CERTIFICATION OF APPROVAL

Statistical Process Control for Debutanizer Column of PETRONAS Penapisan Terengganu Sdn. Bhd. (PPTSB)

by

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A project dissertation submitted to the
Chemical Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
Bachelor of Engineering (Hons)
Chemical Engineering

Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

January 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons

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(ZULFADZLI B MAHAMAD @ MUHAMAD)

ABSTRACT

Statistical Process Control (SPC) come up to implement and solving business problems by systematic problem-solving tools. This statistical method is useful in monitoring processes, reducing variability through elimination of assignable causes. In this project, the writer would be doing the Statistical Process Control (SPC) for the debutanizer column. This report will highlight background of the study, problem statement, objectives and scope of study, methodology, results and discussion, conclusion and recommendations for the project.

By means of case study, the purpose of this project is to apply statistical process control for debutanizer column of PPTSB. The first section will elaborate on the historical review of monitoring and product quality control for CDU column. Then, the study focus on operation of debutanizer column which the function for this column will elaborate detail.. The discussion on problem statement begins with the objective of using statistical process control for monitoring processes, reducing variability through elimination of assignable causes. Furthermore, this section will elaborate more on the objectives and scope of study for this project.

The second section contains the literature review which elaborates on the introduction to Fractionator Column, Debutanizer Column, and Statistical Process Control and benefits of using this tool. The structure of Neural Networks is introduced in this section. The discussion begins with an overview of Neural Network architecture, and how the Neural Network is constructed.

The third section discusses the methodology of the project. SPSS software and MICROSOFT EXCEL will be used at all time in order to accomplish the objectives. The latter part covers result and discussion for the Statistical Process Control, which includes data arrangement and graphical analysis. Conclusion part is covered at the end part of this section.

ACKNOWLEDGEMENT

First and foremost, the author expresses biggest thanks to Allah for giving the strength and ability to achieve what had been accomplished in this report. By the name of the Almighty God, the author would like to express her highly gratitude to her supervisor, Mr. Naseer bin Ramli for all his helpful guidance, advices, valuable lessons and encouragements towards the completion of this project. All his thoughts and ideas are very useful to the author and had helped her through various problems faced during the project period. Special thanks dedicated to PETRONAS Penapisan (Terengganu) Sdn. Bhd and their staffs especially who played their major role in the development of this project. Appreciation also goes to the author's friends for their support and assistance throughout the project. These are the people that have given supports and encouragements, which have helped her in the process of completing her project work. Last but not least, heartfelt thanks go to the author beloved family for their never ending support, care and encouragement. Thank you once again.

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CHAPTER 1
INTRODUCTION

1.1 Background of the Study

Crude Distillation Unit (CDU), also known as the Topping Unit of PP(T)SB. This unit was originally built to process Tapis Blend crude and was subsequently debottleneck to process 40 KBPSD as part of PP(T)SB's "Kerteh Refinery Debottleneck project KR-1B", by installation of Preflash Tower and exchangers in the preheat train. The CDU comprises the following four sections: Crude Preheat Section, Crude Distillation Section, ***LPG Recovery Unit***, and Chemical Injection Section. LPG recovery section consists of two main units Deethanizer and ***Debutanizer***.

The successful operation of the unit requires close monitoring and quality control of products specification. So a close monitoring and control of product specification properties will help in controlling the properties of final refinery products. It is often sufficient to characterize refinery products in terms of certain gross properties such as Reid Vapor Pressure for volatile products, Flash Point for light distillate, Pour Point for heavy distillate etc. Continuous control of the unit demands that these properties should be measured on-line so that it can be effectively controlled through a feedback mechanism.

The debutanizer column at Petronas Penapisan Terengganu Sdn. Bhd., PP(T)SB produces LPG (liquefied petroleum gas) as the top stream and light naphtha as the bottom stream. The controlled outputs which are the critical product quality to be measured are the composition of C2, C3, i-C4, n-C4, i-C5, n-C5 and $C5^+$ in the top stream and the Reid Vapor Pressure (RVP) of the bottom stream. RVP is defined as the vapor pressure of a product determined in a volume of air four times greater than the liquid volume at 100^oF.

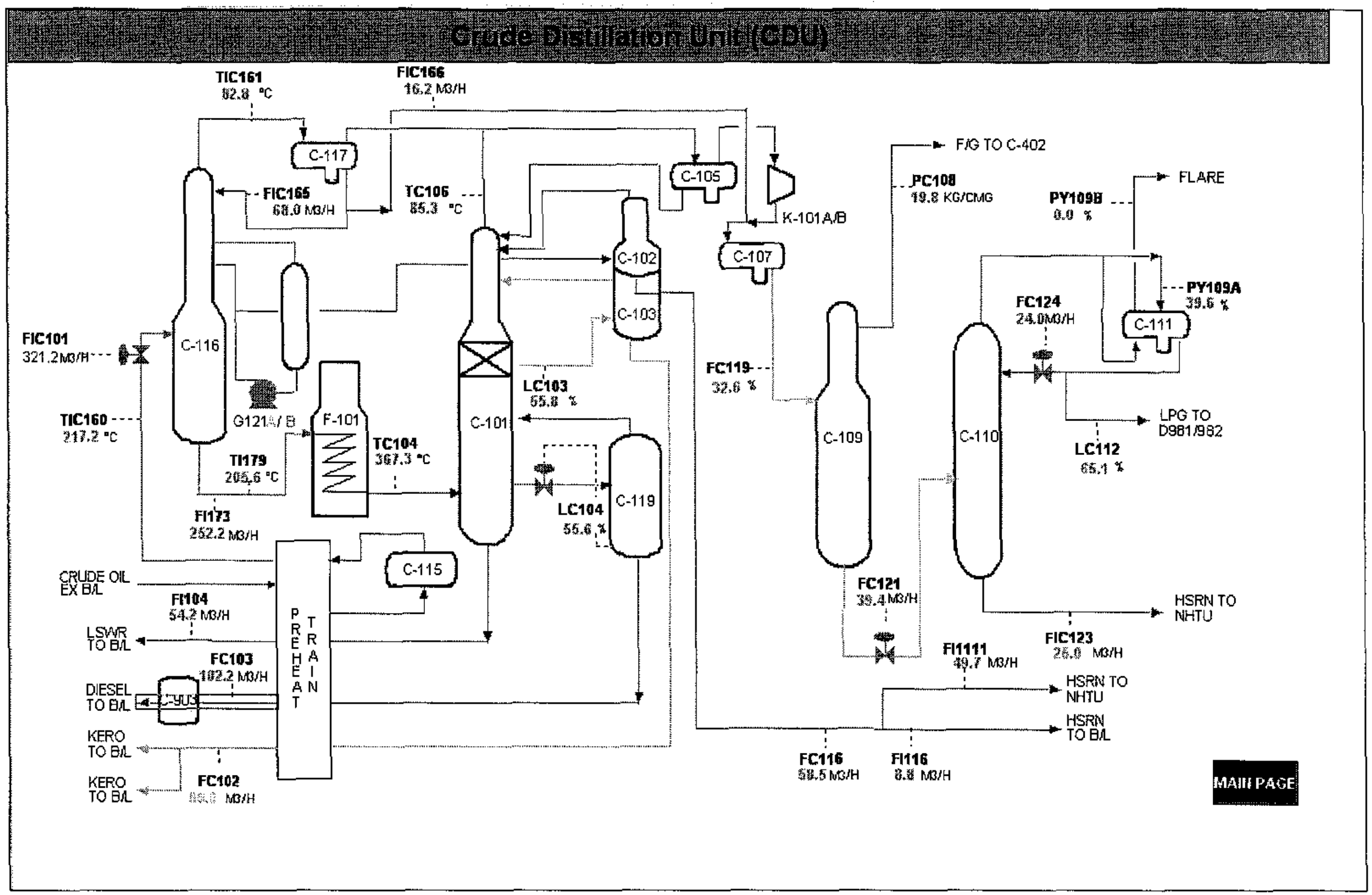

Figure 1.1: Crude Distillation Unit (CDU) Section Simplified Flow Diagram

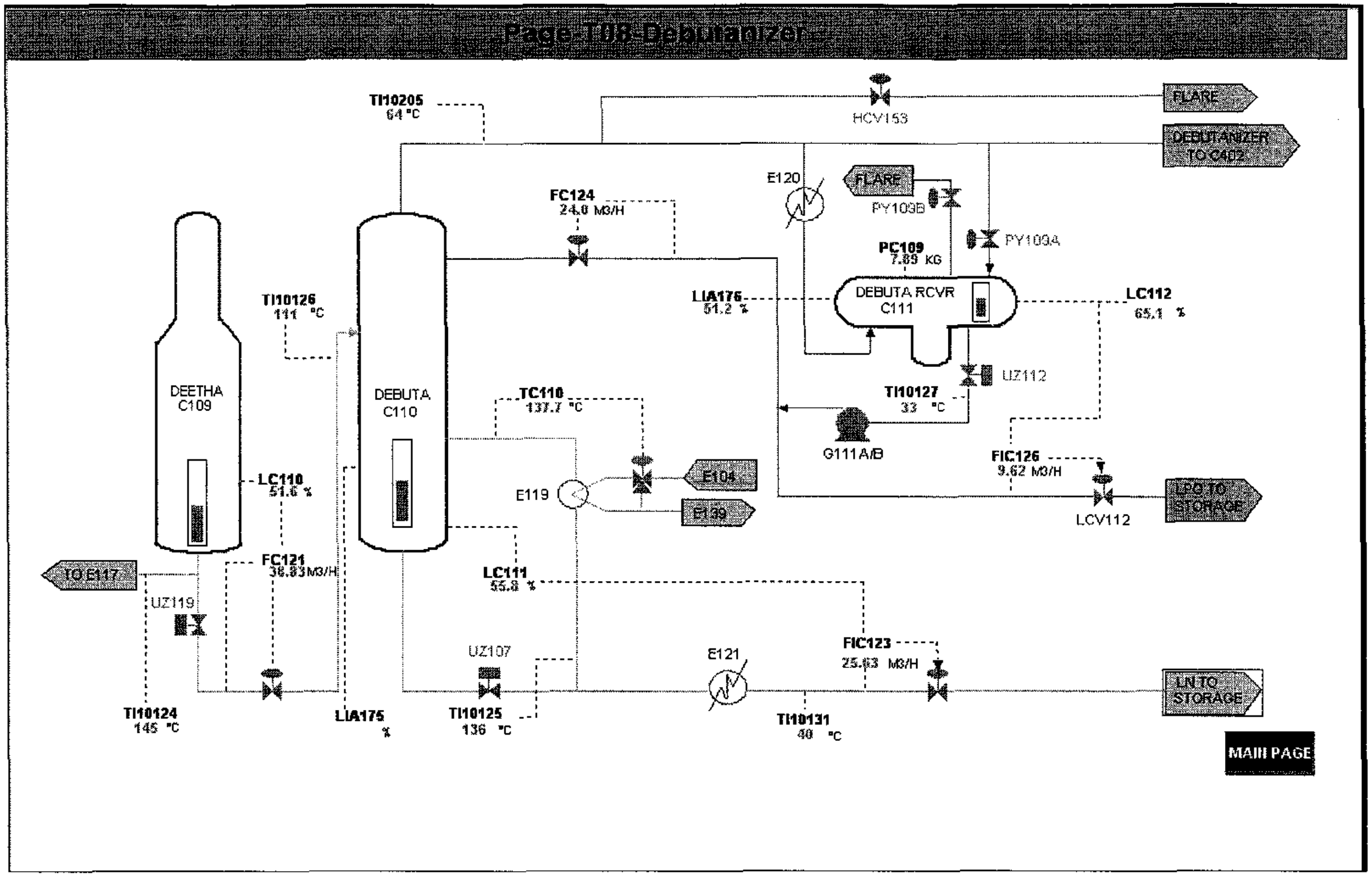

Figure 1.2: Debutanizer Column Section Simplified Flow Diagram

1.2 Problem Statement

1.2.1 Problem Identification

Quality is inversely proportional to variability. Quality improvement is reduction of variability in process and products. Since variability can only be described in statistical terms, statistical method play a central role in quality improvement efforts. Based on three years collected data from January 2006 till May 2008 display the opportunity to reduce the variation of Debutanizer column performances. Since variability is often a major source of a poor quality, statistical method, which is very high demand in industry right now will be used to monitor process behavior and able us to analyze the variations in the process that may affect the quality of the end product. From the analysis, author hope to come up with the best way in controlling all the variables at the column.

1.2.2 Significant of the Project

Statistical Process Control (SPC) is an effective method of monitoring a process through the use of control charts. Control charts enable the use of objective criteria for distinguishing background variation from events of significance based on statistical techniques. Much of its power lies in the ability to monitor both process center and its variation about that center. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. With its emphasis on early detection and prevention of problems, SPC has a distinct advantage over quality methods, such as inspection, that apply resources to detecting and correcting problems in the end product or service. In this project, Statistical Process Control SPC will used to gain optimal quality control and improvement on the debutanizer column.

This title was chosen based on some characteristics which are:

(a) Unique – no previous student has done it before,

(b) Feasibility – the project is doable and within the writer's capability and the project can be completed within time frame given.

Finally, this project hope meets all the objectives stated. The long term target is to gain improvement on a continuous basis and implement the result in industry.

1.3 Objectives

Statistical Process Control (SPC) techniques, when applied to measurement data, can be used to highlight areas that would benefit from further investigation. These techniques enable the user to identify variation within their process. Understanding this variation is the first step towards quality improvement. There are many different SPC techniques that can be applied to data. The simplest SPC techniques to implement are the run and control charts. The purpose of these techniques is to identify when the process is displaying unusual behaviour. SPC techniques are a tool for highlighting this unusual behaviour. However, these techniques do not necessarily indicate that the process is either right or wrong – they merely indicate areas of the process that could merit further investigation.

The objectives of this project are as follows:

- To study the debutanizer column process and measure the capability analysis for improvement.
- To study Statistical Process Control techniques as a problem-solving tools in quality improvement efforts.
- To apply Statistical Process Control on debutanizer column at Petronas Penapisan Terengganu Sdn. Bhd. (PPTSB), Kerteh.
- To measure and analyze the variation in the processes.

- To monitor the consistency of processes used to manufacture the product as designed.
- To suggest the best way in controlling all the variables at the column.

The other purpose of the project is to develop a framework, which will enhance author's skills in the process of applying knowledge, expanding thoughts, solving problems independently and presenting findings through minimum guidance and supervision.

1.4 Scope of Study

The scope of the project mostly on the computer programming and analyzing data. The area and scope of the project should be narrowed down so that the project is feasible and could be completed within the allocated time frame. The scope of study is focus on the implementation of Statistical Process Control by analysis of input data and performance monitoring of the process. SPSS software and Microsoft Excel is used throughout the development of the project. In doing this project, the scopes of study are:

- **Study on Statistical Process Control (SPC)**
  -Which is consist of understanding quality of improvement, process quality, methods and philosophy of SPC, using control chart, measurement system analysis, design control plan and etc.
- **Study on fractionation column, mainly on debutanizer column**
  -Which is consist of familiarize the debutanizer column operation, the process description, process flow diagram, process quality control, product specification and etc.
- **Study on SSPS software (a statistical software used to assist in analyzing data)**
  -Which is consisting of understanding how to use this computer software, ability to solve the problem regarding to this project, produce statistical analysis and etc.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction to Statistical Process Control (SPC)

If a product is to meet or exceed customer expectations, generally it should be produced by a process that is stable or repeatable. More precisely, the process must be capable of operating with the little variability around the target or nominal dimensions of the product's quality characteristics. Statistical process control (SPC) is a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability. SPC can be applied to any process. Its seven major tools are;

1. Histogram or stem-and leaf plot
2. Check sheet
3. Pareto chart
4. Cause-and-effect diagram
5. Defect concentration diagram
6. Scatter diagram
7. Control chart

Statistical process control (SPC) involves using statistical techniques to measure and analyze the variation in processes. Most often used for manufacturing processes, the intent of SPC is to monitor product quality and maintain processes to fixed targets. Statistical quality control refers to using statistical techniques for measuring and improving the quality of processes and includes SPC in addition to other techniques, such as sampling plans, experimental design, variation reduction, process capability analysis, and process improvement plans.

2.2 Why uses Statistical Process Control (SPC)

SPC is used to monitor the consistency of processes used to manufacture a product as designed. It aims to get and keep processes under control. No matter how good or bad the design, SPC can ensure that the product is being manufactured as designed and intended. Thus, SPC will not improve a poorly designed product's reliability, but can be used to maintain the consistency of how the product is made and, therefore, of the manufactured product itself and its as-designed reliability.

A primary tool used for SPC is the control chart, a graphical representation of certain descriptive statistics for specific quantitative measurements of the manufacturing process. These descriptive statistics are displayed in the control chart in comparison to their "in-control" sampling distributions. The comparison detects any unusual variation in the manufacturing process, which could indicate a problem with the process. Several different descriptive statistics can be used in control charts and there are several different types of control charts that can test for different causes, such as how quickly major vs. minor shifts in process means are detected. Control charts are also used with product measurements to analyze process capability and for continuous process improvement efforts.

Some of the benefits of applying SPC in processes are:

- *Effective method of monitoring a process* – A primary tool used for SPC is the control chart, a graphical representation that can be analyzed to detect any unusual variation in the manufacturing process, which could indicate a problem with the process. It is also used with product measurements to analyze process capability and for continuous process improvement efforts.
- *Detects assignable causes of variation* – By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected. From here, the pattern can be analyzed and thus preventing the problems to be passed on

to the customer. This would also means that by applying SPC, the process can be kept in control.

- *Accomplishes process characterization* – From the pattern, the process characterization required can be achieved. For examples, in operating a distillation column, by doing SPC, the optimum operating conditions can be obtained leading to on-spec product and optimum process.
- *Reduces need for inspection* – With its emphasis on early detection and prevention of problems, SPC has a distinct advantage over quality methods, such as inspection, that apply resources to detecting and correcting problems in the end product or service.
- *Reduce the time required to produce the product* – The SPC data can be used to identify bottlenecks, wait times, and other sources of delays within the process. Process cycle time reductions coupled with improvements in yield have made SPC a valuable tool from both a cost reduction and a customer satisfaction standpoint.

2.3 Distillation/Fractionation Column

Petroleum industry is one of the most prolific and dynamic industries of modern civilization. Because of a highly competitive market and stringent environmental laws, strict quality control of refinery products is a must. Crude distillation unit (CDU) is one through which entire crude entering a refinery must be processed. So a close monitoring and control of CDU product properties will help in controlling the properties of final refinery products. It is often sufficient to characterize refinery products in terms of certain gross properties such as Reid Vapor Pressure for volatile products, Flash Point for light distillate, Pour Point for heavy distillate etc. Continuous control of the unit demands that these properties should be measured on-line so that it can be effectively controlled through a feedback mechanism.

