TIME SERIES MODELLING OF A HIGH RATE ANAEROBIC DOWNFLOW STATIONARY FIXED FILM REACTOR

BY

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ABSTRACT

A two phase experimental program was conducted on a high rate anaerobic downflow stationary fixed film (DSFF) pilot plant over a period of four months to allow evaluation of three input variables: influent COD concentration, volumetric organic loading, and hydraulic retention time.

It was found from the results of the first phase experimental program that the performance of the DSFF reactor treating dairy wastewater is limited by the levels of solids and volatile fatty acids content of the effluent. However, COD removal efficiencies up to 85% and a rate of gas production up to 4.30 m3/m3/day were achieved depending on operational conditions.

The statistical analysis of operating data resulted in the conclusion that when individual control variables, ie. influent COD concentration, flow rate, and volumetric organic loading, were used a relation between the individual control variables and effluent concentration does not exit. However, when the control variables were analyzed together, 60% of the variance of effluent filtered COD, 42% of the variance of acetic acid content of the effluent, 77% of the variance of gas production, and 85% of the variance of

substrate removal rate were explained by the three control variables. The remaining unexplained variations are inherent to the process itself.

Box - Jenkins time series modelling enables to predict the effluent filtered COD using both volumetric organic loading and influent filtered COD concentration.

RESUME

Un programme expérimental fut mené lors d'une étude pilote consistant en un digesteur anaerobique de haute performance à biofilm fixe (DSFF), sur une période de quatre mois divisée en deux phases, permettant l'évaluation de trois variables: concentration de la DCO à l'influent, charge organique volumétrique et temps de rétention hydraulique.

A partir des résultats obtenus lors de la première phase expérimentale, nous avons trouvé que la performance du reacteur DSFF traitant des eaux résiduaires de laiterie est limitée par les niveaux de solides et acides organiques volatils dans l'effluent. Cependant, l'efficacité de traitement de la DCO a atteint 83% et un niveau de production de gas de 4.30 m3/m3/jour dépendant des conditions d'operation.

Les analyses statistiques des données empiriques ont permis de conclure qu'aucune relation consistante n'existe entre les variables individuelles de controle et la concentration de l'effluent. Cependant, quand les variables de controle sont analysees ensemble, 60% de la variance de DCO filtree, 42% de la variance du contenu en acide acetique

de l'effluent, 76% de la variance de la production de gaz, 85% de la variance des vitesses d'élimation sont expliquees par les trois variables de controle. La variance non-expliquée est due au procédé de traitement.

L'utilization de la methode Box - Jenkins permet de prevoir le DCO filtree à la sortie en utilisent la charge organique volumétrique et la concentration de la DCO filtree à l'influent

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ABBREVIATIONS AND SYMBOLS

AIC	-	Akaike information criterion
ANOVA	-	analysis of variance
ARIMA	-	autoregressive integrated moving average
Avg	-	average
B	-	backward shift operator
b	-	time delay of the system
BOD, DBO	-	biochemical oxygen demand
BOD5	-	5-day biochemical oxygen demand
Ca	-	calcium
$CaCO_3$	-	alkalinity as calcium carbonate
°C	-	Celsius
COD, DCO	-	chemical oxygen demand
CO_2	-	carbon dioxide
CH_4	-	methane
cm	-	centimeter
C2	-	acetic acid
C3	-	propionic acid
C4	-	butyric acid
DSFF	-	downflow stationary fixed film reactor
ECOD	-	effluent total COD
EFCOD	-	effluent filtered COD
ESS	-	effluent suspended solids
EVSS	-	effluent volatile suspended solids

°F	-	Fahrenheit
FCOD	-	filtered COD
Hrs	-	hours
H_2	-	hydrogen
HCO_3	-	bicarbonate
HRT	-	hydraulic retention time
ICOD	-	influent total COD
IFCOD	-	influent filtered COD
K	-	number of parameter in transfer function noise model
kg	-	kilogram
l	-	litre
mm	-	millimeter
m^3	-	cubic meter
mg	-	milligram
Mg	-	magnesium
Na	-	sodium
N_2	-	nitrogen
PSRRF	-	percentage of substrate removal as filtered COD
PSRRT	-	percentage of substrate removal as total COD
(r, s)	-	transfer function orders
r^2	-	Pearson correlation coefficient
R^2	-	coefficient of determination
r_a^2	-	autocorrelation of model residuals

r^2_{xa}	-	crosscorrelation of prewhitened input and model residuals
RBC	-	rotating biological contactor
SRRF	-	substrate removal rate as filtered COD
SRRT	-	substrate removal rate as total COD
SS	-	suspended solids
STP	-	standard temperature and pressure
τ	-	the process time constant
TEMP	-	temperature
TCOD	-	total COD
VFA	-	volatile fatty acids
VF	-	volumetric organic loading as filtered COD
VL	-	volumetric organic loading as total COD
VSS	-	volatile suspended solids
%	-	percent
ω, δ	-	transfer function model's parameters, same as NUM and DEN respectively in Appendices A - C
ϕ, θ	-	noise model's parameters, same as AR and MA respectively in Appendices A - C

1. INTRODUCTION

The anaerobic sludge digestion process is not a recent development. At least 100 years ago in France, Louis Mouras designed and constructed fermenters to liquefy the sludge obtained from domestic wastes (Buswell, 1964). Since the turn of the century, the anaerobic fermentation process has been used extensively in the treatment of wastewater solids, ie. sludge. However, the first digesters were used primarily as storage basins. It has only been recently that new anaerobic digestion processes have evolved either up to pilot or full scale operation for application to low, medium, and high strength organic wastes, and for methane production from biomass as a renewable source of energy.

It has been pointed out that anaerobic treatment of organic wastes may be described as a sequential three step process involving the conversion of complex organic material found in the wastes to simpler soluble organic compounds (Kormanik, 1968). The soluble organics are then converted by acid forming bacteria into short chain fatty acids, called volatile acids, ie. ultimately acetic acid, as well as carbon dioxide, hydrogen and other end products. Finally, the volatile fatty acids are converted into methane and carbon dioxide by methane forming bacteria. Other acids must first be fermented to acetic acid (Kormanik, 1968; Toerien and Hattingh, 1969; Henze and Harremoes, 1983).

Studies on anaerobic digestion treatment and its application over a number of years have demonstrated that certain factors influence digestion. It has been found that the potential factors influencing the performance of a specific digester are organic and hydraulic loading, toxic overloading, the temperature of operation, the design of the digester, the mode of operation, and the source of inoculum of microorganisms required to digest the substrate (Kotze et al, 1969; Graef and Andrews, 1974; Henze and Harremoes, 1983).

The following factors are most frequently used to characterize a digester and are normally used to indicate the course of anaerobic digestion: pH, alkalinity, volatile fatty acid concentration, the rate of gas production and gas composition.

The development of high - rate methane fermentation has produced a variety of process configurations to satisfy the need for greater efficiency and economy in the treatment of municipal and industrial wastes. Several have been studied on laboratory scale, and only a few have been demonstrated at full scale (Heertjes and Van der Meer, 1979). A common aspect among these systems is the retention of active microbial biomass in the digester, instead of allowing it to escape with the treated effluent, thus developing a long solids retention time which allows operation with a relatively short hydraulic retention time, increasing process stability and decreasing reactor volume (Young and McCarty, 1969; Van den Berg and Lentz, 1979).

The present project is concerned only with a high - rate downflow stationary fixed film (DSFF) anaerobic reactor. The downflow stationary fixed film reactor recently developed at the laboratories of Canada's National Research Council has alleviated many of the problems that are associated with conventional anaerobic digestion. According to Van den Berg and Lentz (1979), Kennedy and Van den Berg (1981, 1982), and Van den Berg and Kennedy (1981, 1982), the process has provided adequate treatment of medium and high strength wastes, could be changed over from one waste to another without adverse effects, could be operated at temperatures as low as 10°C, and could handle severe organic and hydraulic overloading, both intermittent and continuous. Furthermore, these studies have implied that the process is available to treat soluble and concentrated wastes, without the need for solids recycle.

Many food and dairy operations produce large quantities of high strength waste effluents that constitute a major disposal problem. Many of these streams are soluble, yet have a BOD, and/or COD in the range of 40 mg/l - 48000 mg/l (Harper et al, 1971; Brown and Pico, 1979). The high strength of the wastes makes conventional aerobic treatment very difficult and expensive. Therefore, the DSFF's ability makes it ideally suited for such applications.

Despite the widespread application of the anaerobic digestion processes and its theoretical benefits, the design and operation of these systems have been very conservative, primarily because of the debate that exists amongst researchers about the degree of empiricism that prevailed in the design and operation. While recent studies have significantly increased the understanding of the microbiology and biochemistry, and factors influencing anaerobic digestion treatment, a more rational approach to the design and operation of the system is possible.

A survey of design and operation approaches presently being used to describe the anaerobic digestion process indicates that kinetic reaction relationships have been used successfully in predicting the performance of anaerobic processes treating municipal and industrial wastes.

The mathematical models are based on the assumption of steady state and/or use equilibrium relationships, stoichiometric coefficients, material balance relationships, mass transfer equations, and diffusinal coefficients to reflect the interactions which occur in and between the biological, liquid, and gas phase (Andrews and Graef, 1971). The extention of this approach to anaerobic fixed film reactors has provided a means for unifying the available data and serves as a quantitative basis in describing future process performance.

These models have proven their value on a qualitative basis by indicating needed changes in system analysis (Muller and Mancini, 1975; DeWalle and Chian, 1976; Rittmann and McCarty, 1980). However, in most instances, they are not adequate to describe process operation since the inputs are far from constant, and there are considerable variations in the effluent response with respect to time. An alternative to these types of models, although not necessarily a competing one, is dynamic modelling. One such method is the Box - Jenkins Time Series Analysis (Box and Jenkins, 1976). This method has been successfully applied to aerobic processes such as: activated sludge (Berthouex et al, 1978; Kenneth and Sims, 1981), rotating biological contactor (Filion et al, 1979), suspended growth systems

(Murphy et al, 1977), and to the biological fluidized bed process (Nutt et al, 1981). It was used to determine the extent to which treated effluent is related to the influent, and, to predict effluent response under different operational conditions.

The objectives of this present work were, therefore, to assess the influence of control variables on the performance of a high rate DSFF anaerobic reactor under different operating conditions; to determine the nature and extent of the variability in effluent quality and gas production; to identify factors contributing to this variability through statistical analysis of pilot plant data; to apply Box - Jenkins time series transfer function - noise models to characterize the dynamic response of a DSFF reactor under a given organic loading condition; and to develop a time series model to predict effluent response of the DSFF reactor. The resultant model, which relates effluent response to variations in the influent variables, defines indicators of process response such as the process time constant, the process steady state gain, and the process dead time.

To achieve the above objectives, a two phase experimental program was conducted on a high rate anaerobic

DSFF pilot plant at the Wastewater Technology Center, Canada Center for Inland Waters, Burlington, Ontario, over a period of four months, (December, 1983 to April, 1984), to allow evaluation of three input variables: influent substrate concentration (mg/l as COD), volumetric loading (kg COD/m3/day), and hydraulic retention time (days).

2. ANAEROBIC DIGESTION PROCESS OVERVIEW

2.1. A Brief History of The Anaerobic Digestion Process

Anaerobic digestion, as applied to wastewater treatment, appears to date from the Austin Tank by Metcalf, having first been constructed in 1857. About the same time, (1860), Louis H. Mouras, a French engineer, built the "Mauras Automatic Scavenger". Liquifaction of organic solids was the recognized effect of the action in these tanks and this was early attributed to anaerobic organisms by bacteriologists of the time (Buswell, 1964).

Separation of sedimentation and digestion by means of a two storey tank was the next development. The Travis Tank built in England and the Imhoff tank of Germany, circa 1907, were the most successful examples. The Imhoff tank found wide use in the U.S. largely because of its suitability to the hot summer climate (Buswell, 1964).

In the meantime, Imhoff and co-workers in Germany, and O'Schaugnessy in England had developed much of the basic chemistry and bacteriology required for starting and operating anaerobic sludge in either two storey or separate tanks (Buswell, 1964).

To summarize the situation, as of 1925, anaerobic digestion had the following characteristics : (1) It produced an inoffensive stable sludge which dried easily to a disposable consistency; (2) Approximately half of the organic matter was converted to a gas and the BOD of the sludge was reduced by an equivalent amount; (3) The process required a large inoculum and thorough mixing; (4) If insufficiently seeded, acids developed and the formation of methane was partly or completely inhibited; and (5) The tanks to accomodate the proper amount of seed were large and hence the capital cost was high. Anaerobic digestion was attractive because the products were completely disposable. The gas could be burned for heat or power (Buswell, 1964).

During the more recent past new anaerobic process configurations have evolved for application to both municipal and industrial wastewaters. The need for greater efficiency and economy in the treatment of industrial and municipal liquid wastes and interest in methane production from biomass as a renewable source of energy has led to renewed interest in anaerobic digestion and the study of new types of fermenters. These new types have in common the retention of active microbial biomass in the fermenters, instead of allowing it to escape with the treated effluent (Van den Berg and Lentz, 1979). In order to meet the various needs of municipal and industrial waste treatment a wide variety of systems have evolved either up to pilot or full-scale operation. These include the following: attached film expanded bed reactor (Switzenbaum and Jewell, 1980); anaerobic fixed film reactor (Van den Berg and Lentz, 1979); anaerobic filter (Young and McCarty, 1969); up-flow anaerobic sludge blanket-reactor (de Zeeuw and Lettinga, 1980); two-phase digestion process (Cohen et al, 1979).

In general, all these various types of the anaerobic process are capable of achieving the goals of maximizing methane yields and production rates, increasing process stability and the most important, decreasing reactor volume. However each process configuration has its associated weaknesses and disadvantages when wastewater characteristics (such as contents of soluble and insoluble organics), pumping requirement, structure of reactor, requirements of operation and maintenance are involved in design and operation (Yang and Wong, 1982).

2.2. Theory of Anaerobic Digestion Treatment

An understanding of the fundamentals of anaerobic decomposition is helpful for proper design, operation, and control of anaerobic processes. This is especially true when considering the relative merits and potential applications of the process to treat large volumes of wastewaters from domestic, industrial, commercial, and agricultural sources.

A brief review of the general principles of anaerobic treatment is presented to facilitate further discussion.

Decomposition of organics in an anaerobic process is an extremely complex symbiotic interaction of a variety of anaerobic and facultative bacteria (Toerien and Hattingh, 1969). Decomposition of complex and soluble organics can be characterized as a sequential, three-step process involving:

Step 1 : Hydrolysis of suspended organics and soluble organics of high molecular weight.

Step 2 : Organic acid formation and degradation of small organic molecules to various volatile fatty acids (VFA), ultimately acetic acid.

Step 3 : Production of methane primarily from acetic acid but also from hydrogen and carbon dioxide.

However, it should be understood that even though the anaerobic process is presented as being sequential in nature, the three steps take place simultaneously and synchronously in an active, well- buffered system (Benefield and Randall, 1980).

In the first step, insoluble and soluble organics of high molecular weight such as lipids (fats, fatty acids, etc.), cellulose, proteins, and carbohydrates are converted to less complex soluble organic compounds by enzymatic hydrolysis produced by a heterogeneous group of facultative and anaerobic bacteria. Hydrolysis of this complex organic material occurs when extracellular enzymes catalyze hydrolysis of complex carbohydrates to simple sugars; proteins to peptides and amino acids; and fats to peptides and fatty acids (McCarty, 1964; Kormanik, 1968; Toerien and Hattingh, 1969; Benefield and Randall, 1980).

In the second step, these bacteria then subject the products of hydrolysis to fermentations, B-oxidations, and other metabolic processes leading to the formation of simple organic compounds, mainly short chain alcohols, and volatile organic acids such as acetic, propionic, and butyric acids along with the gaseous products of CO_2, CH_4, N_2, and H_2. This stage is commonly referred to as "acid fermentation". The type and quantity of the end products of the second step depend on the pH, the temperature, the relative fractions of fats, carbohydrates, and proteins in the feed, the presence or absence of specific trace nutrients, the characteristics of the microbial flora, the solids retention time (SRT), and the bio-chemical or other mechanisms available for ultimate removal or stabilization of the second step end products. It should be noted that in this stage organic material is simply converted to organic acids, alcohols, and new bacterial cells so that little stabilization of BOD or COD is realized (McCarty, 1964; Kormanik, 1968; Toerien and Hattingh, 1969; Benefield and Randall, 1980).

However, in the third step, the end products of the first two steps are converted to gases, mainly methane and carbon dioxide, by several different species of strictly anaerobic bacteria called "the methane producing bacteria". Thus, it is here that true stabilization of the influent substrate, BOD or COD, occurs, in which the volatile organic acids, mainly acetic, propionic, and butyric acids are gasified to methane and carbon dioxide as a result of growth and metabolism of the obligate anaerobic methane bacteria (Kormanik, 1968; Kotze et al, 1969; Toerien and Hattingh, 1969). The exception to this, under anaerobic conditions, is removal resulting from formation of hydrogen or reduction of inorganic electron acceptors such as sulfates, nitrates, and nitrites (Kotze et al, 1969). The composition of the microbial population in an anaerobic digester will be dependent on the composition and amount of substrates it receives. In general, microbial growth rates and relative response to changes in the environment vary among groups (Toerien and Hattingh, 1969).

A general outline of the metabolic pathways and microbial ecology is summarized in Figure 1 which shows the four groups of bacteria now believed to be involved in the apparently simple conversion of glucose into carbon dioxide and methane.

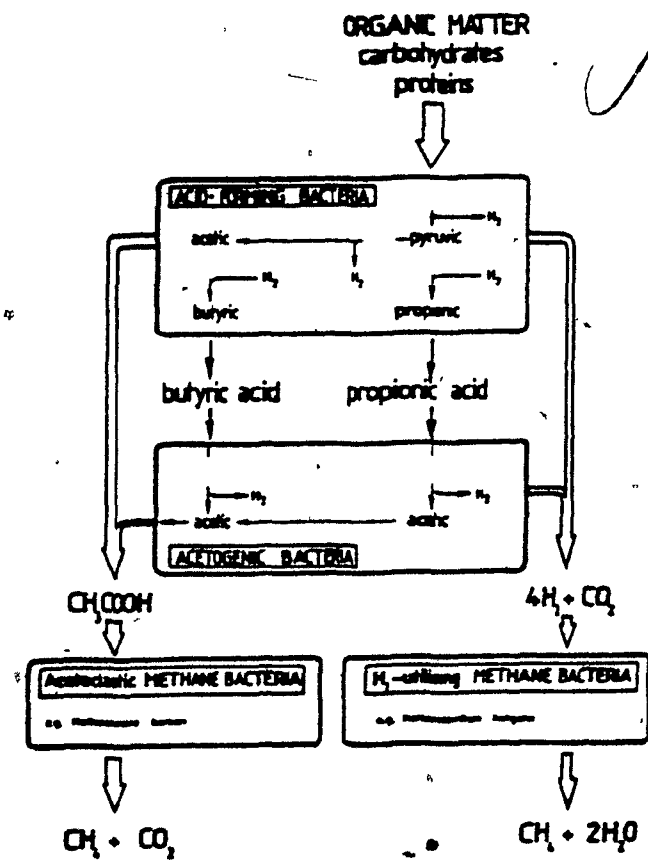


Figure 1. The Microbial Ecology of The Anaerobic Digestion Process (After Mosey, 1983)

2.3. Common Factors Affecting Anaerobic Digestion Treatment

Studies on anaerobic digestion treatment and its application over a number of years have demonstrated that certain factors influence digestion. No single factor, (parameter), can be used as a control measure of the process of anaerobic digestion, as the degradation of organic matter to methane and carbon dioxide, is brought about by a heterogeneous microbial population (Kotze et al, 1969).

In digestion practice, process failure has occurred in some cases simply because an operator did not recognize the signs of impending difficulty. It is likely that failure could have been offset had the proper process variables, viz input loads, effluent quality, pH, VFA and alkalinity, gas production and gas composition, been monitored at an appropriate frequency (Graef and Andrews, 1974).

A lack of agreement has persisted over what variables or combinations of variables provide the best warning of pending digester instability (Henze and Harremoes, 1983). One of the objectives of this work is to identify those digester variables that best indicate the reactor condition and provide sufficient warning of impending failure.

2.3.1. Potential Factors Affecting The Stability of Anaerobic Digestion Treatment

Potential factors of digester instability and variability, and ultimate failure, are hydraulic, organic, and toxic overloading. Behavior of the DSFF reactor under various levels of hydraulic and organic overloading have been analyzed herein and the DSFF's responses to the operational factors are pointed out in further sections. The influence of toxic overloading on the DSFF reactor was not analyzed herein, but will be considered in the present section for understanding the causes of instability that interfere with methane fermentation.

In chemostats hydraulic overloading occurs whenever the effective residence time, which is defined as the effective reactor volume divided by the influent wastewater flow rate, is reduced to the point at which organisms cannot reproduce before being washed out (Graef and Andrews, 1974). Effective residence time can also be decreased by volume changes if excessive solids accumulate in the reactor causing clogging, channelling, and short circuiting, or when insufficient mixing produces stagnation zones in the reactor.

Organic overloading can result whenever an excessive mass rate of organic addition to a digester causes an accumulation of VFA that can inhibit the methanogenic organisms. This can be caused in practice by a sudden increase in the organic feed concentration (Graef and Andrews, 1974). Two typical cases readily found in the literature are: attempting to start up a digester too rapidly, and excessive digester loading on an infrequent basis (Van den Berg and Kennedy, 1982; Kennedy and Droste, 1983).

Toxic overloading can be caused by the introduction of material that can kill the methanogenic organisms. For example, heavy metals, detergents, organic chemicals, ammonia, and various cations, Na, Ca, and Mg are all possible contributors.

Inhibitory substances are introduced into the digester in two ways: A single slug addition of toxicant may occur, nominally termed "transient toxicity" (intermittant slug doses may also occur), and inhibitory substances may be chronically present in the influent waste and be added continuously to the system along with the organics and other nutrients (Parkin and Miller, 1982).

2.4. Principal Indices To Indicate The Course of Anaerobic Digestion Treatment

The following factors are most frequently used to characterize a digester and are normally used to control anaerobic digestion: pH, alkalinity, volatile fatty acids, (which are interdependent), the rate of gas production, and composition of the gas produced.

2.4.1. pH, Alkalinity, and Volatile Fatty Acids (VFA)

The heterogeneous bacterial population in an anaerobic digester comprises a wide variety of bacterial species. Each specific species has an optimum pH range in which growth is best and in which its metabolic processes function at optimum levels. In anaerobic digestion the optimum pH range is the integral result of the different contributions by the different reactions taking place (Kotze et al, 1969), (see Figure 1). The preferred pH range for anaerobic treatment is from 6.4 to 7.6 with an optimum range of approximately 6.9 to 7.1. Beyond these limits digestion is less efficient (Van den Berg et al, 1976).

At pH < 6.2 the efficiency drops off rapidly, and the acidic conditions produced can become toxic to the methane bacteria (McCarty, 1964; Benefield and Randall, 1980). Whatever the pH of a digester in equilibrium may be, any definite drop in pH value, as a result of production of VFA, will be an indication of a disturbance of this equilibrium and will necessitate some method of control (McCarty, 1964).

To ensure that sufficient buffering capacity is available to counteract sudden increases in fatty acid content, the alkalinity titrated to pH 6.0 should be greater than 1000 mg HCO3/l (Dague, 1968). Kotze et al (1969) state that as a good measure of safety, alkalinity in the more desirable range of 2500 to 5000 mg/l as $CaCO_3$ provides a better buffer capacity.

Volatile fatty acids content of the mixed liquor of a digester is one of the most useful parameters in controlling digestion (Barnes et al, 1982). Any sudden increase from a constant value is an indication of a disruption of equilibrium conditions. It should be noted that a high volatile acid concentration is the result of unbalanced treatment and not the cause as is sometimes believed (McCarty, 1964).

The level of VFA content is a debating point amongst workers in the field of anaerobic digestion. However, a VFA content in the range of 100-300 mg/l is preferred.

2.4.2. Rate of Gas Production and Composition of Gas

Any decline in the rate of gas production from a constant value accompanied by a change in the methane-to-carbon dioxide rates is indicative of unbalanced conditions (McCarty, 1964). Typically, digester gas is comprised of approximately two-thirds methane and one-third carbon dioxide by volume fraction. However, distribution varies depending on the partial pressure, alkalinity, pH, and waste composition (Kotze et al, 1969). The CH_4/CO_2 ratio for the gas produced from carbohydrates, fats, and proteins are 1.0, 2.3, and 5.3 respectively.

2.5. Temperature

Temperature is an important consideration in anaerobic treatment because of the effect it has on the values of microbial kinetics. Temperature has a significant influence on digester performance as well. The optimum temperature for the anaerobic digestion process in the non- thermophilic range has been agreed upon to be between 90°F to 95°F (32°C - 35°C) (Van den Berg et al, 1976). Thus, temperature, which can be controlled externally, is certainly active in selecting the ultimate population that will prevail in a digester.

2.6. Physical Description of Downflow Stationary Fixed Film (DSFF) Reactors

There are two major design configurations for anaerobic fixed film reactors, one being the static bed reactor, the other, fluidized-bed (expanded-bed) reactor. For reference, the static-bed submerged media anaerobic reactor, (SMAR), was initially referred to as the anaerobic filter or the downflow bed reactor, but recently it took the name stationary fixed film reactor; the fluidized-bed SMAR became the anaerobic attached film expanded-bed reactor (AAFEB).

The main difference between both types is the direction of flow. The stationary fixed film reactor is almost exclusively downflow, introduced at the top with any activity in the liquid originating from bacteria leaving the film. A fluidized bed reactor consists of a bed of small particles expanded by an upward flow introduced at the base with a significant part of the activity in the liquid present in the lower half of the column (Van den Berg and Lentz, 1979).

This project is concerned only with the downflow stationary fixed film reactor (DSFF).

A downflow stationary fixed film reactor consists of an inert support medium contained in a vertical column to retain biomass within the reactor, thus developing a long solids retention time and providing a large specific surface available for microbial growth which is necessary for anaerobic treatment. A sketch of the DSFF reactor used in this study is shown in Figure 2.

In a DSFF reactor, bacteria, (particularly methanogens), attach themselves to stationary supports especially provided to form conglomerates, and are prevented from being washed out with the effluent by the solid support to which they are attached. As such, a DSFF reactor is capable of effective treatment of high strength wastewaters at relatively short hydraulic detention times (0.5 days to 11.8 days depending upon wastewater characteristics and temperatures) (Van den Berg and Kennedy, 1981).

There are several types of support media for stationary fixed film reactors. Rock has been frequently used as a microbial support medium as it is a cheap and robust material. Other support materials reported include potter's

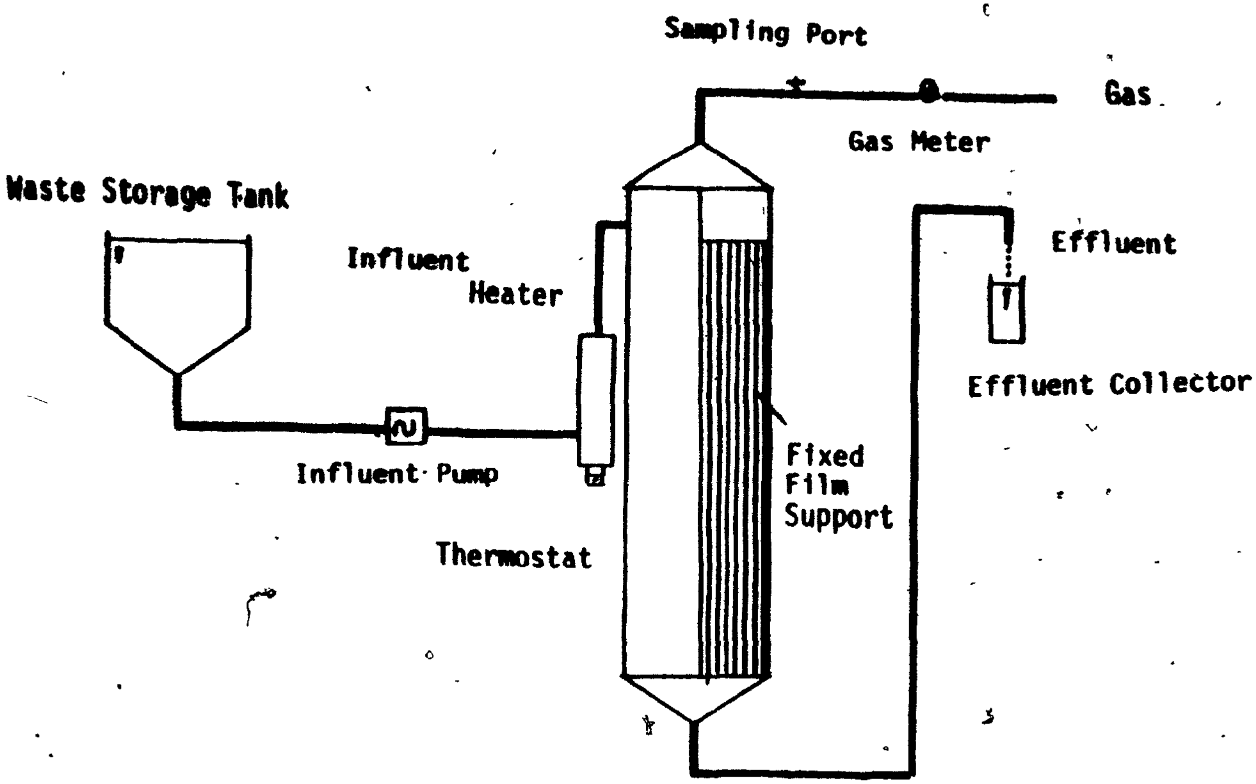


Figure 2. A Sketch of the DSFF Anaerobic Reactor Used in This Study

clay, draintile clay, needle punched polyester, and polyvinylchloride (Van den Berg and Kennedy, 1981; Young and Dahab, 1983).

