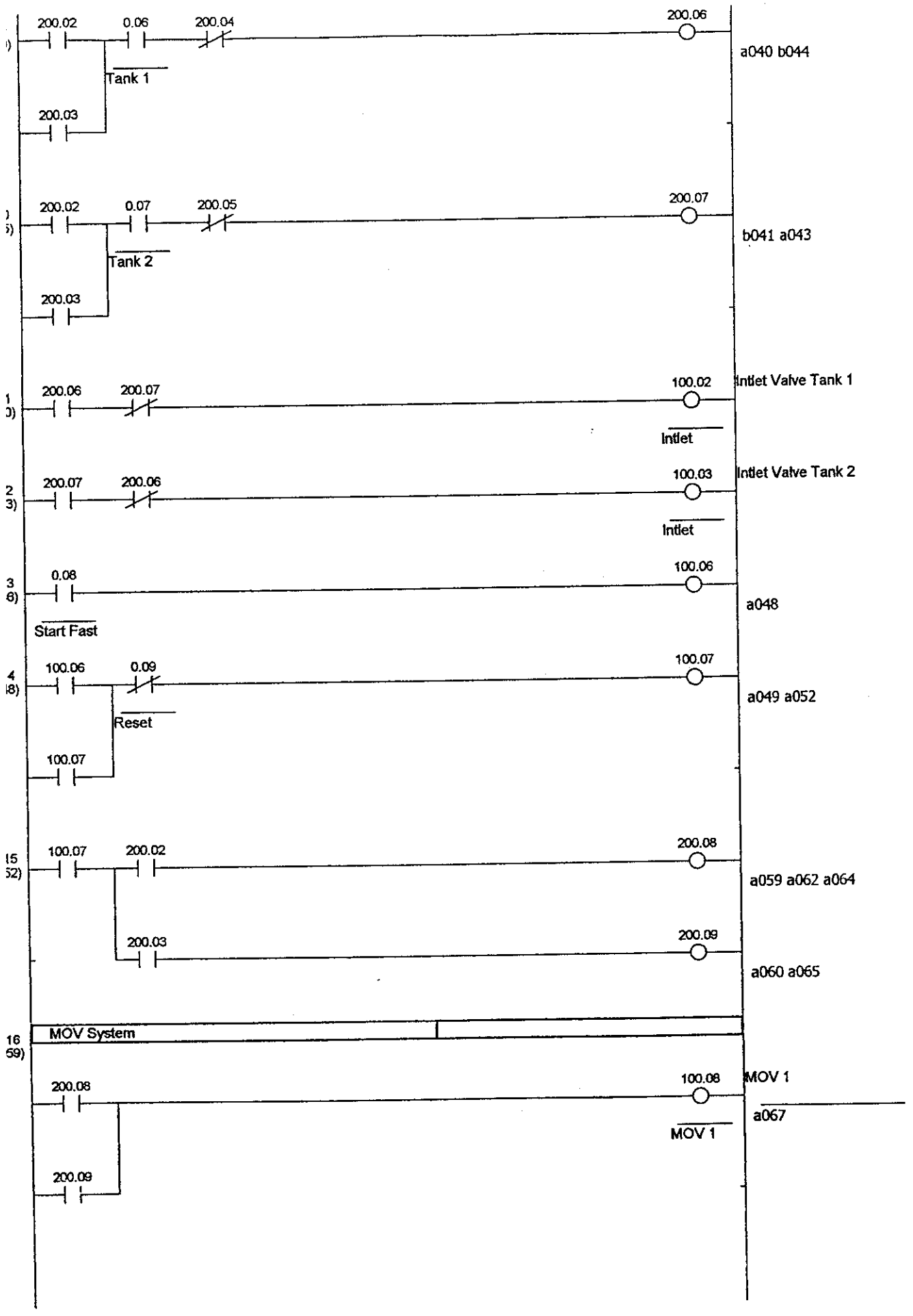
   Close the receiving tank

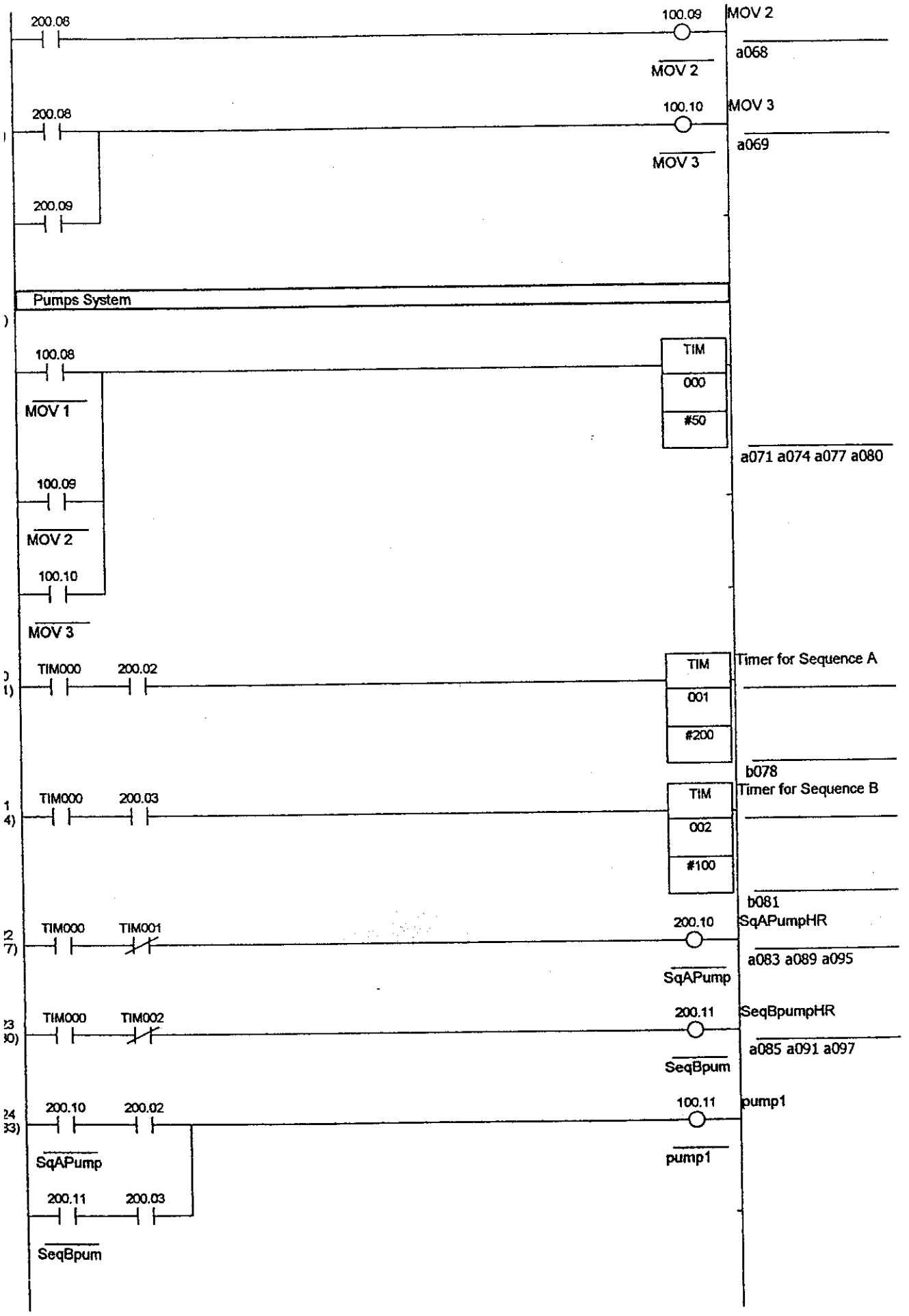
9. **Resume with Normal Operation**

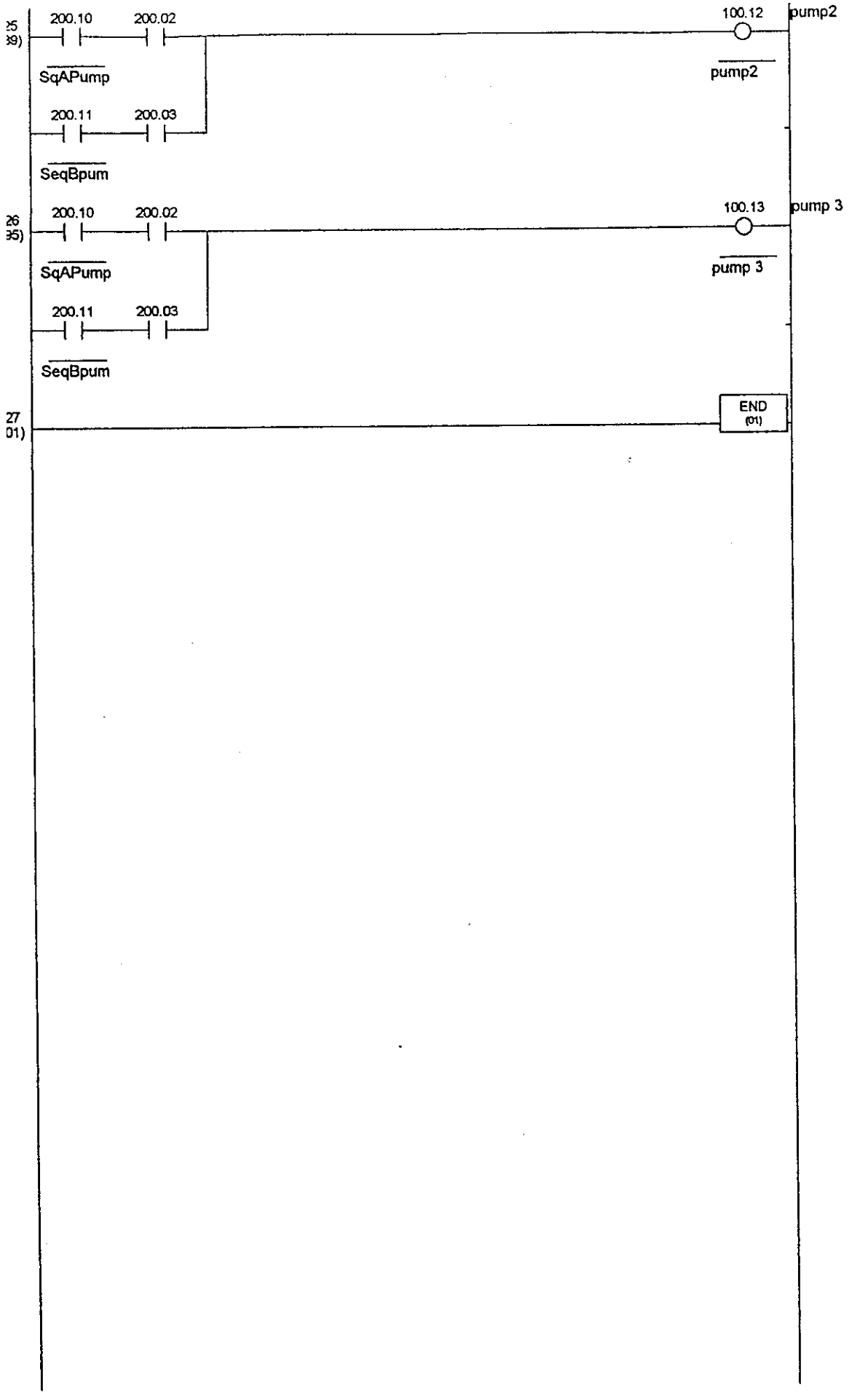
APPENDIX IV

SCALED DOWN SYSTEM PLC LADDER DIAGRAM


am Name : Section1]
Aviation Fuelling System Fast Flushing Control
on Name : Section1]
g the Operation
100.04
a002
e
0.01
100.05
a003
reset
5
200.00
a010 a014
te
0.03
200.00
200.02
a016 a020 a030 a035
a054 a072 a084 a090
a096
Select
0.02
200.00
200.03
a017 a021 a031 a036
a057 a075 a086 a092
a098
Select
02
0.04
200.04
a025 b027 b033
Tank 1
03
02
0.05
200.05
b024 a028 b038
Tank 2
03
.05
200.04
100.00
Outlet Valve Tank 1
Outlet
.04
200.05
100.01
Outlet Valve Tank 2
Outlet