Fractional distillation is one of the unit operations of chemical engineering Fractionating columns are widely used in the chemical process industries where large quantities of liquids have to be distilled. Such industries are the petroleum processing, petrochemical production, natural gas processing, hydrocarbon solvents production and other similar industries but it finds its widest application in petroleum refineries.

The design and operation of a fractionating column depends on the composition of the feed and as well as the composition of the desired products. Given a simple, binary component feed, analytical methods such as the McCabe-Thiele method or the Fenske equation can be used. For a multi-component feed, simulation models are used both for design, operation and construction.

The Fractionation Column in LPG Recovery Unit at PPTSB, Kerteh is an example of a fractionation system. This unit is to recover light gases and LPG from the overhead distillate before producing Light Naphtha. The light gases mainly C_2 is used or routed to Refinery Fuel Gas System and Mixed LPG (C_3 & C_4) to LPG storage. The unit includes Deethanizer and Debutanizer Columns.

2.4 Debutanizer Column

The main function of Debutanizer column (C-110) of PPTSB is to fraction bottom product from Deethanizer column (C-109) to C_3 & C_4 to the overhead and Light Straight Run naphtha (LSRN), the heavier components in the bottom. The debutanizer column produces LPG (liquefied petroleum gas) as the top stream and light naphtha as the bottom stream. The controlled outputs which are the critical product quality to be measured are the concentration of $C5^+$ in the top stream and the Reid Vapor Pressure (RVP) of the bottom stream. RVP is defined as the vapor pressure of a product determined in a volume of air four times greater than the liquid volume at 100^oF.

Deethanizer (C-109) bottom product entered as feed to Debutanizer Column above Tray No. 23. Debutanizer Column (C-110) is equipped with 35 valve Type Trays (one liquid pass). The low-boiling point components rise up the tower in contact with the internal reflux and the high-boiling point heavy components flow down in contact with vapor produced in Debutanizer Reboiler (E-119). Thus hydrocarbon feed to Debutanizer (C-110) is fractionated to C_3 & C_4 to the overhead and Light Straight Run naphtha (LSRN), the heavier components in the bottom.

The overhead vapor is then condensed by Debutanizer Condenser (E-120) and part of it may bypass the condenser as per System Overhead pressure Controller (PCV-109) before going into Debutanizer Receiver Drum (C-111). The Debutanizer Overhead System pressure is controlled at 8.0 kg/cm^2 by Debutanizer Overhead Pressure Control Valve (PCV-109) which have two split ranges control.PCV-109B will open and vent the excess off-gas to flare if pressure increased and PCV-109A open and bypassing part of the overhead gas from the Debutanizer Condenser if pressure is low. Handwhell Operated Valve (HCV-153) can be used to flare the system pressure if increases too much. The off-gas can also be routed to Refinery Fuel Gas System by opening the tie-in block valve incase of emergency lost of fuel gas system.

The condensed hydrocarbon collected is pump by Debutanizer Reflux Pumps (G-111 A/B) and part of it is pump back to the Debutanizer top as reflux under controlled by Debutanizer Overhead Reflux Control Valve (FCV-124) and the flow is measured by Reflux Flowrate (FI-124), The balanced can be routed to flare if product (LPG) is off-spec or to storage spheres D-981/982 Via Debutanizer Reflux Drum Level Controller (LCV-111) and flowrate is measured by Liquid Petroleum Gas Rundown Flowrate (FI-126).

Debutanizer (C-110) bottom section is provided with Debutanizer Reboiler (E-119) which is heated by Kerosene Pumparound System, to strip the light components. The Reboiler temperature can be controlled by Debutanizer Reboiler Temperature Control Valve (TCV-110). The bottom level is controlled by the Debutanizer Bottom Level Controller (LCV-111) and by pressure gravity is then routed via Light Naphtha Rundown Cooler (E-121) to Light Straight Run Naphtha rundown tank or to slop if off-spec. LSRN rundown rate is measured by Light Straight Run Naphtha Rundown Flowrate (FI-111).

If the Deethanizer bottom liquid flow drops below 3.5 t/hr, which is expected only if pure Dulang Crude is feed to unit, Debutanizer bottoms can be recycled via

Debutanizer Bottom Recycle Flow Controller (FIC-168) back to the Deethanizer Charge Drum (C-107) as to maintain liquid load in the Deethanizer (C-109).

Based on the above, the purpose of this project is to apply the statistical process control in order to control the variation of product qualities on the debutanizer column of PPTSB. This statistical tool is expected to be able to measure and analyze the variation of the process, suggest the best way in controlling all the variables at the column and finally reduce the variation of the product qualities.

CHAPTER 3
METHODOLOGY

3.1 Flowchart Of Methodology

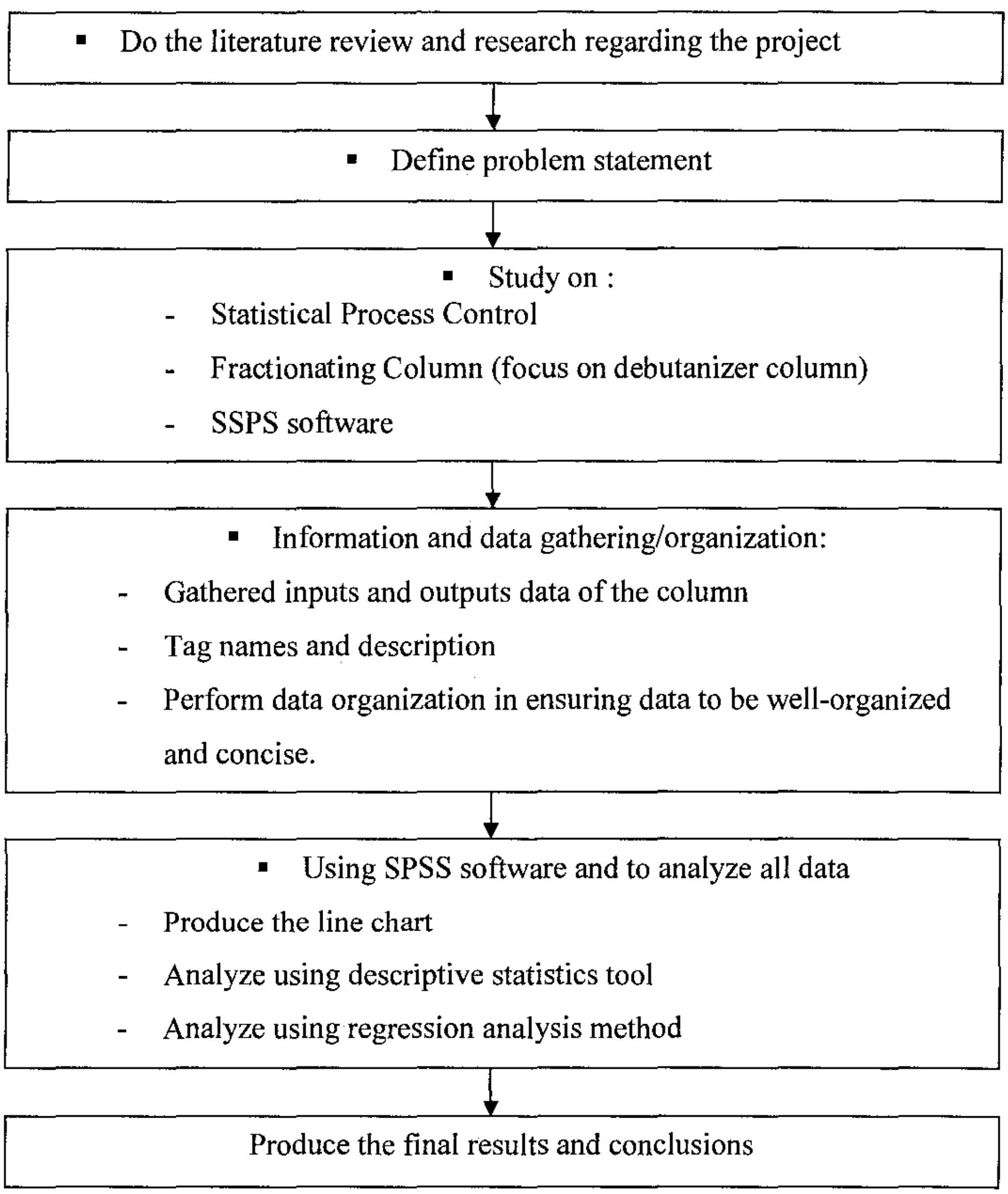

Figure 3.1: Flowchart of the Methodology

3.1.1 Literature Review and Research

Research has to be done throughout the project period on the concept of statistical process tool and its latest technology apart from the development of Neural Network models by using SPSS software. Besides of that, a lot of reading has to be done on the debutanizer column process behavior and also critical performance analysis of debutanizer column operation.

3.1.2 Define problem statement

To define the problem statement, it is important to first understand the process behavior of debutanizer column of PPTSB. This is done by referring to the operation manuals of crude distillation unit (CDU) of KR-1 of PPTSB and by consulting appropriate engineers and panel operators. Second, it is crucial to know the controlled output of the column and also the feeds (inputs). From this, the objective of this project can be target.

3.1.3 Data gathering / organization

After the problem is clearly defined, data (inputs and outputs to the column) were gathered. Supervisor is already getting the data from PI systems of the refinery that are currently being used by PPTSB. Then, the organization of data can be done through data partitioning, data randomization and data normalization in ensuring data to be well-organized and concise. MICROSOFT EXCEL is used for this process.

3.1.3 Data Analysis

Data Analysis has been done on the data to summarize the data, numerically or graphically by using line chart. There are some statistic methods were used which are descriptive statistics and regression analysis.

3.2 Final Year Project II Gantt Chart

Table 3.1: Final Year Project 1 Gantt Chart

	Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14	15	16	17	18	19	20
No	Description Date	19-Jan	26-Jan	2-Feb	9-Feb	16-Feb	23-Feb	2-Mar	9-Mar	16-Mar	23-Mar	30-Mar	6-Apr	13-Apr	20-Apr	27-Apr	4-May	11-May	18-May	25-May	1-Jun	8-Jun
1	Briefing & Update Progress																					
2	Project Work Commences																					
3	Submission of Progress Report 1																					
4	Submission of Progress Report 2(Draft Final Report)																					
5	Poster Exhibition / Pre-EDX/ Progress Reporting																					
6	EDX																					
7	Submission of Final Report (CD Softcopy & Softbound)																					
9	Final Oral Presentation																					
10	Submission of hardbound copies																					

Milestones
Midterm Break
Study & Exam week

3.3 Tools

SPSS software will be used to throughout this entire project. SPSS is among the most widely used programs for statistical analysis in social science. It is used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations and others.Since it also provides tools for data analysis, this software is the appropriate choice to be used for that matter. MICROSOFT EXCEL has been used to perform data organization.. Moreover, this software has also been used by engineering student at all time, so it will be easier for student to deal with it.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Data Findings

Raw data on debutanizer column of PPTSB were obtained on the input (affecting parameters around Deethanizer and debutanizer column e.g. Feed Temperature Indicator) and the outputs of the column. 205 data are finalized with 11 inputs and 8 outputs from 23 inputs and 8 outputs. The elimination of input data were done based on the nature of the input whether it is group under set point, controlled variable, manipulated variable or disturbance. The point of interest is only on the controlled variable. All 23 parameters around Deethanizer and debutanizer column were being studied and 12 parameters were eliminated as they are group under manipulated variables, disturbance variables and set point.

Table 4.1: Finalized inputs of data

Tag number	**Tag name**
TI10205.pv	Debutanizer Top Column Temperature Indicator
TC110.pv	Debutanizer Reboiler Temperature Controller (via Control Valve)
TI10127.pv	Debutanizer Condenser Temperature Indicator
TI10131.pv	Debutanizer Bottom Column Temperature Indicator
LC111.pv	Debutanizer Reflux Drum Level Controller (via Control Valve)
LC112.pv	Debutanizer Condenser Level Controller (via Control Valve)
TI10123.pv	Deethanizer Top Column Temperature Indicator
TI10124.pv	Deethanizer Bottom Column Temperature Indicator
TC109.pv	Deethanizer Reboiler Temperature Controller (via Control Valve)
LC110.pv	Deethanizer Bottom Level Controller (via Control Valve)
LC1114.pv	Deethanizer Reflux Drum Level Controller (via Control Valve)

Table 4.2: Finalized outputs of data

Stream	Stream name	Parameter studied
C2	Top product – Ethane	C2 % liquid volume
C3	Top product – Propane	C3 % liquid volume
iC4	Top product – i-Butane	iC4 % liquid volume
nC4	Top product – n-Butane	nC4 % liquid volume
iC5	Top product – i-Pentane	iC5 % liquid volume
nC5	Top product – n-Pentane	nC5 % liquid volume
C5 and heavier	Top product – Pentane and heavier	C5+ % liquid volume
RVP	Bottom product – Light Straight Run Naphtha	Reid Vapor Pressure (RVP) of Light Naphtha

All eleven inputs and eight outputs were analyzed using the statistical techniques to further eliminates unnecessary parameters.

4.2 Data Analysis

Statistical analysis is a scientific method of dealing with large volumes of data in order to summarize the essential features, determine any discernible patterns, arid find evidence for future tendencies. Few data analysis techniques can be used such as graphical chart, regression, frequency distribution, and descriptive statistics.

A primary tool used for SPC is the control chart, a graphical representation of certain descriptive statistics for specific quantitative measurements of the manufacturing process. These descriptive statistics are displayed in the control chart in comparison to their "in-control" sampling distributions. The comparison detects any unusual variation in the manufacturing process, which could indicate a problem with the process. Several different descriptive statistics can be used in control charts. Control charts are also used with product measurements to analyze process capability and for continuous process improvement efforts. Below are line chart used to monitor the process consistency of debutanizer column (produced with SPSS Software).

4.2.1 Data Analysis: Line Chart

Tag Name Temperature versus Time

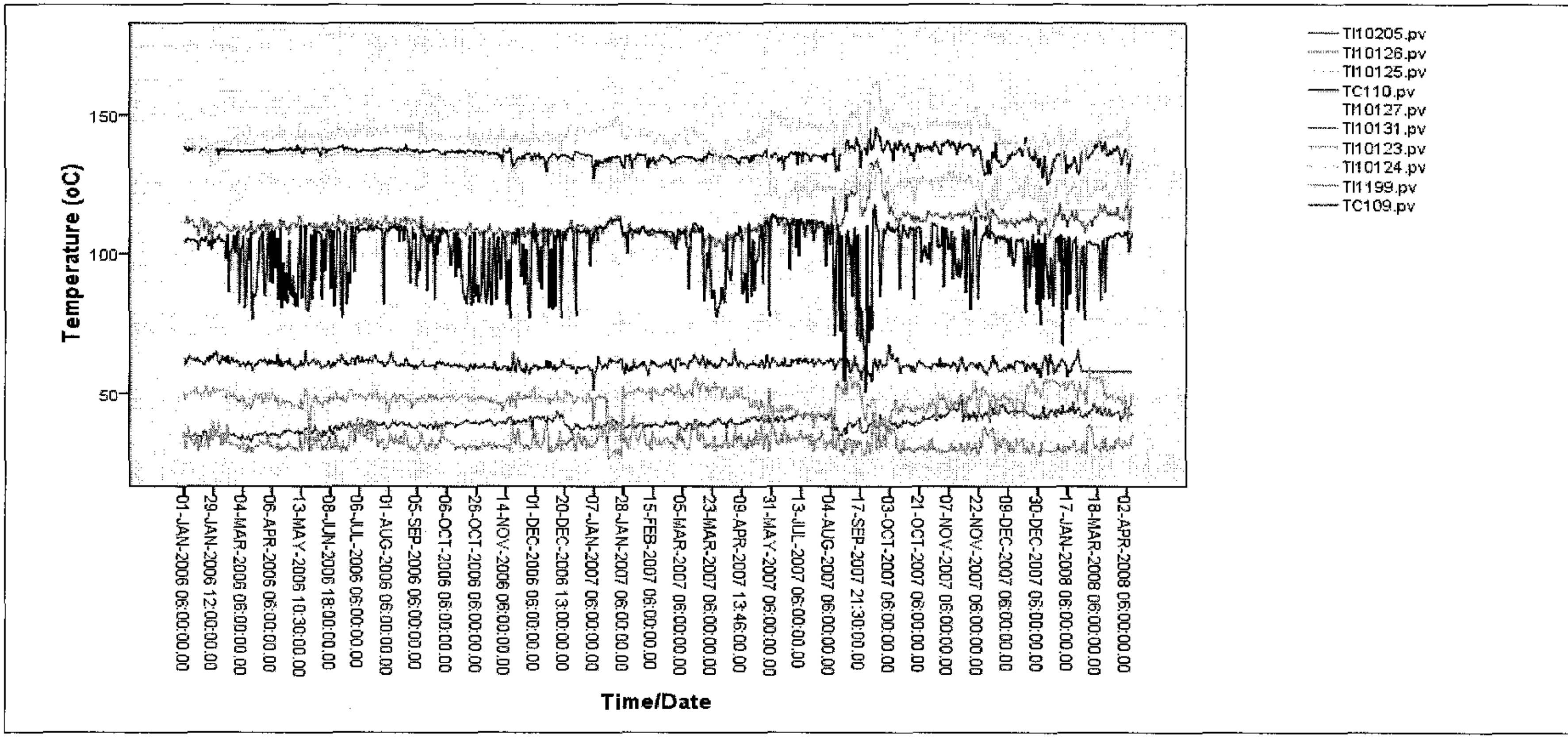

Figure 4.1: Line chart for combine all tag name temperature versus time.