2.7. Application of Anaerobic Fixed Film Reactors To Wastewater Treatment: Dairy Industry

Many dairy wastewaters are typically dilute solutions of milk and cleaning materials, (4-5% total solids), yet have a BOD range for plant effluents of 40 mg/l - 48000 mg/l with a mean of 2300 mg/l, and a COD range 80 mg/l - 95000 mg/l with an average of about 4500 mg/l (Harper et al, 1971; Brown and Pico 1979; Carawan et al, 1979). Although dairy wastewaters are treated by common biological methods (Bull et al, 1983), there is an interest in the use of high rate methane fermentation systems to provide more efficient and economic treatment (Switzenbaum and Danskin, 1981; Hall et al, 1983; Van den Berg and Kennedy, 1983).

The DSFF reactor's ability to handle high organic loadings (6.4 - 39.2 kg COD/m3/day) and high rates of methane production (2 - 8 m3/m3/day), at relatively short hydraulic retention time (depending on the tipe of waste and temperature) makes it ideally suited to such applications. Furthermore, the DSFF reactor is applicable to a wide variety of soluble wastes ranging from food processing and chemical wastes to heat-treat liquors resulting from thermal conditioning of municipal sludge (Van den Berg and Kennedy, 1981; Kennedy and Van den Berg, 1981,1982; Hall and Jovanovic, 1982). The excellent ability to handle intermittent loads makes it acceptable for treatment of wastes from industries operating only a few days each week as well as from seasonal wastes streams (Van den Berg and Kennedy, 1982).

2.8. Advantages and Disadvantages of Anaerobic Treatment Processes

Anaerobic biological treatment of high strength organic wastes has a number of advantages which make it preferable to either aerobic biological or physical chemical treatment.

The main advantages are:

1. A high degree of waste stabilization can be accomplished with a relatively low production of biological solids thus reducing the costs associated with sludge disposal.

2. Low nutrient requirements and no oxygen requirements, thus eliminating expensive and energy-intensive aeration equipment.

3. The formation of valuable methane gas as an end product. Energy can be recovered from the gas by subsequent combustion.

4. No environmental nuisance, since the process by its very nature is totally enclosed and all the exhaust gas is either burned in a gas utility or in an automatically controlled flamestack.

5. Measurable and identifiable intermediate products which offer an additional control potential.

However, anaerobic processes have some drawbacks which consistently are based on the same properties as some of the advantages:

1. It is temperature dependent and may require heat to maintain an optimum microbial growth rate.

2. Slow growth of methane producing bacteria, so recovery from adverse conditions is difficult.

3. Methane sensitivity, so presence of oxidizing agents is toxic.

It is important to mention that a fixed film reactor has a number of advantages and disadvantages over other types of fermenters designed to retain the active microbial biomass in the fermenter:

1. It obviates mixing, which is difficult to provide for

adequately in large tanks, and settling, a major problem with anaerobic contact processes.

2. It can be designed to avoid channelling, a problem inherent in upflow filters, and possibly in other upflow reactors.

3. With the bacteria adhering to a surface, the reactor height is not limited as it appears to be with the anaerobic filter.

4. Other important features include their capability to handle dilute and concentrated wastes (with and without high suspended solids), to operate at low temperatures (down to 10°C), to change over from one waste to another with little or no loss in performance, to withstand weeks or months of cooling and starvation without major adverse effects on performance, and finally to be able to withstand severe hydraulic overloading and handle high organic shock loads, as well as intermittent (once or twice a day) slug loading (McCarty, 1964; Pfeffer et al, 1967; Dewalle and Chian, 1976; Van den Berg and Lentz, 1979; Anderson et al, 1982; Parkin and Miller, 1982)

Potential disadvantages of fixed film reactors include slow initial development of the film and slow reestablishment after failure. Continued growth of the film may eventually limit efficiency by reducing effective surface area. Accumulation of primarily attached solids in the fixed film reactor reduces the size of the actively mixed zone and may cause a form of plugging or short circuiting. And finally, gas bubbles that occur during the methane conversion may cause disturbance of the biofilm by adhering to flocs/bed particles, causing them to rise in the reactor, resulting in the wash out of biomass, or deterioration of effluent quality (Hall, 1982; Hall et al, 1983, Henze and Harremoes, 1983; Kennedy and Droste, 1983).

2.9. Current Mathematical Models For Anaerobic Digestion Processes

For anaerobic treatment processes, most mathematical models currently used to describe them are steady-state models (Lawrence and McCarty, 1969; Switzenbaum and Jewell; 1980). Therefore, they cannot be used for process control and prediction of process performance during start-up operations, or under transient and/or dynamic conditions resulting from changes in process input. As well, in the special case of stationary fixed film anaerobic reactors, dynamic models which describe the processes are very limited.

In recent years, Andrews and Graef (1971) developed a dynamic model for anaerobic digestion of sludges which was based on a continuous culture theory and incorporates several modifications. Mueller and Mancini (1975) adopted the same concept to anaerobic filters. The key features of these models are: use of an inhibition function instead of the Monod expression to relate volatile acids concentration and specific growth rate of methane bacteria; the consideration of the unionized fraction of the volatile acids as both the growth-limiting substrate and inhibiting agents; and the interaction which occurs in and between the biological, liquid and gas phases of the digester. Furthermore, they use equilibrium relationships, kinetic expressions, stoichiometric coefficients, material balance relationships, and mass transfer equations to reflect these interactions. Lindgren (1983) developed a relatively complex mathematical model describing the anaerobic degradation of organic carbon and nitrogen in anaerobic filters. He used eleven state variables, nine related to the liquid phase and two to the gas phase, to simulate the anaerobic filter as a two-step process under steady state data. The model is based on Monod kinetics incorporating a pH inhibition function (based on Andrews and Graef's principle, 1971), but neglecting solids transport and biofilm diffusion. Rittmann and McCarty (1980) presented elements of the biofilm kinetics with application to denitrification and to methanogenesis. Based on the general kinetic constants known from other investigations they calculated substrate profiles for comparison with data from Young and McCarty (1969). Henze and Harremoes (1983) pointed out that the comparison of this model to Young's data was not sufficiently comprehensive to be taken as verification for the applicability of biofilm kinetics to anaerobic processes in fixed film reactors.

Although simulation studies have provided qualitative evidence for the validity of the models by predicting results and response of the systems close to those observed in the field, their applicability to anaerobic fixed film reactors has not yet been established.

From the aforementioned models a number of difficulties have been identified which hinder or prevent their applicability to fixed film reactors under variable loading conditions and for control of the processes:

1. Many parameters such as kinetic rate coefficients are unknown and must be determined for each specific wastewater to be treated.

2. There is a complicated relationship between the removal rates, the growth rates, the diffusional build-up of acidity and lowering of pH inside the biofilm, plus the toxic

effects on the methanogens inside the biofilm.

3. Noise in the measurements of system performance may also make calibration and verification difficult.

4. Substrate removal rates are affected by substrate concentration, specific surface area, flow rate, temperature, and type of support medium.

5. Time-varying inputs frequently may cause the expected performance of a system to be completely different from that predicted by a steady state model.

6. Fluctuations in input loads; environmental conditions; in-plant biological and operational parameters; size of plant and type of process; human factors; and inherent process variability are given very little consideration in these models for system design and operational control.

7. The anaerobic fixed film reactor's parameters are not stationary and require constant updating of model parameters.

8. Out diffusion of gaseous products of low solubility may give rise to bubble formation in the biofilm. This phenomenon can significantly alter the kinetics of the film and can give rise to sloughing off of biofilm particles under heavy loading conditions.

2.10. Time Series Analysis As An Alternate Method To Study The Dynamic Behavior of An Anaerobic DSFF Reactor: The Box-Jenkins Time Series Analysis

One of the purposes of the present work is to apply a Box - Jenkins time series transfer function model to characterize the response of a DSFF reactor under organic loading conditions and to develop a dynamic model to predict effluent quality under dynamic conditions.

The time series transfer function methodology as developed by Box and Jenkins (1976) involves monitoring the process response to a regulated sequence of perturbations of the influent variables. The resultant model, which relates effluent response to variations in the influent variables, defines the significant variables affecting performance and is a basis for process assessment and possible control.

This is valuable in the descriptive analysis of processes susceptible to variable inputs in time and in design of schemes to reduce the impact of variable or shock loads or to manipulate other variables for control purposes (Nutt et al, 1981).

In the past, Box-Jenkins Time Series Analysis has only been successfully applied to aerobic treatment processes. For instance, Berthouex et al (1978), applied this technique to determine the extent to which effluent BOD5 is related to influent BOD5 for a municipal activated sludge process. Murphy et al (1977) described the dynamic nature of nitrifying biological suspended growth systems applying this methodology. The empirical transfer function models which were developed describe both combined and separate sludge systems operating under critical nitrifying conditions and were able to forecast the temporal variation in nitrification achieved.

Filion et al (1979) predicted the performance of a rotating biological contactor under transient loading conditions. They verified the models by predicting the effluent response obtained from independent studies and pointed out that an adequate representation of the dynamic effluent response can be obtained through time series model building.

Nutt et al (1981) developed dynamic transfer function noise models based on multiple process inputs which predicted the response of the biological fluidized-bed treatment system under dynamic operating conditions.

Stochastic modelling, using a Box-Jenkins time series transfer function model, was done by Kenneth and Sims (1981) for an industrial activated sludge process. They pointed out that the use of BOD5 as a measured variable in a feed-forward/feed-back control system may not be suitable because of the long analysis time of the BOD5 test. COD, on the other hand, can be measured rapidly and can be used as a measured variable in a control scheme.

From these studies a number of advantages of using Box-Jenkins Time Series may be drawn:

1. There is a well defined method of calculating model parameters from process data.

2. The models in use are easily updated.

3. The complexity of the models is easily increased or decreased.

4. The models take noise into account.

5. Procedures are available to determine how well the models are working and how to improve them.

6. The time series transfer functions are suitable for the design of feed-forward/feed-back control systems.

7. Probability limits for each forecast of the response variable are given.

8. Using few parameters, these models can closely approximate a system whose true nature is likely much more

complex.

9. From the dynamic model parameters (ω, δ), it is possible to calculate indicators of process response such as the process time constant, τ, and the process steady-state gain, g, (% change in output / % change in input).

10. Using such characteristic values, one may predict the time to approach a new steady-state value after a step change in process input or to return to steady-state after a shock load.

2.10.1. The Basic Steps In Developing A Box - Jenkins Transfer Function Noise Model

Box and Jenkins (1976) have effectively put together in a comprehensive manner the relevant information required to understand and use combined transfer function noise models.

The general form of the Box - Jenkins tranfer function noise models to be considered is:

$$Y_t = V(B)X_{t-b} + \psi(B)a_t \qquad (1)$$

where: Y_t = the effluent response variable at time t.

$V(B)$ = a polynomial of the operator B, defined as $(V_0 + V_1 B + V_2 B^2 + \ldots\ldots)$; known as the impulse response function, it is the transfer function part of the model.

B = the backward shift operator defined as $BX_t = X_{t-1}$, $B^2X_t = X_{t-2}$, etc. Note for example $(1 - B)X = X_t - X_{t-1}$.

b = time delay of the system.

X_{t-b} = the influent variable at time t-b.

$\psi(B)$ = a polynomial of the operator B defined as $(\psi_0 + \psi_1 B + \psi_2 B^2 + \ldots\ldots\ldots)$.

a_t = white noise, ie. uncorrelated, normally distributed with zero mean and constant variance. Hence, $N_t = \psi(B)a_t$ is the noise at time t.

This general model applies to situations where the data (Y_t, X_t) are simultaneous pairs of observations at discrete equispaced times. In equation (1) one may substitute:

$$V(B) = \frac{\omega(B)}{\delta(B)} = \frac{(\omega_0 + \omega_1 B + \ldots\ldots + \omega_s B^s)}{(1 + \delta_1 B + \ldots\ldots + \delta_r B^r)} \qquad (2)$$

where: ω, δ = transfer function model parameters.

r, s = transfer function model orders.

Typically only a few ω_i values and δ_i values are needed for adequately modelling transfer functions of real systems (Box and Jenkins, 1976).

Similarly, for the Noise:

$$\psi(B)a_t = \frac{\theta(B)}{\phi(B)} a_t = \frac{(1 - \theta_1 B - \ldots\ldots - \theta_q B^q)}{(1 - B)^d (1 - \phi_1 B - \ldots\ldots - \phi_p B^p)} a_t \qquad (3)$$

where: θ, ϕ = noise model parameters.

p, d, q = noise model orders.

The general approach for building models of this type involves an iterative procedure to identify tentative models, to estimate model parameters, and to test residuals to determine the adequacy of the fit (Box and Jenkins, 1976). Figure 3 presents a flowchart of the basic steps in developing a transfer function model, including the prewhitening phase.

Before this can be discussed the crosscovariance and the crosscorrelation functions must be defined.

The crosscovariance is:

$$C_{xy}(k) = 1/n \sum_{t=1}^{n-k} (X_t - \bar{X})(Y_{t+k} - \bar{Y}) \qquad k=0,1,2,\ldots$$

$$= 1/n \sum_{t=1}^{n+k} (Y_t - \bar{Y})(X_{t-k} - \bar{X}) \qquad k=0,-1,-2,\ldots \qquad (4)$$

where: X, Y = the input and output time series respectively.

$\bar{X}$, $\bar{Y}$ = mean of X, Y time series respectively.

n = number of observations.

k = lag between X and Y in sampling units of time.

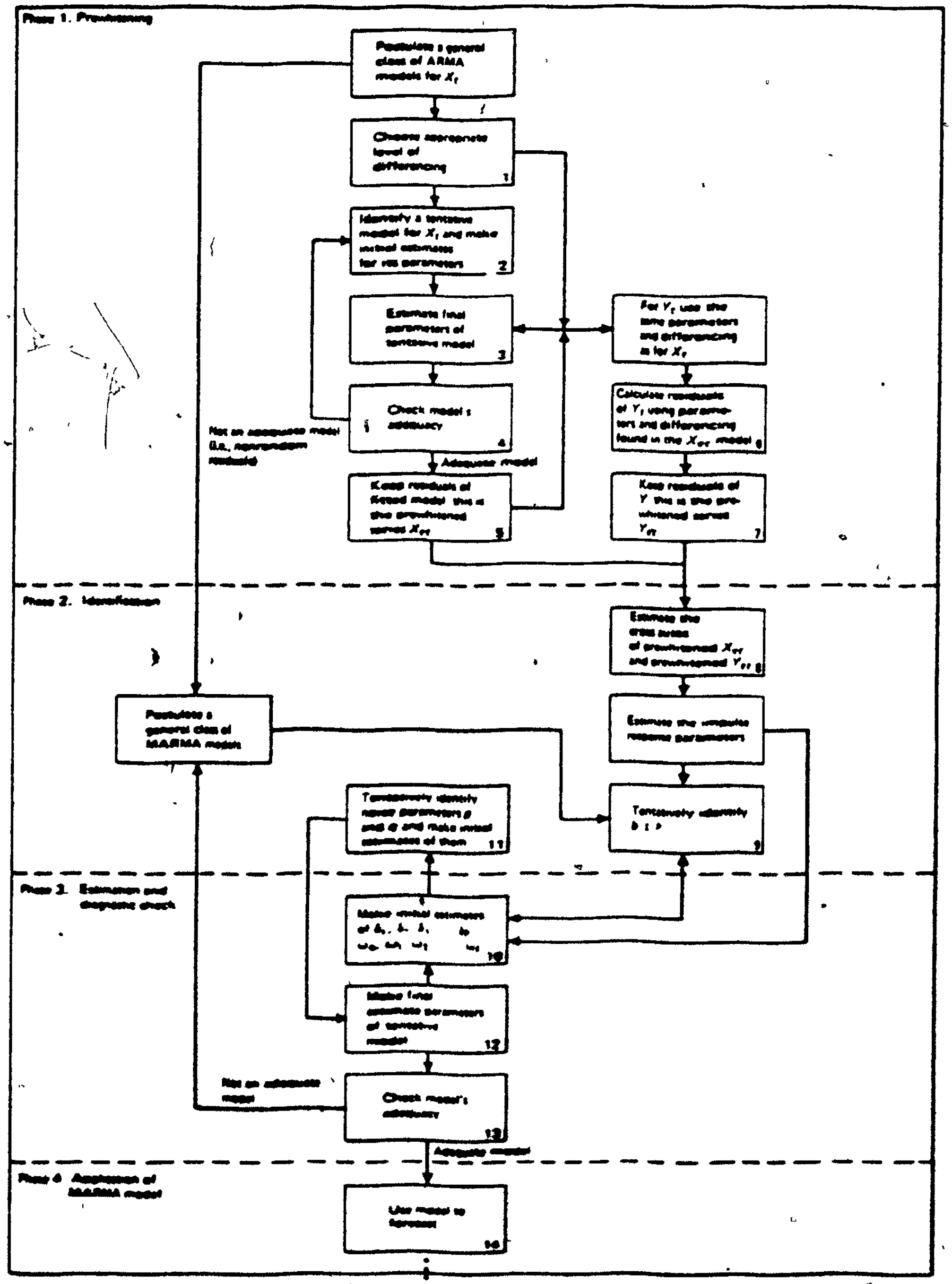


Figure 3. Basic Steps in Developing a Transfer Function Noise Model (After Makridakis and Wheelwright, 1978)

The crosscorrelation is:

$$r_{xy}(k) = \frac{C_{xy}(k)}{S_x\ S_y}, \quad k=0,\ \pm 1,\ \pm 2, \ldots\ldots \quad (5)$$

Where S_x, S_y = the sample standard deviations of X and Y series respectively.

To identify Box-Jenkins transfer function noise models, estimate the crosscorrelation function between the prewhitened input data series and correspondingly transformed output data series. The purpose of prewhitenig the input is to allow direct calculation of the impulse response function, V(B), since only when the series, X_t, is not autocorrelated does the crosscorrelation function, estimate V(B) directly. To prewhiten the input an identification of autoregressive integrated moving average (ARIMA) process is made of the input data series X_t (Box and Jenkins, 1976).

$$\phi_x\ (B)\ X_t = \theta_x(B)\,\alpha_t \quad (6)$$

where α_t is the uncorrelated white noise series.

This transformation is now applied to Y_t to obtain:

$$\phi_x\ (B)\ Y_t = \theta_x(B)\,\beta_t \quad (7)$$

One can write equation (1) as:

$$\beta_t = \frac{\phi_x(B)}{\theta_x(B)} Y_t = V(B)\alpha_t + \psi(B)a_t$$

$$\beta_t = \underbrace{\frac{\omega(B)}{\delta(B)}}_{V(B)} \underbrace{\frac{\phi_x(B)}{\theta_x(B)} X_{t-b}}_{\alpha_t} + N_t \qquad (8)$$

This yields two transformed series α_t and β_t whose sample crosscorrelation function $r_{\alpha\beta}$ can be used to estimate the impulse response function, $V(B)$ (Box and Jenkins, 1976). To find the impulse response function, $V(B)$, the crosscorrelations, $r_{\alpha\beta}$, are multiplied by a ratio of the standard deviation of the output series residuals, S_α, over the standard deviation of the input series residuals, S_β:

$$V(B) = r_{\alpha\beta}(S_\beta/S_\alpha) \qquad (9)$$

Analysis of the estimated impulse response function allows identification of potential transfer function models, the model's order (r,s), the delay period (b), which is identified as the time lag corresponding to the first significant crosscorrelation, and the transfer function model's parameters, (ω, δ).

The autocorrelation functions of the residuals of the fitted transfer function models are used to identify the noise model, Nt. Once the parameters of the combined transfer function noise model are estimated efficiently, using a non-linear least squares technique, model adequacy can be verified through diagnostic checks.

Parsimonious use of parameters is important. A good model should account for as much of the variation in the data as possible while using only a few parameters.

The fit of the model is indicated by the residual mean square.

$$\text{Residual mean square} = \sum_{t=m}^{n} a_t^2/(n-m-p) \qquad (10)$$

where (n-m-p) is the number of degree of freedom associated with any given model; n is the number of observations; m is the number of lost values a_t ; and p is the number of parameters in the model. The smaller the value of the residual mean square, the more variation in the data the model has been able to explain.

Serious model inadequacy can be usually detected by examining:

a) The autocorrelation function of the residuals from the fitted model.

b) The crosscorrelation function involving input and residuals, in particular the crosscorrelation function between the prewhitened input series and the model residuals.

If the model is inadequate, this brings one back to the identification step and, in fact, into an iterative model building process of identification, fitting, checking, identification, and so on (Box and Jenkins, 1976). This is discussed further in Section 4.6. Diagnostic Check of Model Adequacy.

3. PERFORMANCE OF AN ANAEROBIC DSFF REACTOR TREATING DAIRY WASTEWATER UNDER CONTINUOUS LOADING CONDITIONS

3.1 Source of Data

A two-phase experimental program was developed at the Wastewater Technology Center, Canada Center for Inland Waters, Burlington, Ontario, to assess the performance of a high rate anaerobic downflow stationary fixed film reactor (DSFF) under different operating conditions. The operating conditions and experimental results obtained from this two phase experimental work are included in Appendix D.

In Phase I, pseudo-steady-state runs were conducted over a period of three months to characterize the DSFF reactor's response to a range of hydraulic loading and substrate loading conditions for chemical oxygen demand; to assess the variability of process performance; and, to characterize the effluent response in terms of filtered COD under varying COD loadings.

In phase II, the dynamic response of the DSFF reactor was measured over a period of 18 days in order to develop Time Series Models to predict effluent quality under dynamic conditions.

3.2. Pilot Plant Description

The design and previous operation of the DSFF reactor has been described elsewhere (Hall et al, 1983). A schematic diagram of the DSFF reactor was shown in Figure 2. The DSFF reactor consisted of a 45 cm diameter cylindrical column, 220 cm tall with conical ends to improve outlet flow distribution of gas and treated effluent. The column was fitted with 25 cylinders of a plastic packing medium, "Cloisonyle", which in turn contains smaller cylinders of approximately 2.5 cm inside diameter, with a wall thickness of approximately 5 mm, and length of 180 cm. The total empty bed volume was 320 l. This packing medium was chosen because of the need for high voidage DSFF support material to maximize reactor volume utilization and to reduce the risk of bed plugging (Hall et al, 1983).

A high speed peristaltic pump, equipped with a timer to regulate the feed flow rate, fed the wastewater from the reactor feed tank, volume 13,200 l, to the DSFF reactor.

Before the incoming dairy wastewater was passed through the DSFF, the temperature of the dairy wastewater was raised to approximately 35°C by passage through in-line electric immersion heaters, so as to ensure maximum rate of mesophilic digestion. Reactor temperature was kept at ± 35°C by thermostatically controlled resistance heating on the wall.

Once the temperature of the dairy wastewater was increased the wastewater was then introduced to the DSFF reactor, 3 cm above the medium and passed downward through the support medium. Treated effluent was withdrawn from the bottom for disposal or analysis. Effluent samples were collected using a discrete sampler and stored at 4°C.

The system was equipped with a pH recorder-controller which monitored pH in a 3 cm deep pool above the media. A minimum pH of 6.5 was maintained automatically by the addition of 1-2N NaOH to the reactor infuent.

Biogas production was removed through the top of the reactor. Offgas flow rates were then measured using an oil-filled wet test meter.

3.3. Sampling and Analytical Procedure

During the two-phase experimental program, routine reactor performance was assessed in the following manner. Samples of the dairy wastewater in the reactor feed tank were analyzed twice daily, with an interval of 18 - 24 hours between sampling. For the treated effluent, samples were collected using an automatic sampler at intervals of 4 hours at the effluent stream of the DSFF reactor. The samples were kept under refrigeration at 4°C until they could be analyzed later in the laboratory.

Eleven parameters were monitored to assess the performance of the DSFF reactor and its response to continuous inputs by determining influent feed quality, effluent concentration (total and filtered COD), solids content (suspended solids and volatile suspended solids) of the effluent, volatile fatty acids content of the effluent as acetic, propionic, and butyric acid, pH, temperature, and feed rate.

The chemical analyses for the two phase experimental program are summarized in Table 1.

Table 1. Chemical Analysis of Dairy Wastewater

Parameter	Method of Analysis
Total COD	Optical Method (Hall & Jovanovic, 1982)
Filtered COD	Optical Method (Hall & Jovanovic, 1982)
Suspended solids	Glass fiber filter at 180 °C (Standard Methods, 1980)
Volatile suspended solids	Glass fiber filter at 550 °C (Standard Methods, 1980)
Volatile fatty acids	Gas Chromatography (Hall et al, 1983)
pH of the effluent	pH meter glass electrode
Biogas production	Oil-filled wet test meter
Temperature	Non-indicating temperature controllers

3.4. Dairy Wastewater Characteristics

Dairy wastewater was drawn directly from the dairy plant and shipped to the Wastewater Technology Center by truck where it was stored at 4-8°C. The strength of the dairy wastewater was measured at 60000 - 70000 mg COD/l upon arrival from the dairy plant. Continued measurement of its strength was done weekly, checking for deterioration.

To avoid maintaining large volumes of dilute wastewater for the operational conditions to be studied, feed batches were prepared with concentrated dairy wastewater and tap water twice daily to give the proper waste strength. By varying the volume of tap water any combination of waste strength could be obtained.

The physical and chemical characteristics of the diluted dairy wastewater for each operational condition during phase I of the experiment are summarized in Table 2.

Table 2. Dairy Wastewater Characteristics During Phase I of The Experiment (mg/l except pH)

	Run (average value)					
	1	2	3	4	5	6
Total COD	6290	19720	15150	9250	20500	14600
Filtered COD	5950	18125	13800	8500	18350	12600
SS	92	545	195	53	750	721
VSS	87	502	160	44	703	665
Volatile acid as:						
Acetic Acid	187	890	695	480	535	330
Propionic Acid		35	30	12	25	50
Butyric Acid		31	32	16	41	139
pH	4.3	4.1	3.6	3.8	4.3	4.0

3.5. Experimental Program

The experimental protocol was designed to allow evaluation of three input variables : influent substrate concentration (COD), mg/l, volumetric organic loadings (VL), kg COD/m3/day, and hydraulic retention time (HRT), days. The ranges of input variables were based on previous studies on the performance of the DSFF anaerobic reactor (Hall et al 1983). The levels at which the input variables were controlled are outlined in Table 3.

Table 3. Design Levels For Input Variables During Phase I of The Experiment

Variable	Level		
	-1	0	+1
COD	6950	13900	20850
HRT	0.39	1.15	3.50
VL	6	12	18

3.5.1. Anaerobic DSFF Pilot Plant Operation

To accomplish the objectives of this two phase experimental program, pilot plant operations with the DSFF reactor were initiated on December 20, 1983, through April 5, 1984. The high rate DSFF reactor had been used prior to this study at the Wastewater Technology Center, having been exposed to a range of hydraulic and organic loadings, thus having already developed sufficient and mature anaerobic attached films.

The first phase of the study, which lasted 82 days, involved six experimental runs at different operating conditions. Each one of the operating conditions was maintained for a period of 13 days ±1.5 days.

After changing the operating conditions the DSFF reactor was not allowed to acclimate to the new change in the control variables. The reason for this was in order to evaluate the step response of the system by means of time series analysis, as discused in Section 4.0 when the influent substrate concentration and hydraulic retention time were varied independently of each other.

The operational conditions for each run are summarized in Table 4, showing a difference between the designed influent concentration (COD) and the actual average concentration attained by diluting the concentrated dairy wastewater.

Table 4. Pseudo-Steady State Experimental Conditions

Designed Input Variables				Actual Avg
Run	COD (mg/l)	HRT (days)	VL (kg COD/ m3/day)	COD (mg/l)
1	6950	0.38	18	6290
2	20850	3.50	6	19725
3	13900	1.15	12	15150
4	6950	1.15	6	9250
5	20850	1.15	18	20500
6	13900	1.15	12	14600

The actual influent COD and flow rates during the pseudo-steady state experiment are shown in Figures 4 - 9.