200.02
0.06
200.04
200.06
a040 b044
Tank 1
200.03
200.02
0.07
200.05
200.07
b041 a043
Tank 2
200.03
200.06
200.07
100.02
Intlet Valve Tank 1
Intlet
200.07
200.06
100.03
Intlet Valve Tank 2
Intlet
0.08
100.06
a048
Start Fast
100.06
0.09
100.07
a049 a052
Reset
100.07
100.07
200.02
200.08
a059 a062 a064
200.03
200.09
a060 a065
MOV System
200.08
100.08
MOV 1
a067
MOV 1
200.09


200.08
100.09
MOV 2
a068
MOV 2
200.08
100.10
MOV 3
a069
MOV 3
200.09
Pumps System
100.08
TIM
000
#50
MOV 1
a071 a074 a077 a080
100.09
MOV 2
100.10
MOV 3
TIM000
200.02
TIM
001
#200
Timer for Sequence A
b078
TIM000
200.03
TIM
002
#100
Timer for Sequence B
b081
SqAPumpHR
TIM000
TIM001
200.10
SqAPump
a083 a089 a095
TIM000
TIM002
200.11
SeqBpumpHR
SeqBpum
a085 a091 a097
200.10
200.02
100.11
pump1
SqAPump
pump1
200.11
200.03
SeqBpum


200.10
200.02
100.12
pump2
SqAPump
pump2
200.11
200.03
SeqBpum
200.10
200.02
100.13
pump 3
SqAPump
pump 3
200.11
200.03
SeqBpum
END
(01)