Tag Name Level versus Time

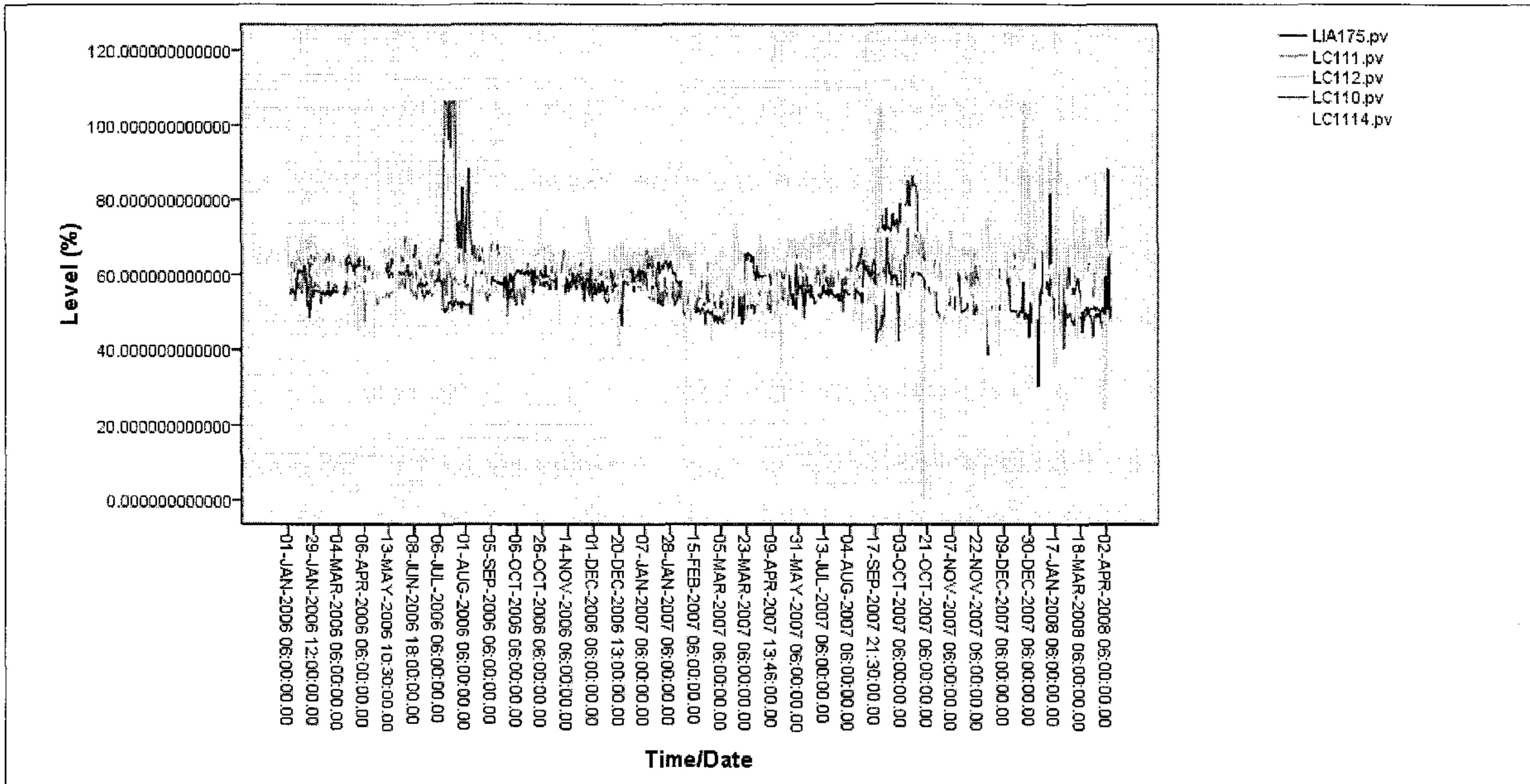

Figure 4.2: Line chart for combine all tag name level versus time.

Tag Name Flowrate versus Time

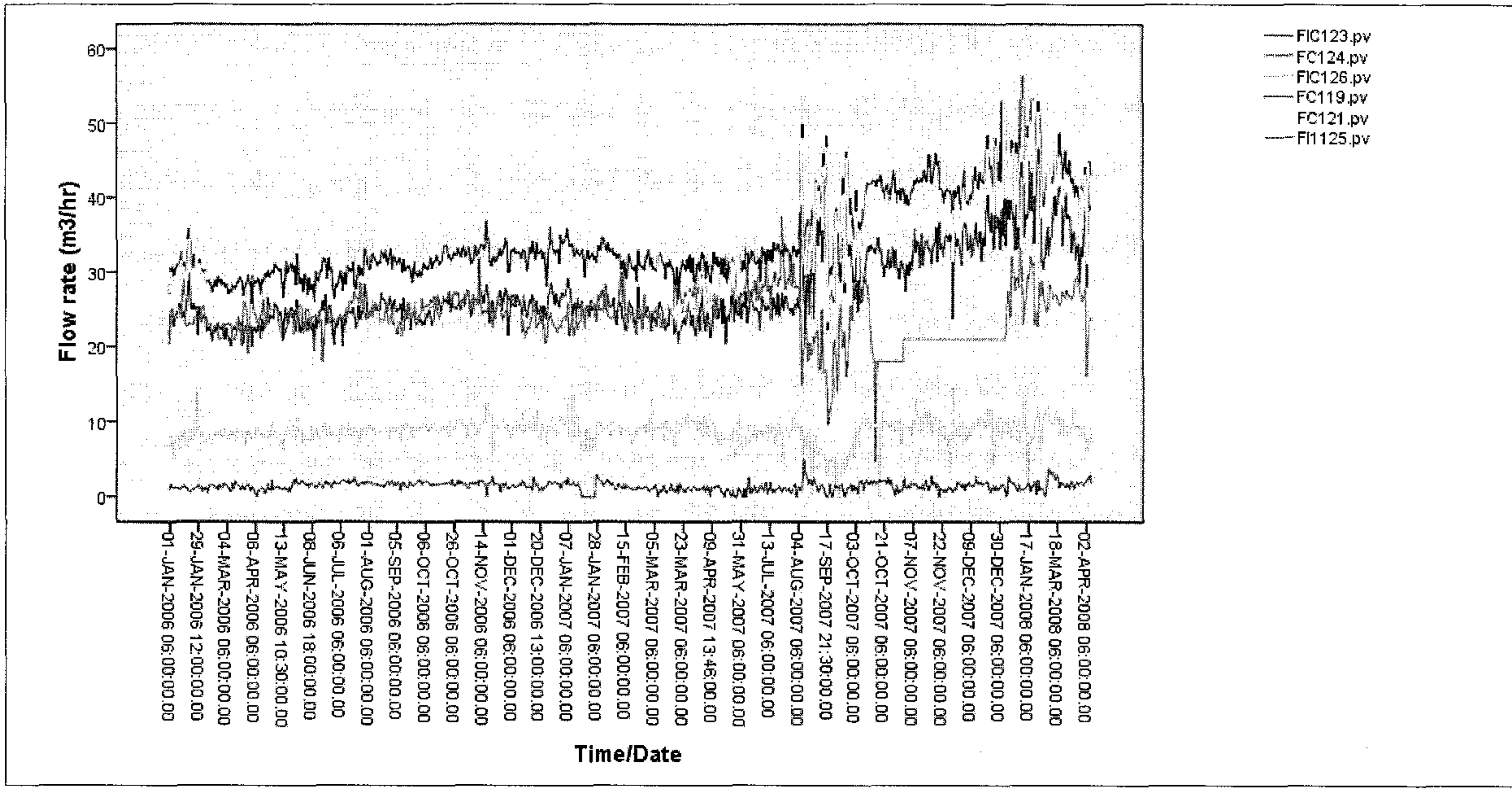

Figure 4.3: Line chart for combine all tag name flowrate versus time.

Composition C2 (%) versus Time

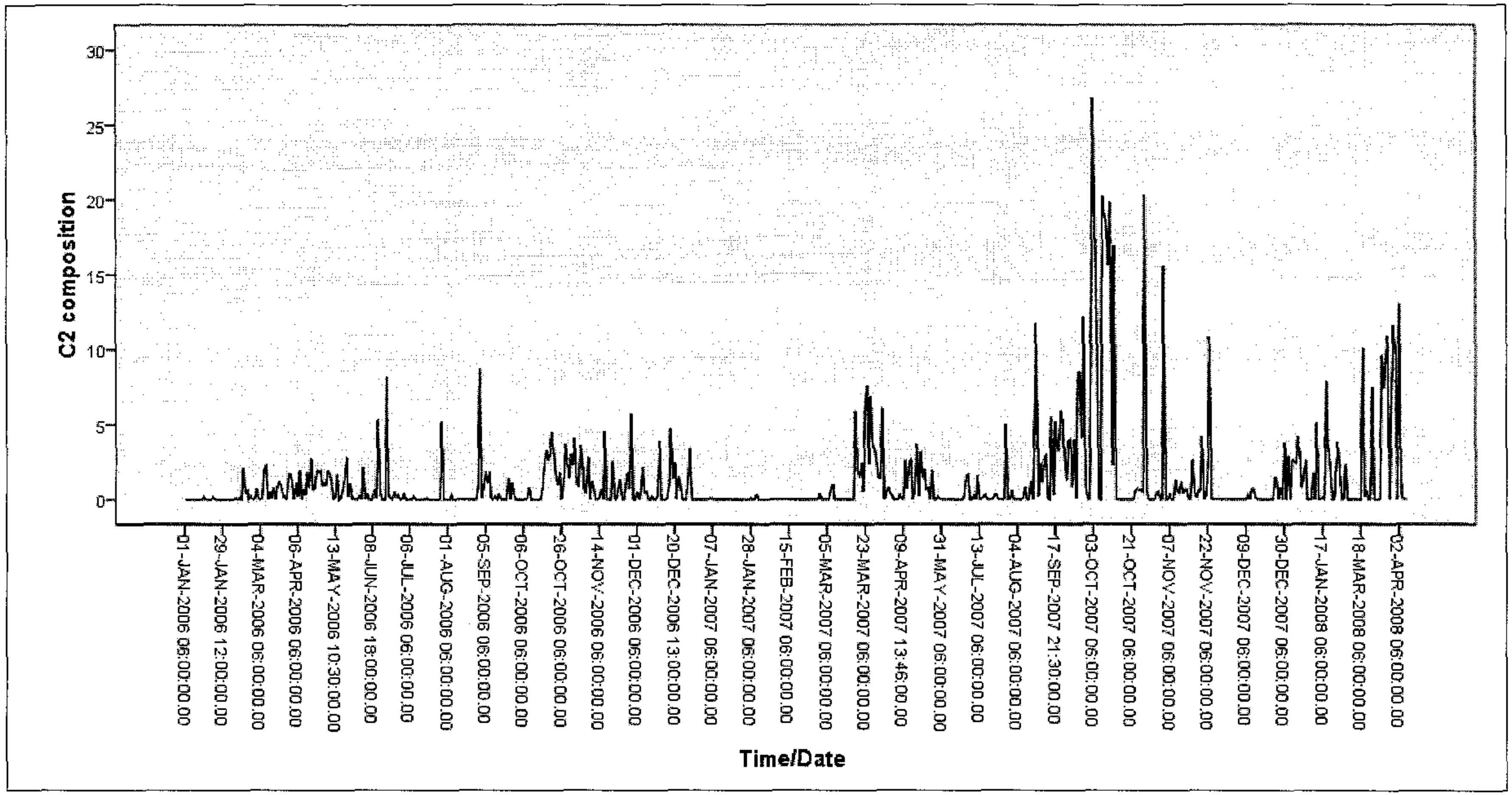

Figure 4.4: Line chart for composition C2 versus time.

Composition C3 (%) versus Time

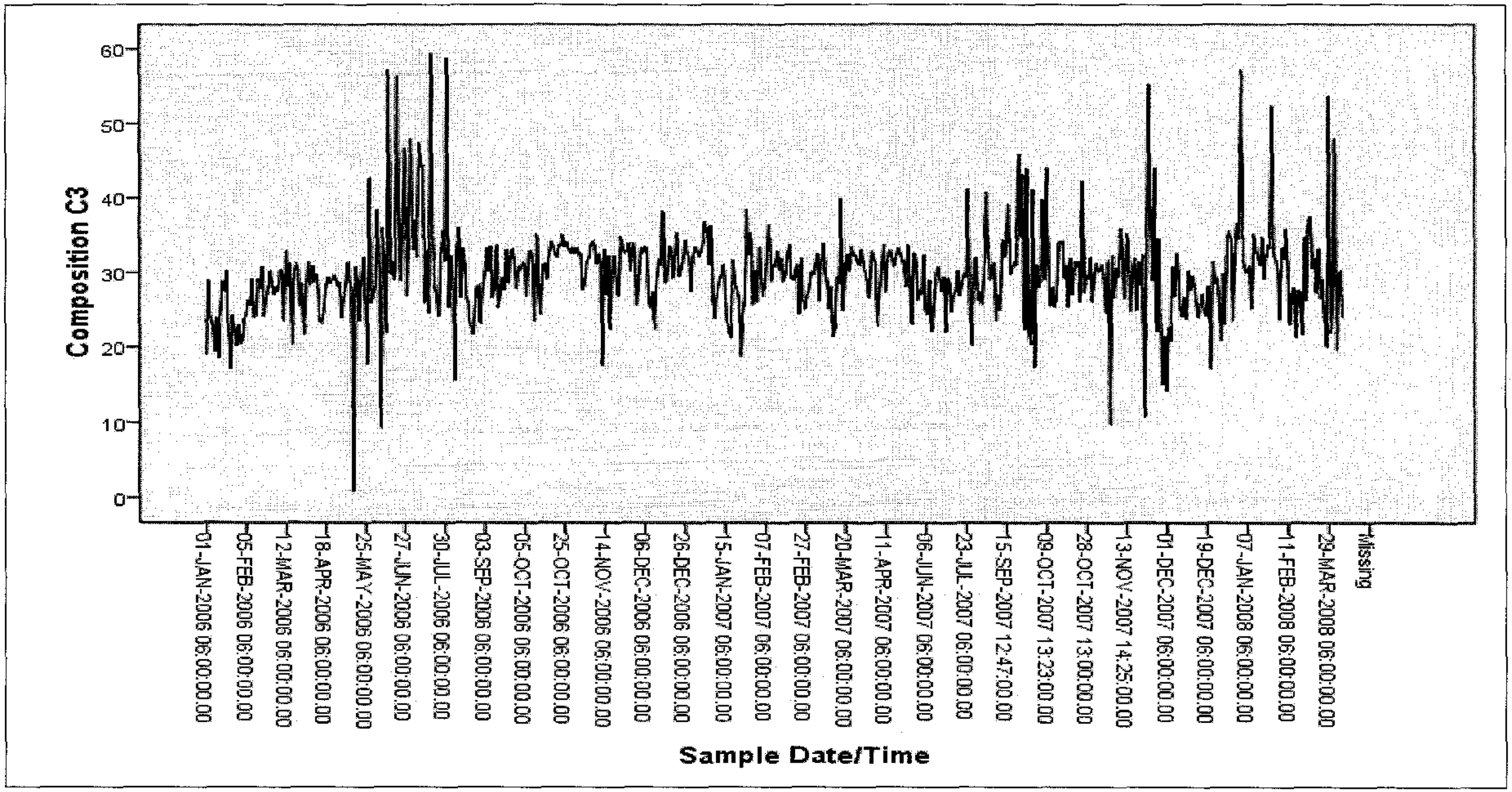

Figure 4.5: Line chart for composition C3 versus time.

Composition iC4 (%) versus Time

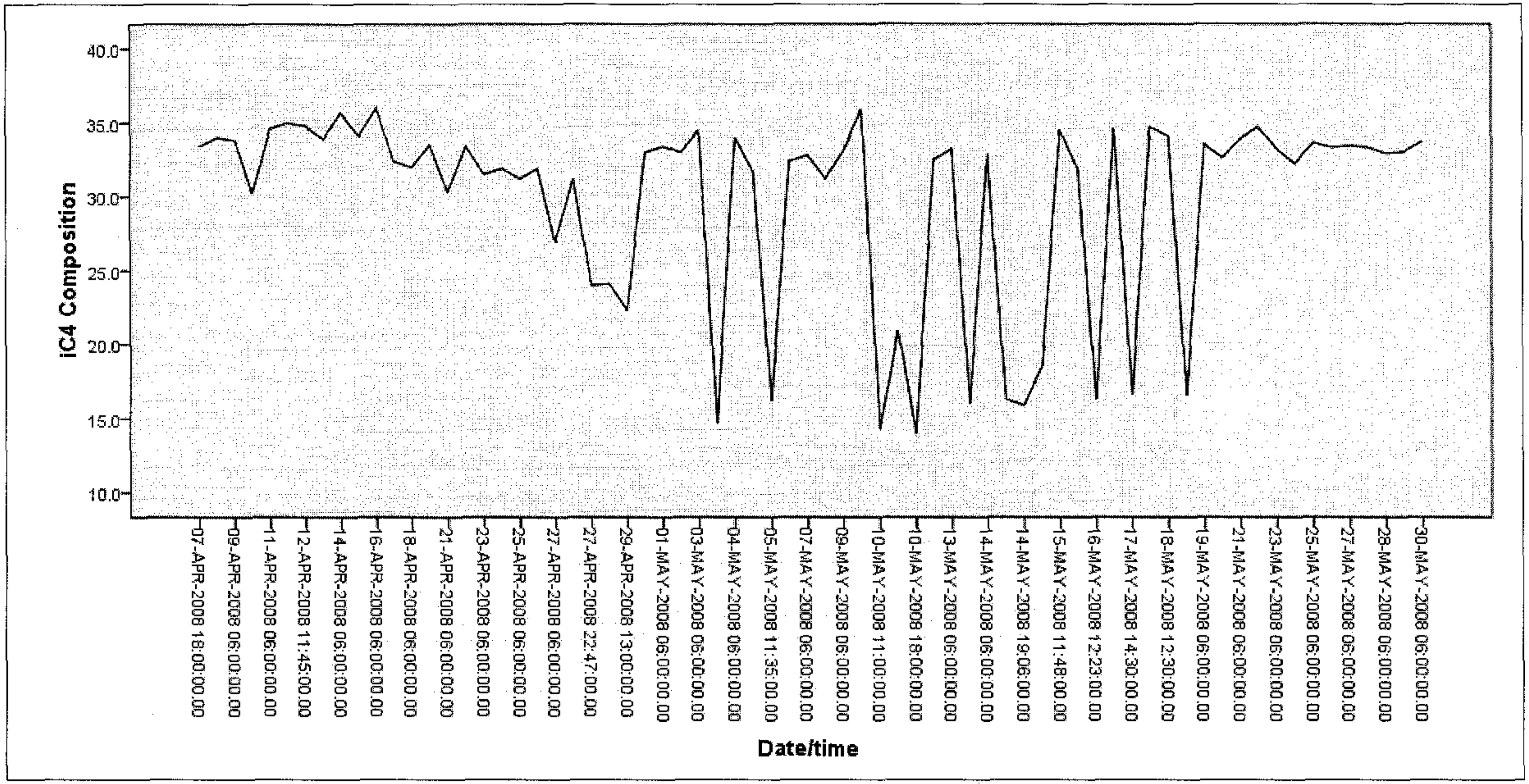

Figure 4.6: Line chart for composition i-C4 versus time.