Run 6, Figures 8 and 9, was a replicate of run 3 at the same range of influent COD concentration, 10000 - 17000 mg/l. Although the range of influent COD concentration was almost similar, the feed rate was more variable and solids content in the feed were higher in run 6 than run 3. This replicate was carried out because of a failure of the sample collector during run 3 at the effluent stream of the DSFF reactor and operational conditions which prevailed from 716

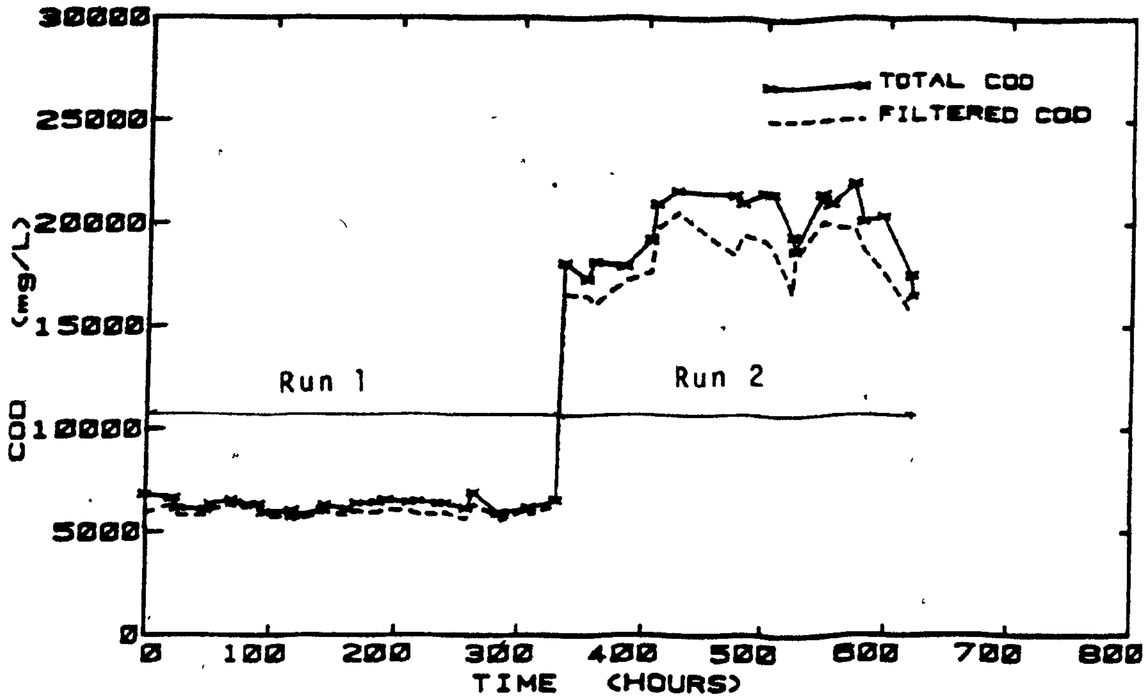


Figure 4. Runs 1 and 2. Influent Total COD and Filtered COD

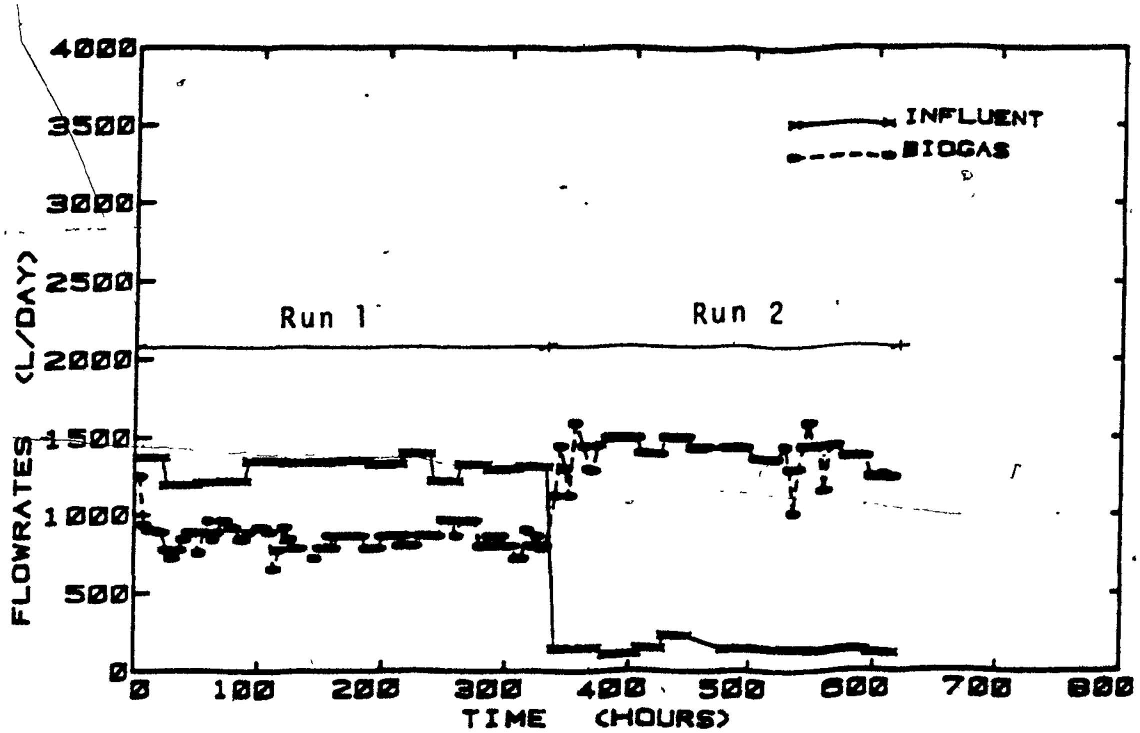


Figure 5. Runs 1 and 2. Flow Rates: Feed and Biogas

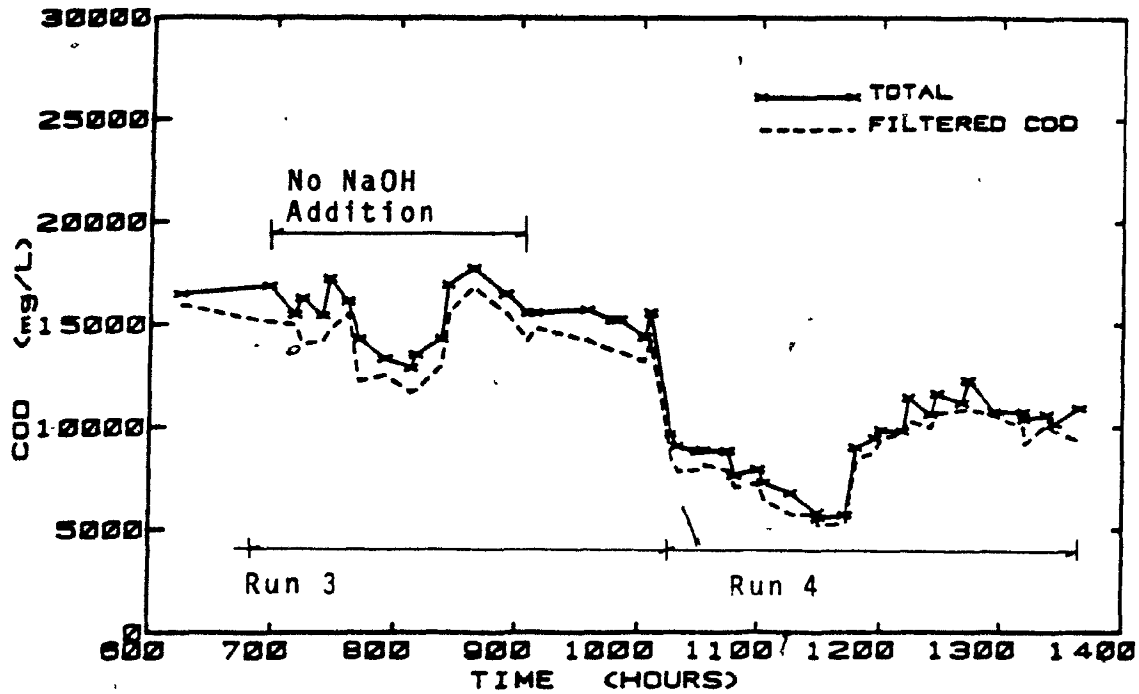


Figure 6. Runs 3 and 4. Influent Total COD and Filtered COD

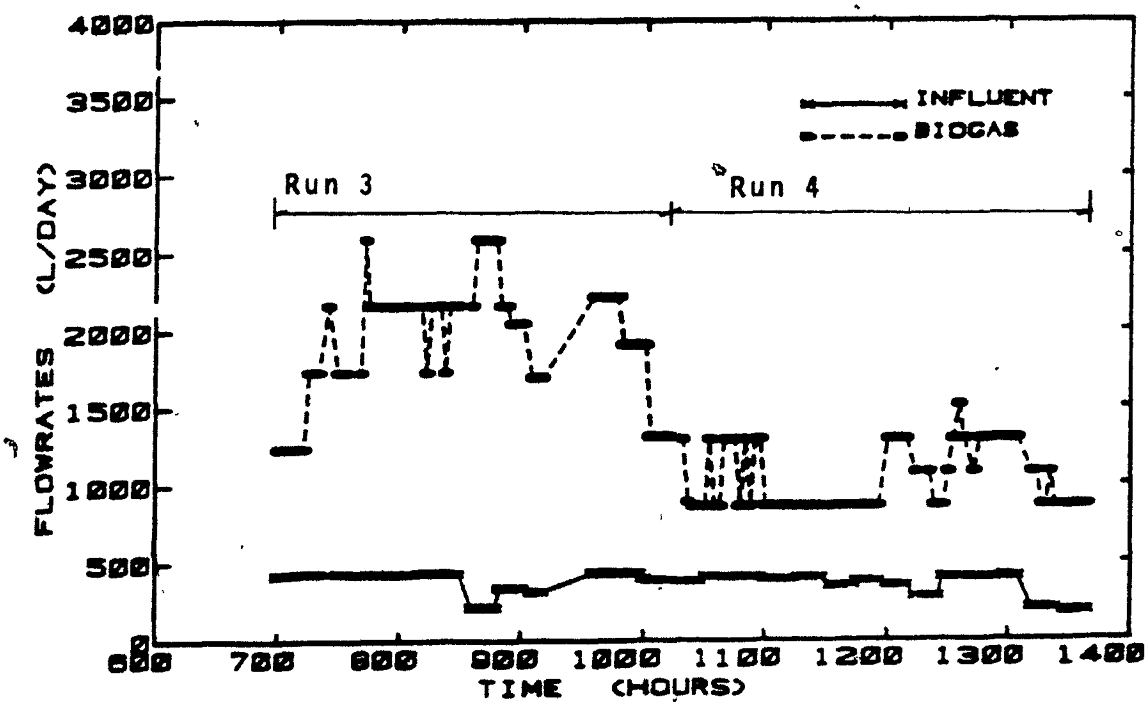


Figure 7. Runs 3 and 4. Flow Rates: Feed and Biogas

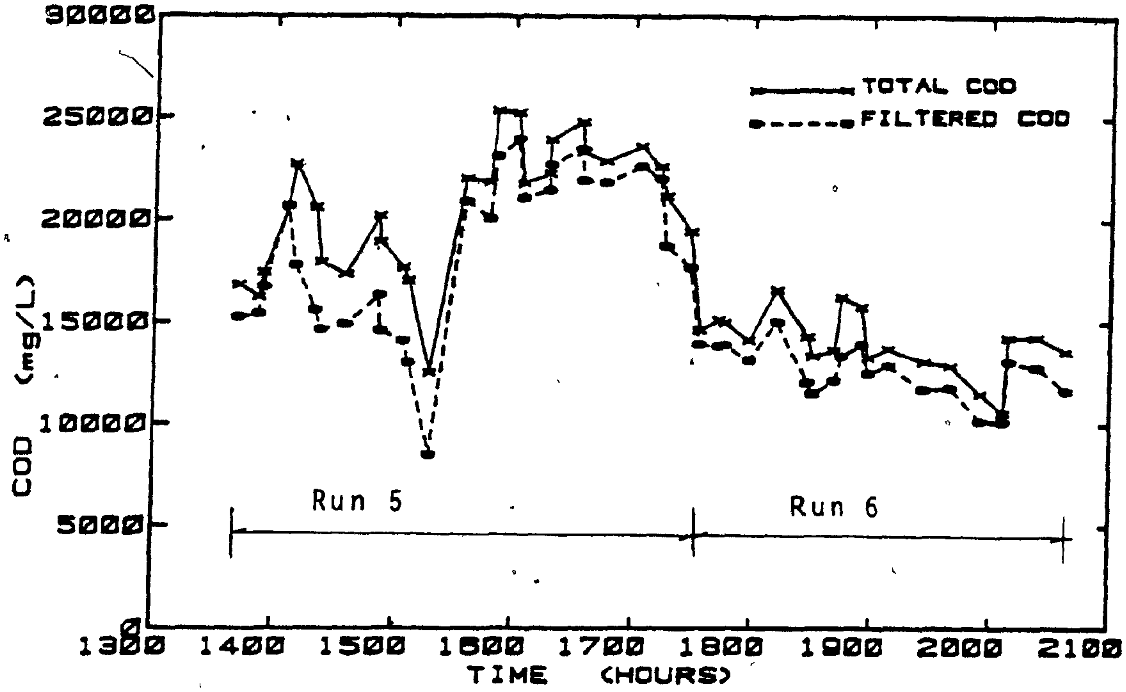


Figure 8. Runs 5 and 6. Influent Total COD and Filtered COD

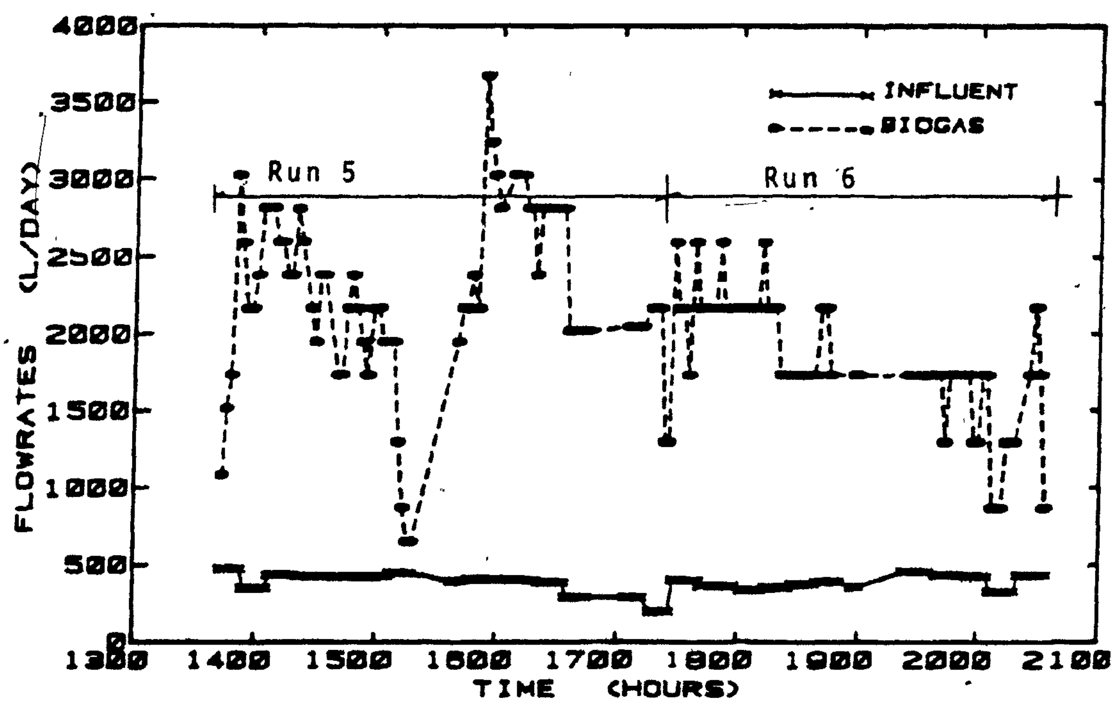


Figure 9. Runs 5 and 6. Flow Rates: Feed and Biogas

to 908 hours in run 3. The lack of pH control to maintain a minimum pH in the reactor of 6.5 during this period of time led the system to operate in an acidic condition, pH of 5.3, at a high loading rate of 11.55 kg TCOD/m3/day.

The overall range of temperatures and pH in which the system was operated in this first phase experimental program were 32 - 35°C and 5.9 - 6.7 pH.

3.6. First Phase Experimental Results

The performance of the DSFF reactor under varying influent substrate concentrations and hydraulic loadings is given in Table 5 along with the DSFF's response in Figures 10 - 18 for each operating condition. Each effluent parameter in Table 5 is the average value calculated after three hydraulic retention times from the data collected at each operating condition studied during the first phase experimental program.

At the operational conditions of run 1, (organic loading of 15.90 kg COD/m3/day), the HRT of 0.39 days became too short for complete hydrolysis of the organic substrate, and acid fermentation. The gas production was low, averaging approximately 1.65 m3/m3/day. The sharp decrease in effluent quality, as shown in Figures 10 and 11, is an indication of overloading and unbalanced treatment.

When the loading rate was reduced, run 2, to 5.60 kg COD/m3/day, the DSFF reactor recovered substantially after 56 hrs and after 516 hrs no effects of initial overloading could be detected from an analysis of pilot plant effluent. At loading rates of 5.60 kg COD/m3/day, filtered COD removals averaged 85%, while at 15.90 kg COD/m3/day they

Table 5. DSFF Anaerobic Reactor Performance Using Dairy Wastewater As A Substrate

Run	1	2	3	4	5	6
HRT (hrs)	9.50	84.50	31.50	35.00	33.00	32.50
Organic Loading (Kg COD/m3/day)	15.90	5.60	11.55	6.30	14.90	10.40
Temperature (°C)	32.5	35	35	33	34	35
pH	6.5	6.6	5.9	6.7	6.7	6.6
Inf. TCOD (mg/l)	6290	19725	15150	9250	20500	14000
Inf. FCOD (mg/l)	5955	18125	13800	8530	18350	12600
Eff. TCOD[1] (mg/l)	6584	4015	9746	4525	9435	5770
Eff. FCOD[1] (mg/l)	4100	2750	6524	3330	6700	4380
Eff. SS[1] (mg/l)	2309	1156	1590	585	1513	790
Volatile Fatty Acids						
Acetic Acid (mg/l)	781	1200	1285	910	1860	1810
Propionic Acid (mg/l)	611	655	349	191	597	632
Butyric Acid (mg/l)	176	113	714	320	561	348
% COD Removal[1]						
Total - Total		79.7	35.7	51.1	54.0	58.8
Filtered - Filtered	31.2	85.0	53.0	61.0	63.5	65.2
Substrate Removal Rate[1] (Kg COD/m3/day)	4.7	4.4	5.5	3.6	8.5	6.1
Gas Production[1] (m3/m3/day)	1.65	2.70	3.80	2.00	4.30	3.50