APPENDIX V
CODING FOR GUI PROGRAMMING

```
for FORM1

ub Chk1_Click()
alue = 1 Then
 Resume Next
ng App.EXEName, "Options", "Ckd1", 1

 Resume Next
ng App.EXEName, "Options", "Ckd1", 0


ub Chk1_MouseUp(Button As Integer, Shift As Integer, X As Single, Y As Single)
alue = 1 And Chk2.Value = 1 Then
abled = True

abled = False

 Resume Next
cus


Sub Chk2_Click()
Value = 1 Then
 Resume Next
ing App.EXEName, "Options", "Ckd2", 1

 Resume Next
ing App.EXEName, "Options", "Ckd2", 0


Sub Chk2_MouseUp(Button As Integer, Shift As Integer, X As Single, Y As Single)
Value = 1 And Chk2.Value = 1 Then
abled = True

abled = False

 Resume Next
cus


Sub Chknp_Click()
.Value = 0 Then GoTo A
.Value = 1 Then GoTo B


aption = "" Then GoTo A1
xt = nam.Caption And T2.Text = pas1.Caption Then GoTo A1
xt <> nam.Caption Or T2.Text <> pas1.Caption Then GoTo B1


 Resume Next
ing App.EXEName, "Options", "Usrn", T1.Text
 Resume Next
ing App.EXEName, "Options", "Pass", T2.Text
t1 = nam.Caption 'send the user name to text box in form 6
isible = True 'Change this to your main form name
ide
s.Visible = False


"The User Name or Password is incorrect.", vbOKOnly + vbInformation, "Sorry"
 = ""
 = ""
t1.Enabled = False

r Resume Next
ocus
```

```
:t = nam.Caption And T2.Text = pas1.Caption Then GoTo A2
:t <> nam.Caption Or T2.Text <> pas1.Caption Then GoTo B2


.ue = 0
ible = False
= ""
. ""
ion = ""
tion = ""
tion = "&New"
oled = False
ue = 0
ue = 0
 Resume Next
ing App.EXEName, "Options", "Usrn", T1.Text
 Resume Next
ing App.EXEName, "Options", "Pass", T2.Text
 Resume Next
cus


The User Name & Password is incorrect.", vbOKOnly + vbInformation, "Sorry"
= ""
= ""
 Resume Next
cus


Sub Chknp_MouseUp(Button As Integer, Shift As Integer, X As Single, Y As Single)
 Resume Next
cus


Sub gfhc_Click()


Sub Nwnp_MouseDown(Button As Integer, Shift As Integer, X As Single, Y As Single)
Caption = "&New" Then GoTo A
.Caption = "&Cancel" Then GoTo B
)


otion = "&Cancel"
alue = 1
) = 72
sible = True
)


otion = "&New"
alue = 0
) = 72
sible = False


Sub Nwnp_MouseUp(Button As Integer, Shift As Integer, X As Single, Y As Single)
on = 1 Then
 = ""
 = ""
r Resume Next
ocus


Sub Qnp_Click()
ide
```

```
)W


)ub Form_Load()
) = ((Screen.Height - Form6.Height) / 2)
:t = ((Screen.Width - Form6.Width) / 2)

 Resume Next
etSetting(App.EXEName, "Options", "Usrn", "")
 Resume Next
ion = usrn

 Resume Next
etSetting(App.EXEName, "Options", "Pass", "")
 Resume Next
tion = pass

aption <> "" And pas1.Caption <> "" Then Nwnp.Enabled = True

 Resume Next
etSetting(App.EXEName, "Options", "Ckd1", 0)
= 1 Then
ue = 1
= nam.Caption


 Resume Next
etSetting(App.EXEName, "Options", "Ckd2", 0)
= 1 Then
ue = 1
= pas1.Caption


Value = 1 And Chk2.Value = 1 Then Chknp.Value = True


 Sub T1_Change()
ext <> "" And T2.Text <> "" Then
abled = True


abled = False



 Sub T1_GotFocus()
) = 72


 Sub T1_KeyPress(KeyAscii As Integer)
ext = "" Then GoTo W
scii = 13 Then
ocus

)



 Sub T2_Change()
ext <> "" And T2.Text <> "" Then
nabled = True

nabled = False



 Sub T2_GotFocus()
p = 96
```

```
ub T2_KeyPress(KeyAscii As Integer)
t = "" Then GoTo W
t = "" Then GoTo W
ii = 13 Then
ue = True
```

```
ɔub cmdStart_Click(Index As Integer)
ɔled = True
ɔled = True

ıe operation RUng 0

1.writeArea plcAreaCIO, 210, 1, "0008"
1.writeArea plcAreaCIO, 246, 1, "0000"



Sub cmdStop_Click(Index As Integer)
bled = False
bled = False
.Enabled = False

he operation RUng 0
1.writeArea plcAreaCIO, 246, 1, "8000"
1.writeArea plcAreaCIO, 210, 1, "0000"



 Sub Command3_Click()
ınButton As String = vbOKOnly + vbInformation
ıer As Integer

ɔpt1 = vbUnchecked Or opt2 = vbUnchecked Then

ı2.Hide
ı3.Show

ɜ
ɾ "No Click Detected!"


 If



 Sub Command4_Click()
ıow
ide


 4 Form4

 Sub Form_Load()
 the form
ɔp = (Screen.Height - Form2.Height) / 2
eft = (Screen.Width - Form2.Width) / 2


 Sub Frame2_DragDrop(Source As Control, X As Single, Y As Single)



 Sub opt1_Click()
.Value = vbChecked Then
m5.txt1.Text = "Sequence 1"
mand3.Enabled = True
m6.txt4.Text = "Sequence 1"
m6.txt7.Text = "30"

C Select Sequence1
```

```
FAC_C1.writeArea plcAreaCIO, 211, 1, "0010"
FAC_C1.writeArea plcAreaCIO, 245, 1, "0000"


leSelect Sequence1

FAC_C1.writeArea plcAreaCIO, 245, 1, "0800"
FAC_C1.writeArea plcAreaCIO, 211, 1, "0000"




Sub opt2_Click()
t2.Value = vbChecked Then
5.txt1.Text = "Sequence 2"
and3.Enabled = True
6.txt4 = "Sequence 2"
6.txt7.Text = "20"


 Select Sequence 2

AC_C1.writeArea plcAreaCIO, 212, 1, "0020"
AC_C1.writeArea plcAreaCIO, 246, 1, "0000"


 deSelect Sequence 2

AC_C1.writeArea plcAreaCIO, 246, 1, "0002"
AC_C1.writeArea plcAreaCIO, 212, 1, "0000"
```

```
Sub cmd2_Click()
ow
de


Sub cmd3_Click()
ow
de

4 Form 3

Sub Form_Load()
the form
p = (Screen.Height - Form3.Height) / 2
ft = (Screen.Width - Form3.Width) / 2


Sub opt1_Click()
ue = vbChecked
t2.Text = "Tank 1"
t5.Text = "Tank 1"

ect Inlet tAnk 1

AC_C1.writeArea plcAreaCIO, 213, 1, "0040"
AC_C1.writeArea plcAreaCIO, 243, 1, "0000"


bled = False
bled = True
bled = True



Sub opt2_Click()
ue = vbChecked
t2.Text = "Tank 2"
t5.Text = "Tank 2"

ect Inlet tAnk 2

AC_C1.writeArea plcAreaCIO, 214, 1, "0080"
AC_C1.writeArea plcAreaCIO, 242, 1, "0000"

bled = False
bled = True
bled = True



Sub opt3_Click()
ue = vbChecked
t2.Text = "Tank 1"
t5.Text = "Tank 1"

ect outlet tAnk 1

AC_C1.writeArea plcAreaCIO, 209, 1, "0002"
AC_C1.writeArea plcAreaCIO, 241, 1, "0000"



Sub opt4_Click()
ue = vbChecked
t3.Text = "Tank 2"
t6.Text = "Tank 2"

ect outlet tAnk 2
```

```
AC_C1.writeArea plcAreaCIO, 208, 1, "0002"
AC_C1.writeArea plcAreaCIO, 240, 1, "0000"



Sub opt7_Click()
```

```
! Form 4
Sub cmdCLOSE_Click()


Sub cmdENTER_Click()
ow
de
.Text = ""
.Text = ""


Sub Form_Load()


Sub Image1_Click()
```

```
1 Form 5
Sub Command1_Click()
ıser with msgBox and wait for user response
ıtBtns As Integer = vbYesNoCancel + vbExclamation + vbDefaultButton1 + vbApplicatic

serResponse As Integer
esponse = MsgBox("Do yo want to START the operation?", vbYesNoCancel + vbExclamatic
Button1 + vbApplicationModal, "Test")

erResponse = vbYes Then
ow
ow
de
mer1.Enabled = True
mer2.Enabled = True

RT OPERATION

AC_C1.writeArea plcAreaCIO, 207, 1, "0002"
AC_C1.writeArea plcAreaCIO, 230, 1, "0000"



ET OPERATION

AC_C1.writeArea plcAreaCIO, 230, 1, "0040"
AC_C1.writeArea plcAreaCIO, 207, 1, "0000"



 Sub Command2_Click()
ıow
.de


 Sub Form_Load()
 the form
)p = (Screen.Height - Form5.Height) / 2
:ft = (Screen.Width - Form5.Width) / 2



 Sub Frame1_DragDrop(Source As Control, X As Single, Y As Single)
```