Composition n-C4 (%) versus Time

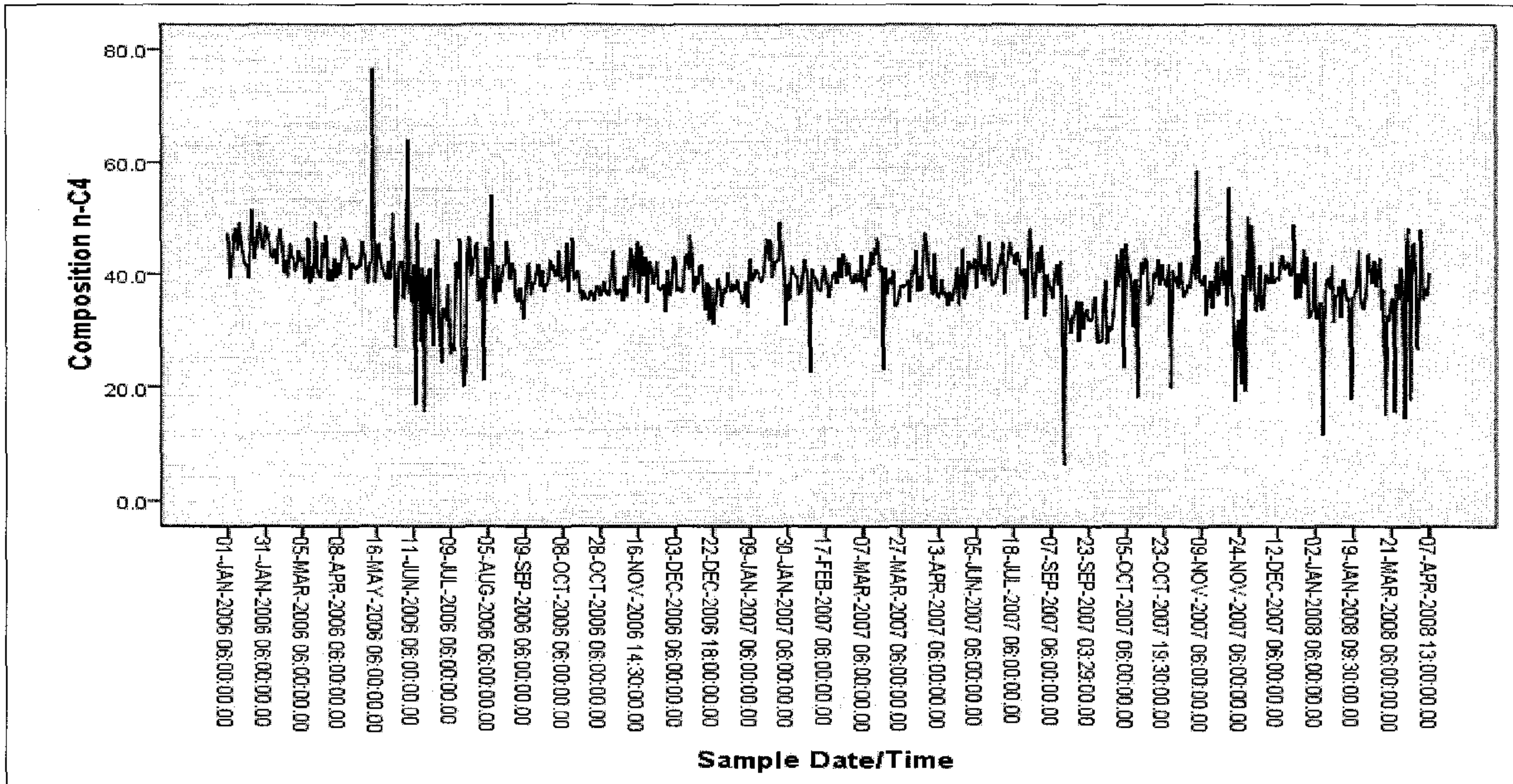

Figure 4.7: Line chart for composition n-C4 versus time.

Composition i-C5 (%) versus Time

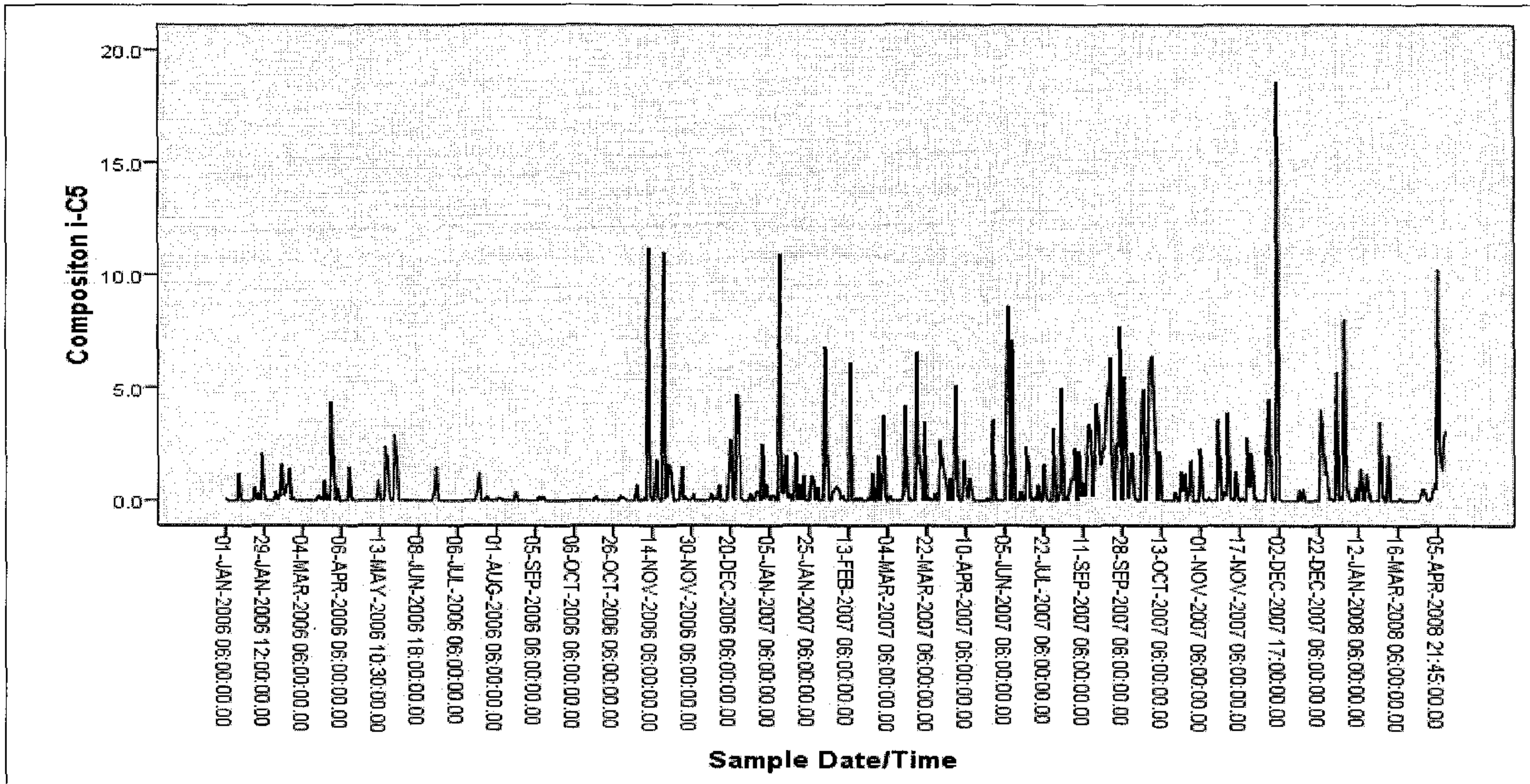

Figure 4.8: Line chart for composition i-C5 versus time.

Composition n-C5 (%) versus Time

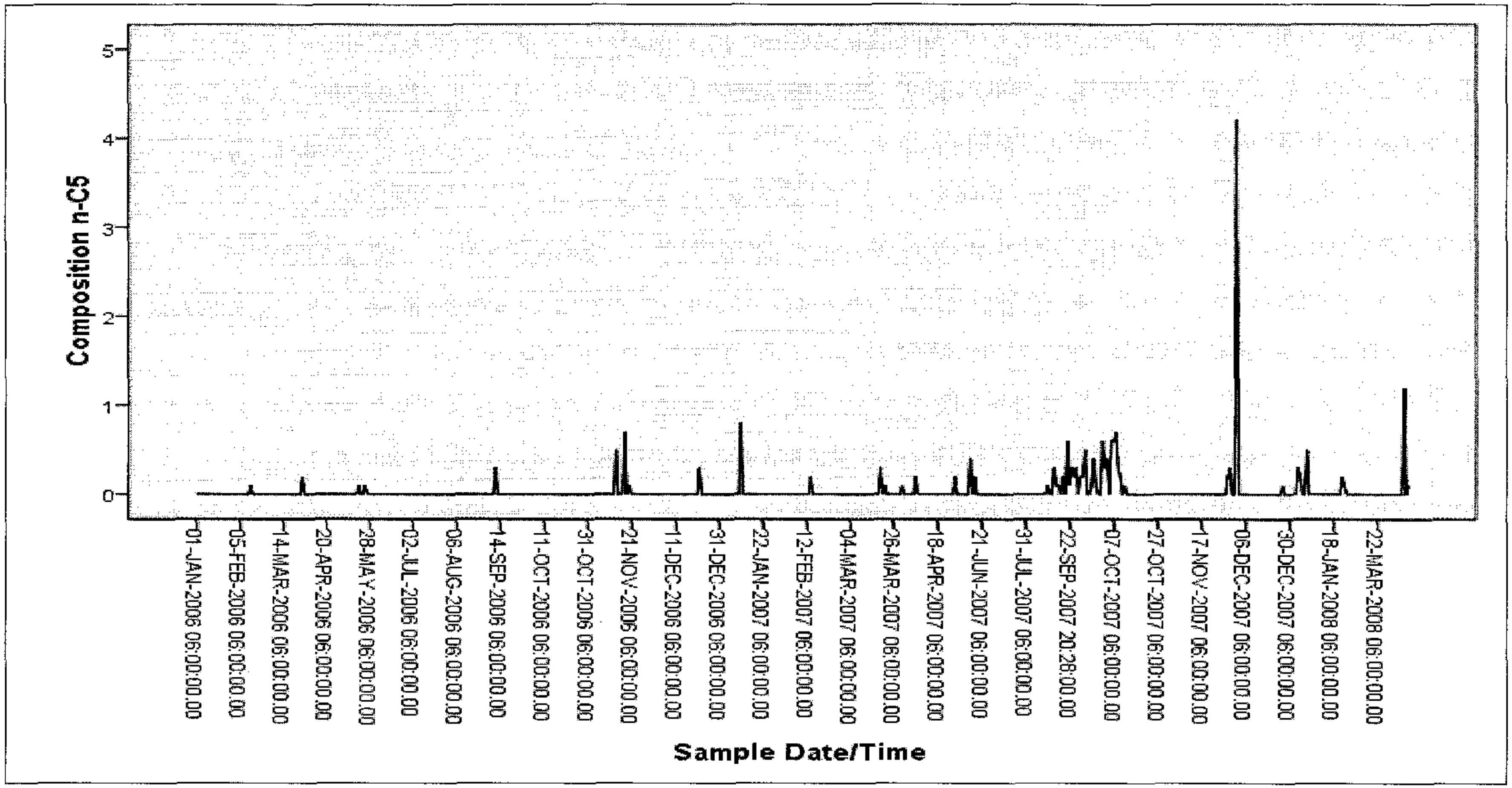

Figure 4.9: Line chart for composition n-C5 versus time.

Composition LPG (%) versus Time

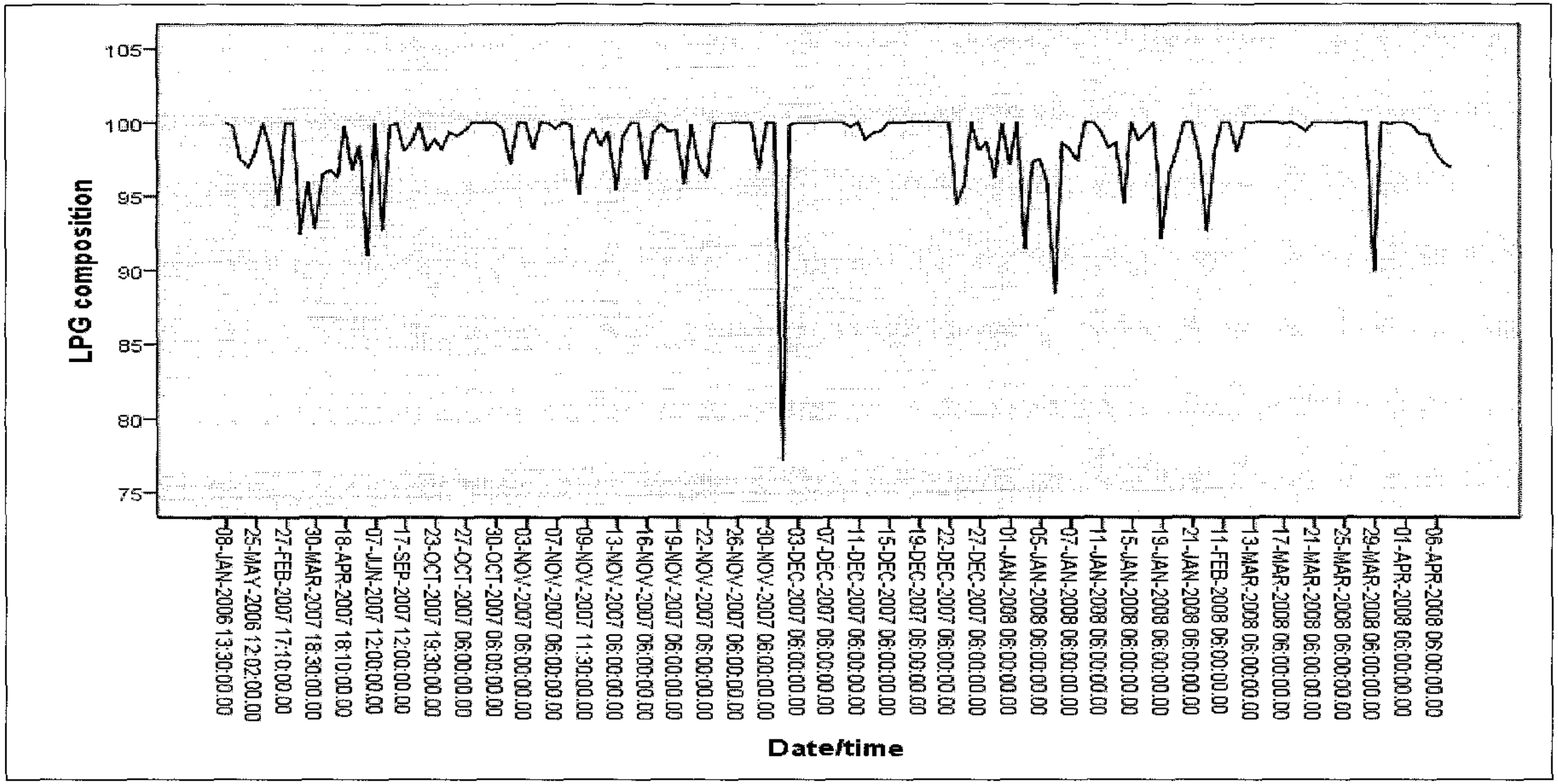

Figure 4.10: Line chart for composition LPG versus time.

Debutanizer Top Temperature, TI10205.pv (°C) versus Time

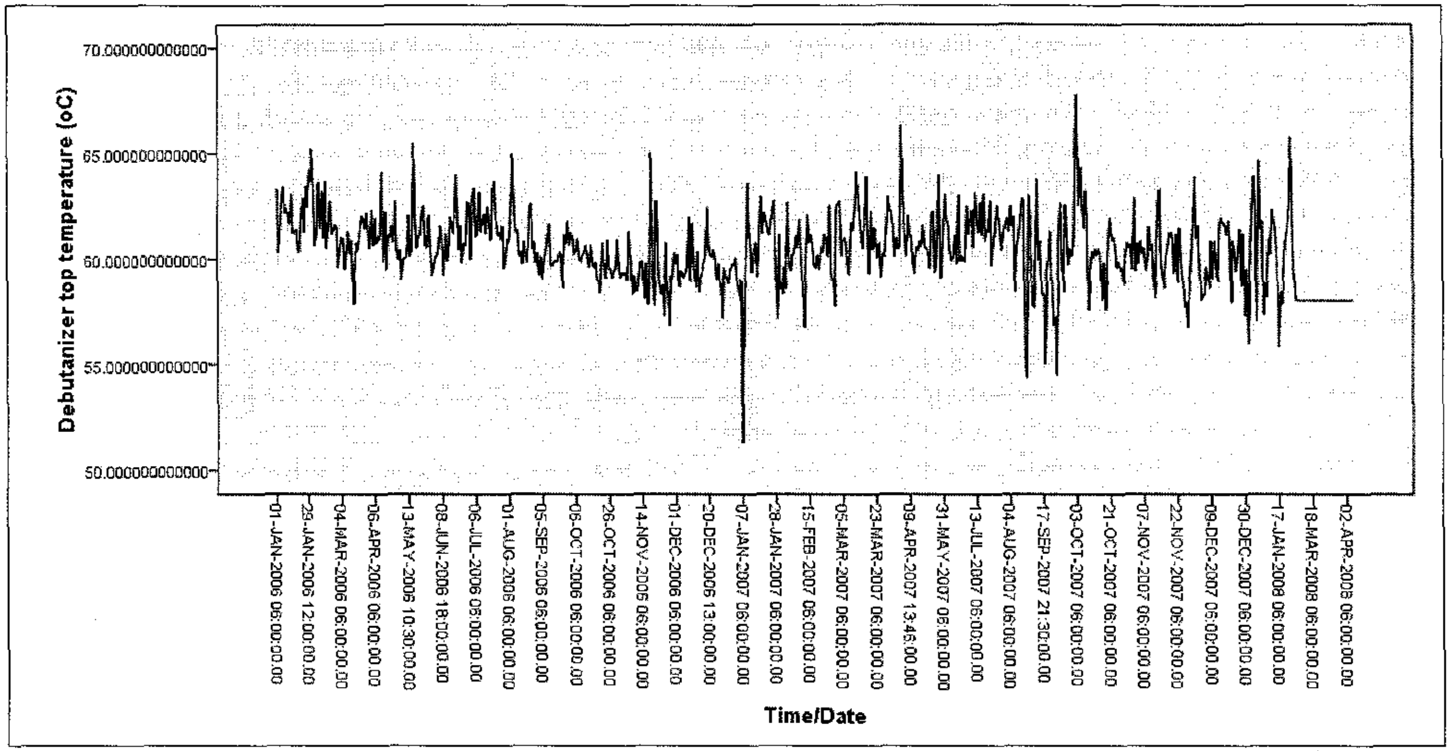

Figure 4.11: Line chart for Debutanizer Top Temperature (*TI10205.pv) versus *time.