[1] Average value obtained after three hydraulic retention times

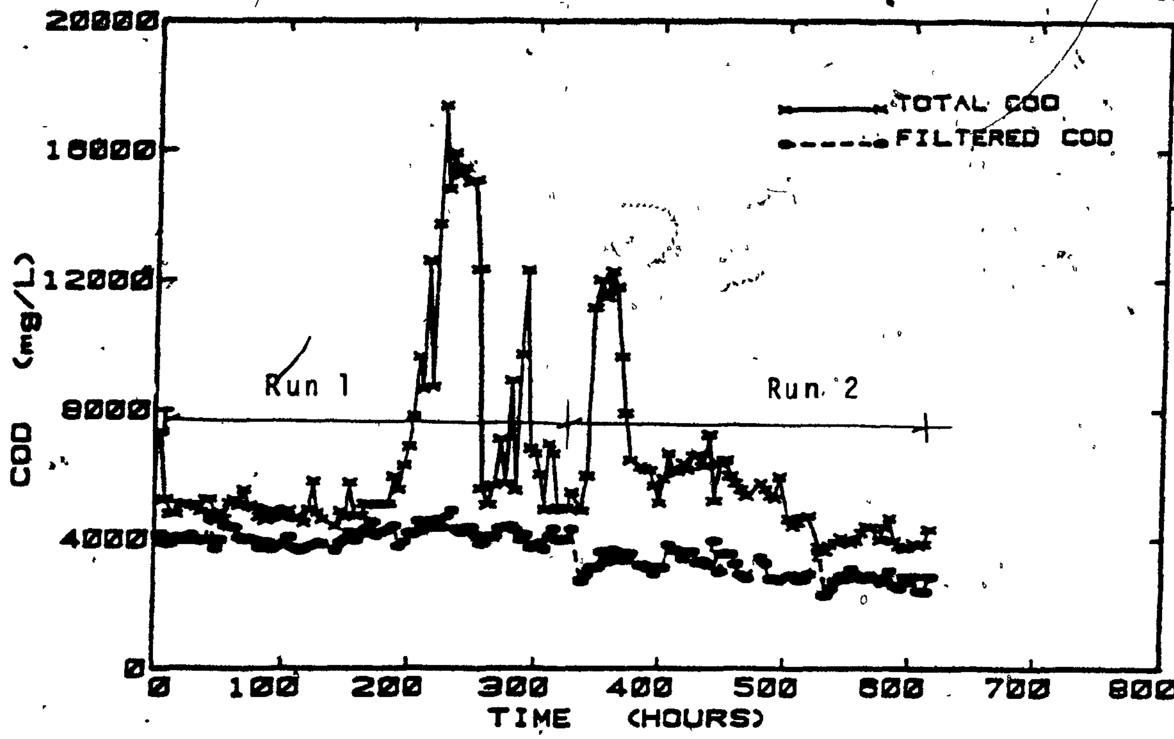


Figure 10. Runs 1 and 2. Effluent Total COD and Filtered COD

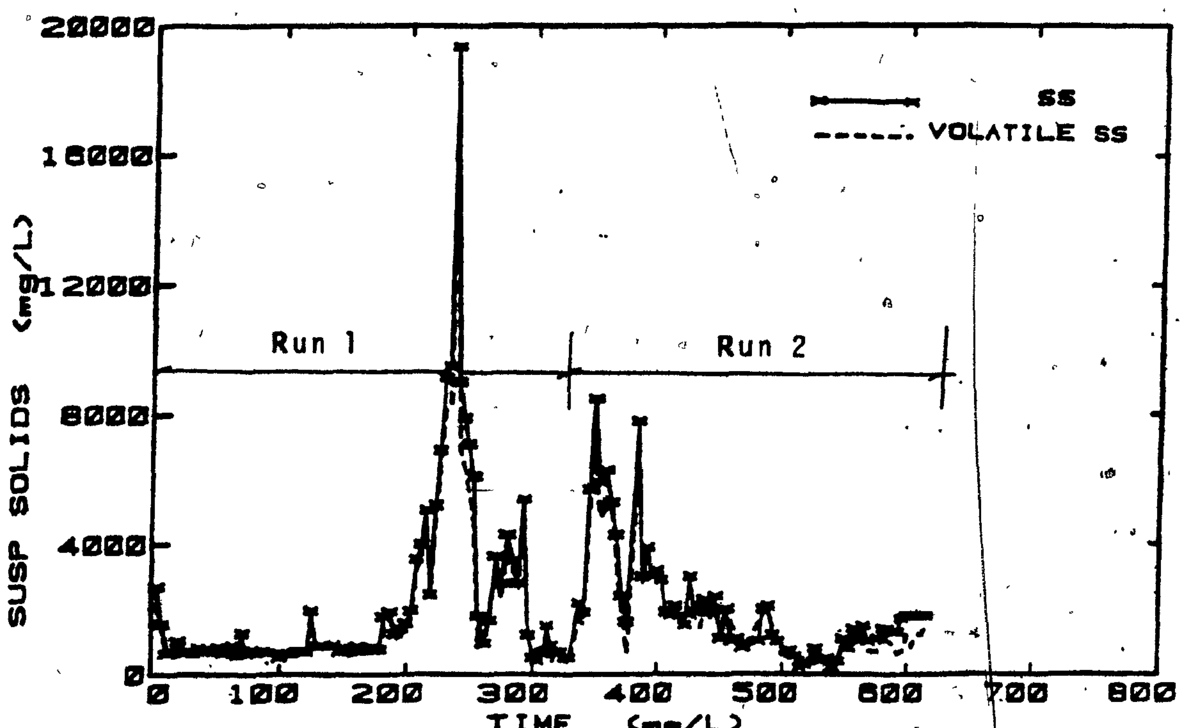


Figure 11. Runs 1 and 2. Effluent Suspended Solids and Volatile Suspended Solids

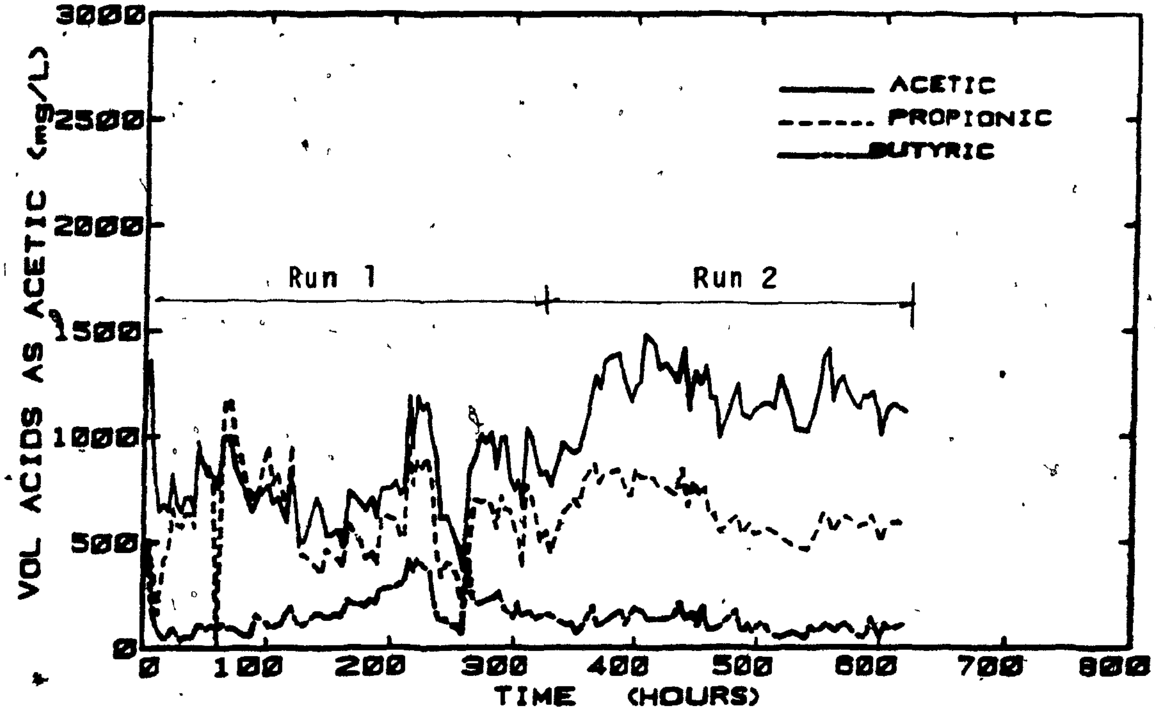


Figure 12. Runs 1 and 2. Volatile Fatty Acid Content of The Effluent

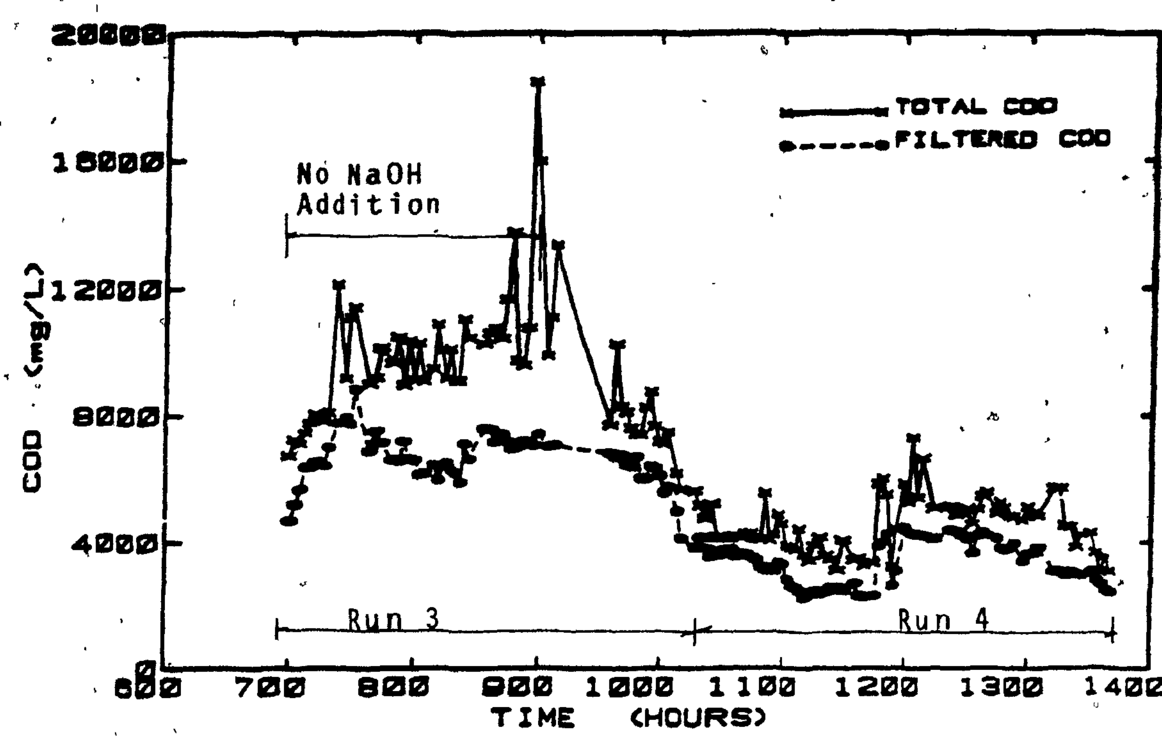


Figure 13. Runs 3 and 4. Effluent Total COD and Filtered COD

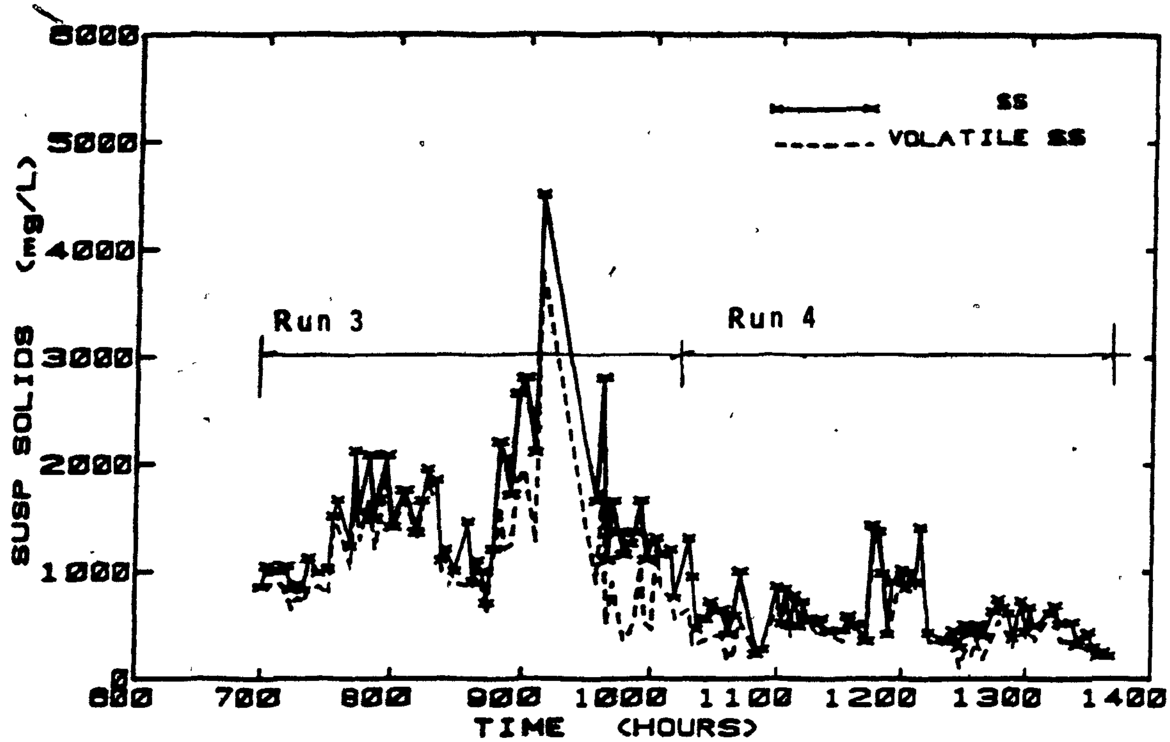


Figure 14. Runs 3 and 4. Effluent Suspended Solids and Volatile Suspended Solids

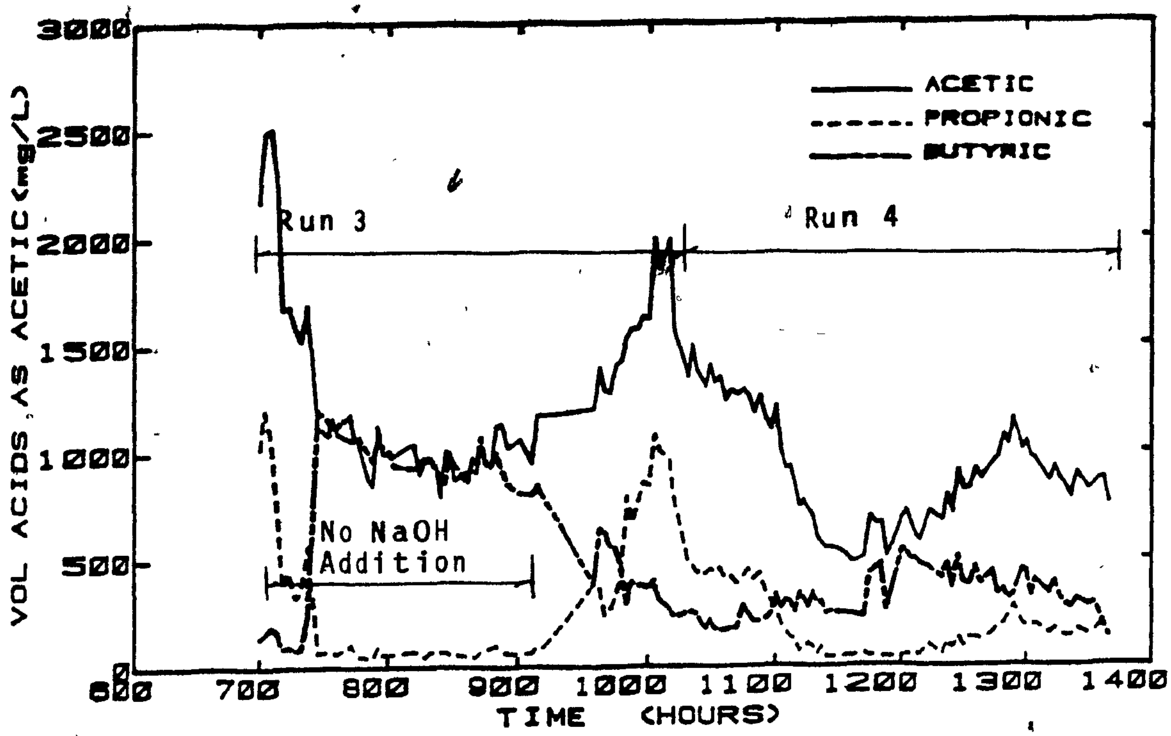


Figure 15. Runs 3 and 4. Volatile Fatty Acid Content of The Effluent

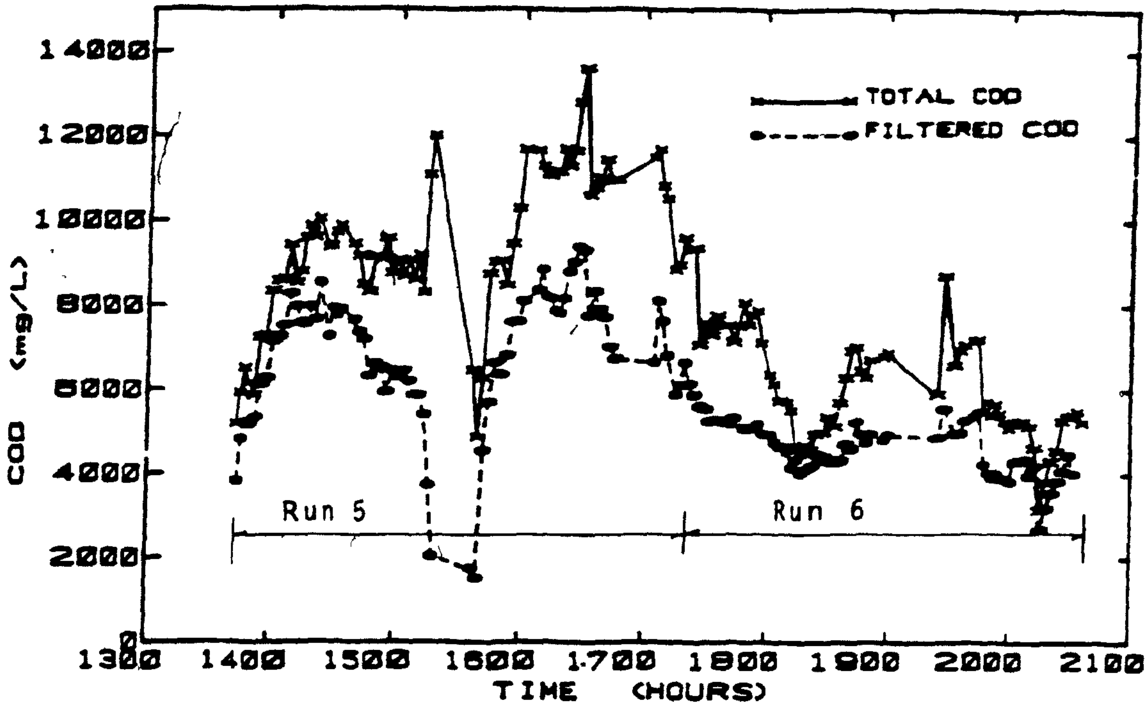


Figure 16. Runs 5 and 6. Effluent Total COD and Filtered COD

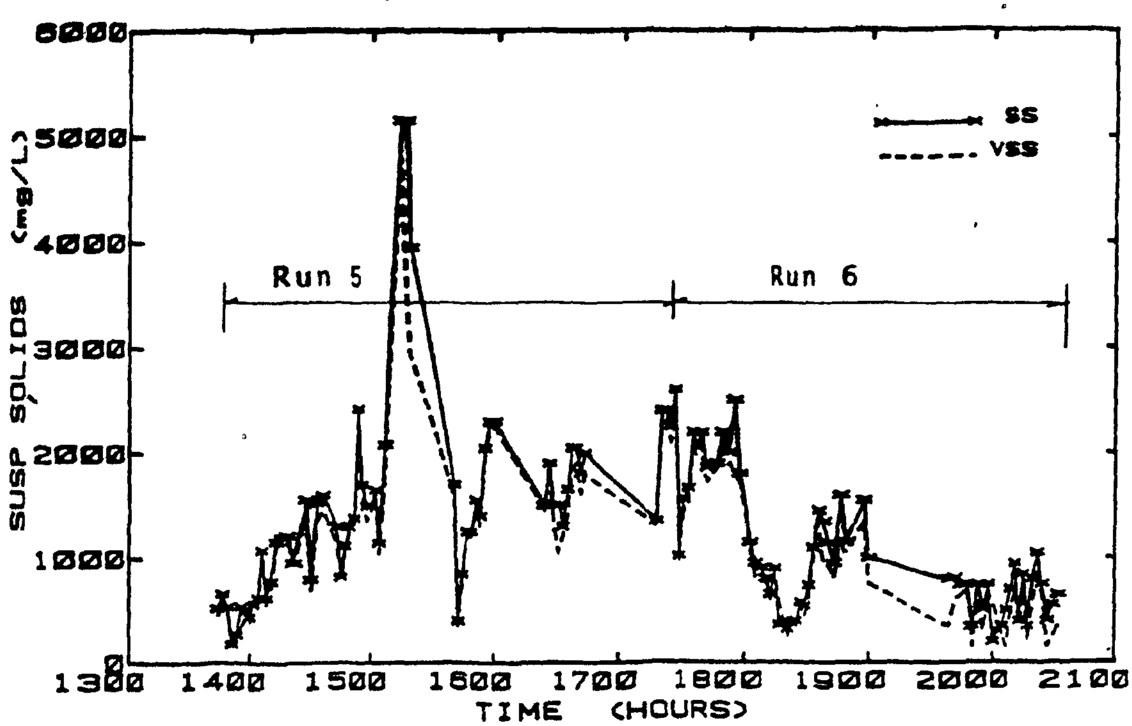


Figure 17. Runs 5 and 6. Effluent Suspended Solids and Volatile Suspended Solids

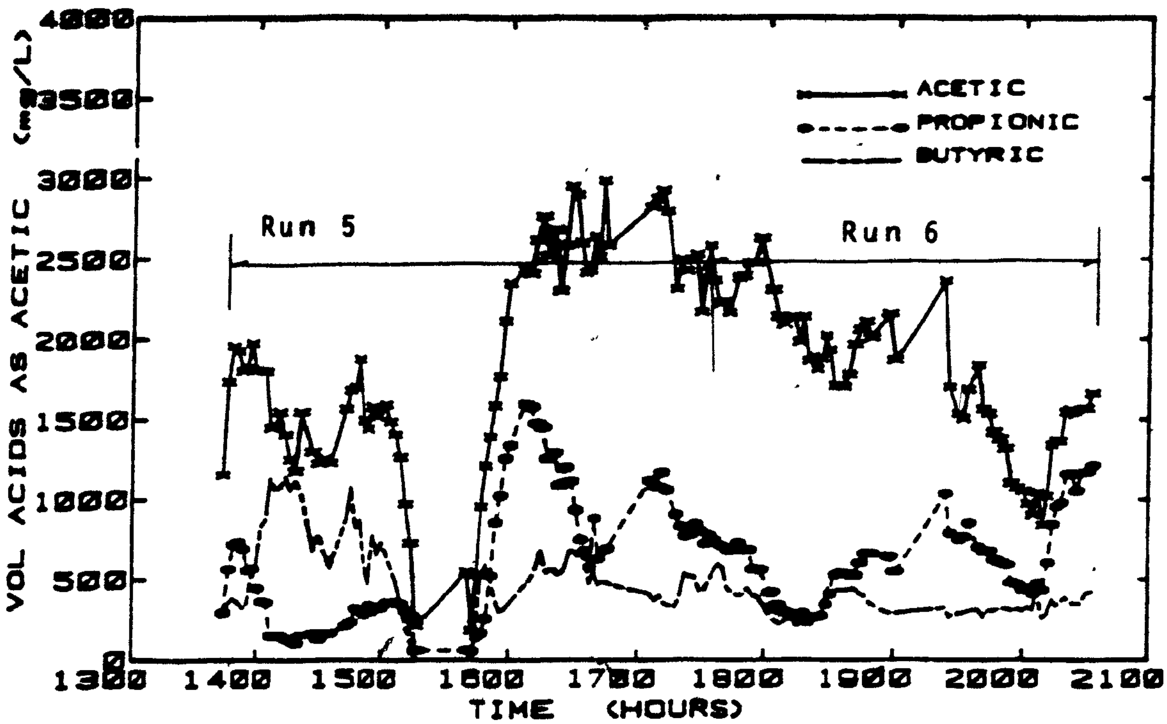


Figure 18. Runs 5 and 6. Volatile Fatty Acid Content of The Effluent

averaged only 31.2%. At the high loading rate, VFA levels had increased, (Figure 12), and the DSFF reactor became unstable.

During run 3, the capability of the DSFF reactor to operate without the increased alkalinity for the first 200 hrs is readily noticeable, (Figure 13). At high loading rates, 11.55 kg COD/m3/day, the rapid decrease of pH led the system to operate only with the buffering capacity provided by the influent. Without the increased alkalinity the reactor showed some degree of instability. The most significant aspects of this instability were the greater reduction in pH (Table 5), decreased effluent quality (Figures 13 and 14), low efficiencies and high rate of gas production (Figure 7), and longer period of recovery ie. 96 hrs, following the increase in alkalinity.

Over the last three runs, the DSFF reactor showed good stability against changes in organic loads. High organic loads were tolerated, these being 6.30, 14.90, and 10.40 kg TCOD/m3/day, (Table 5). This stability is due to the long solids retention times of fixed film reactors independent of the hydraulic load.

These organic load changes brought the DSFF reactor to a very high activity level with sharp increases in gas production, up to 4.30 m3/m3/day, (Figure 9), and a rise in all VFA concentrations, (Figures 18). This in turn caused a decrease in effluent quality due to the subsequent increase in effluent COD concentration, (Figure 16), and suspended solids concentration, (Figure 17), to values up to 9435 mg TCOD/l and 5150 mg/l SS respectively.

The response of gas production after each change in operational conditions is readily noticeable. The rate of gas production increased and/or decreased in proportion to the range of organic loading, (see Table 5). Gas production peaked immediately after an increased in COD load (Figures 5, 7, and 9), then returned quickly (ie. decreased) to pseudo-steady-state levels as organic substrates were metabolized and reactor conditions returned to normal from the effects of the slug-loadings.

During Phase I of the experiment the temperature range was 32-35°C, and pH ranged from 5.4 to 6.7.

The relative performance of the DSFF reactor analyzed in this project, compared to other types of reactors and other wastes, is shown in Table 6.

Table 6. Comparison of High Rate Anaerobic Fixed Film Reactors Treating Dairy Wastewater

Reference	Reactor Type	Waste	HRT (hrs)	Temp (°C)	Raw Waste (mg COD/l)	Loading (Kg COD/ m3/day)	% Removal
Switzenbaum and Danskin (1981)	AAFEB	Whey	8.9-27.1	28-31	10000	8.9-27	77-93
			13.8-16.4	35	5-15000	8.2-22	61-92
Van den Berg and Kennedy (1983)	Upflow Sludge Blanket	Dairy Waste	6.4-19.2	35	4000	5-15	67-83
	Fixed Film	Dairy Waste	6.4-19.2	35	4000	5-15	66-92
		Whey	79-316	35	66000	5-20	87-98
		Skim Milk	9.6-19.2	35	4000	5-10	60-82
Van den Berg and Kennedy (1981)	Fixed Film	Dairy Waste	12	35	4400	9.4	45
Hall et al (1983)	Fixed Film	Whey	38.40	35	31400	18.6	65
This Study (1984)	Fixed Film	Dairy Waste	9.5-86	32-38	5-23000	5-15	53-83

3.7. Discussion of First Phase Experimental Results

3.7.1. Influence of Control Variables On Process Performance

An examination of Table 5 along with the DSFF reactor's response in Figures 10 - 18 shows that the process was able to achieve high COD removal efficiencies at high volumetric organic loading rates. Volumetric organic loading rates up to 15.90 kg COD/m3/day, and COD removal efficiencies of 53 - 85 % were about the same as those reported for stationary fixed film and upflow sludge blanket reactors, (Van den Berg and Kennedy, 1981, 1983), for dairy wastewater and skim milk wastes. However, they were not as high as those reported for the expanded bed reactor, (Switzenbaum and Danskin, 1981) and DSFF reactor, (Hall et al, 1983), for whey wastewater.

The response of the DSFF reactor to continuous loading reflects the effects of both hydraulic wash out and biological degradation. A hydraulic retention time less than 0.39 days could not be maintained. This is demonstrated by the decrease in effluent quality, (Figures 10 and 11), and the low percentage of COD removals and low gas production, (Table 5). On the other hand, COD loading rates were limited to 14.90 kg/m3/day. COD removal efficiency averaged 63.5 % and decreased with loading rate. However, substrate removal rate was independent of the hydraulic loading rate and increased with an increase in COD loading, (Table 5). Therefore, it can be seen that increasing the COD loading does not have the same effect as increasing the hydraulic loading rate. The hydraulic loading increase lessens the contact time between the substrate and the bacteria embedded in the film, resulting in a decrease of the efficiency of the DSFF reactor.

The effects of COD loading on VFA content of the effluent can be seen in Figures 12, 15 and 18. Van den Berg and Kennedy (1981) have indicated that at short hydraulic retention time (HRT=0.6 days) the hydrolysis and acid reactions become limiting. This condition is indicated by the low and erratic gas production, 1.65 m3/m3/day, (Figure 5), low % COD removed and an almost equal concentration of acetic and propionic acids, (see Table 5 and Figure 12). Although the HRT was increased to 3.5 days (run 2), the concentration of propionic acid, 655 mg/l, persisted in the DSFF reactor for a considerable time. The increase of propionic acid and its accumulation under unsteady state and varying loads is common and has been reported by Cohen et al (1979), Barnes et al (1982), Kennedy and Van den Berg

(1982), and Hosey (1983).

At a COD loading rate over 12.0 kg/m3/day, VFA increased and the DSFF reactor became less stable. High VFA levels during run 3, (Figure 15), and runs 5 and 6, (Figure 18), accounted for a large proportion of the COD content of the effluent. These high VFA levels led to an eventual inhibition of the fermentation process since they are not converted to methane and carbon dioxide and consequently are not removed from the system, thus causing the decrease in COD removal efficiency.

It should be pointed out that although high VFA levels were produced under pseudo-steady-state conditions, the DSFF reactor had a reserve methanogenic capacity. This is shown by the high biogas yield coefficient which averaged approximately 0.54 m3 per kg COD removed (STP). Furthermore acetate is utilized even in the presence of high VFA concentration, and high rates of gas were produced, (Figures 9 and 18).

It can be concluded from the results obtained in phase I of the experiment that the use of anaerobic downflow stationary fixed film reactors for the treatment of dairy wastes is extremely promising. The treatment of dairy wastewater by DSFF reactors offers the dual advantage of energy production in which the production of gas is attractive from an economic point of view, and as a pollution control in which as much BOD/COD is removed as is feasible at relatively short HRT and at high organic loading rates. However, the system would require control to keep the pH level above 6.5 and post-treatment of the anaerobic effluent to reduce suspended solids and COD to acceptable levels for receiving waters.

3.7.2. Factors Affecting Effluent Variability In The DSFF Reactor

The objective of this section is to determine the nature and extent of the variability in effluent quality and to identify factors contributing to this variability through statistical analysis of operating data. Both experimental and analytical research studies have been conducted, examining DSFF reactor performance variations under laboratory conditions. Thus, the results reported herein reflect conditions encountered in pilot scale operations.

The statistical analysis of operating data included correlation and regression analysis, and time series analysis of the effluent response in terms of effluent filtered COD.

Different available statistical packages were studied, and the Statistical Analysis System (SAS), 1982 was chosen to carry out this analysis because of its versatility, and easy operating mode.

3.7.2.1. Correlation and Regression Analyisis For Phase I of The Experiment

Correlation and Regression analysis were used as descriptive tools to evaluate the contribution of a specific variable or set of variables to the effluent response variation (Niku and Schroeder, 1981).

The control variables were studied both individually and in combination to determine the individual and combined effects of the control variables on effluent fluctuations and gas production. The data used in the present analysis comprised the entire set of data collected during phase I of the experiment. The reason for considering the entire set of data was in an attempt to establish the nature of the relationship between the selected variables and effluent response. Thus the functional relationship between variables was studied and a mechanism of analyzing the effluent fluctuations from the DSFF reactor was provided.

The results of correlation analysis for phase I of the experiment are presented in Table 7. The relationship between selected control variables and effluent concentration showed moderate dispersion. Less than 16% of the effluent COD variations, ($r^2=0.16$), can be explained by changes in ICOD, (see Figure 19). Volumetric organic loading, VL, accounted for 30% of the effluent COD fluctuations, (Figure 20). HRT was unrelated to ECOD or EFCOD, the maximum correlation coefficient for EFCOD being 0.054.

ICOD, VL, and HRT did not have a significant influence in effluent SS. Only 3% of ESS variations were explained by changes in the control variables, (see Figure 21). Most of the COD of the effluent was in suspended form, (Figures 11, 14, and 17). This suspended COD appeared to be largely due to the excess biomass produced in the reactor. Deterioration of effluent quality by the increase in SS is probably due to wash-out of reactor suspended solids affected by changes in the loading rates and the increase in gas production where unattached biomass particles become attached to gas bubbles. As well, biomass may also have sloughed off from the support media due to increased gas

Table 7. Correlation Analysis: Pearson Corralation Coefficient Between Effluent Concentration, Removal Rates, and Gas Production, and Operational Variables For Phase 1 of The Experiment

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 412

	ECOD	EFCOD	ESS	EVSS	SRRT	SRRF	PSRRT	PSRRF	C2	C3	C4	GAS	PH
ICOD	0.36365 0.0001	0.48642 0.0001	0.02553 0.5542	0.03750 0.4425	0.53137 0.0001	0.57514 0.0001	0.55616 0.0001	0.74216 0.0001	0.59555 0.0001	0.31866 0.0001	0.27647 0.0001	0.74160 0.0001	0.03298 0.5040
IFCOD	0.36163 0.0001	0.40159 0.0001	0.02366 0.6320	0.03244 0.5116	0.51862 0.0001	0.55762 0.0001	0.54549 0.0001	0.73631 0.0001	0.61369 0.0001	0.36141 0.0001	0.23668 0.0001	0.73059 0.0001	0.01902 0.7003
VL	0.49254 0.0001	0.57665 0.0001	0.14246 0.0036	0.16268 0.0009	0.02126 0.6672	0.62661 0.0001	-0.44103 0.0001	-0.57410 0.0001	0.12433 0.0116	0.36417 0.0001	0.29210 0.0001	0.26013 0.0001	-0.29871 0.0001
VF	0.45622 0.0001	0.55171 0.0001	0.12768 0.0098	0.14722 0.0027	-0.00076 0.5877	0.61583 0.0001	-0.45347 0.0001	-0.59273 0.0001	0.12304 0.0124	0.31161 0.0001	0.23090 0.0001	0.24184 0.0001	-0.31760 0.0001
HRT	0.05447 0.2700	0.00071 0.5886	0.15600 0.0018	0.15989 0.0011	-0.46040 0.0001	-0.06834 0.1662	-0.72130 0.0001	-0.88353 0.0001	-0.30800 0.0001	0.07650 0.1209	-0.18742 0.0001	-0.44226 0.0001	-0.20598 0.0001
C2	0.38831 0.0001	0.64065 0.0001	-0.02804 0.5554	-0.00571 0.6442	0.36730 0.0001	0.46385 0.0001	0.28464 0.0001	0.27323 0.0001	1.00000 0.0000	0.56859 0.0001	0.43686 0.0001	0.75813 0.0001	-0.04858 0.3253
C3	0.31261 0.0001	0.31853 0.0001	0.15532 0.0016	0.16021 0.0011	0.04387 0.3744	0.31765 0.0001	-0.03213 0.5166	0.03261 0.5092	0.56659 0.0001	1.00000 0.0000	-0.08440 0.0871	0.33217 0.0001	-0.29750 0.0001
C4	0.39018 0.0001	0.73518 0.0001	-0.09157 0.0633	-0.06221 0.2077	0.26879 0.0001	0.32201 0.0001	0.06744 0.1719	-0.08597 0.0814	0.43686 0.0001	-0.08440 0.0871	1.00000 0.0000	0.57166 0.0001	0.30195 0.0001
PH	-0.01276 0.7962	-0.00381 0.5366	0.00255 0.9602	0.01047 0.8322	0.00665 0.8903	-0.17261 0.0004	0.09214 0.0617	0.12999 0.0083	-0.04858 0.3253	-0.25760 0.0001	0.30198 0.0001	0.03752 0.4427	1.00000 0.0000
TIME	0.17703 0.0003	0.39446 0.0001	-0.23420 0.0001	-0.22076 0.0001	0.46574 0.0001	0.48258 0.0001	0.38940 0.0001	0.36015 0.0001	0.59164 0.0001	-0.01410 0.7763	0.53970 0.0001	0.59982 0.0001	0.19902 0.0001
TEMP	-0.16664 0.0007	-0.12476 0.0112	-0.12283 0.0126	-0.13142 0.0076	0.25658 0.0001	0.02910 0.5559	0.54473 0.0001	0.67085 0.0001	0.32600 0.0001	0.15762 0.0001	-0.17028 0.0005	0.27865 0.0001	0.05214 0.2916