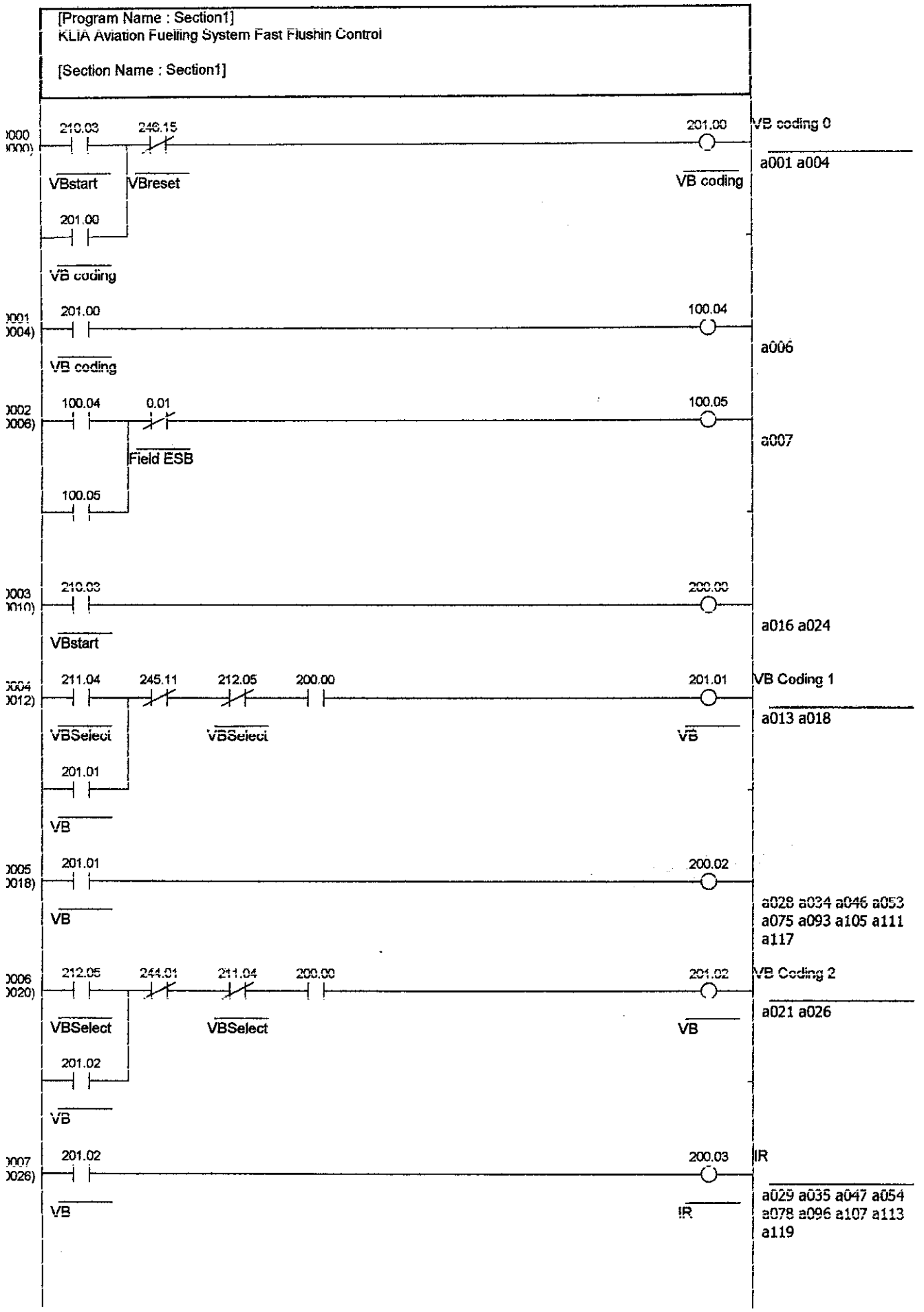
```
Sub cmdClock_Click()
ıow


Sub cmdEND_Click()
user with msgBox and wait for user response
ɔntBtns As Integer = vbYesNoCancel + vbExclamation + vbDefaultButton1 + vbApplicati

JserResponse As Integer
JserResponse2 As Integer
Response = MsgBox("Do yo want to END the operation?", vbYesNoCancel + vbExclamation
ıtton1 + vbApplicationModal, "Test")

serResponse = vbYes Then
Response2 = MsgBox("Thank You!!", vbOKOnly + vbApplicationModal, "GOOD BYE!!")
IntUserResponse2 = vbOK Then
n6.Hide
nX.Hide
n4.Show
Timer.Caption = "0" 'reset the textbox to zero
sabling command of form 2
n2.opt1.Enabled = False
n2.opt2.Enabled = False
n2.Command3.Enabled = False
 If


SET EVERYTHING


SET the operation RUng 0

C1.writeArea plcAreaCIO, 246, 1, "8000"
C1.writeArea plcAreaCIO, 210, 1, "0000"

SET OPERATION

MAC_C1.writeArea plcAreaCIO, 230, 1, "0040"
MAC_C1.writeArea plcAreaCIO, 207, 1, "0000"

Select Sequence1

MAC_C1.writeArea plcAreaCIO, 245, 1, "0800"
MAC_C1.writeArea plcAreaCIO, 211, 1, "0000"

Select Sequence 2

MAC_C1.writeArea plcAreaCIO, 246, 1, "0002"
MAC_C1.writeArea plcAreaCIO, 212, 1, "0000"


SET TANK 1 Inlet

MAC_C1.writeArea plcAreaCIO, 243, 1, "0004"
MAC_C1.writeArea plcAreaCIO, 213, 1, "0000"

SET TANK 2 Inlet

MAC_C1.writeArea plcAreaCIO, 242, 1, "0008"
MAC_C1.writeArea plcAreaCIO, 214, 1, "0000"

SET TANK 1 Outlet

MAC_C1.writeArea plcAreaCIO, 241, 1, "0010"
MAC_C1.writeArea plcAreaCIO, 209, 1, "0000"


SET TANK 2 Outlet

MAC_C1.writeArea plcAreaCIO, 240, 1, "0020"
```