The other line chart also produced by using another remaining tag name temperature (TI10126.pv, TI10125.pv, TC110.pv, TI10127.pv, TI10131.pv, TI10123.pv, TI10124.pv, TI1199.pv, and TC109.pv).

Debutanizer Level, LIA175.pv (%) versus Time

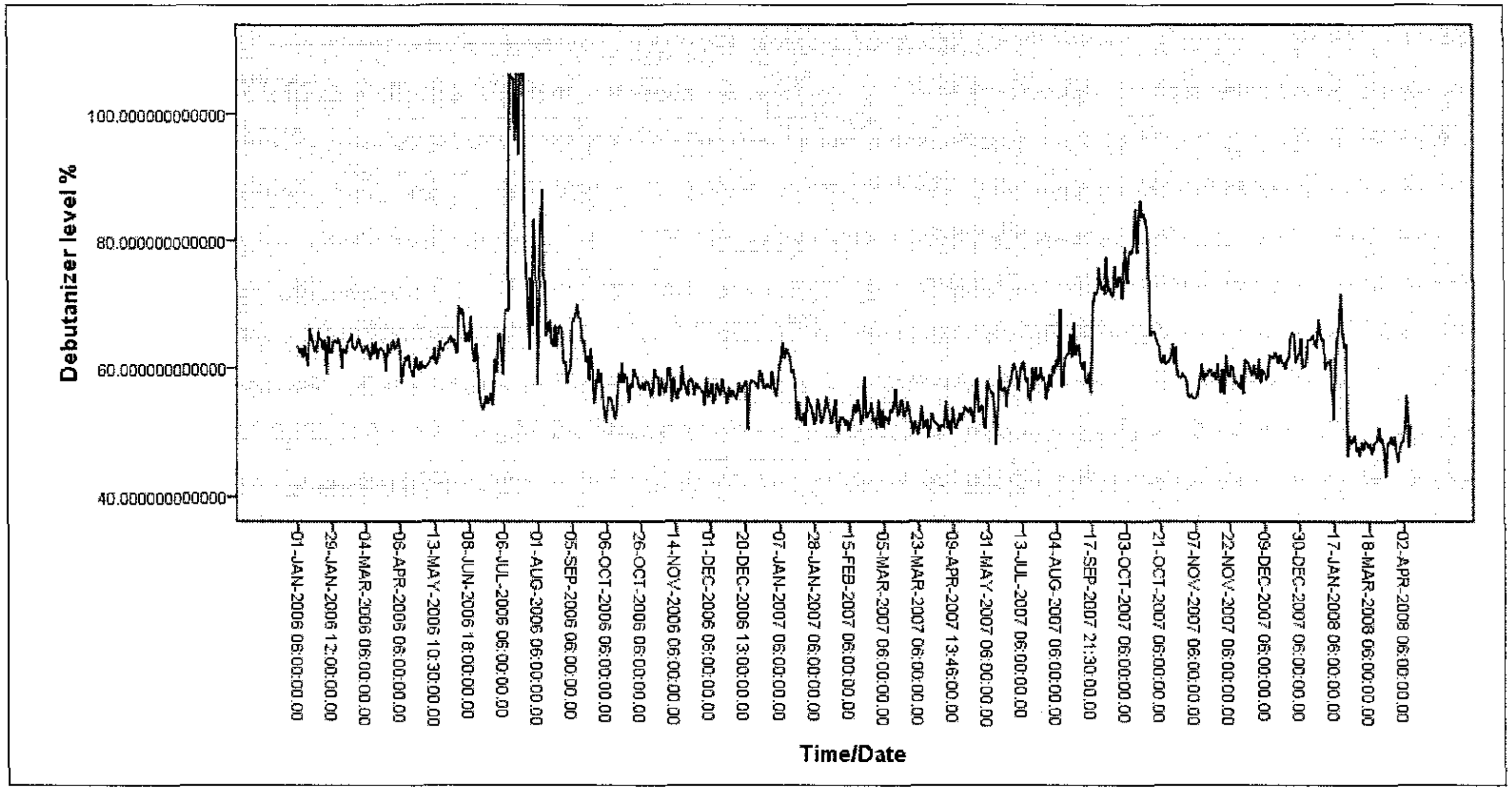

Figure 4.12: Line chart for Debutanizer Level (LIA175.pv) versus time.

The other line chart also produced by using another remaining tag name level (LC111.pv, LC112.pv, LC110.pv, LC114.pv).

Light Naphtha flow, FIC123.pv (m^3/hr) versus Time

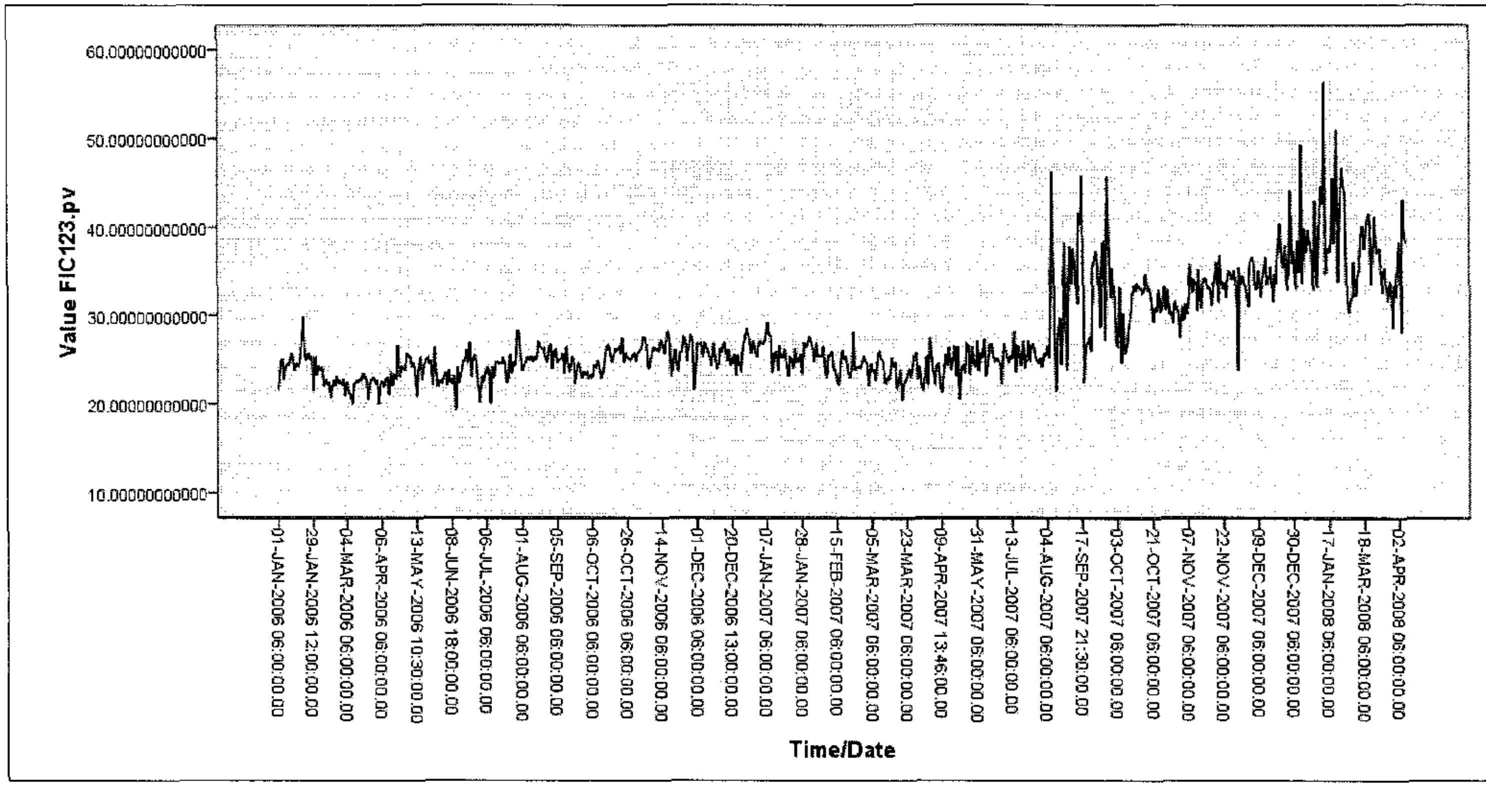

Figure 4.13: Line chart for Light Naphtha flow (FIC123.pv) versus time.

The other line chart also produced by using another remaining tag name flowrate (FC124.pv, FIC126.pv, FC119.pv, FC121.pv, FI1125.pv, FI120.pv).

4.2.2 Scatter Diagram

Scatter diagram usually is a plot of the variables versus the output. The purpose of scatter diagram is to check correlation between inlet variables and output. Plot of input parameters (11 inputs) versus output (8 outputs) based on the debutanizer column data are plotted and reviewed. Strong pattern can be seen in all graphs showing that all 11 inputs are important in predicting the 8 outputs. Refer to Appendix 2 for scatter diagrams of all input and output parameters.

4.2.3 Frequency Distribution

It is necessary to group or arrange the data obtained in a manageable form since the data sets are quite large. Frequency Distribution is used to achieve this purpose. Frequency table summarizes the data in an informative manner. It serves as the graphical representation of data. Charts and diagrams make it easier to get an overview of the data visually. Histogram is the most common way of representing a frequency distribution. It consists of a sequence of vertical bars whose heights are proportional to the frequencies represented.

Histogram on all parameters (inputs and outputs) are done using Microsoft Excel Data Analysis tool. For theoretical reasons, a distribution is usually expected to be symmetrical. Histogram of inputs TI10205.pv, TI10127.pv, TI10124.pv and LC1114.pv of Figure 3.1, Figure 3.3, figure 3.8 and Figure 3.11, respectively (Refer to Appendix 3) shows presence of outliers. Outliers are points that lie far from the main distributions or the main trends of one or more variables In the real world, outliers have a range of causes, from as simple as operator blunders, equipment failures, day-to-day effects, batch-to-batch differences or abnormal input conditions. However, the outliers will not be removed for the network construction, as the models will be trained to recognize outliers to make it more robust. Apart from that, it is also observed that most all the graphs have symmetrical frequency distribution, relatively peaked distribution except for output C2, iC5, nC5 and C5+ which have flat distribution and extending towards negative values.

This is because, data for composition of C2, iC5, nC5 and C5+ are not affected much by the input variables. The data obtained for that 4 output parameters mostly have zero values. From this, it is assumed that, output C2, iC5, nC5 and C5+ are not directly related to the input variables. Thus, these outputs variables can be eliminated from the Neural Network configuration on the debutanizer column of PPTSB.

4.2.4 Descriptive Statistic

Descriptive Statistics are used to present quantitative descriptions in a manageable form. In a research study we may have lots of measures. Descriptive statistics helps to simply large amounts of data in a sensible way. Each descriptive statistic reduces lots of data into a simpler summary. There are different sets of measures to describe different characteristics of data. Usual measures in descriptive statistics are mean, standard error, median, sample variance, range, standard deviation, average, minimum and maximum. **Skewness** and **kurtosis** are two other characteristics commonly used in describing a sample. Skewness characterizes the degree of asymmetry (or lack of symmetry) in the data, whereas kurtosis describes how peaked the frequency distribution is. Based on this property distributions can be classified as platykurtic (flatter than normal), mesokurtic (normal peakedness), or leptokurtic (more peaked than normal).

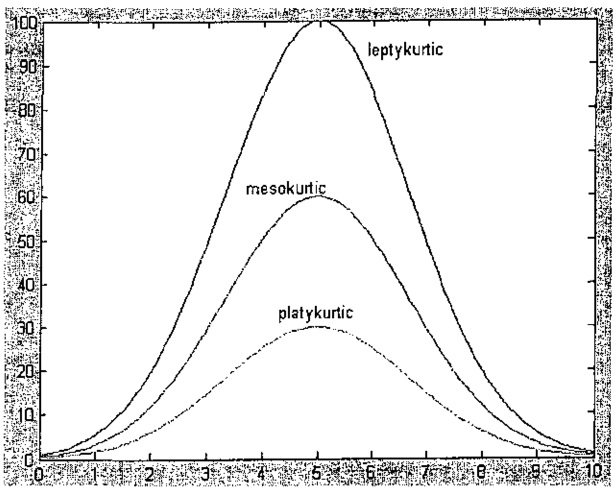

Figure 4.2: Classification of curves based on kurtosis

The descriptive statistics for original data set, training data set, validation data set and testing data set are shown in Appendix 4.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Result	625	.0	18.6	.676	1.7082
TI10205.pv	625	5.130378087574E1	6.781396031698E1	6.05055078392017E1	1.777777075063569E0
Valid N (listwise)	625				

4.2.5 Normal Probability Plot

Probability is the basis for developing mathematical models of processes governed by 'chance effects", which are effects that cannot be controlled or predicted with certainty. It is useful in analyzing the outcomes of experiments. The normal probability plot is a graphical technique for assessing whether or not a data set is approximately normally distributed. Normal Probability Plot is constructed to all 11 inputs and 8 outputs to see whether the data set are normally distributed or not. All figures from Appendix 5 show nearly linear pattern (some have short tails and some have long tails) proved that the data are normally distributed except from output C2, iC5, nC5 and C5+ and there are only minor deviations from the line fit to the points on the normal probability plot. It is further proved that, the data of these 4 outputs should be eliminated from the network construction.

4.2.6 Linear Regression

Plot of inputs versus output are performed in observing the trend of the inputs towards output. Refer Appendix 7 for sample graph of inputs versus output C3 and i-C4 showing the trend of inputs and outputs.

4.2.7 ANOVA Test

In summary, from Appendix 6, it is noticed that the variances for all the four sets are nearly the same with the original set of data with error of ±0.6 to ±0.8. The ANOVA test was done for all the variables of the debutanizer column; the input parameter and outputs,

The term '*Average*' is the average value of groups involve. *Variance* is the mean squared variation. '*F* value' is for testing the hypothesis that the group means are equal. Thus if the null hypothesis is correct we expect '*F* value' to be about 1, whereas large *F* indicates a location effect. The term '*d.f.*' is the number of degrees of freedom. '*Mean Square*' is the sum of squares divided by the degrees of freedom. The term '*SS*' is the sum of squares.

The '*F* critical', will determine whether or not there is statistical evidence to claim that the variance is random or due to chance. '*P-value*' reports the significance level. The '*P-value*' is greater than 0.05, and this shows that the original, training, validation and testing data is statistically the same.

ANOVA test proves further that the minor differences seen are not statistically significant. Thus we see that the three-segmented data sets can be assumed to have the same characteristics as the original set of data. Refer to Appendix 6 for ANOVA Test result.

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	TI10205.pv[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Result

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.189[a]	.036	.034	1.6789

a. Predictors: (Constant), TI10205.pv

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	64.732	1	64.732	22.965	.000[a]
	Residual	1756.103	623	2.819		
	Total	1820.835	624			

a. Predictors: (Constant), TI10205.pv

b. Dependent Variable: Result

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-10.286	2.288		-4.495	.000
	TI10205.pv	.181	.038	.189	4.792	.000

a. Dependent Variable: Result

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

As a conclusion for this report, here, I would like some advantages of this project. The Statistical Process Control for this project expected to be effective method of monitoring a process through the use of Control charts enable the use of objective criteria for distinguishing background variation from events of significance based on statistical techniques. Much of its power lies in the ability to monitor both process center and its variation about that center.

By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. With its emphasis on early detection and prevention of problems, SPC has a distinct advantage over quality methods, such as inspection, that apply resources to detecting and correcting problems in the end product or service.

Finally, I hope that with this project, I will enhance my skills in the process of applying knowledge, expanding thoughts, solving problems independently and presenting findings through guidance and supervision. I also hope this project will expand and apply my knowledge on statistical process control as I go through. For the PPTSB, hopefully this project can be implementing to real operation line in order to improve the performance of the debutanizer column operation.