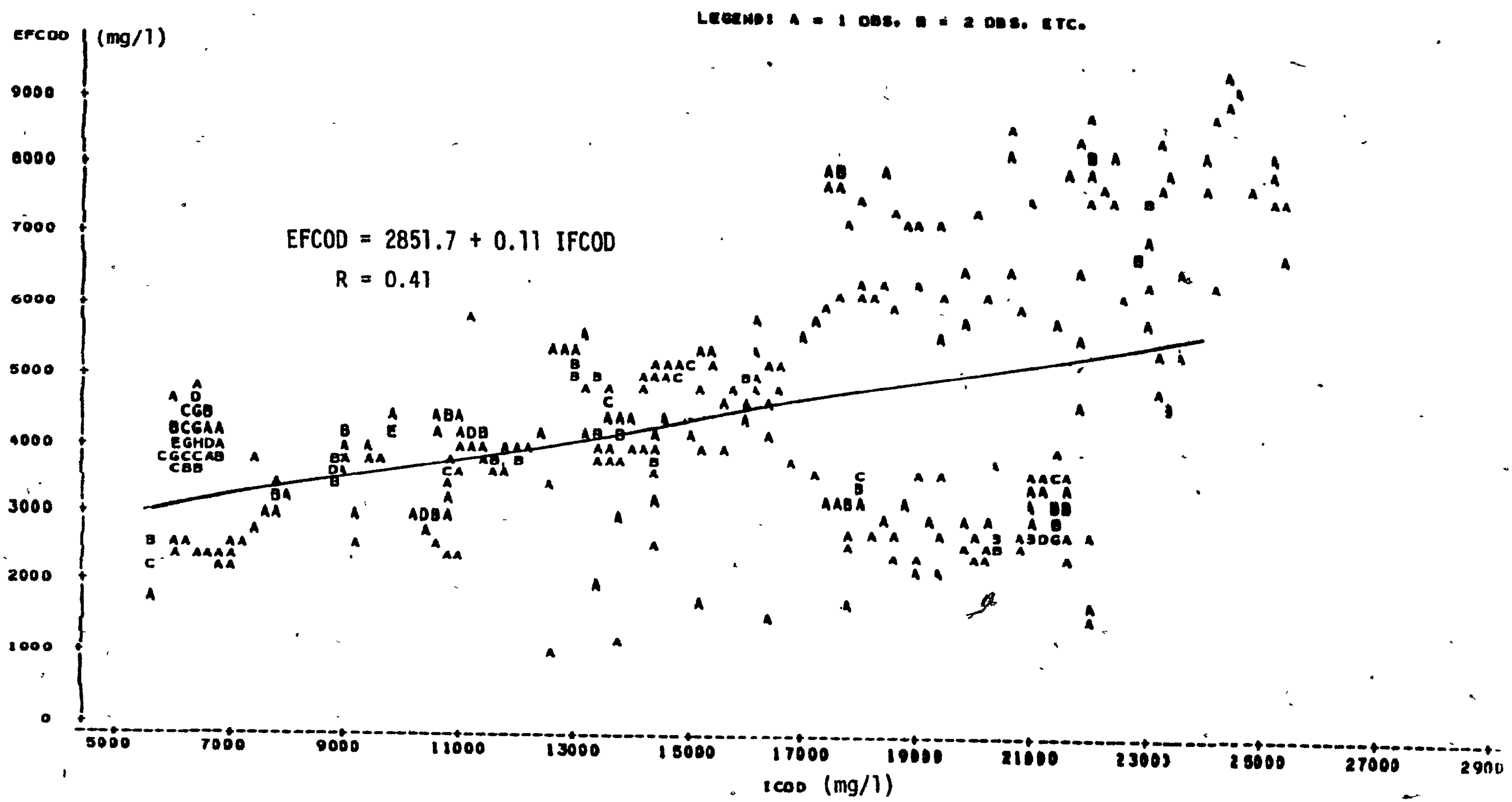


Figure 19. Effect of COD Concentration on Effluent Filtered COD

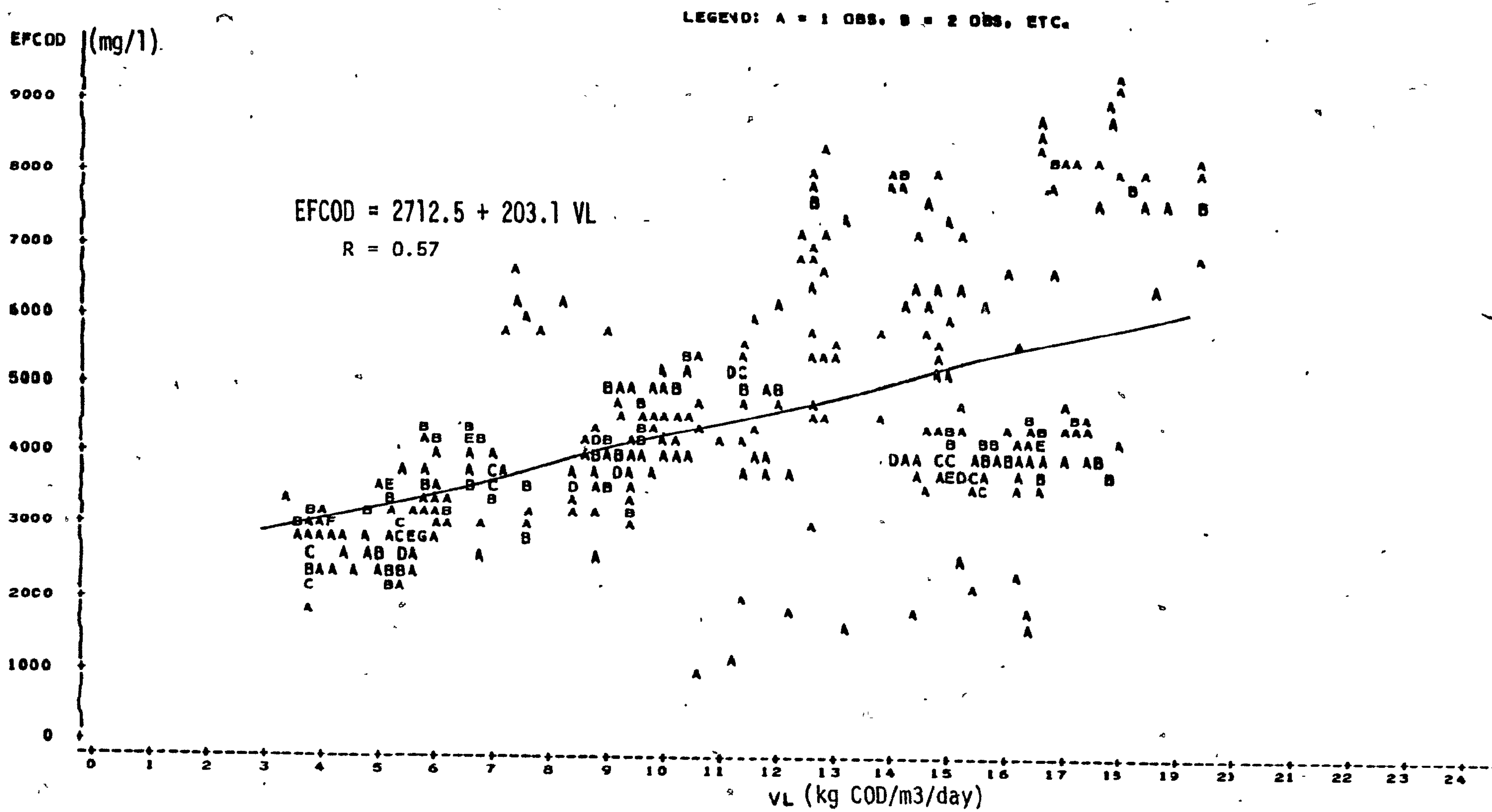


Figure 20. Effect of COD Loading on Effluent Filtered COD

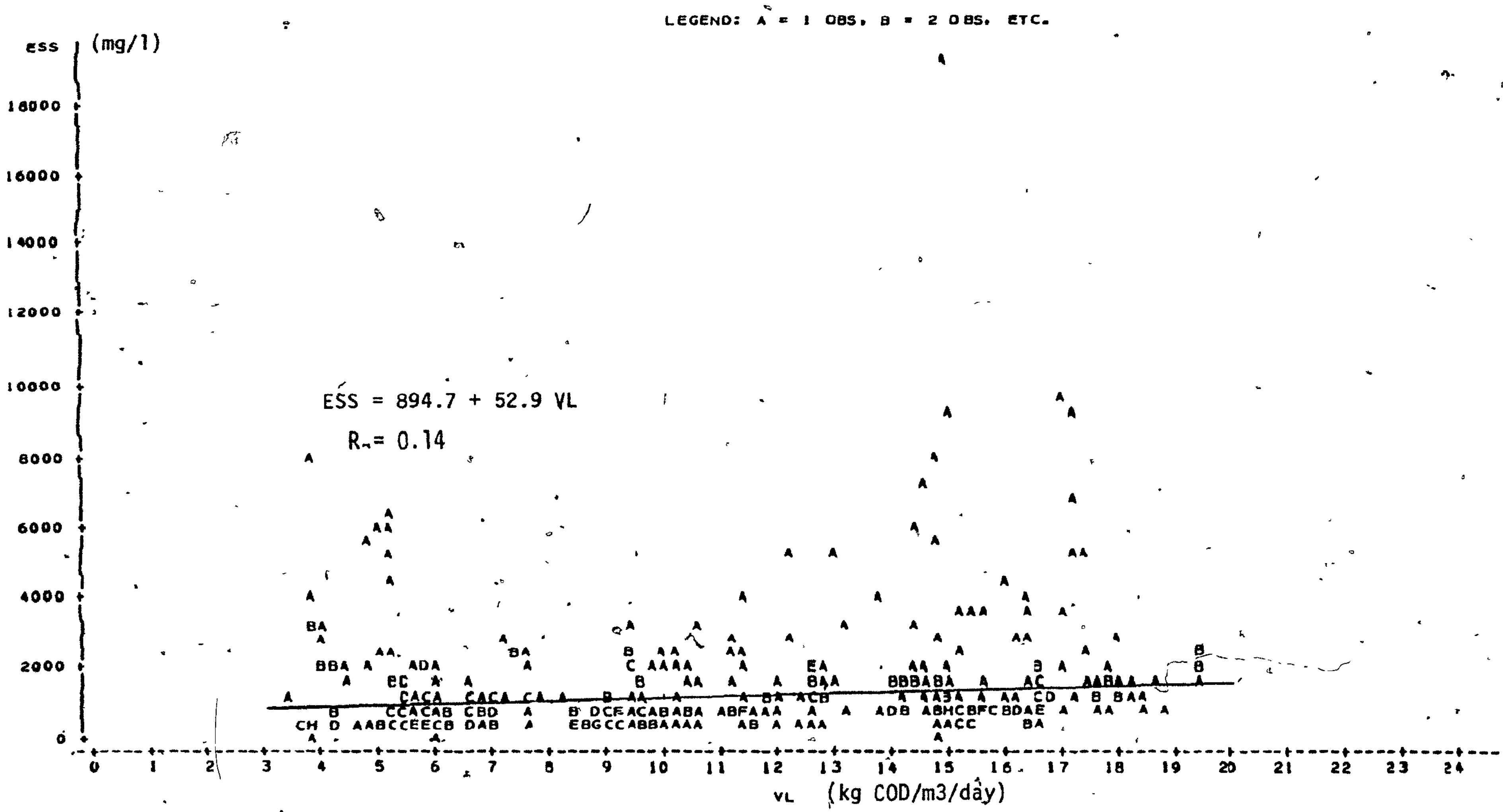


Figure 21. Effect of COD Loading on Effluent Suspended Solids

production within the film and relatively short HRT. These effects have been observed in overloaded reactors (Kennedy and Van den Berg, 1981, 1982; Hall, 1982; Bull et al, 1983; Van den Berg and Kennedy, 1983).

It was found that up to 40% of COD removal rates (SRRT and SRRF) and up to 33% of COD efficiency (PSRRT and PSRRF) variations were caused by volumetric organic loading, VL (see Figures 22 and 23). ICOD accounted for 54% of the variations of PSRRF and 34% of SRRF. HRT was found to be significant in explaining the PSRRF, PSRRT, and SRRT variations but not SRRF. The total contribution of HRT to removal rates were 78% for PSRRF, 52% for PSRRT, 21% for SRRT, and only 0.3% for SRRF. Therefore, it can be seen that ICOD, VL, and HRT have a high influence in COD removal rates.

The highly significant relationship between selected control variables and removal rates indicates that the % COD removed and COD removal rate of a DSFF reactor are a function of the organic loading and concomitant HRT. These results are in agreement with the results presented by Kennedy and Van den Berg (1982), Hall et al (1983), and Van den Berg and Kennedy (1983) for anaerobic DSFF reactors, and Switzenbaum and Jewell (1980) for the expanded bed reactor.

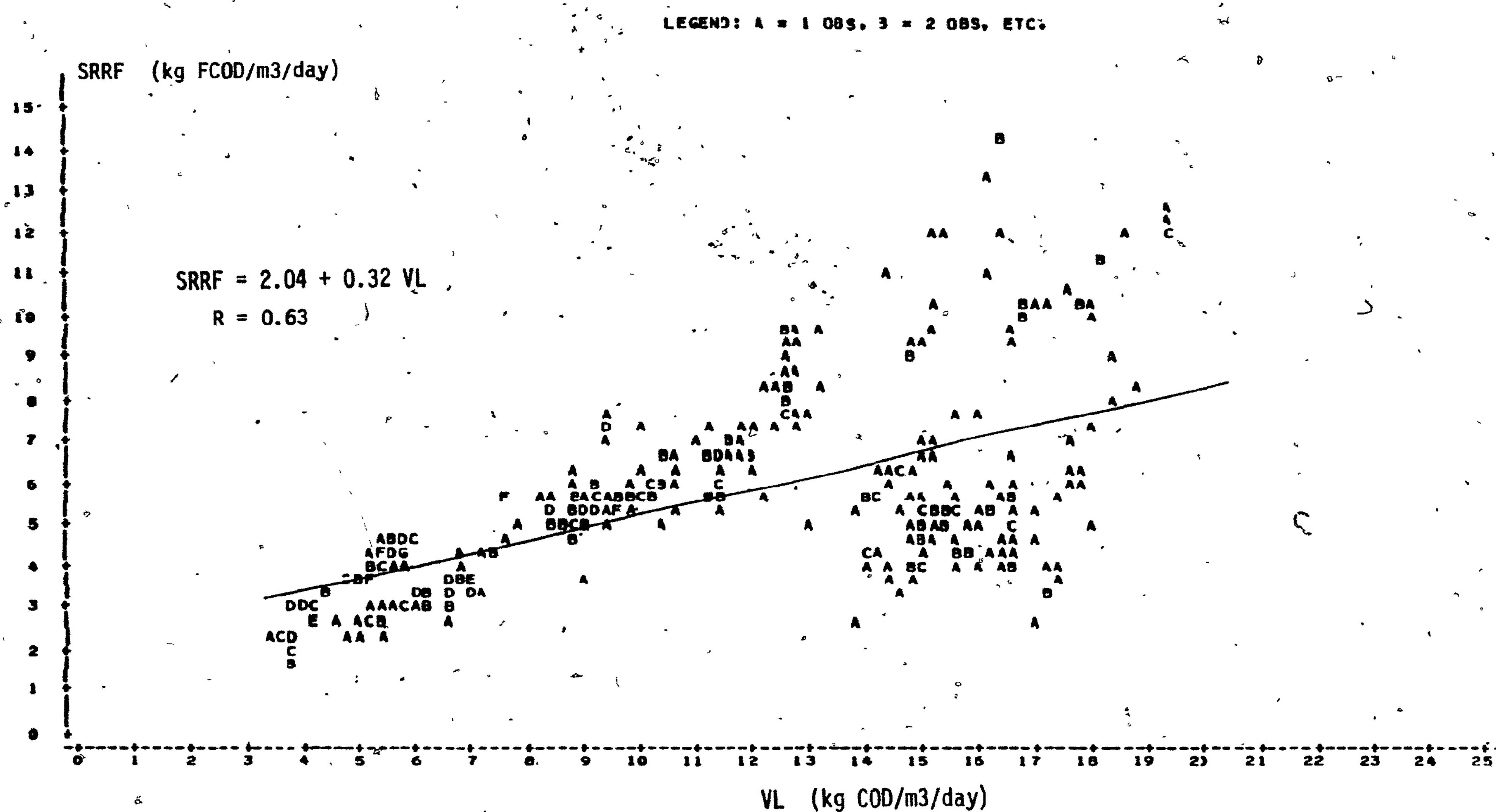


Figure 22. Effect of COD loading on COD Removal Rate in Terms of Filtered COD

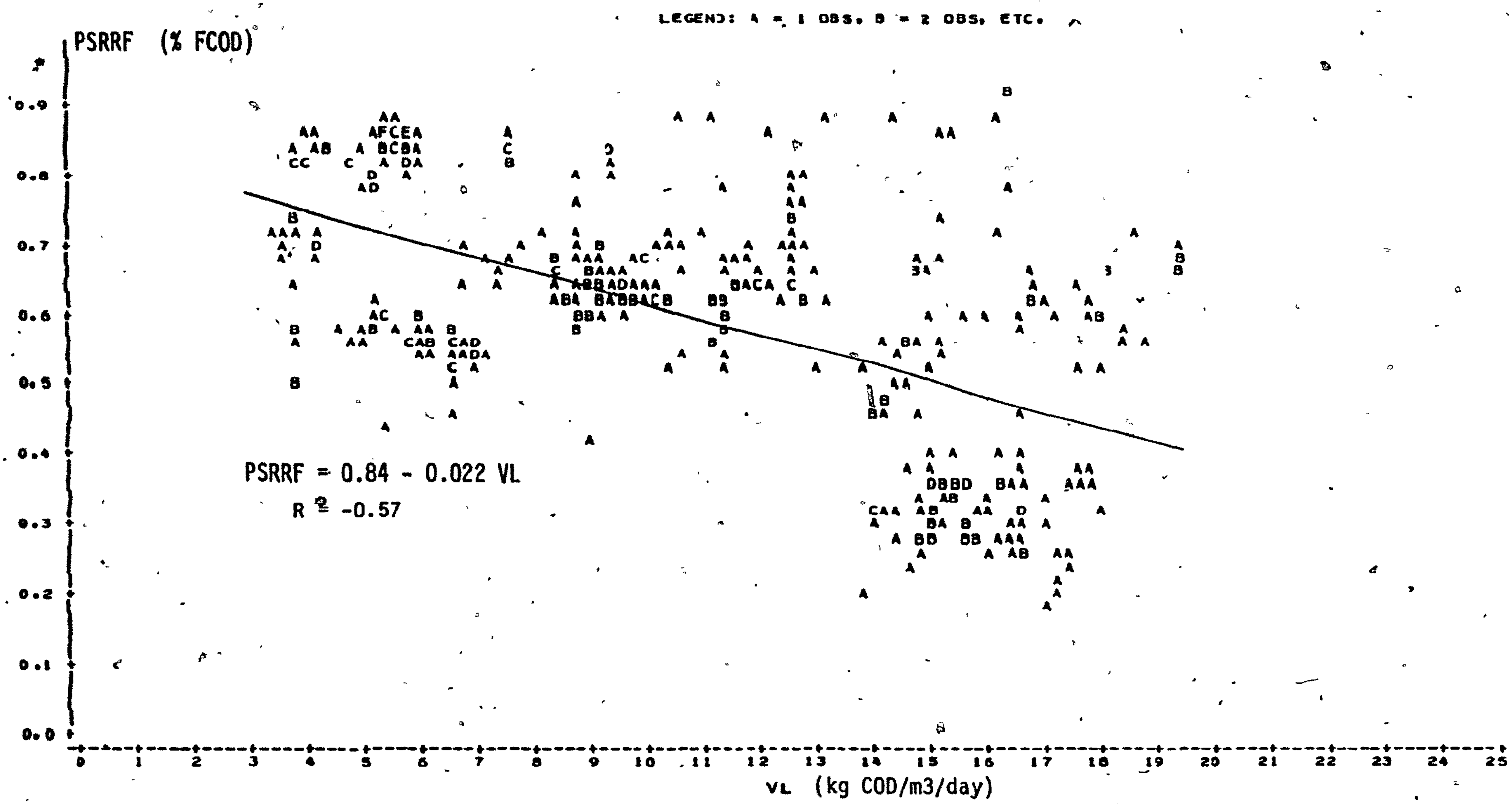


Figure 23. Effect of COD Loading on COD Removal Efficiency in Terms of Filtered COD

38% of acetic acid (C2) variations were explained by changes in influent COD, (see Figure 24). VF did not have significant relationship with C2, $r^2=0.015$. The correlation coefficient between HRT and acetic acid was $r=-0.38$. ICOD and VL had a relatively high correlation with gas production, (Figure 25). Up to 55% of gas production variation was explained by these variables, thus indicating that the rates of gas production and VFA levels increase with increased input loads.

Multiple regression analysis was used to relate effluent quality, removal rates, and gas production to the variables influencing performance; this analysis is summarized in Table 8. A combination of ICOD, VL, and HRT was able to describe up to 40% of the variance of effluent quality, 85% of the variance of removal rates, and 77% of the variance of gas production. Among all the variables, organic loading (VL) is the most important factor influencing performance, but performance was also influenced by the ICOD and HRT. The unexplained variation may be caused by other variables not included in the regression analysis, such as pH and inherent variability of process itself. Temperature was kept in the mesophilic range, 32°-35°C.

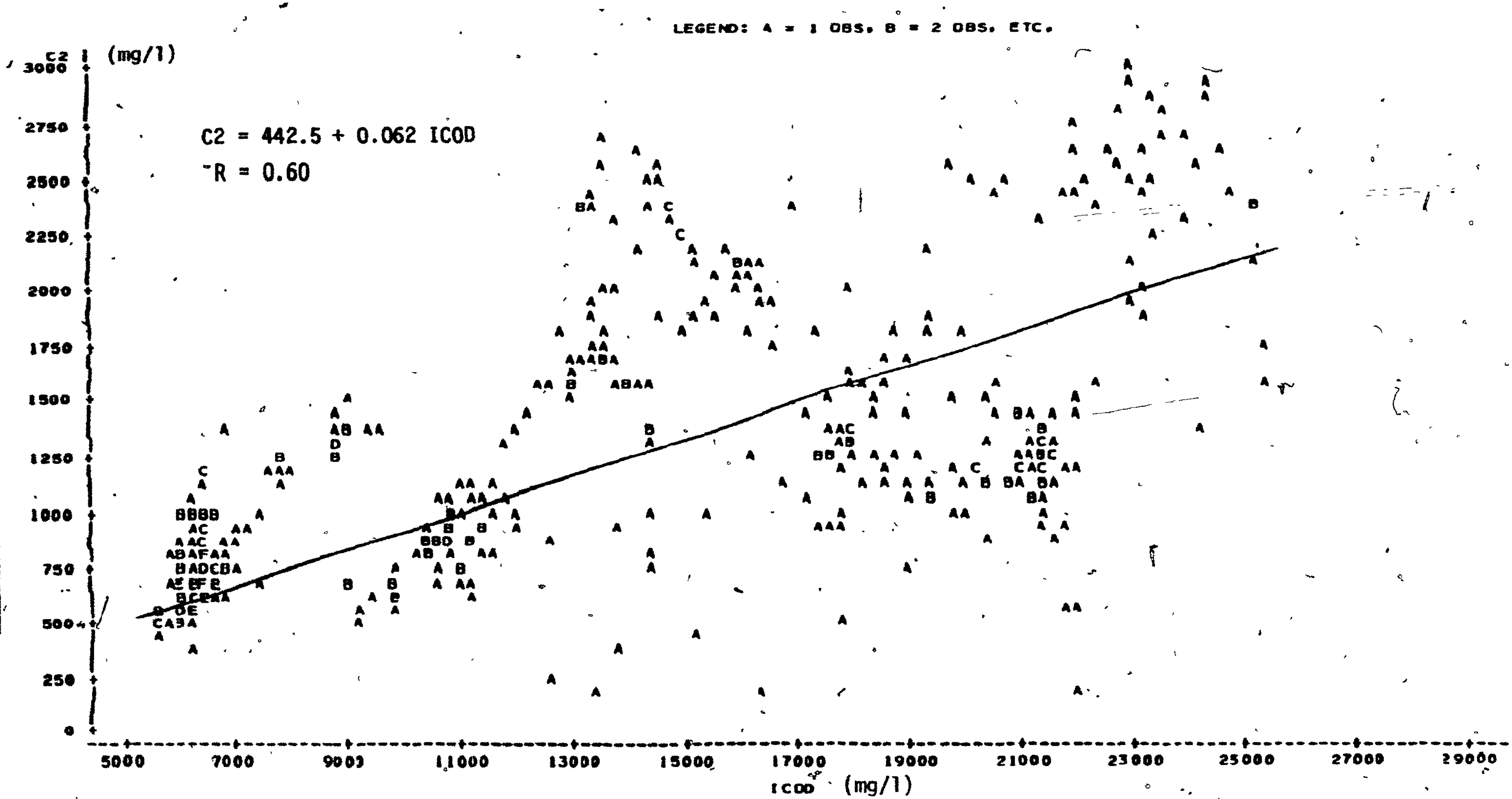


Figure 24. Effect of COD Concentration on Acetic Acid

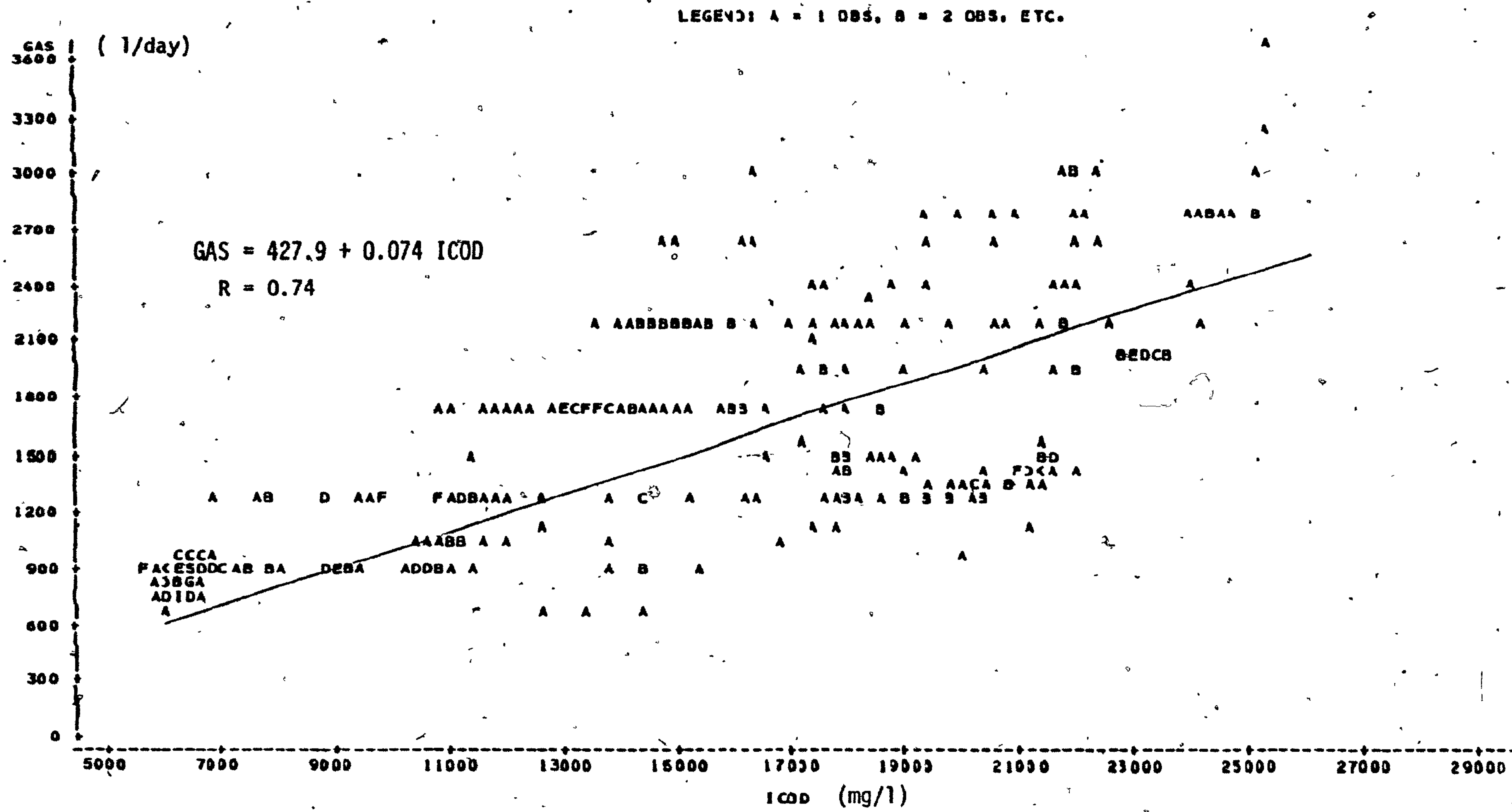


Figure 25. Effect of COD Concentration on Gas Production

Table 8. Regression Analysis: Coefficient of Determination For Treated Effluent and Control Variables

DEP VARIABLE: ECCD

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|		
INTERCEP	1	1500.816	538.985	2.785	0.0056	R-SQUARE	0.3959
ICOD	1	0.126297	0.037366	3.380	0.0008	ADJ R-SQ	0.3915
VL	1	368.918	48.445008	7.615	0.0001		
HRT	1	-561.950	385.494	-1.458	0.1457		

DEP VARIABLE: EFCOD

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|		
INTERCEP	1	2175.890	257.949	8.435	0.0001		
ICOD	1	-0.027688	0.017883	-1.548	0.1223	R-SQUARE	0.5989
VL	1	393.528	23.184955	16.973	0.0001	ADJ R-SQ	0.5960
HRT	1	-1660.682	184.491	-9.001	0.0001		

DEP VARIABLE: ESS

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|		
INTERCEP	1	-791.492	411.047	-1.926	0.0549		
ICOD	1	0.140161	0.028496	4.919	0.0001	R-SQUARE	0.0815
VL	1	-113.864	36.945659	-3.082	0.0022	ADJ R-SQ	0.0747
HRT	1	1516.249	293.990	5.157	0.0001		

DEP VARIABLE: SRRF

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|		
INTERCEP	1	0.818073	0.243291	3.363	0.0008		
ICOD	1	0.000048653	.00001686639	2.885	0.0041		
VL	1	0.570655	0.021867	26.096	0.0001	R-SQUARE	0.8286
HRT	1	-2.139878	0.174007	-12.298	0.0001	ADJ R-SQ	0.8273

DEP VARIABLE: FSRRF

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|		
INTERCEP	1	0.588770	0.017531	33.58[illegible]	0.0001		
ICOD	1	.00001650428	.00000121539	13.579	0.0001	R-SQUARE	0.8492
VL	1	-0.015324	0.001575762	-9.725	0.0001	ADJ R-SQ	0.8481
HRT	1	-0.052761	0.012539	-4.208	0.0001		

DEP VARIABLE: C2

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|		
INTERCEP	1	713.339	121.113	5.890	0.0001		
ICOD	1	0.019610	0.008396291	2.336	0.0200	R-SQUARE	0.4248
VL	1	76.255729	10.885863	7.[illegible]	0.0001	ADJ R-SQ	0.4205
HRT	1	-499.880	86.6226[illegible]	-5.771	0.0001		

DEP VARIABLE: GAS

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|		
INTERCEP	1	778.973	73.750595	10.562	0.0001		
ICOD	1	0.007384859	0.005112839	1.444	0.1494	R-SQUARE	0.7692
VL	1	127.760	6.628840	19.273	0.0001	ADJ R-SQ	0.7675
HRT	1	-792.003	52.748041	-15.015	0.0001		

pH during phase I of the experiment ranged between 6.5 to 7.3, except in run 3 in which the pH of the system dropped to 5.3. It should be noted that the DSFF reactor was not operating in this period of time (700-904 hrs) with any increase in alkalinity. Without the increased alkalinity, there was considerable variability, the most important aspects being the increase in effluent COD, SS, and VFA.