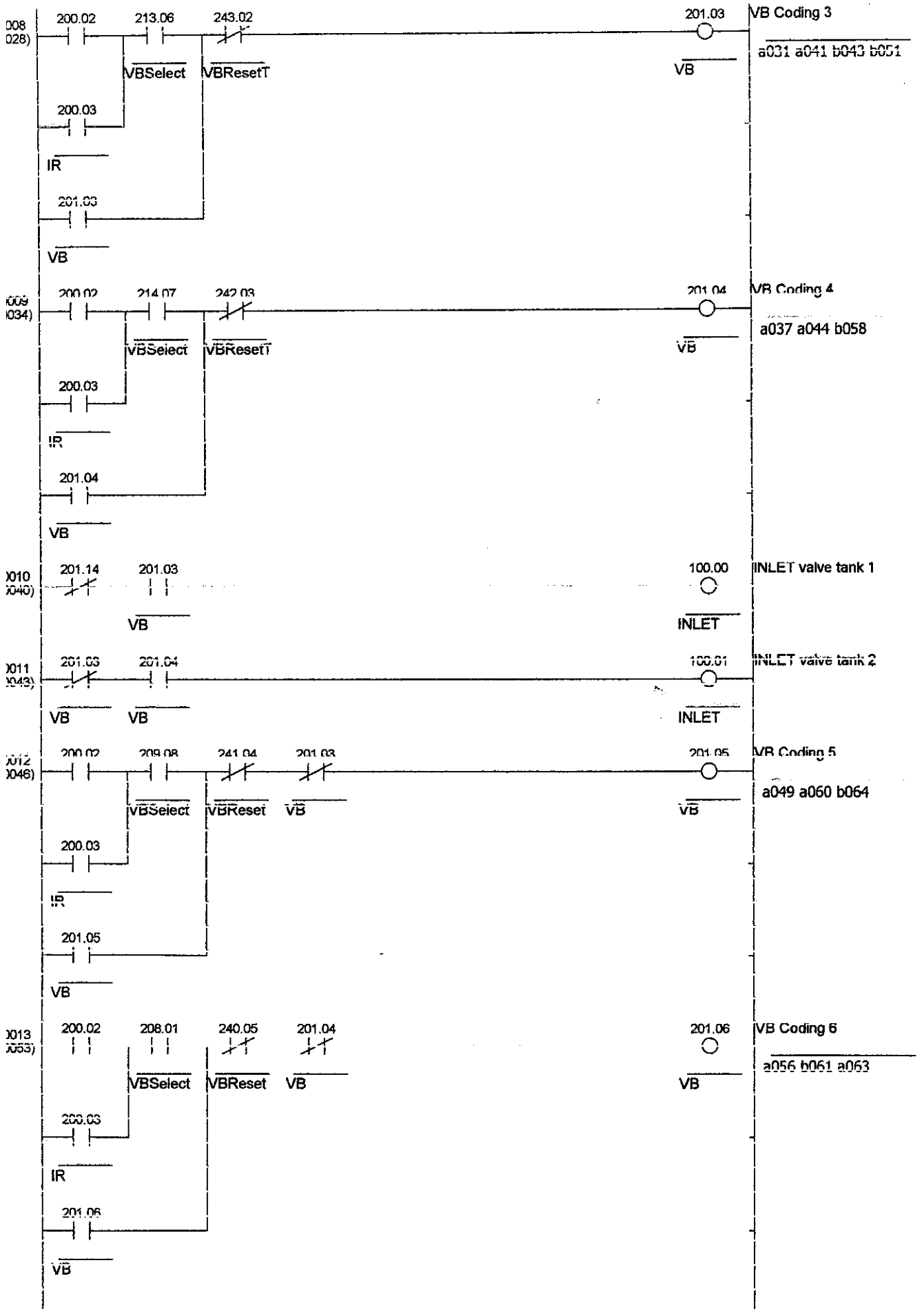
```
MAC_C1.writeArea plcAreaCIO, 208, 1, "0000"



4 Form 6

Sub Form_Load()
the form
op = ((Screen.Height - Form6.Height) / 2)
eft = ((Screen.Width - Form6.Width) / 2)


Sub lbl1_Change()
otion = Form5.txt1



Sub lbl2_Change()
otion = Form5.txt1



Sub Timer1_Timer()
r.Caption = lblTimer.Caption + 1


Sub Timer2_Timer()


imer.Caption = txt7.Text Then
Enabled = False
Enabled = False
as.Caption = "FINISH"
Enabled = True


as.Caption = "RUNNING"
Enabled = False



Sub txt1_Change()
xt = Form1.T1
```