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3. http://en.wikipedia.org/wiki/SPSS

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5. http://books.google.com.my/books?id=JLm1r6rUAdcC&dq=statistical+process+control&source=gbs_summary_s&cad=0

6. http://www.asq.org/learn-about-quality/statistical-process-control/overview/overview.html

7. https://www.goldpractices.com/practices/spc/index.php

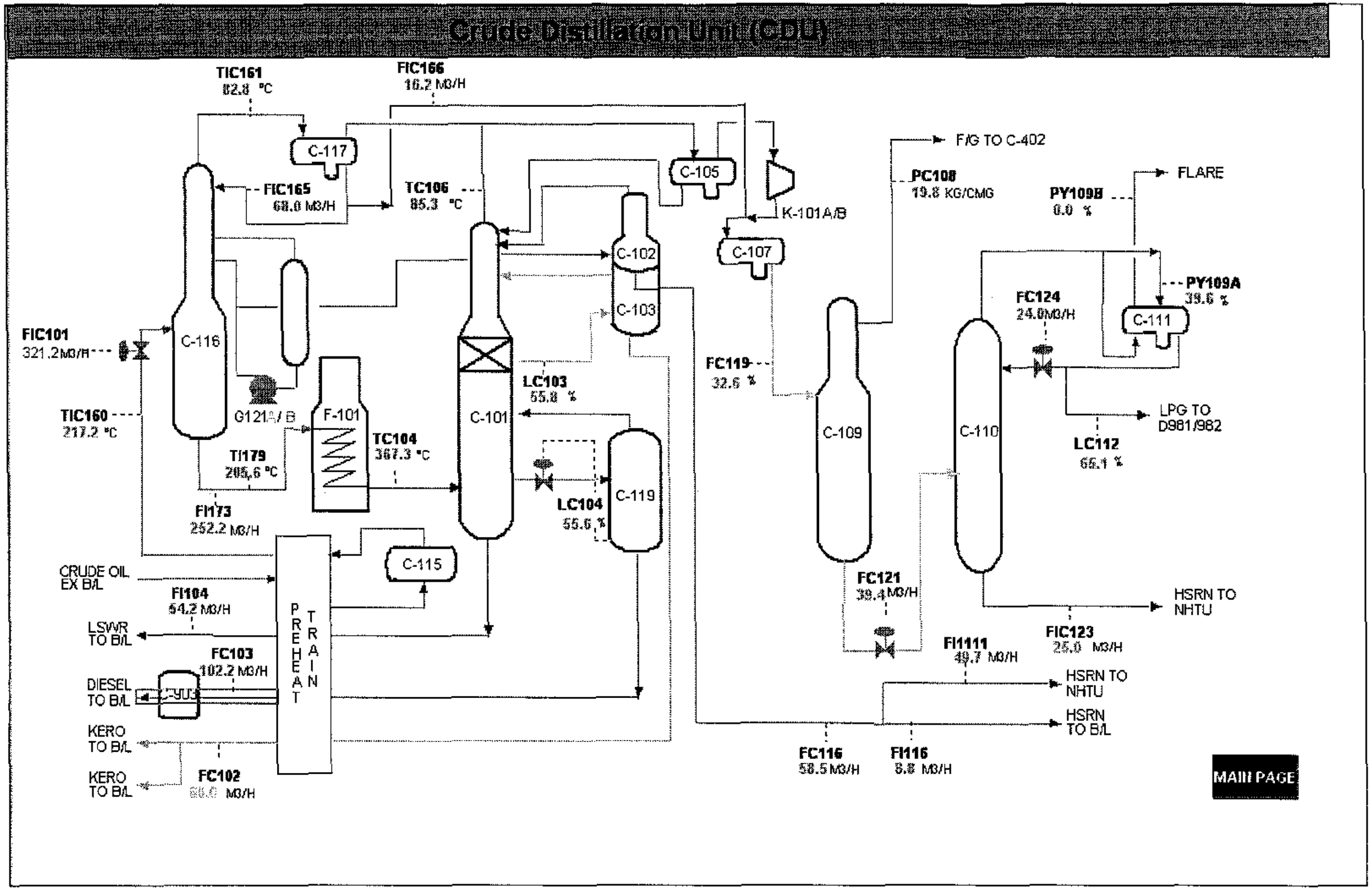

Figure 1.1: Crude Distillation Unit (CDU) Section Simplified Flow Diagram

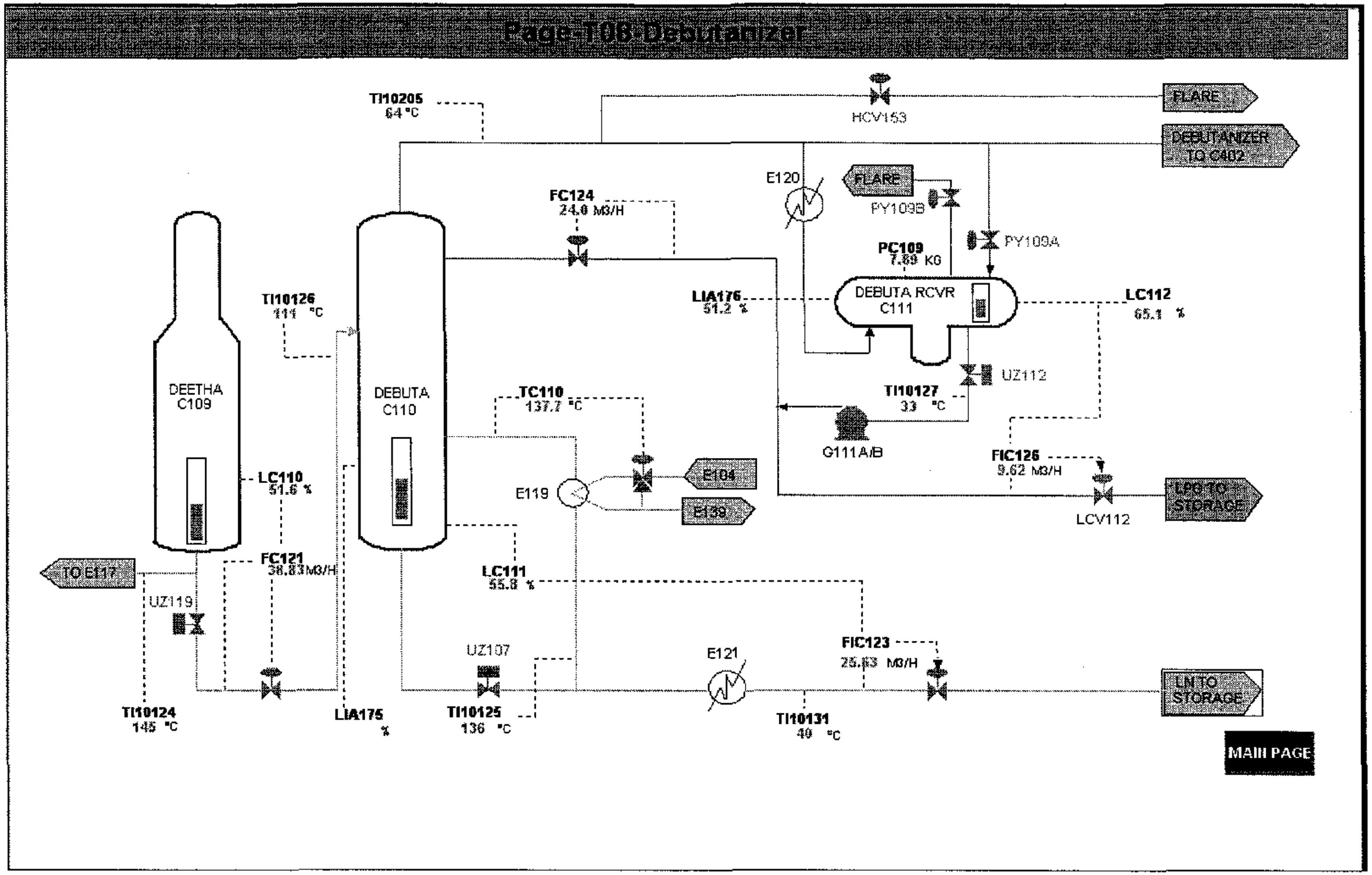

Figure 1.2: Debutanizer Column Section Simplified Flow Diagram

4.2.1 Data Analysis: Line Chart

Tag Name Temperature versus Time

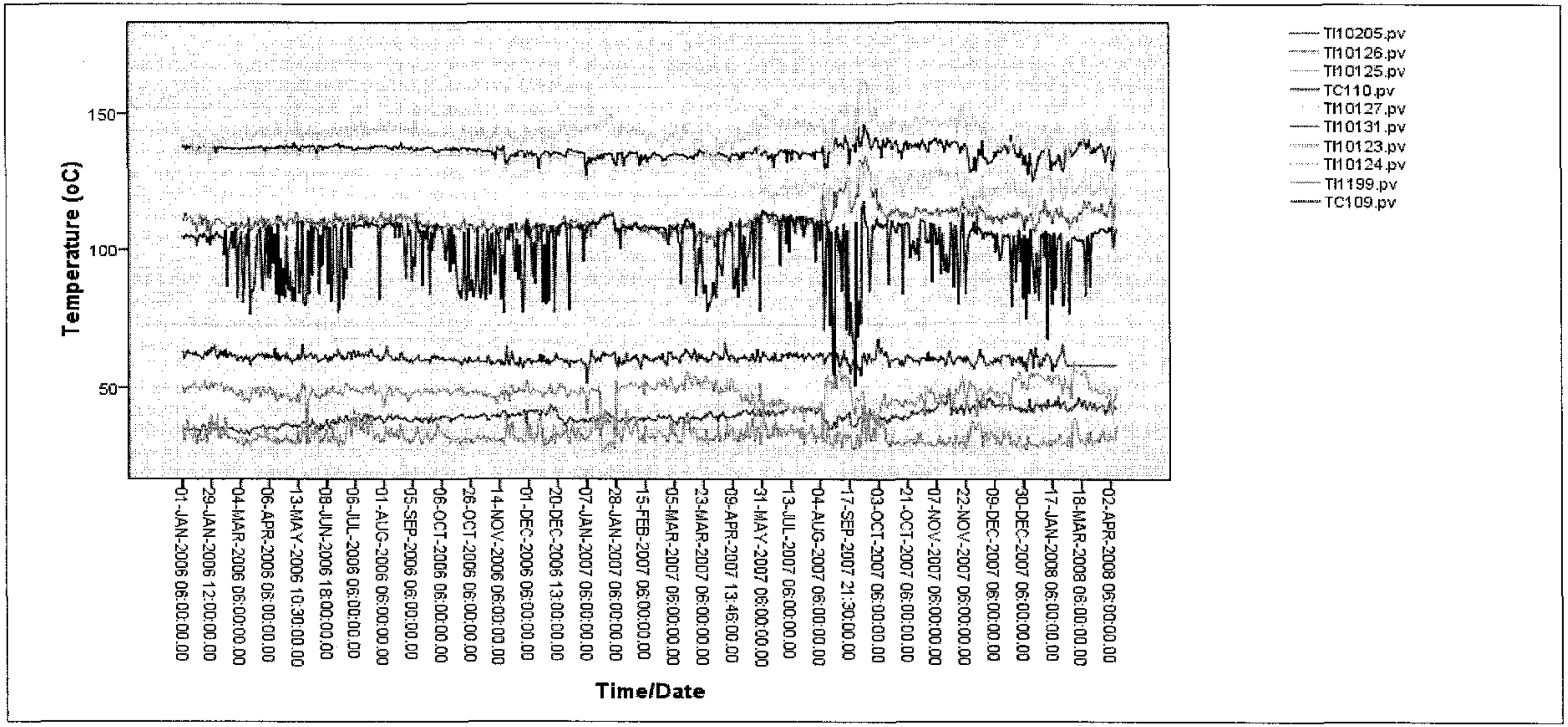

Figure 4.1: Line chart for combine all tag name temperature versus time.

Tag Name Level versus Time

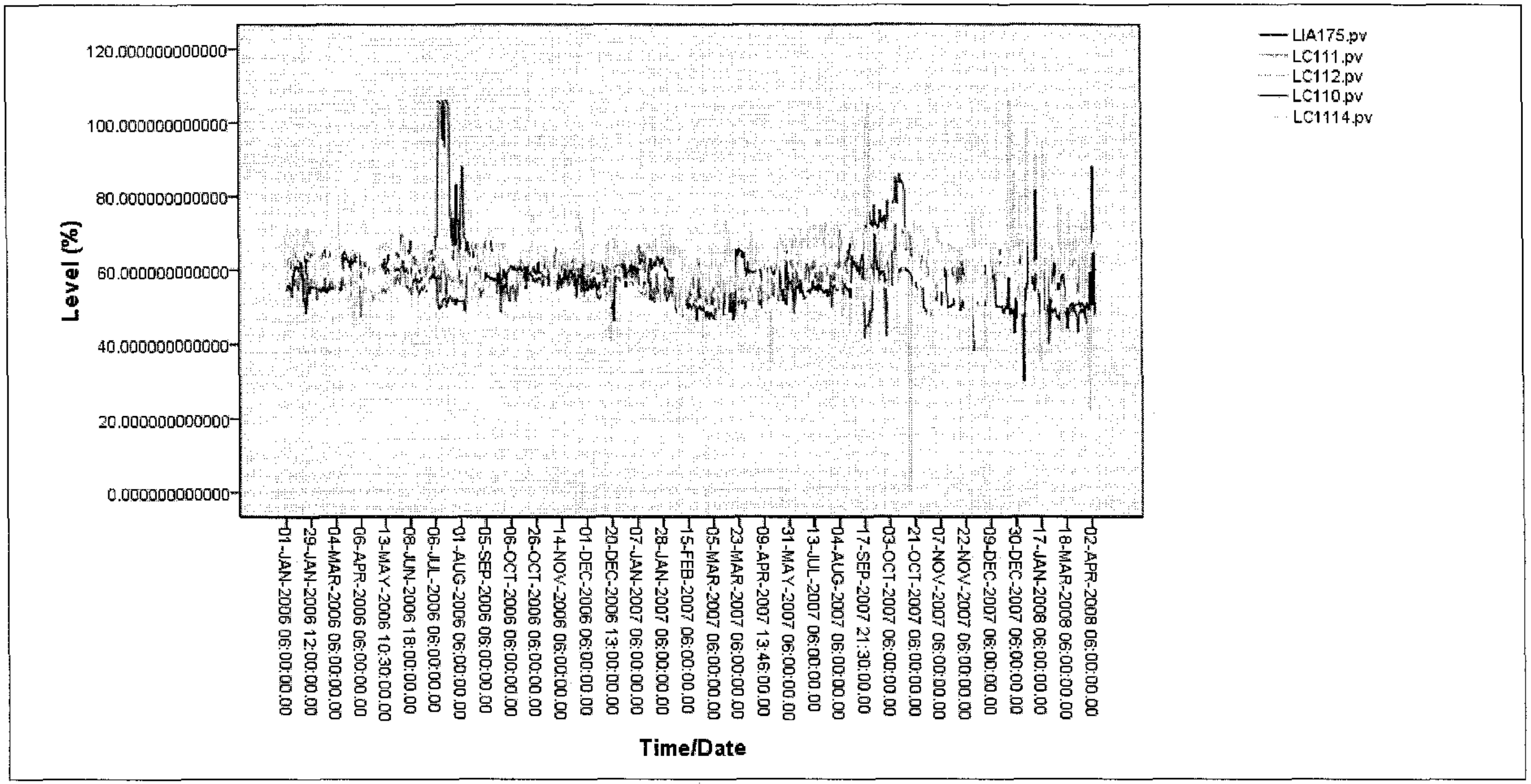

Figure 4.2: Line chart for combine all tag name level versus time.

Tag Name Flowrate versus Time

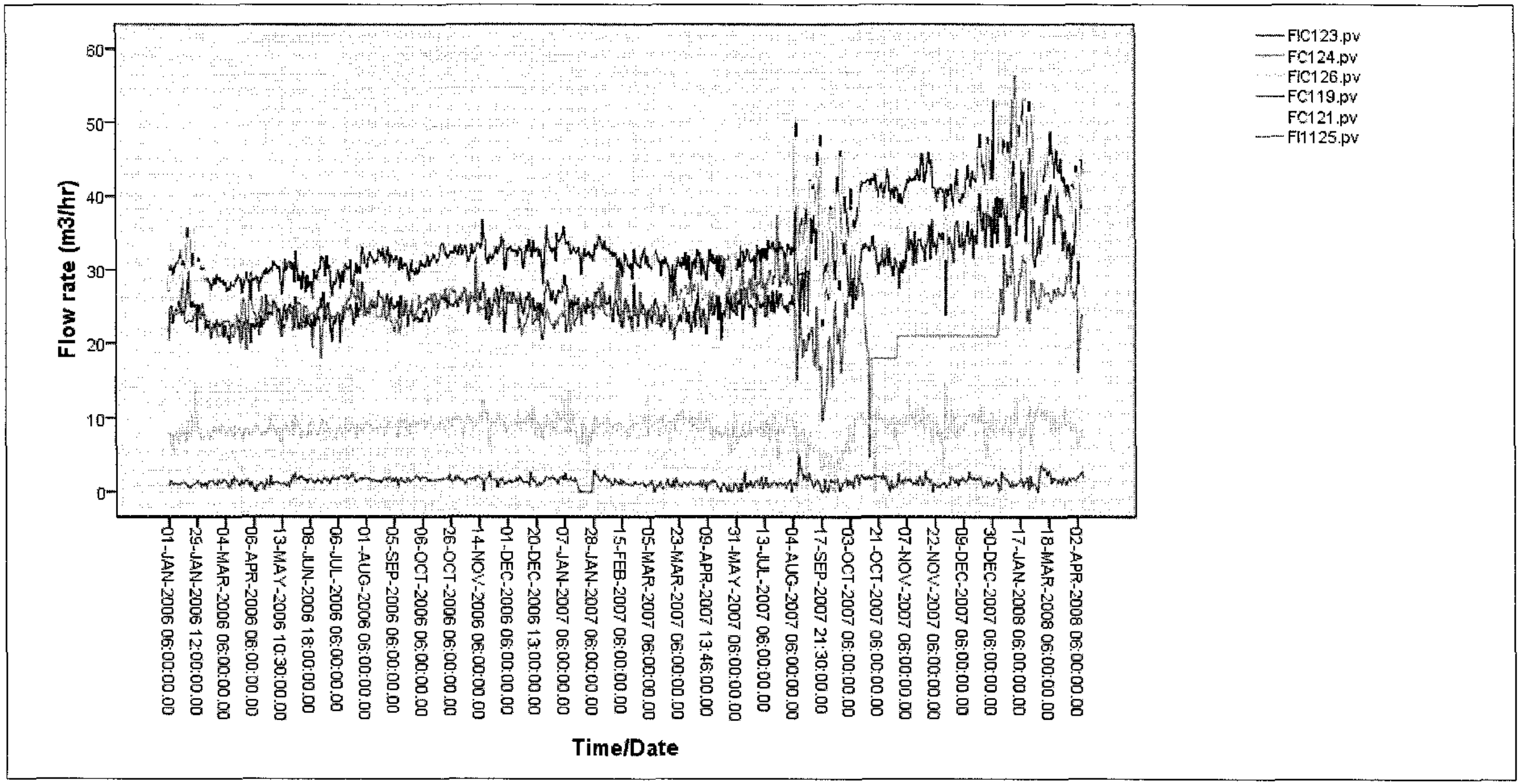

Figure 4.3: Line chart for combine all tag name flowrate versus time.