Based on pseudo steady state data, the results from correlation and regression analysis tend to indicate that COD loadings over 12 kg COD/m3/day could not be mantained in the DSFF treating dairy wastewater because of increasing effluent variability. The increase in effluent variability was more noticeable when the loading resulted from a higher influent COD than from a decrease in HRT. Moreover, the COD removals (SRR) increased with an increase in organic load obtained by a sharp rise in ICOD from 8500 to 17000 mg/l. The gas production increased linearly with the removal rate of COD, showing high variability at a higher loading rate.

It should be noted that given that the scatter diagrams in Figure 19 - 25 show that the dependent variables, EFCOD, ESS, SRRF, PSRRF, C2, and gas production are heteroscedastic, consequently the regression equations and correlation coefficients shown are only indicative and should not be used for predicting.

Finally, the effluent concentration, removal rates, and gas production were subjected to an analysis of variance (ANOVA) procedure to analyze the total variation of their response attributed to changes in the control variables. This analyis, summarized in Table 9, revealed that the only variable which was not significantly affected by the control variables, influent filtered COD (IFCOD) and volumetric organic loading (VF), was effluent suspended solids (SS).

Table 9. ANOVA Procedure for Phase I of The Experiment

Dependent Variable	Source	F-test Calculated	F-test at 5% Level of Significant	Remarks
EFCOD	IFCOD	5.43	1.84	significant
	VF	99.69	2.71	significant
	HRT	15.45	1.32	significant
ESS	IFCOD	1.36	1.84	not significant
	VF	0.74	2.71	not significant
	HRT	12.70	1.32	significant
C2	IFCOD	8.63	1.84	significant
	VF	49.42	2.71	significant
	HRT	29.18	1.32	significant
GAS	IFCOD	6.92	1.84	significant
	VF	678.73	2.71	significant
	HRT	23.95	1.32	significant
PSBRF	IFCOD	5.46	1.84	significant
	VF	41.70	2.71	significant
	HRT	66.47	1.32	significant

3.7.2.2. Time Series Analysis of The Effluent Response in Terms of Filtered COD From The DSFF Reactor Under COD loads

The objective of this section is to apply Box - Jenkins methodology to study how and to what extent effluent filtered COD is related to influent filtered COD in the DSFF reactor. In addition, discrete transfer function noise models to predict the effluent response (in terms of filtered COD) of the DSFF reactor under COD loads were developed. The tool employed here is the crosscorrelation function between influent and effluent, which indicates whether a given output response is statistically related to changes in specific input variables. A significant correlation between an input variable X_t and an output response Y_t generally indicates a relationship if a factorial design or other proper statistical procedure is used in conducting the experiments (Box and Jenkins, 1976).

Before looking at the crosscorrelation function between input and output filtered COD, an inspection of the autocorrelation function of effluent filtered COD was performed to gain further insight into the time variable behavior of treated effluent from the DSFF reactor.

The estimated autocorrelations of the original time series are shown in Figure 26. The autocorrelation depicted in Figure 26 (b) indicates that effluent filtered COD is a nonstationary series because of long persistence of nonzero values for several time period lags. Nonstationary series occur when the underlying physical mechanisms generating the series change, ie. when the principal movements or variations of the series are due to variations caused by its own process, by the generating process for the input, or jointly by previous values of the input and output series. It can be pointed out therefore that in this case, changes in operational conditions have a marked effect upon the soluble COD in the reactor.

Trends of any kind tend to introduce spurious autocorrelations that dominate the autocorrelation pattern. It is imperative, therefore, to remove the nonstationarity from the data before proceeding further with time series analysis. Removing trends can be routinely achieved through the method of differencing (Makridakis and Wheelwright, 1978).

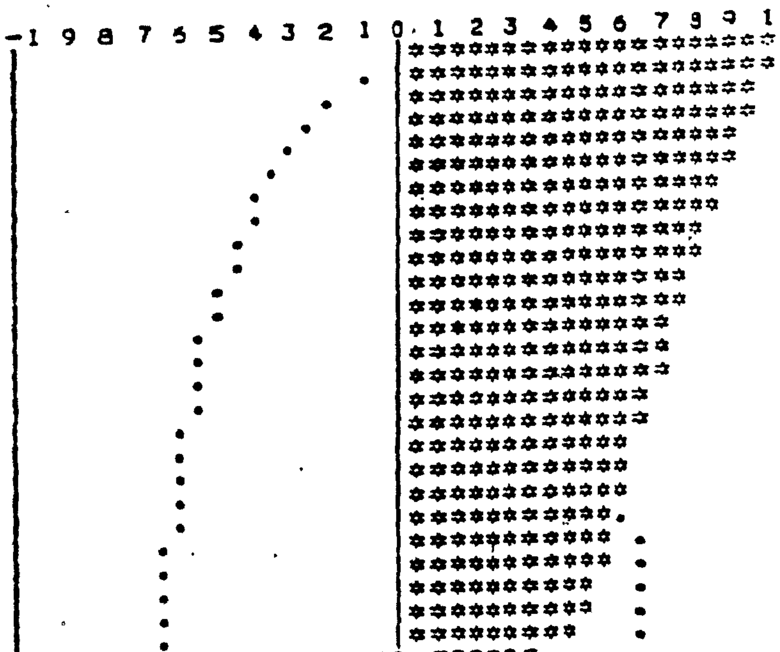
Figure 27 shows the autocorrelation of the differenced influent and effluent filtered COD. Notable features are, firstly, that stationarity is achieved with one degree of

a) NAME OF VARIABLE IFCOD

MEAN OF WORKING SERIES= 13409.2
STANDARD DEVIATION = 4930.45
NUMBER OF OBSERVATIONS= 258

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION
0	24309381	1.00000
1	24024281	0.98827
2	23564584	0.96936
3	23005050	0.94634
4	22392189	0.92113
5	21767398	0.89543
6	21135882	0.86945
7	20522422	0.84422
8	19926840	0.81972
9	19347997	0.79591
10	18761068	0.77176
11	18154440	0.74681
12	17540560	0.72156
13	16967420	0.69798
14	16413649	0.67540
15	15918385	0.65482
16	15484786	0.63699
17	15078838	0.62029
18	14690556	0.60432
19	14318558	0.58901
20	13934275	0.57321
21	13520598	0.55619
22	13071234	0.53770
23	12581966	0.51758
24	12042002	0.49536
25	11490891	0.47269



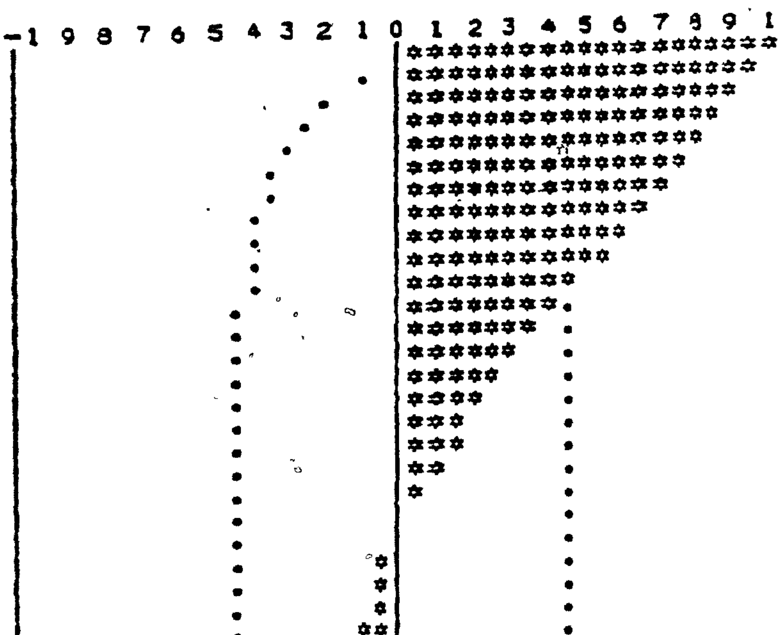
'.' MARKS TWO STANDARD ERRORS.

b) NAME OF VARIABLE = EFCOD

MEAN OF WORKING SERIES= 4806.28
STANDARD DEVIATION = 1819.45
NUMBER OF OBSERVATIONS= 258

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION
0	3310399	1.00000
1	3180011	0.96061
2	3008445	0.90879
3	2826711	0.85389
4	2660277	0.80361
5	2507807	0.75755
6	2324695	0.70224
7	2142101	0.64708
8	1947238	0.58822
9	1745868	0.52739
10	1530196	0.46224
11	1319054	0.39846
12	1125865	0.34010
13	967144	0.29215
14	827775	0.25005
15	703385	0.21248
16	560771	0.16940
17	419524	0.12673
18	278906	0.08425
19	140029	0.04230
20	17618.2	0.00532
21	-71467.1	-0.02159
22	-132825	-0.04012
23	-196661	-0.05941
24	-243994	-0.07371
25	-279130	-0.08432



'.' MARKS TWO STANDARD ERRORS

Figure 26. Estimated Autocorrelation of Influent and Effluent Filtered COD Time Series: a) Influent Filtered COD (IFCOD); b) Effluent Filtered COD (EFCOD)

a)
```
NAME OF VARIABLE          = IFCOD
PERIODS OF DIFFERENCING=  1.

MEAN OF WORKING SERIES=     13.2813
STANDARD DEVIATION     =    683.777
NUMBER OF OBSERVATIONS=         257

                               AUTOCORRELATIONS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9
 0     467551    1.00000   |                    |********************
 1     182512    0.39036   |                  . |********
 2    82519.1    0.17649   |                  . |****
 3    54850.7    0.11731   |                  . |**.
 4    13284.6    0.02841   |                  . |* .
 5    7849.85    0.01679   |                  . |  .
 6   -17607.6   -0.03766   |                  . *|  .
 7   -14008.7   -0.02996   |                  . *|  .
 8   -16687.6   -0.03569   |                  . *|  .
 9     6971.8    0.01491   |                  . |  .
10    18629.6    0.03984   |                  . |* .
11   -11508.5   -0.02461   |                  . |  .
12   -42184.4   -0.09022   |                  .**|  .
13   -36917.9   -0.07896   |                  .**|  .
14   -51451.4   -0.11004   |                  .**|  .
15     -62197   -0.13303   |                  ***|  .
16     -31532   -0.06744   |                  . *|  .
17     -15844   -0.03389   |                  . *|  .
18   -14468.3   -0.03094   |                  . *|  .
19     1969.3    0.00421   |                  . |  .
20      25914    0.05542   |                  . |* .
21    34466.4    0.07372   |                  . |* .
22      38760    0.08277   |                  . |**.
23    48720.1    0.10420   |                  . |**.
24    8248.86    0.01764   |                  . |  .
                           '.' MARKS TWO STANDARD ERRORS
```

b)
```
NAME OF VARIABLE          = EFCOD
PERIODS OF DIFFERENCING=  1.

MEAN OF WORKING SERIES= -0.272374
STANDARD DEVIATION     =   504.716
NUMBER OF OBSERVATIONS=        257

                               AUTOCORRELATIONS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9
 0     254738    1.00000   |                    |********************
 1    42625.2    0.16733   |                  . |***
 2    10502.7    0.04123   |                  . |* .
 3   -14952.2   -0.05870   |                  . *|  .
 4   -16404.4   -0.06440   |                  . *|  .
 5    29983.3    0.11770   |                  . |**.
 6   -1023.22   -0.00402   |                  . |  .
 7    11076.1    0.04348   |                  . |* .
 8     3757.7    0.01475   |                  . |  .
 9    20470.1    0.08036   |                  . |**.
10   -5461.39   -0.02144   |                  . |  .
11   -16844.3   -0.06612   |                  . *|  .
12     -35111   -0.13783   |                  ***|  .
13   -20363.4   -0.07994   |                  .**|  .
14   -9553.69   -0.03750   |                  . *|  .
15    11285.5    0.04430   |                  . |* .
16   -1799.89   -0.00707   |                  . |  .
17    828.251    0.00325   |                  . |  .
18   -2351.19   -0.00923   |                  . |  .
19   -17850.1   -0.07007   |                  . *|  .
20   -33327.9   -0.13083   |                  ***|  .
21   -23210.3   -0.09111   |                  .**|  .
22    1602.11    0.00629   |                  . |  .
23   -17630.2   -0.06921   |                  . *|  .
24   -11986.9   -0.04706   |                  . *|  .
                           '.' MARKS TWO STANDARD ERRORS
```

Figure 27. Estimated Autocorrelation of Differenced Influent and Effluent Filtered COD Time Series: a) Influent Filtered COD (IFCOD); a) Effluent Filtered COD (EFCOD)

differencing, and the mean of the working series does not significantly differ from zero. This is indicated by comparing the means to their own standard deviation (Figure 27 (a) and (b) respectively). Second, there is a lack of significant spikes in the autocorrelation function of effluent filtered COD. None of the estimated autocorrelations are large at the 95% confidence level. Third, the autocorrelation function of influent filtered COD, (Figure 27.a), damps out toward zero quickly in an exponential manner suggesting that an autoregressive process may describe the generating mechanisms of the input filtered COD concentration.

Figure 28 shows the estimated crosscorrelation function between the prewhitened (see page 40) influent filtered COD time series and the correspondingly transformed effluent response in terms of filtered COD time series (Appendix A shows the identified models for the input variables, IFCOD and VF, estimated model parameters, and diagnostic check of models adequacies). The crosscorrelation between effluent filtered COD and influent filtered COD is relatively weak. The data indicate that at a 95% confidence level, effluent quality as filtered COD is significantly affected by influent filtered COD, as some transfer of input to output is detected in the crosscorrelation function at a lag period

CORRELATION OF EFCOD AND IFCOD
FCOD HAS BEEN DIFFERENCED.
PERIODS OF DIFFERENCING=1.
BOTH SERIES HAVE BEEN PREWHITENED.
VARIANCE OF TRANSFORMED SERIES= 262976 385581
NUMBER OF OBSERVATIONS= 257

CROSSCORRELATIONS

LAG	COVARIANCE	CORRELATION
-25	33944	0.10660
-24	-4204.23	-0.01320
-23	-387.786	-0.00122
-22	-16103	-0.05057
-21	7167.15	0.02251
-20	-1375.95	-0.00432
-19	10916.3	0.03428
-18	24867.5	0.07809
-17	-26603.1	-0.08354
-16	7580.35	0.02381
-15	-20725.1	-0.06508
-14	-8929.55	-0.02804
-13	8075.49	0.02536
-12	-6279.85	-0.01972
-11	2873.28	0.00902
-10	-13832.6	-0.04344
-9	-13702.5	-0.04303
-8	4937.04	0.01550
-7	-23935.5	-0.07517
-6	-8157.62	-0.02562
-5	-45954.4	-0.14432
-4	4574.88	0.01437
-3	-3543.51	-0.01113
-2	7917.66	0.02486
-1	37090.6	0.11648
0	10836	0.03403
1	53642.6	0.16846
2	-32303.2	-0.10144
3	26633.3	0.08364
4	34202.4	0.10741
5	14316.6	0.04496
6	12876.9	0.04044
7	16866.3	0.05297
8	9454.2	0.02969
9	41766.8	0.13116
10	-1744.53	-0.00548
11	3217.21	0.01010
12	-7555.2	-0.02373
13	-24834.7	-0.07799
14	35826.3	0.11251
15	-22552.5	-0.07082
16	13511.6	0.04243
17	-2698.59	-0.00847
18	-40657.1	-0.12768
19	27314.8	0.08578
20	11363.2	0.03568
21	-6768.23	-0.02125
22	2106.93	0.00662
23	-7609.25	-0.02390

BOTH VARIABLES HAVE BEEN PREWHITENED BY THE FOLLOWING FILTER

PREWHITENING FILTER
NO MEAN TERM IN THIS MODEL.

AUTOREGRESSIVE FACTORS
FACTOR 1
1-.389215B**(1)

MOVING AVERAGE FACTORS
FACTOR 1
1+0.173205B**(57)

Figure 28. Estimated Crosscorrelation Between Prewhitened Influent Filtered COD (IFCOD) and Correspondingly Transformed Effluent Filtered COD (EFCOD)

of 1 (4 hours). Although the estimated crosscorrelation in Figure 28 shows a significant spike at a lag period of 9 (36 hours), this statistically significant crosscorrelation is felt to be unimportant from an engineering point of view because of the hydraulic retention time of the system, HRT=32 hours. Effective residence time is decreased by volume changes if solids accumulate in the reactor. Hall (1982) concluded that accumulation of primary attached solids in downflow stationary bed reactors reduced the actively mixed zone to 60% of the nominal volume and resulted in 30-35% short circuiting of the incoming flow.

Impulse response weights are related to the crosscorrelation function and may be used to identify significant output responses caused by changes in the levels of input variables (Nutt et al, 1981). Figure 29 shows the impulse response weights for effluent filtered COD during runs 4, 5, and 6. The impulse response weights for effluent filtered COD versus influent filtered COD, (Figure 29.a), indicate a rapid response to step changes in the influent COD concentration. The impulse response weight at lag 1 (4 hrs), with a value of 0.135, following the step change at 0 hour, is significant at the 95% confidence level. As well, Figure 29 (a) shows that a change in the COD concentration entering the DSFF reactor caused a response in the effluent

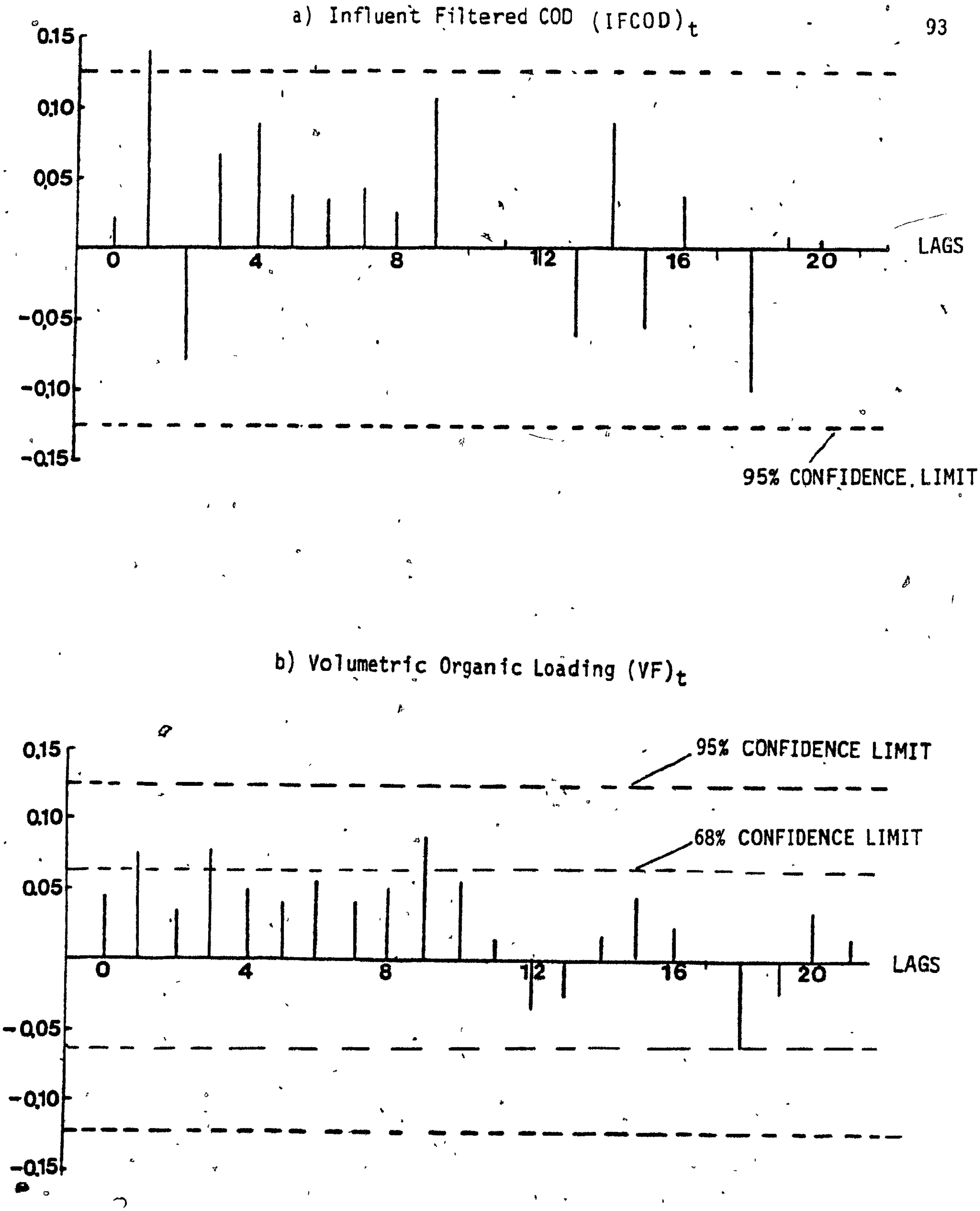


Figure 29. Impulse Response Weights For Effluent Filtered COD Following A Step Change in Input Variables

filtered COD concentration approximately 4 hours after the influent change was made.

Regarding the impulse response weights between effluent filterd COD and organic loading, VF, in Figure 29 (b), it can be seen that the DSFF reactor has a relatively high capacity to withstand high organic loadings or rapid change in raw wastewater conditions, since none of the impulse response weights are significant at the 95% confidene level. However the impulse response weights at lags of 1 (4 hours), and 3 (12 hours) are significant at the 68% confidence level. This may indicate that a change in the organic loading entering the DSFF reactor caused a response four-hours after the loading was changed and reacclimation and normal reactor performance was reestablished, 12 hours after the change was made.

These findings from the impulse response weights during pseudo - steady state operations are similar to the conclusions pointed out by Kennedy and Van den Berg (1981) that DSFF reactors could handle severe overloading without serious problems, and that normal reactor performance would be reestablished 12 - 48 hours after overloading.

3.7.2.3. Predicting The Effluent Response in Terms of Filtered COD by Box - Jenkins Transfer Function Noise Models Under COD Loads

From Figure 29, it is not possible to identify whether the system behaves according to a first order transfer function model, or whether a second order model would be better. Several transfer function noise models were developed relating effluent filtered COD (EFCOD) to influent filtered COD (IFCOD) and organic loading (VF). Table 10 shows the transfer function noise models which provided the best prediction of effluent filtered COD, interpreted as that which produces the smallest standard error of estimates at the output. Figure 30 provides a visual measure of the model adequacy by comparing the predicted effluent response by the transfer function noise model relating EFCOD to VF to those observed in run 6. Appendix A shows the ARIMA least squares estimation, and the autocorrelation plot of the transfer function noise models residuals, as well as, the crosscorrelation check of the residuals with influent filtered COD and VF time series, for the models shown in Table 10.

Table 10. Box - Jenkins Transfer Function Noise Models For The DSFF Reactor Under COD Loads

Model Number	Model Form	Number of Parameters	Std. Error(mg/l)	AIC
1	$(EFCOD)_t = \frac{0.163B}{(1+0.473B)}(IFCOD)_{t-1} + \frac{(1+0.146B)}{(1-0.145B^5+0.13B^{12}+0.15B^{20})}a_t$	6	478	-12
2	$(EFCOD)_t = \frac{0.0889B}{(1-0.822B)}(VF)_{t-1} + \frac{a_t}{(1+0.15B^3+0.147B^4+0.135B^{12})}$	5	476	-14

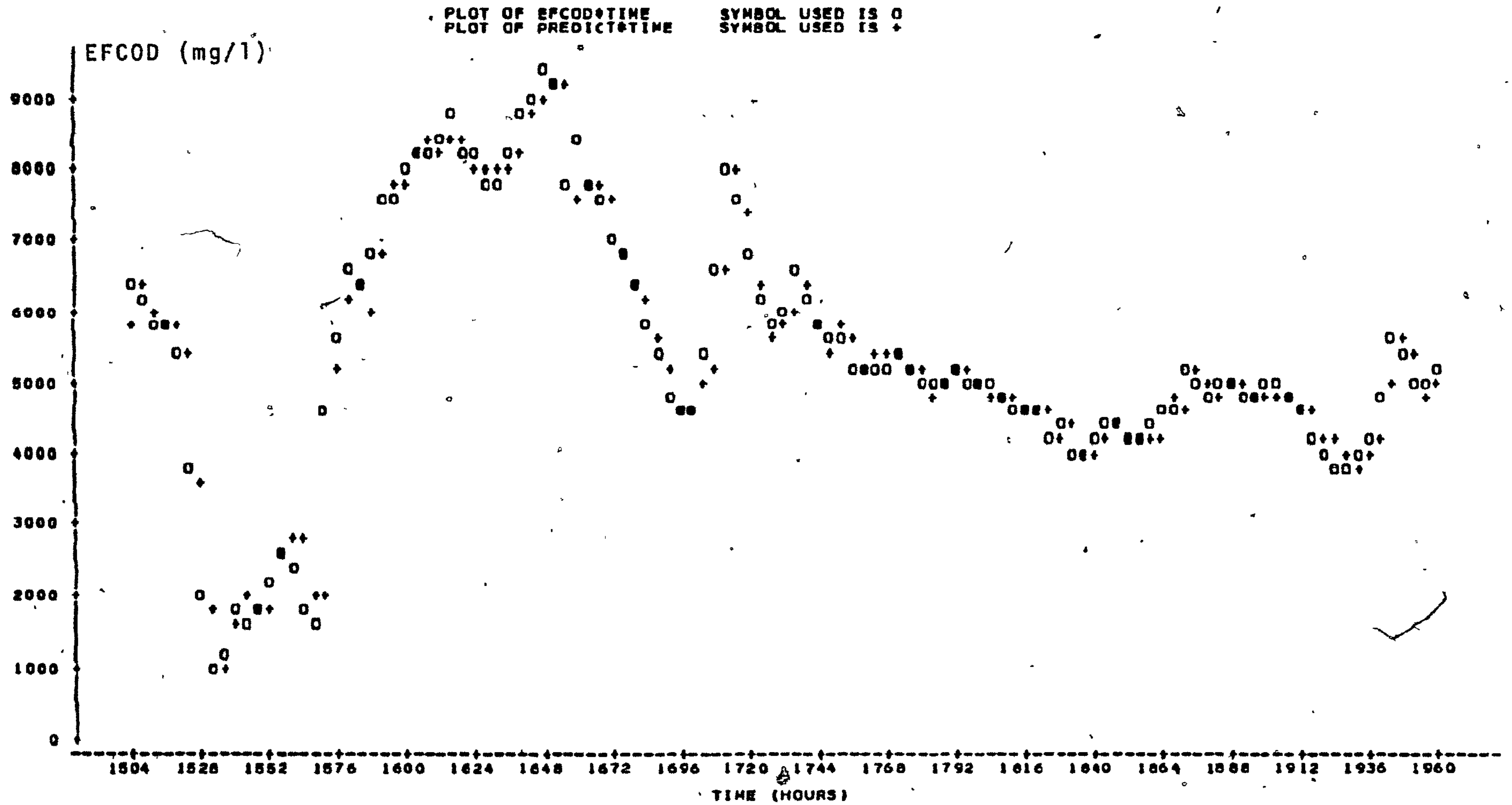


Figure 30. Predicted Effluent Filtered COD by Model 2 Under COD Loads

From Figure 30, it can be seen that the effluent response in terms of filtered COD was reasonably predicted by the Box-Jenkins transfer function noise model relating effluent filtered COD and volumetric organic loading. This model was able to account for 74% of the total variation in the response variable (ie. effluent filtered COD). A similar standard error was obtained relating effluent filtered COD and influent filtered COD (see Table 10). Therefore, it can be concluded from the dynamic modelling that changes in raw wastewater characteristics and loading rate to the DSFF reactor have a marked effect upon the DSFF performance in terms of effluent filtered COD.