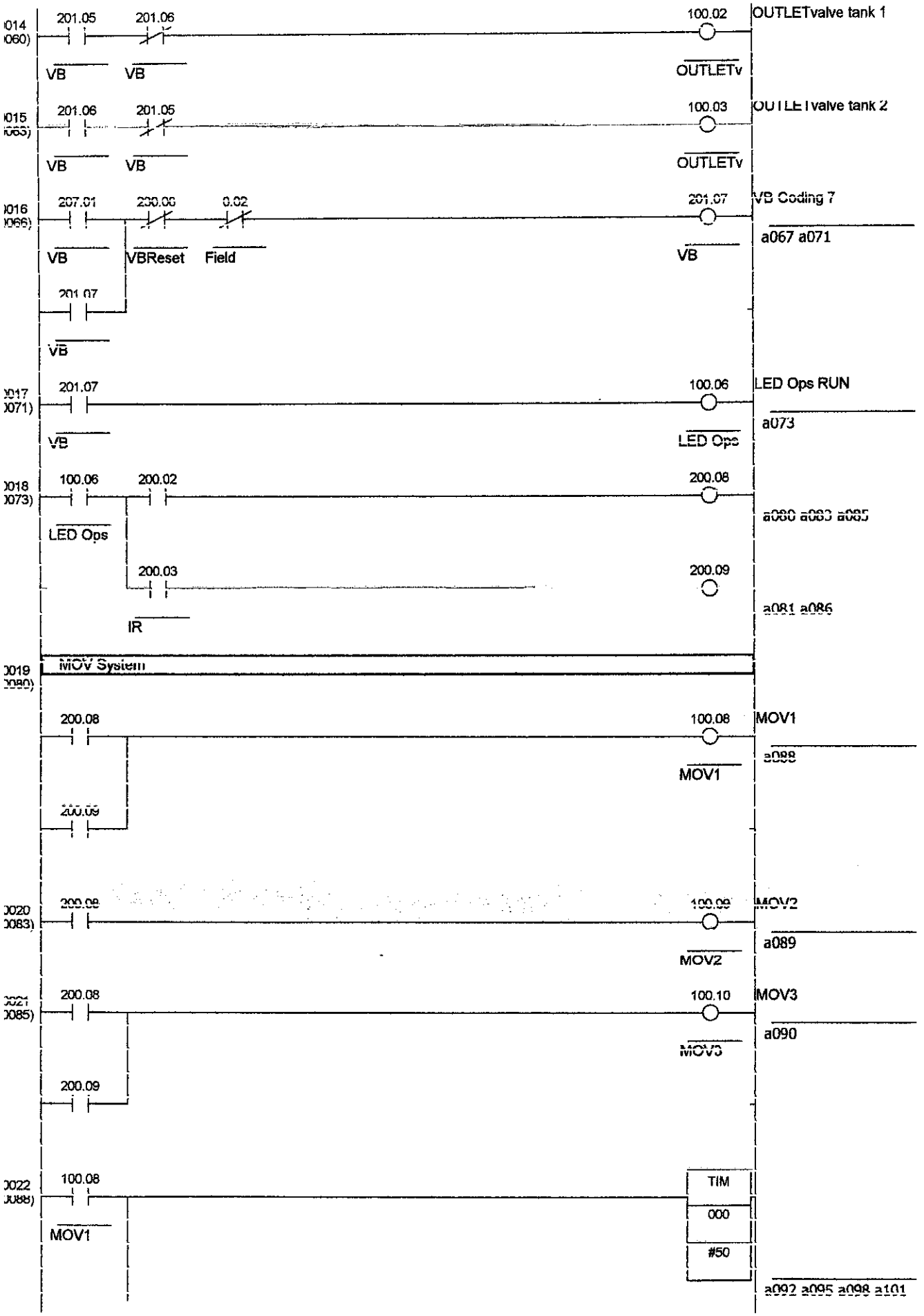
```
4 CLOCK
Sub Form_Load()


Sub Timer1_Timer()

1 To 6
(Format(Time, "HHMMSSAMPM"), j, 1), j - 1


Sub Timer2_Timer()
1 To 6
(Format(Time, "HHMMSS"), j, 1), j - 1


(Wat, Id)
Case Wat
 LCD Id, , False
 LCD Id, False, False, False, False, False
 LCD Id, , , , False, , , False
 LCD Id, , , , False, False
 LCD Id, False, , False, , False
 LCD Id, , , , , False, False
 LCD Id, , , , , , False
 LCD Id, , False, False, False, False
 LCD Id
 LCD Id, , , , , False
ect

(ByVal i As Integer, Optional L1 As Boolean = True, Optional L2 As Boolean = True,
s Boolean = True, Optional L4 As Boolean = True, Optional L5 As Boolean = True, Opt
oolean = True, Optional L7 As Boolean = True)
isible = L1
.Visible = L2
.Visible = L3
.Visible = L4
.Visible = L5
.Visible = L6
.Visible = L7

m()
t(Time, 2) = "PM" Then ARgt2.Visible = False Else ARgt2.Visible = True

 Sub Adj_Click()
r = Hour(Now)
ute = Minute(Now)
ond = Second(Now)
Visible = True

 Sub Pause_Click()
e.Caption = "&Pause" Then Pause.Caption = "&Resume" Else Pause.Caption = "&Pause"
mPm.Value Then
Timer1.Enabled Then Timer1.Enabled = False Else Timer1.Enabled = True

Timer2.Enabled Then Timer2.Enabled = False Else Timer2.Enabled = True


 Sub Xit_Click()
ide

 Sub OK_Click()
ck
Format(Dat.Value, "HH:MM:SS AMPM")

 Sub Can_Click()
Visible = False

 Sub OptT24_Click()
n.Visible = False
```