Composition C2 (%) versus Time

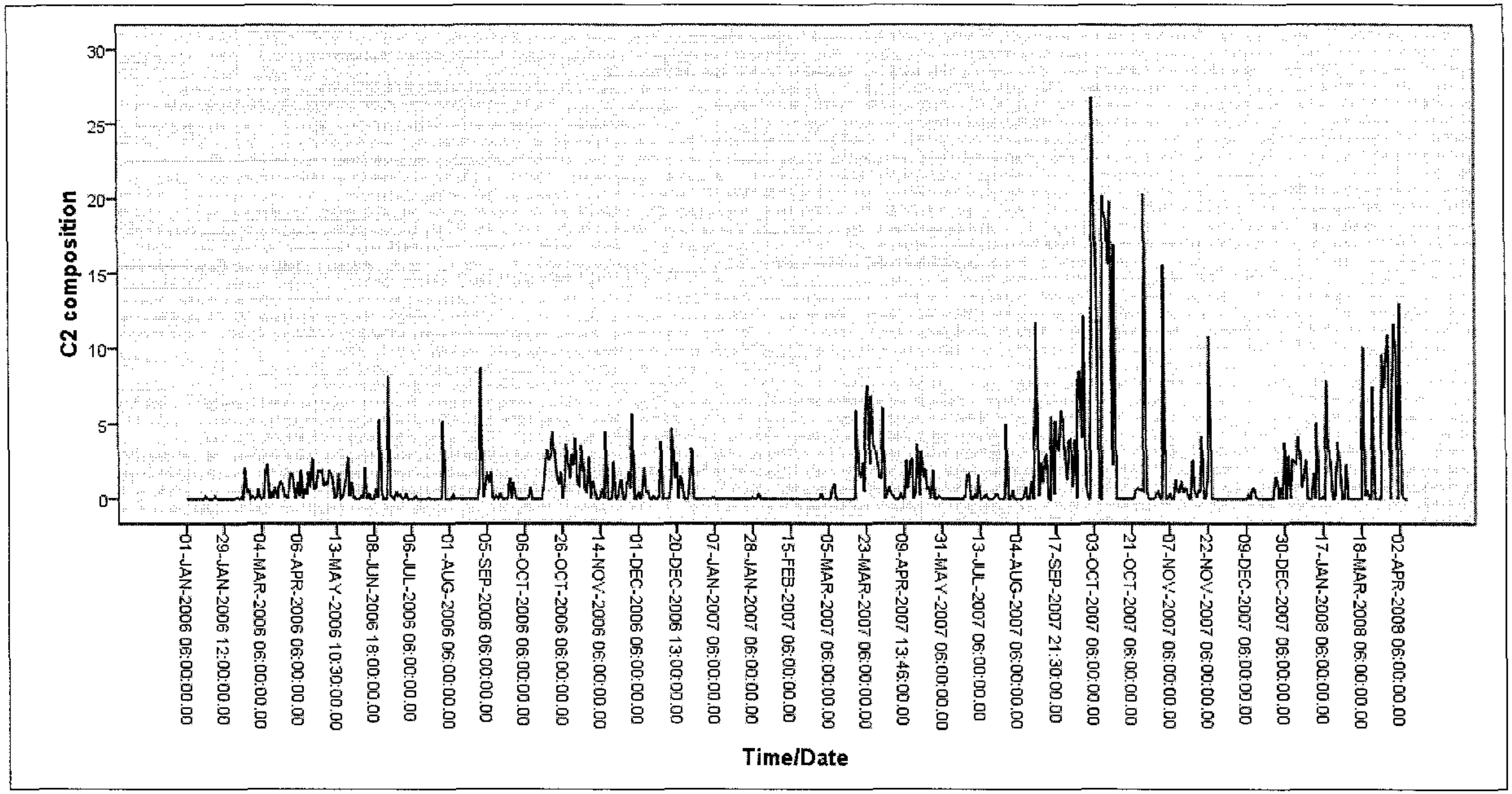

Figure 4.4: Line chart for composition C2 versus time.

Composition C3 (%) versus Time

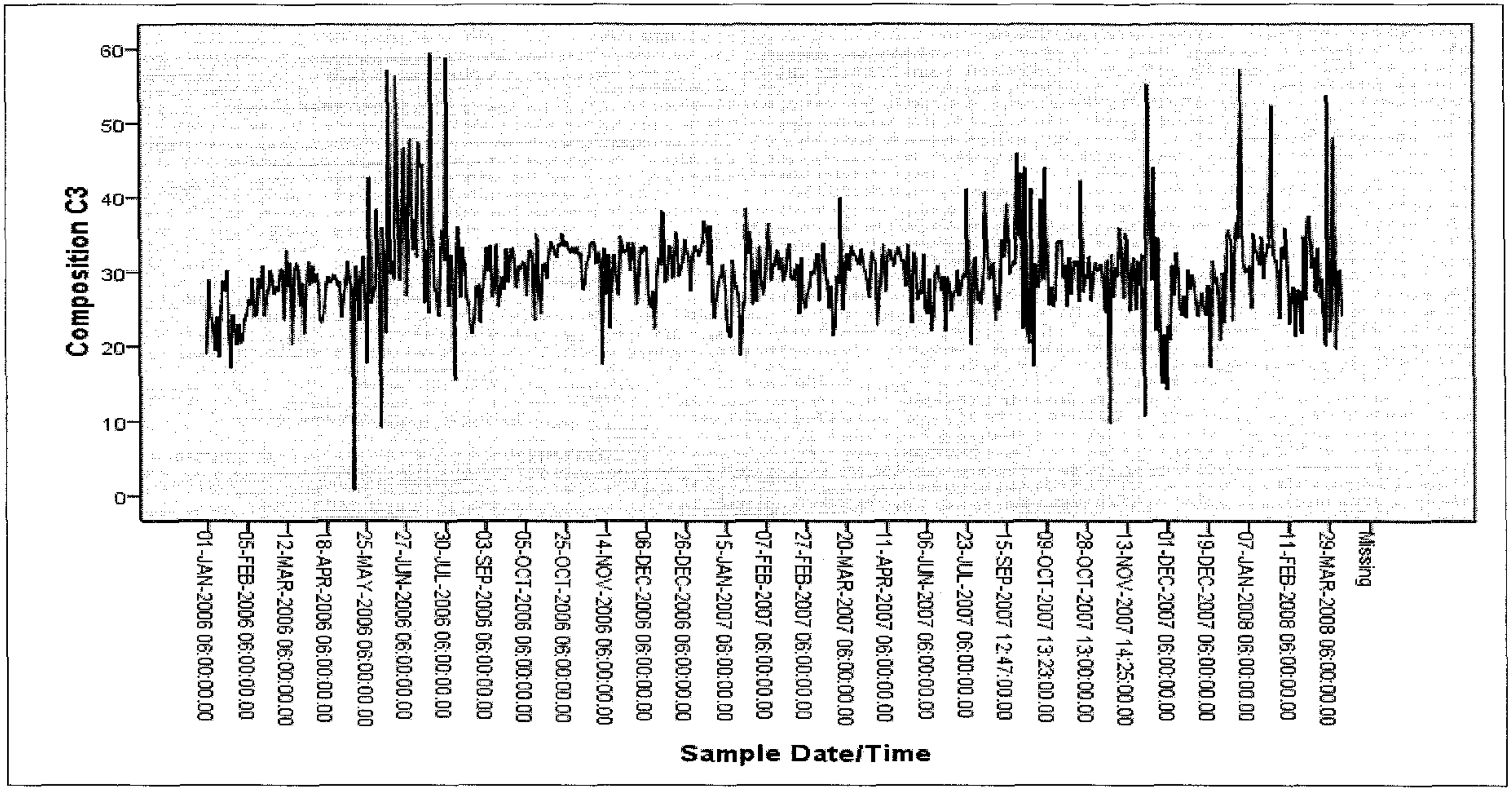

Figure 4.5: Line chart for composition C3 versus time.

Composition iC4 (%) versus Time

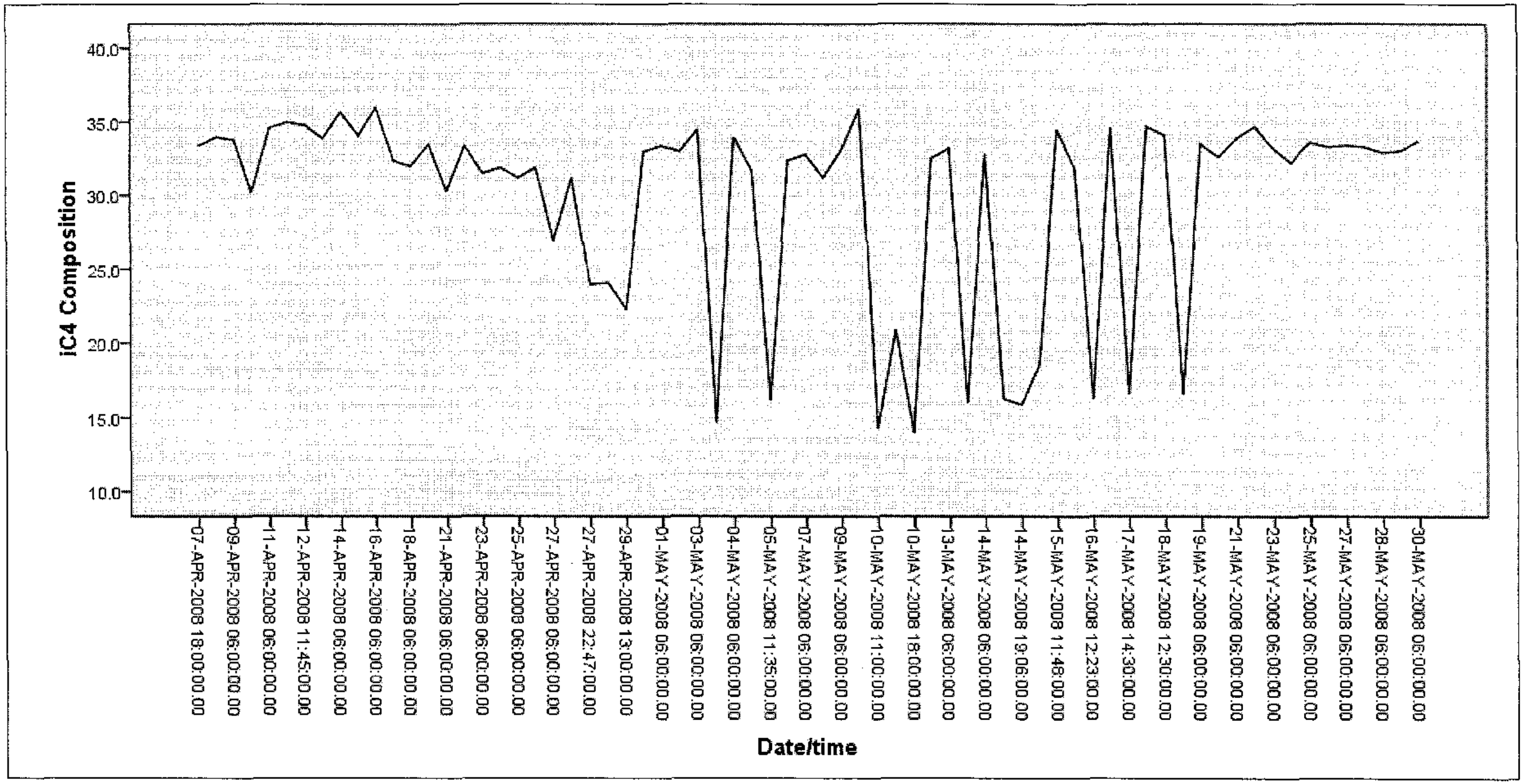

Figure 4.6: Line chart for composition i-C4 versus time.

Composition n-C4 (%) versus Time

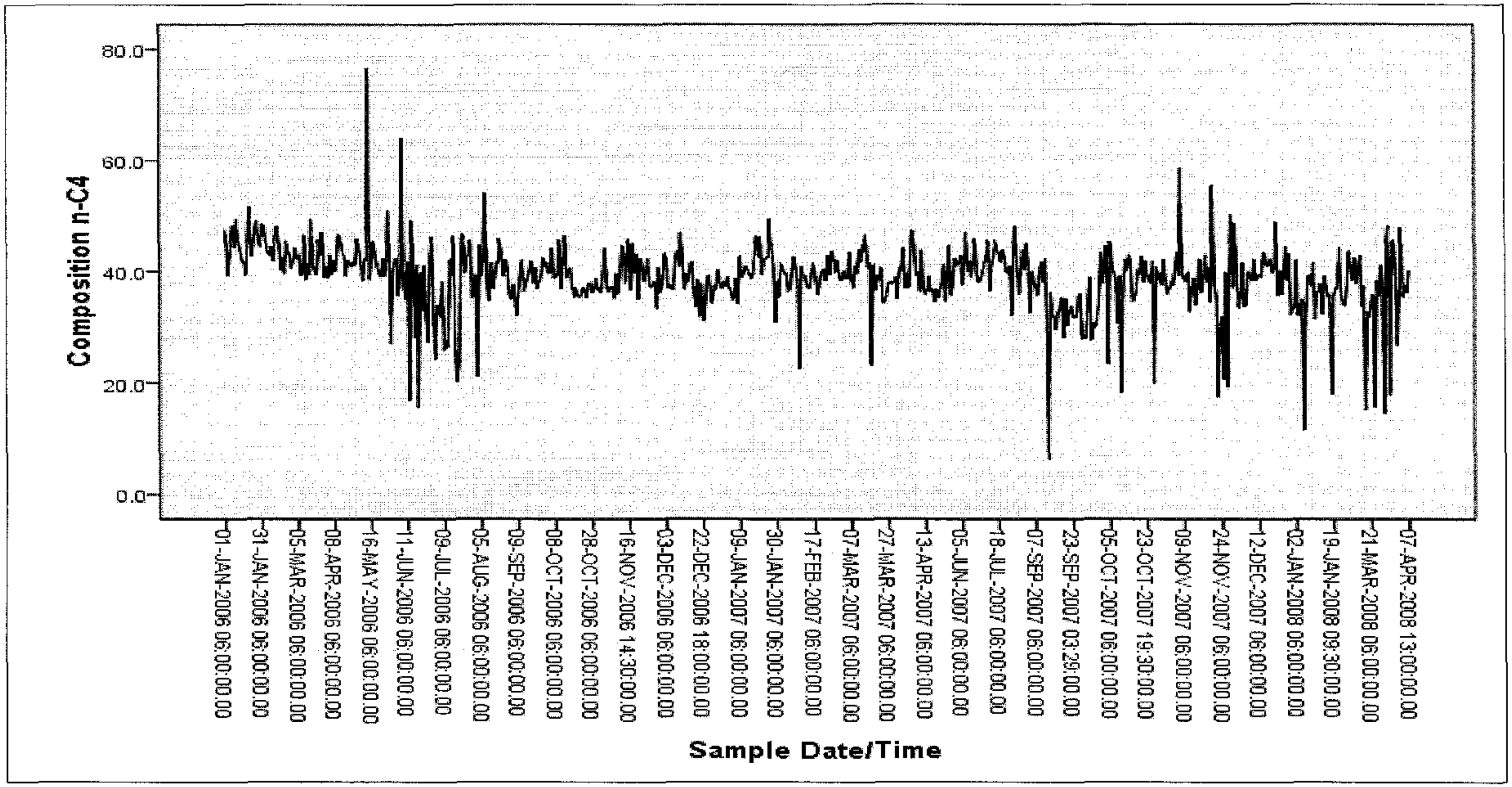

Figure 4.7: Line chart for composition n-C4 versus time.

Composition i-C5 (%) versus Time

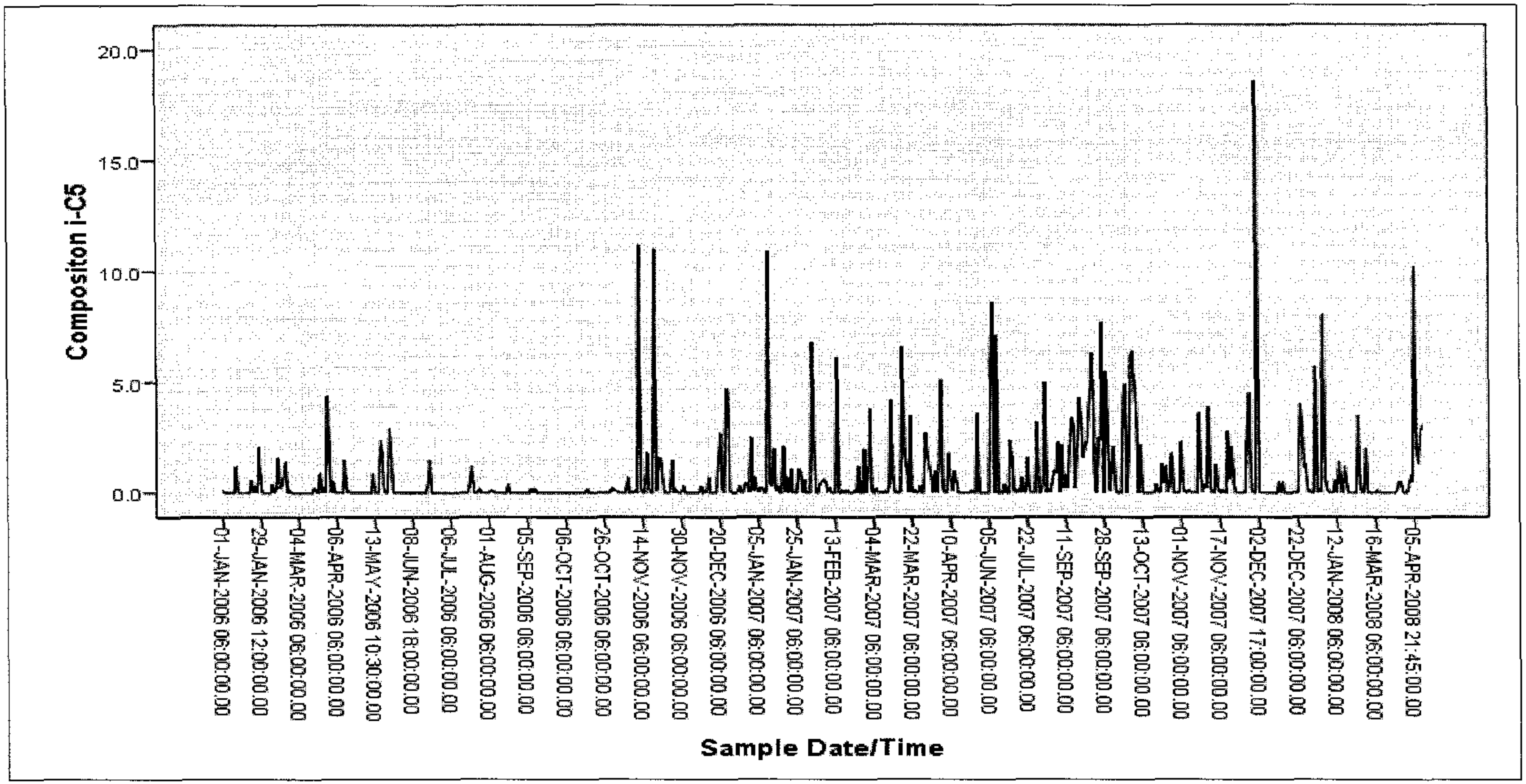

Figure 4.8: Line chart for composition i-C5 versus time.