3.8. Summary of Discussion For Phase I of The Experiment

Based on the results presented in section 3.7, the following summary can be made regarding the DSFF reactor.

- Dairy wastewaters may be anaerobically treated at high organic loading rates, up to 12 kg COD/m3/day, and at a relatively short hydraulic retention time, say 32 hours, in a DSFF reactor with a COD removal efficiency of approximately 65%.

The Time series analysis of the process indicated that effluent quality in terms of filtered COD is affected mainly by the influent COD concentration and the process COD loading. This result agrees with the findings of the correlation and regression analysis. Of the variables investigated under pseudo-steady-state conditions, the effluent quality was significantly correlated to volumetric organic loading. Influent COD concentration and the process loading were also correlated to gas production; of these, influent COD concentration had a more pronounced effect. Substrate removal rates were significantly affected by the process loading and concomitant HRT.

An adequate representation of the effluent response in terms of filtered COD was obtained through time series model building, based on COD loading. The Box-Jenkins transfer function noise models developed (Table 10) were able to account for 74% of the total variation in the response variable effluent filtered COD. Considering the errors inherent in the measurements, sampling procedure, and analytical procedure, this is judged satisfactory.

4. MODELLING DSFF REACTORS UNDER DYNAMIC CONDITIONS

4.1. The Use of Box - Jenkins Time Series Analysis For Predicting The Dynamic Response of An High Rate Anaerobic DSFF Reactor

The need of adequate mathematical tools for describing and understanding wastewater treatment processes, such as a high rate anaerobic DSFF reactor, has made researchers in the field of water pollution to look for better mathematical models which are able to characterize the process response and predict its dynamic behavior under different operational conditions.

Two important approaches used in describing and understanding biological processes are: first, kinetic models, based on continuous culture theory and stoichiometric coefficients, and used for design and operation; second, Box - Jenkins Time Series Analysis, which has been applied only to aerobic processes such as: activated sludge, rotating biological contactor, suspended growth systems, and, lately, to the biological fluidized bed process, (see Section 2.10.), predicting the performance of the processes and characterizing the effluent response of the systems under dynamic conditions.

Steady - state models are unable to predict process performance during start - up operations, and dynamic conditions resulting from changes in process input. Therefore, Box - Jenkins Time Series Models were used for a high - rate anaerobic downflow stationary fixed film reactor in order to achieve the following objectives: One, to relate influent variables with effluent response as filtered COD under dynamic conditions. Second, to predict the effluent response of the DSFF reactor.

4.2. Operational Conditions

The second part of this study, development of time series models, comprised 18 days of operation, (410 hours).

Figures 31, 32, and 33 show the operating condition of this second phase experimental program, and effluent response of the DSFF reactor as total and filtered COD, respectively.

25 observations of the reactor feed tank and 114 observations of the treated effluent were obtained to evaluate indicators of process response and develop discrete time series models for the purpose of predicting effluent response as filtered COD.

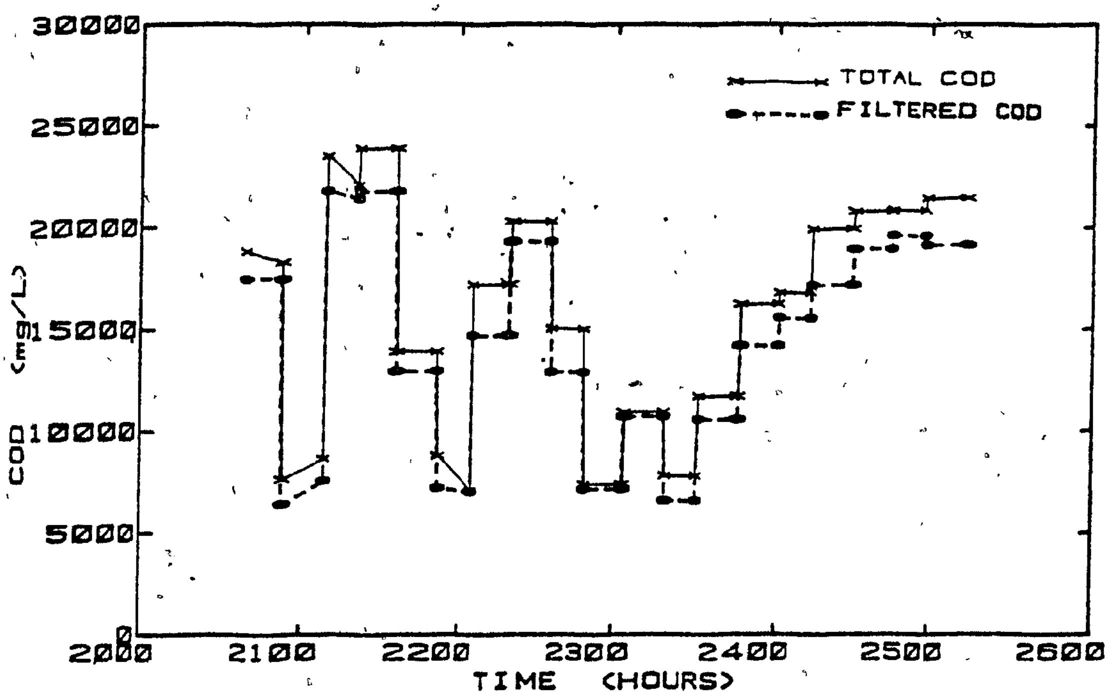


Figure 31. Dynamic Run. Influent Total COD and Filtered COD

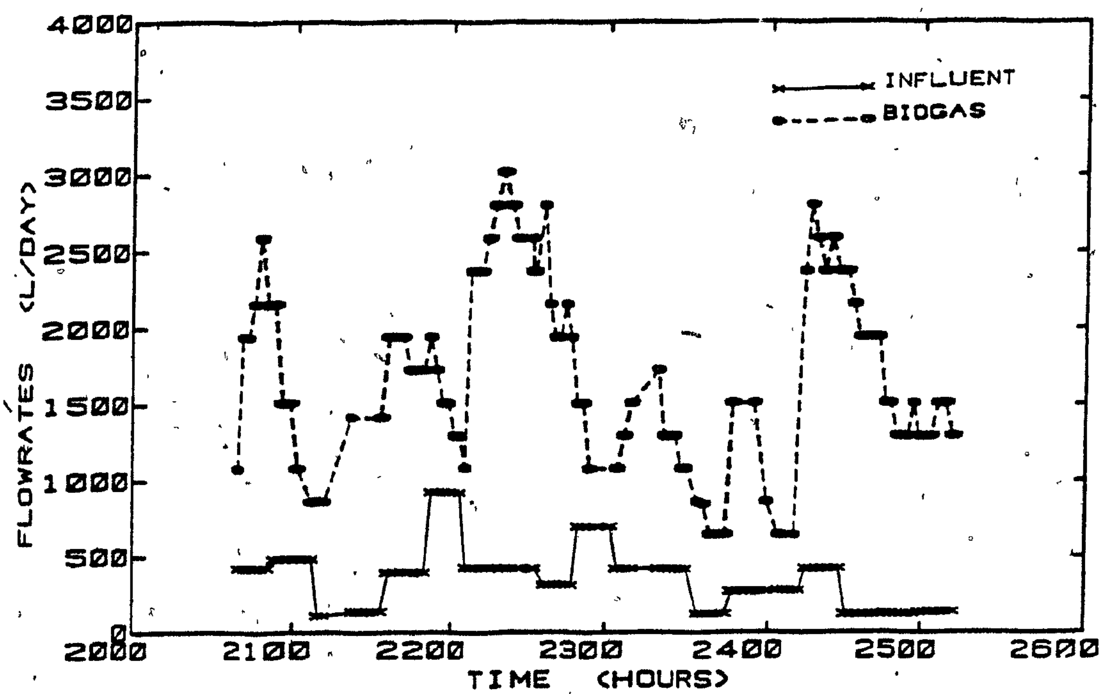


Figure 32. Dynamic Run. Flow Rates: Feed and Biogas

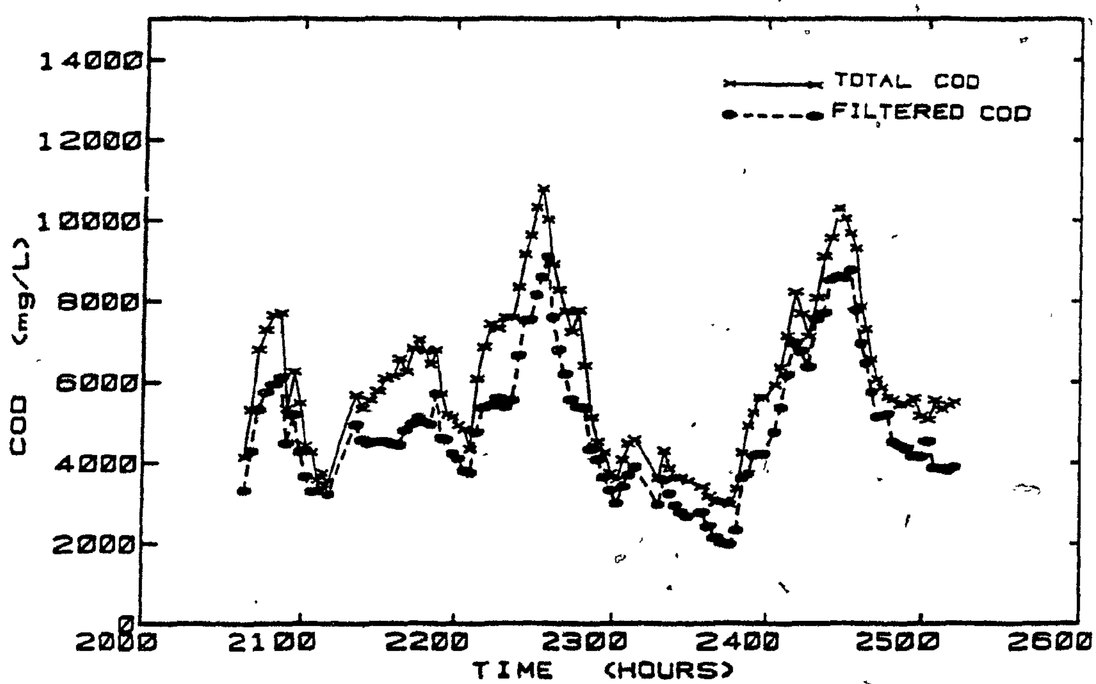


Figure 33. Dynamic Run. Effluent Total COD and Filtered COD

The dynamic run was conducted by varying the influent COD concentration and the hydraulic loading independently of each other during the 18 days of the experiment. Volumetric organic loading varied in the range of 6 to 17 kg COD/m3/day, with influent COD concentration and hydraulic loading of 6400 - 21750 mg/l COD and 0.24 - 1.78 1/day (HRT = 0.56 - 4.22 days) respectively.

Suspended solids and acetic acid content of the influent were variable throughout the entire run in a range of 170 - 570 mg/l and 210 - 1122 mg/l respectively.

The performance of the DSFF reactor under the operational conditions studied is shown in Table 11.

Table 11. DSFF Reactor Performance Under Dynamic Conditions

Parameter	Units	Avg. Value
HRT	hours	34
Organic Load	kg TCOD/m3/day	10.80
Temperature	°C	35
pH		6.65
Influent Total COD	mg/l	15621
Effluent Total COD	mg/l	6087
Effluent Filtered COD	mg/l	4925
Effluent SS	mg/l	459
VFA as Acetic Acid	mg/l	1364
COD Reduction		
Total - Total	%	61.00
COD Reduction		
Total - Filtered	%	68.50
Gas Production	m3/m3/day	3.10

4.3. Quantitative Data Analysis

It must be emphasized that success in statistical modelling depends upon having the best possible data, and, accordingly, great care was taken to ensure that the data was as reliable as possible.

Before modelling could begin, the missing data for the feed was estimated by using linear interpolation between the existing data points. An interpolation technique (Reinsch,1967) was applied to estimate the missing data of the DSFF reactor's effluent response as filtered COD. This technique is an IMSL subroutine, ICSSCU, for cubic spline interpolation (User's Manual,IMSL Library, 1984). ICSSCU places a smooth cubic spline along a given set of data points. A feature of this subroutine is that the user - supplied smoothing parameter controls the extent of smoothing.

As well, the statistical package, Statistical Analysis System, SAS/ETS User's Guide, 1982, was used for identification, estimation of transfer function noise models' parameters and diagnostic check of models' adequacy. The results are shown in Appendix A through C.

4.4. Identification of Box - Jenkins Transfer Function Noise Models Under Dynamic Conditions

The identification procedure of transfer function noise models recommended by Box & Jenkins (1976) requires consideration of the crosscorrelation function between the prewhitened input series, IFCOD, VF, and flow rate (FEED) and correspondingly transformed effluent response in terms of filtered COD.

To prewhiten the input a identification of ARIMA process was made of the input data series. The same transformation, using the same parameters as for input models, was applied to the effluent response. This yields two transformed series αt and βt whose sample crosscorrelation function allows identification of potential transfer function models. A summary of statistical procedure for building this type of model is provided in Section 2.10.1. The basic steps in developing a transfer function model are shown in Figure 3 (page 39) including the prewhitenig phase. The identified models for the input variables, IFCOD, VF, and FEED, estimated models parameters, and diagnostic check of models adequacies (autocorrelation of the residuals) are shown in Appendix B.

After prewhitening the inputs, the crosscorrelation function between the prewhitened inputs and the correspondingly transformed output were computed, shown in Figures B1, B2, and B3 in Appendix. The crosscorrelation functions allow the identification of tranfer function models, the model ordes (r,s), the time delay (b), and the estimates of transfer function's parameters (ω, δ). Next, the autocorrelation functions of the residuals of the fitted transfer function models are used to identify the noise models, N_t, following as well, the same procedure outlined in Figure 3.

These estimated crosscorrelation functions unfortunately do not give any definite clues concerning the form of the transfer function models. Apart from significant spikes at lags 1 and 7 for the hydraulic loading (FEED), (see Figure B3 in Appendix). activity at lags up to 6 is dominating in the crosscorrelations of influent filtered COD (IFCOD) and organic loading (VF), (Figures B1 and B2). Since, in this case, one lag is four hours, the detention time of the DSFF reactor, 34 hours, also suggests that this time period would be of most interest. Therefore, it was decided to fit several reasonable models with time delay b of 0, 1, 2, 3, 4, 5, and 6 lags and evaluate how much of the variation in the response EFCOD each was able to account for.

4.5. Estimation of Transfer Function Noise Models' Parameters

To choose the best model amongst the several models evaluated, the following criteria was used : Box & Jenkins (1976) stress the need to use as few parameters as possible (the model should be parsimonious) so that passes all the diagnostic checks. The AIC (Akaike, 1974) is a mathematical formulation of the parsimony criterion of model building. When there are several competing models to choose from, select the model that gives the minimum of the AIC defined by AIC = $-2Ln\ (sd)^2 + 2K$; where K = (Number of parameters in the model) + 1; The relative measure of the additional contribution of the control variables and parameters in describing the effluent response of the DSFF were based on the F - test at the 5% level of significance; and last, optimal model was interpreted as that which minimize the standard error of the estimates.

For the above criteria, Table 12 indicates the form of the Box - Jenkins time series models that were chosen to predict the observed effluent response. Notice first that all the models use almost the same noise model. This noise model was suggested by the time series analysis of effluent response ie. EFCOD, which led to model 1, a single series model which contains no reference to the input series (IFCOD, VF, and FEED). This model is based only on effluent filtered COD being an autoregressive integrated moving average (ARIMA) of order (p=1, d=1, q=11). The single series model has the greater standard error of the estimates, 508 mg/l, and the residuals have a mean of 2.80

Table 12. Box-Jenkins Transfer Function Noise Models For The DSFF Reactor Under Dynamic Conditions

Model No.	Model Form	No. of Parameters	std. error(mg/l)	AIC
1	$(EFCOD)_t = \frac{(1-0.219B^{11})}{(1-0.263B)} a_t$	2	508	-19
2	$(EFCOD)_t = \frac{0.062B}{(1-0.82B^2)}(IFCOD)_t + \frac{(1-0.214B^{11})}{(1-0.185B)} a_t$	4	471	-15
3	$(EFCOD)t = \frac{0.071B}{(1-0.705B)}(VF)_{t-2} + (1-0.317B^{11})\ a_t$	3	474	-17
4	$(EFCOD)_t = -\ 0.512B\ (FEED)_{t-7} + \frac{(1-0.259B^{11})}{(1-0.359B)} a_t$	3	458	-17
5	$(EFCOD)_t = \frac{0.041B}{(1-0.78B)}(IFCOD)_{t-2} + \frac{0.066B}{(1-0.70B)}(VF)_{t-2} - 0.43(FEED)_{t-7} + (1-0.35B^{11})a_t$	6	426	-10
6	$(EFCOD)_t = \frac{0.059B}{(1-0.79B^2)}(IFCOD)_t + \frac{0.063B}{(1-0.72B)}(VF)_{t-2} + (1-0.29B^{11})a_t$	5	446	-12

mg/l, and the autocorrelation plot of the residuals is shown in Appendix B. However, the Q-statistic (see Section 4.6, Equation 11) was used to check the adequacy of the model and comparison with the Chi-square distribution for 22 degrees of freedom which suggests that the model adequately describes the response of the DSFF reactor, (see Table 13, page 116).

The time delay b differs in the transfer function noise models for single input and multiple input. For single inputs, when IFCOD is used to describe the effluent response, the model with time delay b of 0 lag periods was found to minimize the standard error of the estimates, (Figure B1). This model is a transfer function noise model of order, (r=2, s=0, b=0), which means that the response to a unit step change in input took place in less than one sample interval, b=0 (lag 0), the effluent response is proportional to the input, and the effluent filtered COD is related to its own past value $(EFCOD)_{t-2}$, ie. r=2.

For the transfer function noise model relating the effluent filtered COD and volumetric organic loading, the time delay b was found to be of 2 lag periods, (Figure B2), and is a model of order, (r=1, s=0, b=2), which implies again that the output is proportional to the input, but is displaced by b time interval, and that the effluent filtered COD is related to its own past value ie. r=1.

Although the crosscorrelation function of effluent filtered COD versus flow rate (FEED) shows significant spikes at lags 1, and 7, (Figure B3), it was found that the transfer function noise model with time delay b of 7 lag periods minimize the standard error of the estimates. The order of the model was also found to be of zero order, (r=0, s=0, b=7), but is displaced by b time interval.

When the combined effects of the control variables were used to form multiple input transfer function noise models, it was found that the model with influent filtered COD (IFCOD) and organic loading (VF) at time delay b of 2 lag periods (8 hours), and hydraulic loading (FEED) at time delay of 7 lag periods (28 hours) minimize the standard error of the estimates, 426 mg FCOD/l. Although the multiple input transfer function noise model minimize the standard error of the estimate, the parameter describing the effect of flow rate (FEED), at the 5% level of significance, was not significant, (see ARIMA least square estimation in Table C4 in Appendix C). Furthermore, the estimated parameter describing the effect of flow rate in the single input model was not significant different from zero, at the same confidence level, (Table C3). As well, the AIC criterion shows that the three-varaiable model is not parsimonious since the addition of variables complicate the model and make parameters estimation more uncertain. Therefore, the flow term effectively drops out of the three-variable model.

The parameters describing the effects of IFCOD and VF were highly significant in the single and multiple inputs models at the 5% level of significance, (Tables C1, C2, and C4 in Appendix). Elimination of the flow term (FEED) in the three-variable model, and reestimation of the parameters increased the magnitude of the standard error of the estimates, (Table 12). However, based on an F-test at the 5% level of significance, the single input models were statistically inferior to the multiple input models.

In general, the correlation matrix of the estimates in Tables C1-C5 show that the set of estimated parameters describing the effects of the operational variables, IFCOD, VF, and flow rate (FEED) in the transfer function noise models are not related to each other. The models do not suffer from high parameter correlation (parameter redundancy). Although the three-variable model provided a better prediction of effluent filtered COD concentration than the single input models, the parameter estimates for the two-variable model were more consistent with those for the single input models and appears to best describe the process dynamic. From this analysis, the effluent filtered COD concentration from the DSFF is better predicted by a relationship which accounts for the effects of influent filtered COD concentration and organic loading.

4.6. Diagnostic Check of Models Adequacy

It is common practice in Box - Jenkins modelling to do a careful diagnostic check to test the validity of the transfer function noise models. A helpful overall check of the autocorrelation function of the residuals from the fitted models, which takes account of the distributional effects produced by the fitting is as follows:

If the functional form of the model is adequate, the quantity given by the Q-statistic is approximately distributed as the Chi-square with k-p-q degrees of freedom.

$$\text{Q-statistic} = m \sum_{k=1}^{k} r_a^2 (k) \qquad (11)$$

Note that the degrees of freedom of the Chi-square depends on the number of parameters in the noise model but not on the number of parameters in the transfer function model (Box

& Jenkins, 1976). By referring the Q-statistic to a table of percentage points of the Chi-square, one obtains an approximate test of hypothesis of model adequacy.

In a similar manner, to check the significance of the crosscorrelations between prewhiten inputs and the model residuals, the S-statistic is used and the computed value is compared to the Chi-square distribution with k+1-(r+s+1) degrees of freedom, where (r+s+1) is the number of parameters fitted in the transfer function model.

$$\text{S-statistic} = m \sum_{k=0}^{k} r^2_{xa}(k) \qquad (12)$$

A further assessment of model adequacy is that the estimated autocorrelation of the residuals should be uncorrelated and distributed normally about zero with variance, 1/N, where N is the number of residuals. These checks are presented in Table 13 and Tables C1-C5 for the autocorrelation plot of the transfer function residuals and calculated crosscorrelation check of residuals with input time series.

Table 13. Diagnostic Check of Transfer Function Noise Models Under Dynamic Conditions

Autocorrelation of Model Residuals	Crosscorrelation of Prewhiten Inputs and Model Residuals
If Q-statistics $= m \sum_{k=1}^{24} r_a^2(k)$	If S-statistics $= m \sum_{k=1}^{24} r_{xa}^2(k)$
where: m = No. of residuals k = Lag a = Model residuals	where: m = No. of residuals X = Prewhiten input series
And Chi-Square $= \chi^2_{\nu,\alpha}$ where: $\nu = K-p-q$ $\alpha = 0.95$	And Chi-Square $= \chi^2_{\nu,\alpha}$ where: $\nu = K+1-(r+s+1)$ $\alpha = 0.95$
Then:	
Model 1: $Q = 9.66$, $\chi^2 = 33.92$ $Q < \chi^2$	
Model 2: $Q = 6.59$, $\chi^2 = 33.92$ $Q < \chi^2$	$S = 18.71$, $\chi^2 = 33.92$ $S < \chi^2$
Model 3: $Q = 11.29$, $\chi^2 = 35.17$ $Q < \chi^2$	$S = 12.63$, $\chi^2 = 35.17$ $S < \chi^2$
Model 4: $Q = 8.53$, $\chi^2 = 33.92$ $Q < \chi^2$	$S = 25.06$, $\chi^2 = 33.92$ $S < \chi^2$
Model 5: $Q = 9.80$, $\chi^2 = 35.17$ $Q < \chi^2$	$S = 21.99$, $\chi^2 = 33.92$ $S = 14.07$, $\chi^2 = 35.17$ $S = 25.75$, $\chi^2 = 33.92$ $S < \chi^2$
Model 6: $Q = 7.68$, $\chi^2 = 35.17$ $Q < \chi^2$	$S = 24.07$, $\chi^2 = 33.92$ $S = 15.54$, $\chi^2 = 33.92$ $S < \chi^2$

4.7. Predicting The Effluent Response in Terms of Filtered COD for the DSFF Reactor Under Dynamic Conditions

The aim of this research paper is to see whether Box - Jenkins time series models can be used to predict the dynamic response of a DSFF reactor. The last 12 observed values (2 days) were left representing actual values for comparison with the models' predictions. Figures 34 (a) and (b) show the results of the predicted effluent response in terms of filtered COD by the selected transfer function noise models.

The time delay of b=2 lags (8 hours) and b=7 lags (28 hours) used to predict the effluent response in model 3 and model 4 agree with the findings of Hall (1982) pointing out that the rapid appearance of tracer at the reactor outlet suggested that the anaerobic downflow bed reactor must operate with substantial internal recirculation or short circuiting of the liquid phase. Hence the range of time delay of 8 - 28 hours for COD loading and flow rate is reasonable on physical grounds, being consistent with the residence time distribution conducted by Hall (1982).