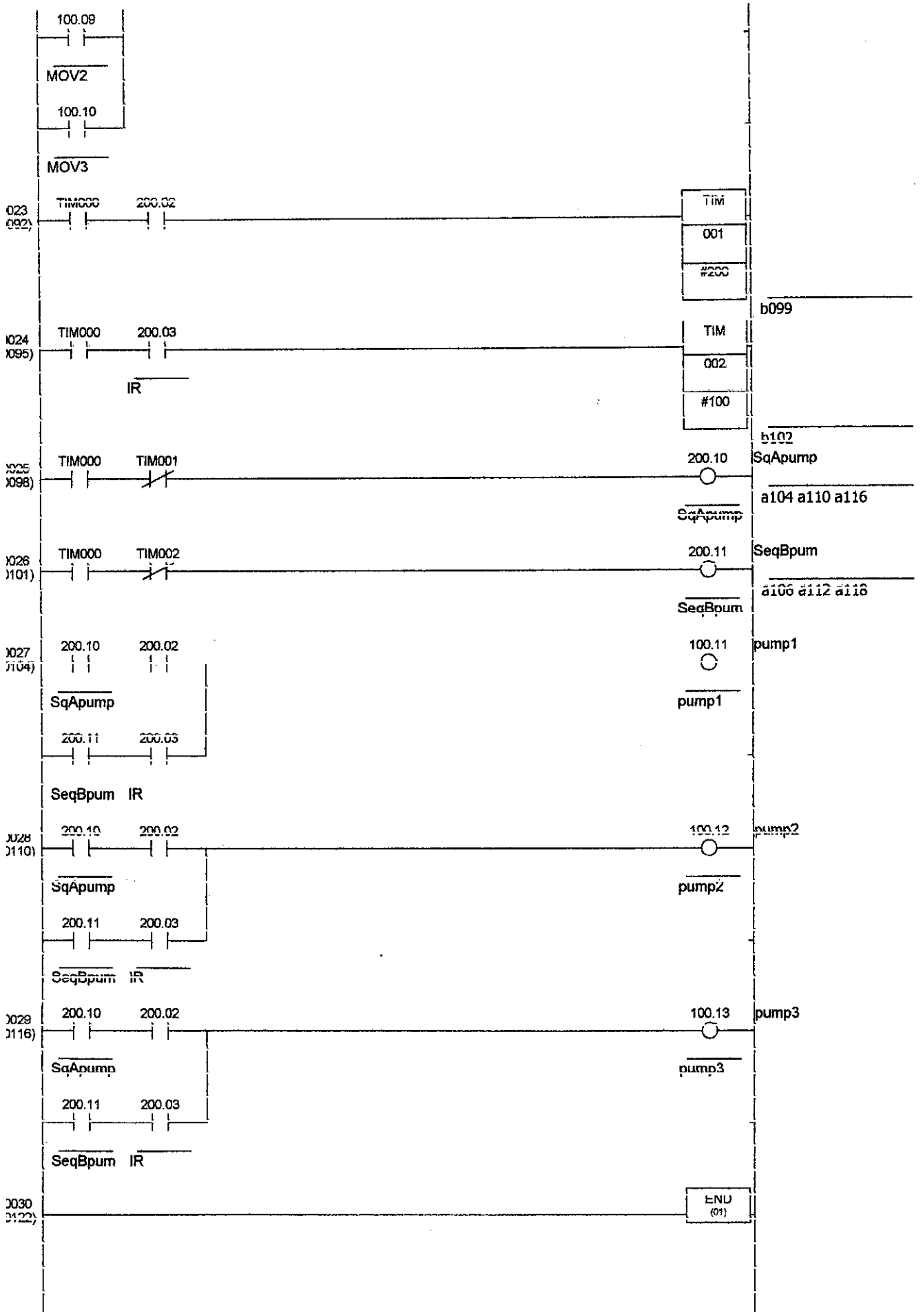
```
Enabled = False
Enabled = True

 Sub OptAmPm_Click()
1.Visible = True
Enabled = True
Enabled = False
```

APPENDIX VI
LADDER DIAGRAM FOR GUI-PLC IMPLEMENTATION


[Program Name : Section1]
KLIA Aviation Fuelling System Fast Flushin Control
[Section Name : Section1]
)000
)000)
210.03
VBstart
246.15
VBreset
201.00
VB coding
VB coding 0
a001 a004
201.00
VB coding
)001
)004)
201.00
VB coding
100.04
a006
)002
)006)
100.04
0.01
Field ESB
100.05
100.05
a007
)003
)010)
210.03
VBstart
200.00
a016 a024
)004
)012)
211.04
VBSelect
245.11
212.05
VBSelect
200.00
201.01
VB
VB Coding 1
a013 a018
201.01
VB
)005
)018)
201.01
VB
200.02
a028 a034 a046 a053
a075 a093 a105 a111
a117
)006
)020)
212.05
VBSelect
244.01
211.04
VBSelect
200.00
201.02
VB
VB Coding 2
a021 a026
201.02
VB
)007
)026)
201.02
VB
200.03
IR
a029 a035 a047 a054
a078 a096 a107 a113
a119


008
028)
200.02
213.06
243.02
201.03
VB Coding 3
a031 a041 b043 b051
VBSelect
VBResetT
VB
200.03
IR
201.03
VB
009
034)
200.02
214.07
242.03
201.04
VB Coding 4
a037 a044 b058
VBSelect
VBResetT
VB
200.03
IR
201.04
VB
010
040)
201.14
201.03
100.00
INLET valve tank 1
VB
INLET
011
043)
201.03
201.04
100.01
INLET valve tank 2
VB
VB
INLET
012
046)
200.02
209.08
241.04
201.03
201.05
VB Coding 5
a049 a060 b064
VBSelect
VBReset
VB
VB
200.03
IR
201.05
VB
013
053)
200.02
208.01
240.05
201.04
201.06
VB Coding 6
a056 b061 a063
VBSelect
VBReset
VB
VB
200.03
IR
201.06
VB


0014
0060)
201.05
201.06
100.02
OUTLETvalve tank 1
VB
VB
OUTLETv
0015
0063)
201.06
201.05
100.03
OUTLETvalve tank 2
VB
VB
OUTLETv
0016
0066)
207.01
200.00
0.02
201.07
VB Coding 7
VB
VBReset
Field
VB
a067 a071
201.07
VB
0017
0071)
201.07
100.06
LED Ops RUN
VB
LED Ops
a073
0018
0073)
100.06
200.02
200.08
LED Ops
a080 a083 a085
200.03
200.09
IR
a081 a086
0019
0080)
MOV System
200.08
100.08
MOV1
MOV1
a088
200.09
0020
0083)
200.08
100.09
MOV2
MOV2
a089
0021
0085)
200.08
100.10
MOV3
MOV3
a090
200.09
0022
0088)
100.08
TIM
000
#50
MOV1
a092 a095 a098 a101


100.09
MOV2
100.10
MOV3
TIM000
200.02
TIM
001
#200
b099
TIM000
200.03
IR
TIM
002
#100
b102
TIM000
TIM001
200.10
SqApump
a104 a110 a116
TIM000
TIM002
200.11
SeqBpum
a106 a112 a118
200.10
200.02
SqApump
100.11
pump1
200.11
200.03
SeqBpum
IR
200.10
200.02
SqApump
100.12
pump2
200.11
200.03
SeqBpum
IR
200.10
200.02
SqApump
100.13
pump3
200.11
200.03
SeqBpum
IR
END
(01)