Composition n-C5 (%) versus Time

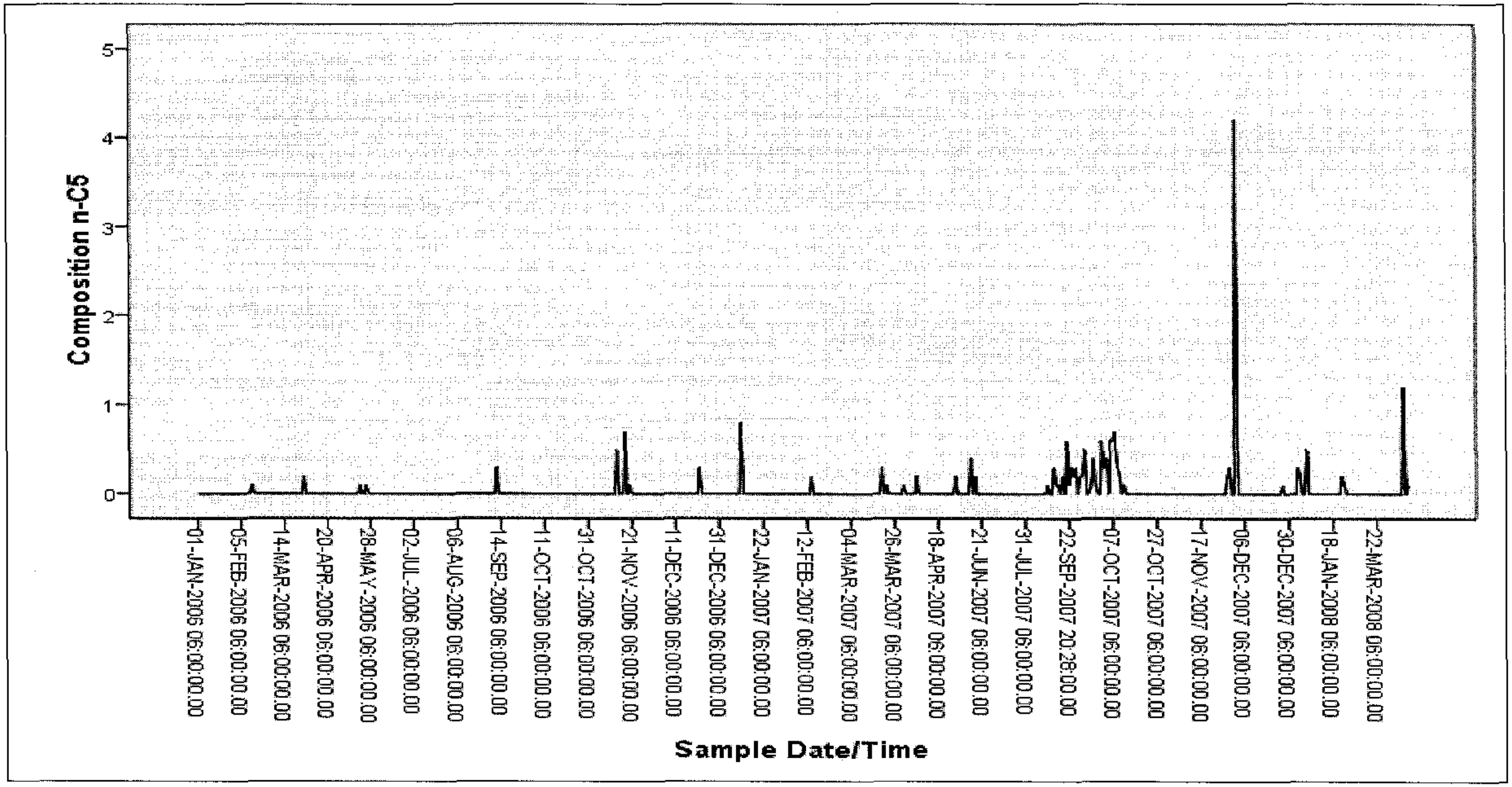

Figure 4.9: Line chart for composition n-C5 versus time.

Composition LPG (%) versus Time

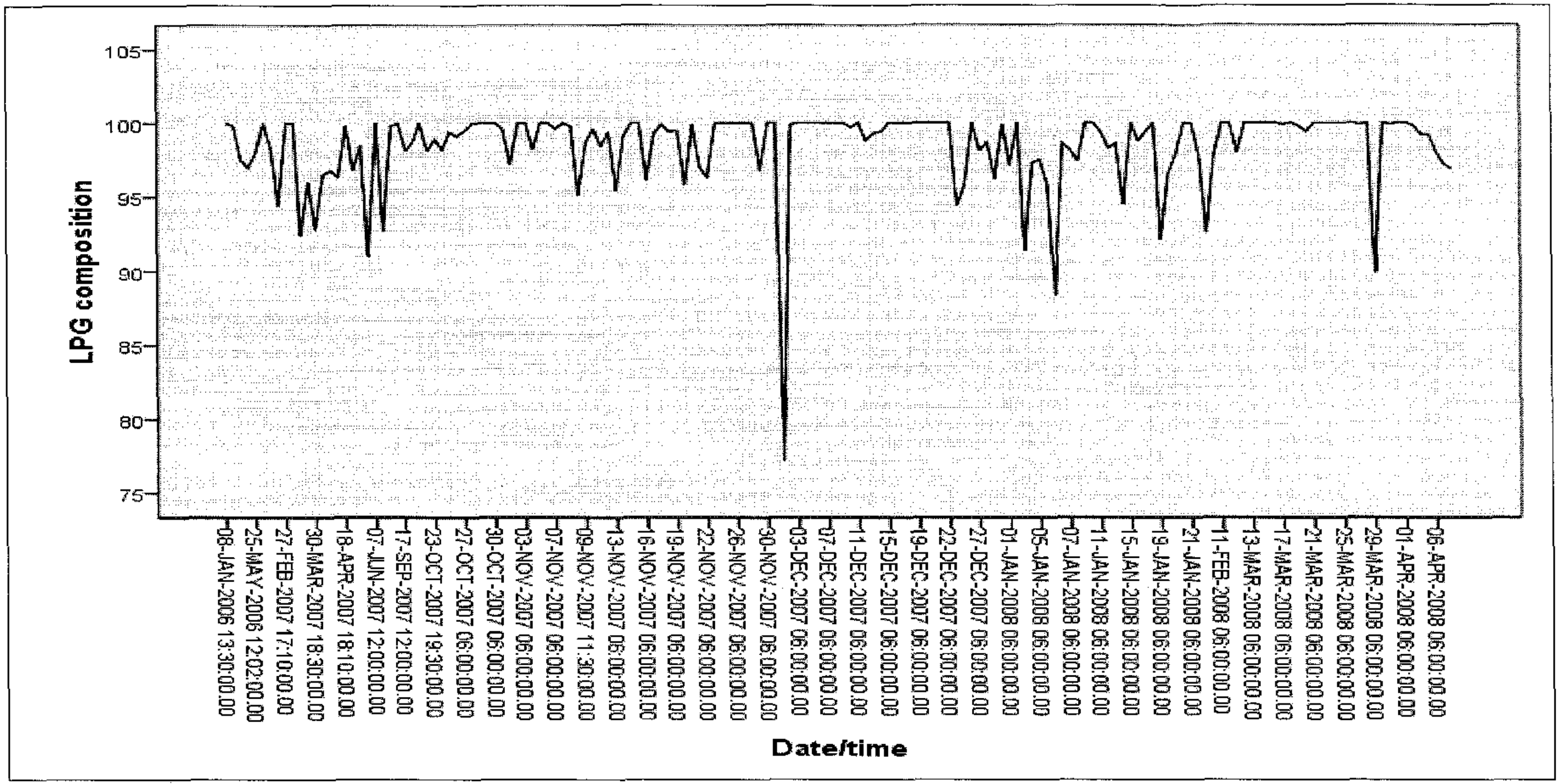

Figure 4.10: Line chart for composition LPG versus time.

Debutanizer Top Temperature, TI10205.pv (^{o}C) versus Time

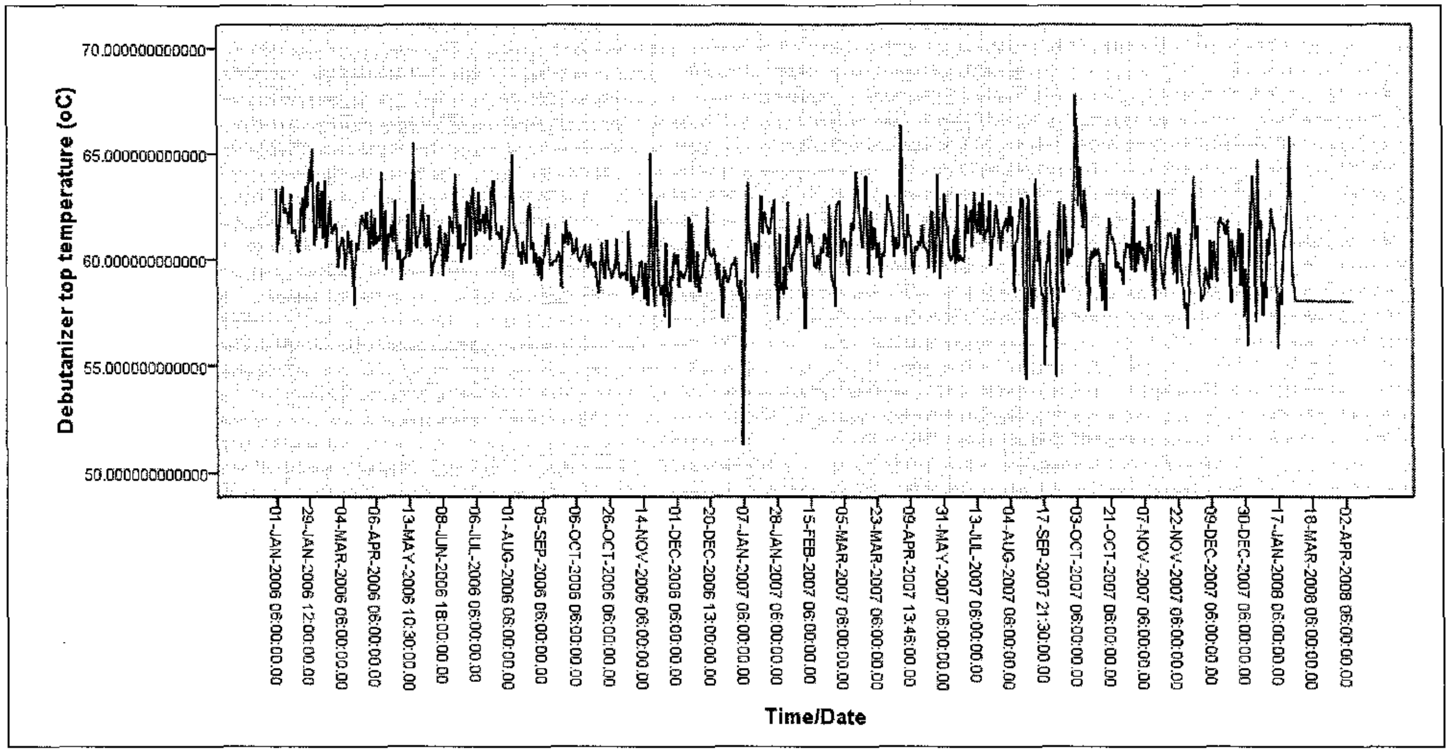

Figure 4.11: Line chart for Debutanizer Top Temperature (*TI10205.pv) versus *time.

The other line chart also produced by using another remaining tag name temperature (TI10126.pv, TI10125.pv, TC110.pv, TI10127.pv, TI10131.pv, TI10123.pv, TI10124.pv, TI1199.pv, and TC109.pv).

Debutanizer Level, LIA175.pv (%) versus Time

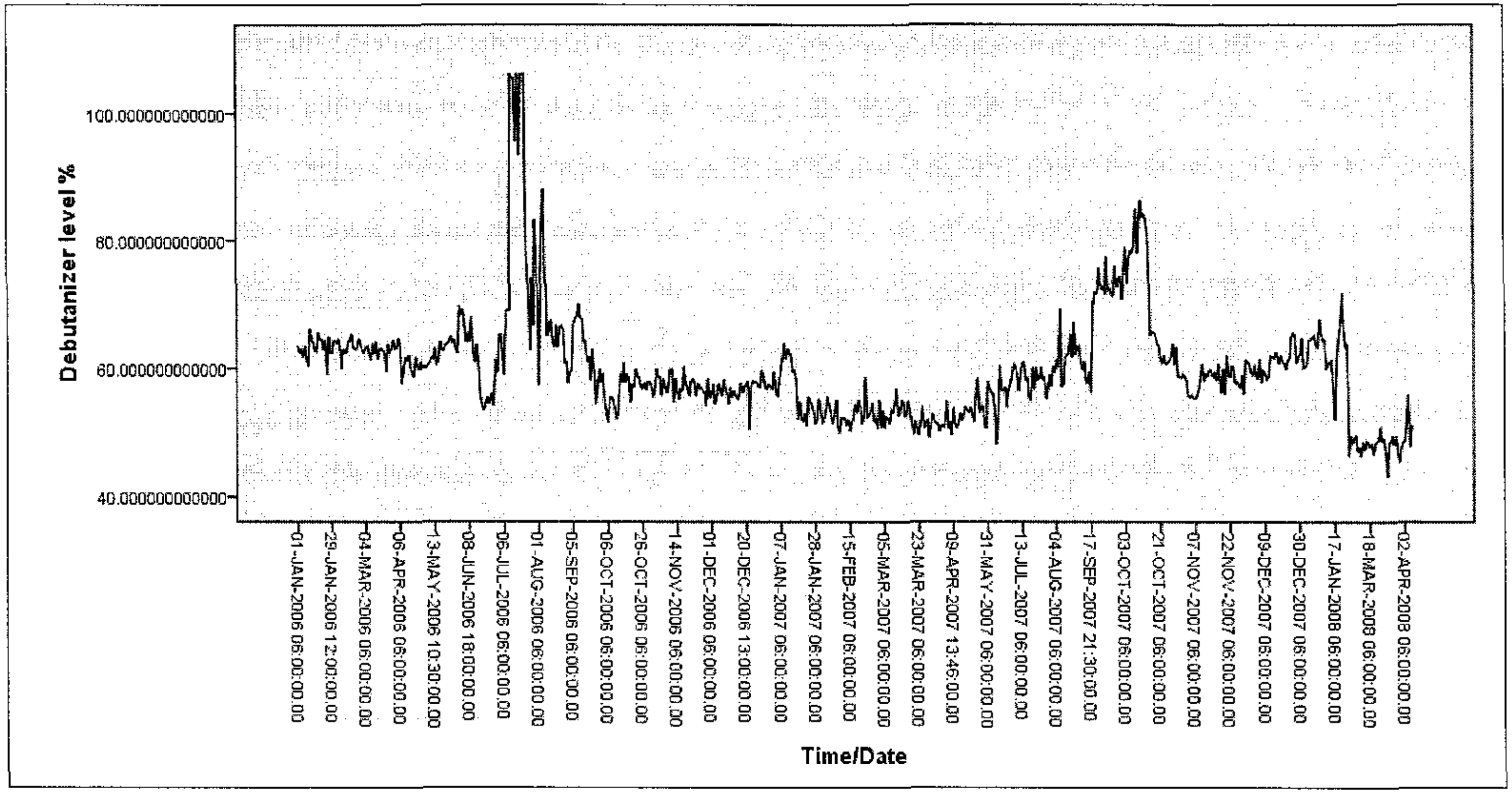

Figure 4.12: Line chart for Debutanizer Level (LIA175.pv) versus time.

The other line chart also produced by using another remaining tag name level (LC111.pv, LC112.pv, LC110.pv, LC114.pv).

Light Naphtha flow, FIC123.pv (m^3/hr) versus Time

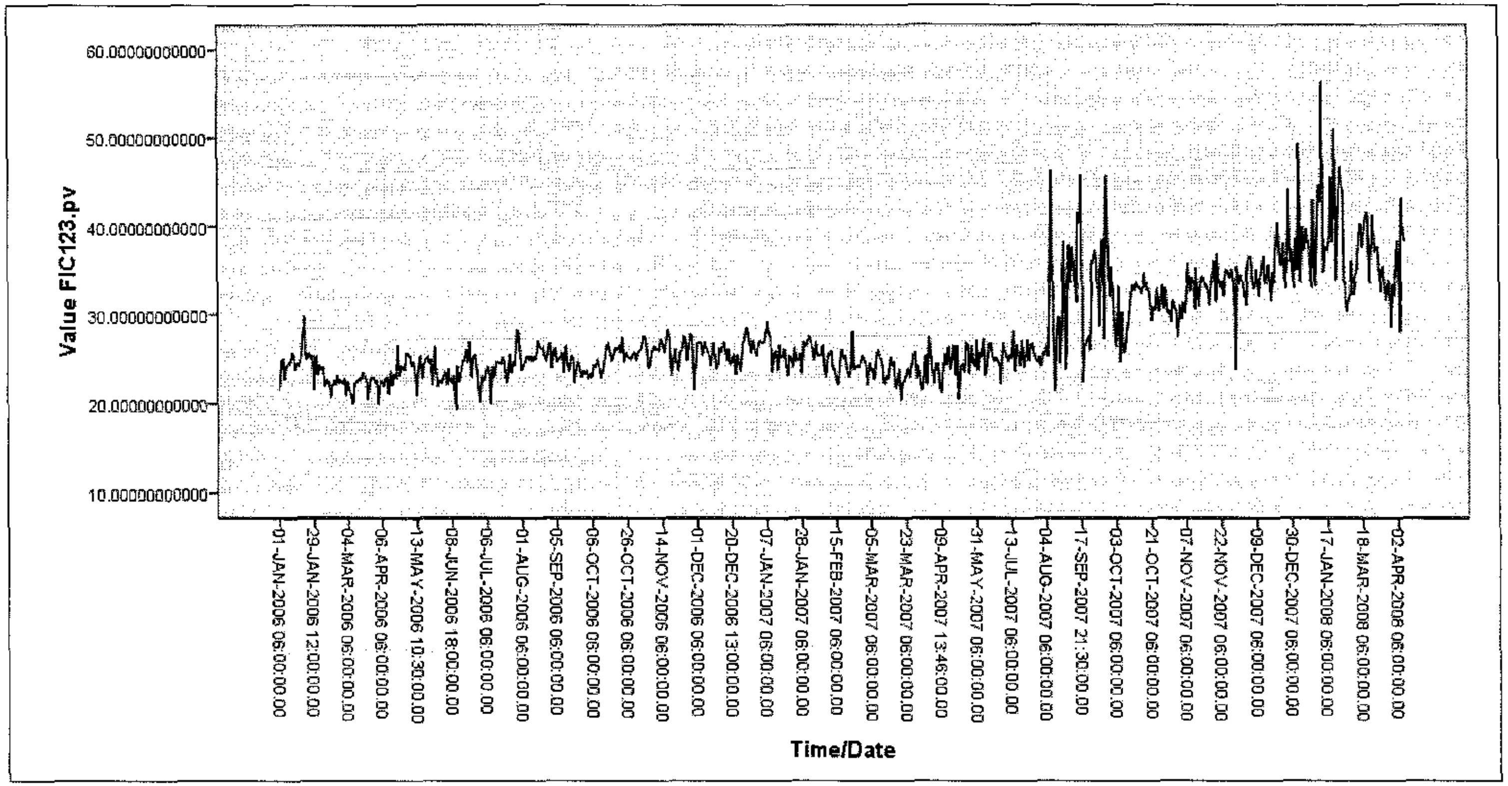

Figure 4.13: Line chart for Light Naphtha flow (FIC123.pv) versus time.

The other line chart also produced by using another remaining tag name flowrate (FC124.pv, FIC126.pv, FC119.pv, FC121.pv, FI1125.pv, FI120.pv).