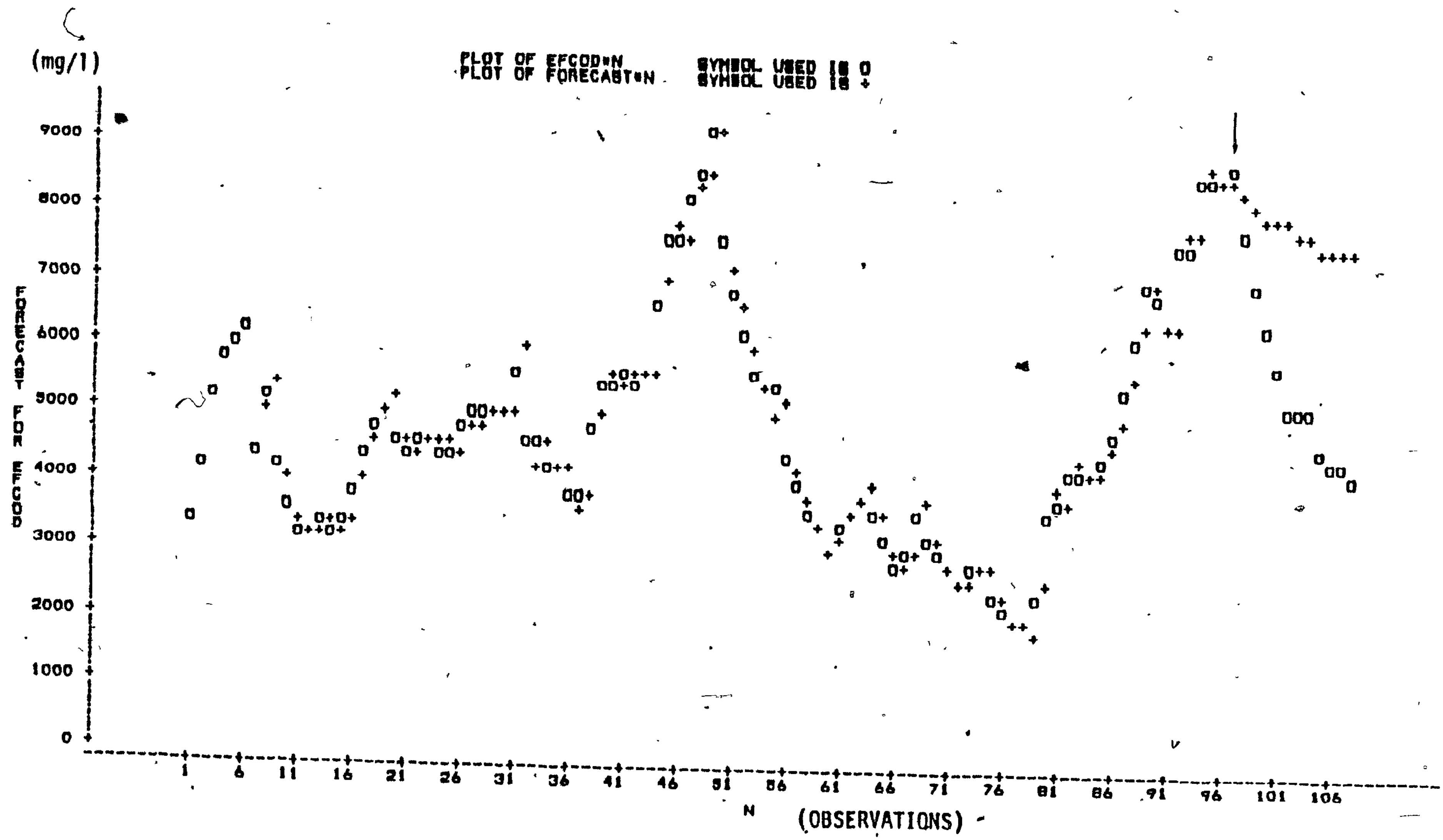


Figure 34.a. Predicted Effluent Filtered COD Under Dynamic Conditions, Model 3

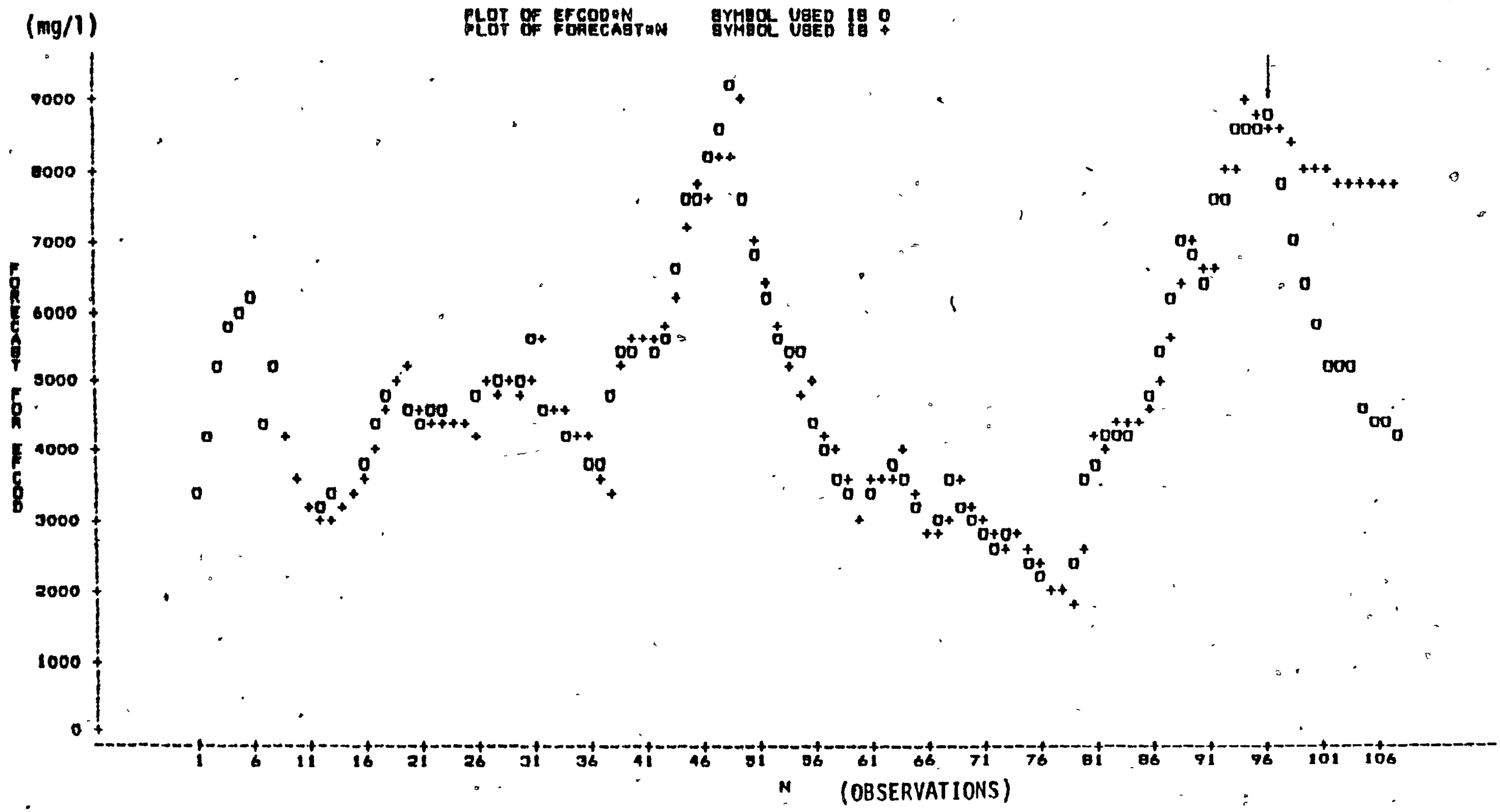


Figure 34.b. Predicted Effluent Filtered COD Under Dynamic Conditions, Model 5

Although the multiple input transfer function noise model provided slightly better one-step ahead prediction of the effluent response, no significant reduction of the standard error of the estimates is achieved, as shown in Table 12. The best transfer function noise models determined by the AIC were the single input models. These models have a standard error with an improvement of 72.0%, 71.5%, and 72.40% for the models 2, 3, and 4 respectively, over the standard deviation of the non-modelled data. A comparison of the predicted effluent filtered COD by models 3 and 5 is shown in Figures 34 (a) and (b) respectively. The last 12 observed values, starting at the arrow, were left for comparison with the predictions made by the models. It should be noted that the fitted combined transfer function noise models do follow the fluctuations in the output much better than the single series model, and this is because they take account of sudden fluctuations in the input variables.

Indicators of process response for the DSFF reactor were obtained from the transfer function noise models under dynamic conditions. The process steady state gain (% change in output/% change in input) for the input concentration term in the two-variable model for COD removal from the dairy wastewater was approximately 0.28. As a basis for comparison with other biofilm reactors using similar procedures to those outlined in this project, the process gain for the RBC (Filion et al, 1979) and fluidized bed reactor (Nutt et al, 1981) for carbon removal from domestic wastewaters were 0.14 and 0.20 respectively. This indicates that for a unit step change in process concentration the DSFF reactor may be expected to have a greater response than the RBC and fluidized bed systems. The process gain based on the input organic loading term in the two-variable model for the DSFF reactor was 0.22 compared to 0.033 for the RBC and 0.011 for the fluidized bed.

The kinetics of carbonaceous oxidation in the three biofilms processes, DSFF reactor, RBC, and fluidized bed differ considerably. The rate of organic stabilization in an RBC system is generally limited by oxygen flux rather than substrate diffusion into the biological film (Bull et al, 1981; Nutt et al, 1981). In the fluidized bed, the biofilm thicknesses ranged from about 50 to 250 microns. At an effluent dissolved oxygen concentration of 5 mg/l, the bottom half of the biological reactor contained dissolved oxygen concentration in excess of 10 mg/l (Nutt et al, 1981). Over this range of biofilm thickness and liquid phase dissolved oxygen concentration, the biofilm can be considered to be aerobically active throughout its depth (La

Mota, 1976). This probably accounts for the smaller gain identified for the fluidized bed compared to the RBC system (Nutt et al, 1981).

On the other hand, it is well known that in anaerobic digesters, acetate-utilizing methanogens are slow growers and have been shown to be present in the film which may be 2 – 4 mm thick (Van den Berg and Kennedy, 1982; Kennedy and Droste, 1983). In spite of the film thickness, it is not likely that diffusion, which normally limits the activity of biological films (La Mota, 1976), played a major role in limiting activity. The high rate of gas production in the film will cause the film to be "mixed" roughly (Hall, 1982; Van den Berg and Kennedy, 1982; Kennedy and Droste, 1983). However, anaerobic treatment of soluble organic wastewater (dairy wastewater) containing easily-hydrolysable substrates (Carawan et al, 1979) might be beset with problems under dynamic conditions and at high loading rates.

Since anaerobic digestion is essentially diphasic (acid phase and methane phase, see Section 2.2 and Figure 1) instability may often be due to imbalances occurring between those groups of microorganisms achieving the initial liquefaction and acidification, and those affecting the final conversion of the substrate to methane (Hanaki and

Nagase, 1981). A too rapid acidification of substrate might reach concentrations sufficient to be inhibitory for methane forming processes (Graef and Andrews, 1974; Chynoweth and Mah, 1977; Barnes et al, 1982; Bull et al, 1983). These intermediates are converted to the end products, but the microbial mass requires a finite time to re-adjust to these transients. Therefore, this may account for the greater gain and large response to a unit step change in influent for the DSFF reactor compared to the RBC (Filion et al, 1979) and fluidized bed (Nutt et al, 1981) systems.

Nutt et al (1981) pointed out that it is informative to estimate the time constant associated with the transfer function noise model, where for the first order systems identified here with a four-hour sampling interval the time constant (τ) in hours is defined by (Box and Jenkins, 1976):

$$\tau = -4/\ln \hat{\delta}$$

The time constants for the concentration and volumetric organic loading terms associated with the two-variable model are approximately 17.0 and 13.0 hours respectively. This indicates that the time constant of 17.0 hours is the time required after initiation of a step change in input concentration for the DSFF reactor to reach 63.2% of its final equilibrium level, and that 95% response ie. essentially complete response, will occur in about three time constants or 51.0 hours. For the loading term, the time constant to reach 95% response will occur in about 39.0 hours.

The time constant associated with the two-variable model is similar to the conclusion pointed out by Kennedy and Van den Berg (1981, 1982) and Bull et al (1983) that increases in influent COD concentration and flow rate caused a deterioration in effluent quality, but normal reactor performance was regained within 12 - 48 hours after overloading.

5. SUMMARY

In summary, the results from the first phase experimental program show that the DSFF reactor is able to achieve COD removal efficiencies in the range of 31.2 - 85% and a high rate of gas production (4.30 m3/m3/day) at volumetric organic loadings of 5.60 - 15.90 kg COD/m3/day. At short hydraulic retention times (less than a day) and with the corresponding wash-out of solids, the hydrolysis of complex organics in the dairy wastewater became limiting, hence the acid formation did not occur.

On the other hand, at COD loadings over 12.00 kg COD/m3/day the VFA increased rapidly to a peak level of 3016 mg/l (sum of acetic acid, propionic acid, and butyric acid), and the reactor became less stable, causing deterioration of effluent quality by an increase of effluent COD and SS.

Based on pseudo-steady-state data, the correlation and regression analysis showed that a combination of the three control variables, ie. influent COD concentration, volumetric organic loading, and hydraulic retention time, was able to describe up to 40% of the variance of effluent quality, 81% of the variance of removal rates, and 77% of the variance of gas production. The remaining unexplained variations are due to other minor process variables, as well as being inherent in the process itself.

The time series analysis of the effluent response in terms of effluent filtered COD (EFCOD) showed that EFCOD is a nonstationary series. This is because of long persistence of nonzero values in the autocorrelation function for several time period lags. It was found from the crosscorrelation functions under COD loading and dynamic conditions that effluent filtered COD is significantly affected by the control variables. However, the process was found to have reserve methanogenic capacity and could handle rapid step changes in raw wastewater without serious problems. Reestablishment of normal reactor performance occurred 39 - 51 hours after a step change was made.

Analysis of the crosscorrelation functions allowed identification of transfer function noise models. The Box-Jenkins transfer function models such as the one presented in this project attempt to formulate complex physical and biological phenomena occurring in biological waste treatment systems (Murphy et al, 1977; Berthouex et al, 1979; Filion et al, 1979; Kenneth and Sims, 1981; Nutt et al, 1981). Such models are applicable only if they adequately describe the effluent response under consideration, or in other words, if they fit the data. Under COD loading and dynamic conditions the transfer function noise models developed in this project appeared to be able to predict the effluent filtered COD reasonably well. The predictions were within a 95% confidence level of the actual effluent filtered COD. This result is excellent when considering the variations that may occurred in such experimental programs.

There has been an increasing need in anaerobic treatment technology for the adoption of operational models for the anaerobic fermentation of industrial wastes. The relationship to bridge this gap has been investigated, developed and assembled in this project. The engineering significance of this project lies in using these relationships in the development of operational criteria for the design of feed-forward/feed-back control systems for high rate anaerobic fixed film reactors.

Influent COD concentration and volumetric organic loading rate have been suggested in this project as the operational variables of choice for the use in predicting the effluent response of the DSFF reactor in terms of EFCOD. The estimated parameters describing the effects of the operational variables selected were highly significant at the 5% level of significance. The transfer function noise models developed in this project were able able to predict the effluent response of the system two steps ahead (8 hours). This in turn could reduce the impact of shock loading due to increases in the level of input variables. However, if the models' predictions were not updated and an attempt then made to predict more than two steps ahead the prediction would become steadily worse.

6. CONCLUSIONS

The following conclusions can be drawn based on the findings of this two phase experimental program.

1. Results showed that the DSFF reactor is applicable to dairy wastewater with a percentage of COD reduction up to 85.0% and gas production up to 4.30 m3/m3/day depending on the operational conditions.

2. Treatment of dairy wastewater was satisfactory over the whole range of influent COD concentration (5000 to 25000 mg/l) and hydraulic retention times (3.5 to 0.40 days). For a shock loading of approximately 12.00 kg COD/m3/day the DSFF reactor exhibits little disruption and continues to provide a high degree of treatment and a high ~~rate~~ of gas is produced. At a hydraulic retention time of 0.40 days the hydrolysis of complex organics in the whole milk became limiting, hence acid formation does not occur and treatment efficiency dropped off rapidly. This condition is indicated by the low gas production, high concentration of solids in the effluent, and low percentage of substrate removal. On the other hand, at a high organic loading rate, 15.00 kg COD/m3/day, and a HRT of 1.35 days, accumulation of VFA was observed. These high VFA levels are not converted to

methane and carbon dioxide as fast as they are formed, and consequently are not removed from the system, thus causing the decrease in COD removal efficiency.

3. Substrate removal rates increased with an increase in COD concentration independent of the HRT. However, the percentage of COD reduction is dependent on the hydraulic retention time and influent COD concentration.

4. The DSFF reactor's efficiency is adversely affected at a pH level below 6.4.

5. The correlation and regression analysis resulted in the conclusion that a consistent relationship between effluent response (as effluent COD concentration and gas production) and individual control variables does not exist. A combination of the three control variables, influent COD concentration, organic loading, and hydraulic retention time was able to describe up to 40% of the variance of effluent quality, 81% of the variance of COD removal rates, 77% of the variance of gas production. The remaining unexplained variations are due to other minor process variables, as well as being inherent in the process itself.

6. The time series analysis of the DSFF reactor under varying COD loadings (runs 4, 5, and 6) and the dynamic study showed that the DSFF reactor treating dairy wastewater has a relatively high capacity to withstand high organic loadings or rapid changes in raw wastewater. Reacclimation and normal reactor performance was reestablished 39 - 51 hours after the change was made.

7. The effects of varying COD loading (runs 4, 5, and 6) were satisfactorily modelled by a Box - Jenkins time series transfer function model, namely:

$$(EFCOD)_t = \frac{0.0889B}{(1-0.822B)}(VF)_{t-1} + \frac{a_t}{(1+0.15B^3+0.147B^4+0.135B^{12})}$$

This model was able to account for 74% of the total variation in the response variable. Considering the errors inherent in the measurements, sampling procedures and analytical procedure, this is judged satisfactory.

8. Although the multiple input Box - Jenkins transfer function noise model relating the three input variables was found to provide slightly better prediction of the effluent response under dynamic conditions, no significant reduction of the standard error of the estimates was achieved. The best models determined by the AIC criterion were the single input models. These models were able to account for 72.0%, 71.5% and 72.40% of the total variation in the effluent response in terms of effluent filtered COD compared to 74.0% for the multiple input model incorporating the three control variables.

9. The high degree of complexity of the anaerobic downflow stationary fixed film reactor reduces the ability of the Box - Jenkins time series models to predict all the variations occurring in the effluent response in terms of filtered COD, but not to a degree that would negate the usefulness of the model to predict, at the 95% confidence level, 8 hours ahead. This in turn could reduce the impact of shock loadings due to changes in the level of input variables.

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APPENDIX A

Table A1. ARIMA Least Squares Estimation For Input (IFCOD) Model

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG
MA1, 1	−0.173205	0.0656596	−2.64	57
AR1, 1	0.389215	0.0576855	6.75	1

VARIANCE ESTIMATE = 388666
STD ERROR ESTIMATE = 623.431
NUMBER OF RESIDUALS= 257

CORRELATIONS OF THE ESTIMATES

	MA1, 1	AR1, 1
MA1, 1	1.000	−0.010
AR1, 1	−0.010	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	2.83	4	0.587	−0.011	0.002	0.078	−0.029	0.041	−0.045
12	5.81	10	0.831	0.010	−0.036	0.009	0.062	−0.034	−0.068
18	9.35	16	0.898	−0.026	−0.065	−0.082	−0.014	0.003	−0.032
24	13.44	22	0.920	−0.008	0.036	0.029	0.031	0.102	−0.029
30	17.82	28	0.930	−0.031	0.056	−0.033	0.009	−0.081	−0.058
36	21.98	34	0.944	−0.060	−0.072	0.049	−0.044	−0.028	−0.006
42	23.66	40	0.981	0.049	−0.019	0.038	−0.032	0.009	−0.013

AUTOCORRELATION PLOT OF RESIDUALS

LAG	COVARIANCE	CORRELATION	−1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
0	388666	1.00000	|********************
1	−4319.04	−0.01111	|
2	617.729	0.00159	|
3	30404.7	0.07823	|**
4	−11193.9	−0.02880	*|
5	15892.1	0.04089	|*
6	−17378.8	−0.04471	*|
7	3928.83	0.01011	|
8	−14045.8	−0.03614	*|
9	3437.27	0.00884	|
10	24026.4	0.06182	|*
11	−13248.7	−0.03409	*|
12	−26318.9	−0.06772	*|
13	−9981.53	−0.02568	*|
14	−25337.7	−0.06519	*|
15	−31879.4	−0.08202	**|
16	−5497.7	−0.01415	|
17	1332.14	0.00343	|
18	−12378.4	−0.03185	*|
19	−3075.45	−0.00791	|
20	13799.7	0.03551	|*
21	11394	0.02932	|*
22	12230.3	0.03147	|*
23	39629.8	0.10196	|**
24	−11156.4	−0.02870	*|
25	−12145.3	−0.03125	*|
26	21667.2	0.05575	|*
27	−12726.6	−0.03274	*|
28	3429.38	0.00882	|
29	−31290.7	−0.08051	**|
30	−22550.2	−0.05802	*|
31	−23245.2	−0.05981	*|
32	−28018.1	−0.07209	*|
33	19211.1	0.04943	|*
34	−17262	−0.04441	*|
35	−11056.1	−0.02845	*|
36	−2211.9	−0.00569	|
37	18903.6	0.04864	|*
38	−7550.76	−0.01943	|
39	14955.5	0.03848	|*
40	−12534.2	−0.03225	*|

'.' MARKS TWO STANDARD ERRORS

Table A2. Statistics of Transfer Function Noise Model For EFCOD Under COD Loads, Model 1

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG	VARIABLE
MA1, 1	-0.146204	0.0637211	-2.29	1	EFCOD
AR1, 1	0.145382	0.0625898	2.32	3	EFCOD
AR1, 2	-0.131064	0.0635531	-2.06	12	EFCOD
AR1, 3	-0.153191	0.0675636	-2.27	20	EFCOD
NUM1	0.163461	0.0463005	3.53	0	IFCOD
DEN1, 1	-0.473727	0.21387	-2.22	1	IFCOD

VARIANCE ESTIMATE = 228786
STD ERROR ESTIMATE = 478.316
NUMBER OF RESIDUALS= 255

CORRELATIONS OF THE ESTIMATES

	MA1, 1	AR1, 1	AR1, 2	AR1, 3	NUM1	DEN1, 1
MA1, 1	1.000	-0.098	-0.015	-0.074	0.089	0.022
AR1, 1	-0.098	1.000	-0.049	-0.052	-0.020	-0.025
AR1, 2	-0.015	-0.049	1.000	0.048	-0.050	-0.057
AR1, 3	-0.074	-0.052	0.048	1.000	-0.030	-0.112
NUM1	0.089	-0.020	-0.050	-0.030	1.000	0.273
DEN1, 1	0.022	-0.025	-0.057	-0.112	0.273	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	6.13	2	0.047	0.003	0.004	-0.065	-0.136	0.006	-0.026
12	9.21	8	0.325	0.035	-0.034	0.071	-0.057	-0.029	-0.006
18	12.80	14	0.542	-0.081	-0.018	0.066	-0.028	0.029	0.017
24	16.63	20	0.677	-0.068	0.015	-0.052	0.033	-0.066	-0.025
30	22.32	26	0.671	-0.042	-0.042	-0.009	-0.068	-0.052	-0.092
36	26.58	32	0.737	0.015	0.048	0.000	0.104	-0.015	0.029
42	31.20	38	0.775	-0.090	-0.043	0.026	0.028	0.062	0.010

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0     228786     1.00000 |                    |********************
  1    640.507     0.00280 |                 .  |  .
  2    914.468     0.00400 |                 .  |  .
  3   -14795.1    -0.06467 |                 . *|  .
  4   -31167.6    -0.13623 |                 ***|  .
  5     1451.4     0.00634 |                 .  |  .
  6   -5915.16    -0.02585 |                 . *|  .
  7    8018.89     0.03505 |                 .  |* .
  8   -7862.77    -0.03437 |                 . *|  .
  9    16239.2     0.07098 |                 .  |* .
 10   -12989.3    -0.05677 |                 . *|  .
 11   -6686.55    -0.02923 |                 . *|  .
 12   -1330.54    -0.00582 |                 .  |  .
 13   -18453.2    -0.08066 |                 .**|  .
 14   -4200.61    -0.01836 |                 .  |  .
 15    15165.8     0.06629 |                 .  |* .
 16   -6508.65    -0.02845 |                 . *|  .
 17    6707.65     0.02932 |                 .  |* .
 18    3974.02     0.01737 |                 .  |  .
 19     -15627    -0.06830 |                 . *|  .
 20    3505.22     0.01532 |                 .  |  .
 21   -11850.6    -0.05180 |                 . *|  .
 22    7589.05     0.03317 |                 .  |* .
 23   -15152.3    -0.06623 |                 . *|  .
 24   -5627.02    -0.02460 |                 .  |  .
 25   -9690.89    -0.04236 |                 . *|  .
 26    -9705.5    -0.04242 |                 . *|  .
 27   -1945.79    -0.00850 |                 .  |  .
 28   -15658.3    -0.06844 |                 . *|  .
 29   -12008.3    -0.05249 |                 . *|  .
 30     -21131    -0.09236 |                 .**|  .
 31    3545.91     0.01550 |                 .  |  .
 32    11040.8     0.04826 |                 .  |* .
 33    5.94033     0.00003 |                 .  |  .
 34    23763.7     0.10387 |                 .  |**.
 35   -3345.43    -0.01462 |                 .  |  .
 36    6578.14     0.02875 |                 .  |* .
 37   -20482.2    -0.08953 |                 .**|  .
 38    -9907.6    -0.04331 |                 . *|  .
 39    5864.94     0.02564 |                 .  |*
 40    6507.96     0.02845 |                 .  |*
                           '.' MARKS TWO STANDARD ERRORS
```

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT IFCOD

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	4.89	4	0.299	0.008	-0.004	0.031	0.109	0.053	0.059
11	13.52	10	0.196	0.071	0.055	0.157	0.015	0.010	-0.028
17	23.88	16	0.092	-0.093	0.092	-0.052	0.057	0.027	-0.130
23	27.06	22	0.209	0.067	0.086	-0.015	0.009	0.014	-0.005
29	30.34	28	0.347	-0.069	-0.013	0.025	-0.001	-0.035	-0.078
35	39.78	34	0.228	0.072	0.033	-0.101	-0.116	-0.084	-0.011
41	45.69	40	0.248	0.025	-0.014	-0.112	-0.048	0.024	0.083

Figure A1. Autocorrelation Plot of Transfer Function Residuals and Crosscorrelation Check of Residuals With Input Filtered COD (IFCOD)

Table A3. ARIMA Least Squares Estimation For Input (VF) Model

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG
MA1,1	0.359376	0.0629707	5.71	6
AR1,1	-0.144845	0.065362	-2.22	12
AR1,2	0.162842	0.0641173	2.54	48

VARIANCE ESTIMATE = 944095
STD ERROR ESTIMATE = 971.646
NUMBER OF RESIDUALS= 257

CORRELATIONS OF THE ESTIMATES

	MA1,1	AR1,1	AR1,2
MA1,1	1.000	0.278	0.078
AR1,1	0.278	1.000	0.124
AR1,2	0.078	0.124	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	2.07	3	0.558	0.058	0.010	0.011	0.009	-0.065	0.000
12	7.65	9	0.570	-0.029	0.031	0.024	0.109	0.079	0.013
18	10.30	15	0.800	-0.078	-0.021	-0.041	0.021	0.017	-0.029
24	15.15	21	0.816	-0.057	-0.004	-0.003	-0.116	-0.021	0.008
30	17.47	27	0.919	-0.025	-0.005	-0.024	-0.068	0.023	0.040
36	21.45	33	0.939	-0.015	-0.010	0.053	-0.019	-0.012	-0.098
42	26.86	39	0.930	-0.052	-0.038	-0.007	-0.030	0.086	0.072

AUTOCORRELATION PLOT OF RESIDUALS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
0	944095	1.00000	! !********************!
1	54881.1	0.05813	! . !*. !
2	9351.59	0.00991	! . ! . !
3	10467.2	0.01109	! . ! . !
4	8463.72	0.00896	! . ! . !
5	-61201.6	-0.06483	! . *! . !
6	142.759	0.00015	! . ! . !
7	-27161.8	-0.02877	! . *! . !
8	29235.2	0.03097	! . !* . !
9	22535.6	0.02387	! . ! . !
10	103109	0.10921	! . !**. !
11	74709.7	0.07913	! . !**. !
12	12032.4	0.01274	! . ! . !
13	-73379.9	-0.07773	! .**! . !
14	-19415.6	-0.02057	! . ! . !
15	-38529.7	-0.04081	! . *! . !
16	19752.6	0.02092	! . ! . !
17	15635.7	0.01656	! . ! . !
18	-27390.8	-0.02901	! . *! . !
19	-53669.7	-0.05685	! . *! . !
20	-3923.92	-0.00416	! . ! . !
21	-3068.34	-0.00325	! . ! . !
22	-109254	-0.11572	! .**! . !
23	-19366.6	-0.02051	! . ! . !
24	7504.52	0.00795	! . ! . !
25	-23363.8	-0.02475	! . ! . !
26	-4598.45	-0.00487	! . ! . !
27	-22427.4	-0.02376	! . ! . !
28	-64439.8	-0.06826	! . *! . !
29	21915.4	0.02321	! . ! . !
30	37538.8	0.03976	! . !* . !
31	-14238.2	-0.01508	! . ! . !
32	-9285.84	-0.00984	! . ! . !
33	49690.9	0.05263	! . !* . !
34	-18293.3	-0.01938	! . ! . !
35	-10932.5	-0.01158	! . ! . !
36	-92881.1	-0.09838	! .**! . !
37	-48951.4	-0.05185	! . *! . !
38	-35891.2	-0.03802	! . *! . !
39	-6712.7	-0.00711	! . ! . !
40	-28019.7	-0 02968	! . *! . !

'.' MARKS TWO STANDARD ERRORS

Table A4. Statistics of Transfer Function Noise Model For EFCOD Under COD Loads, Model 2

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG	VARIABLE
AR1,1	-0.152761	0.0632671	-2.41	3	EFCOD
AR1,2	-0.147994	0.0621913	-2.38	4	EFCOD
AR1,3	-0.135631	0.0635151	-2.14	12	EFCOD
NUM1	0.0889213	0.0164436	5.41	0	VF
DEN1,1	0.822037	0.0393444	20.89	1	VF

VARIANCE ESTIMATE = 227376
STD ERROR ESTIMATE = 476.839
NUMBER OF RESIDUALS= 255

CORRELATIONS OF THE ESTIMATES

	AR1,1	AR1,2	AR1,3	NUM1	DEN1,1
AR1,1	1.000	-0.085	-0.129	-0.175	0.131
AR1,2	-0.085	1.000	-0.006	-0.131	0.077
AR1,3	-0.129	-0.006	1.000	-0.059	0.007
NUM1	-0.175	-0.131	-0.059	1.000	-0.559
DEN1,1	0.131	0.077	0.007	-0.559	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	5.97	3	0.113	0.066	-0.083	-0.009	-0.001	0.086	-0.065
12	9.77	9	0.370	-0.006	-0.010	0.111	-0.010	-0.040	-0.003
18	12.72	15	0.624	-0.066	-0.060	0.010	-0.051	0.006	0.012
24	19.34	21	0.563	-0.040	-0.112	-0.065	0.048	-0.049	-0.026
30	28.35	27	0.393	-0.069	-0.033	-0.007	-0.055	-0.102	-0.109
36	32.64	33	0.485	0.041	0.083	-0.006	0.057	0.038	0.036
42	35.08	39	0.649	-0.027	-0.034	0.016	0.026	0.064	-0.032

AUTOCORRELATION PLOT OF RESIDUALS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
0	227376	1.00000	|********************
1	14945.9	0.06573	. |* .
2	-18922.8	-0.08322	.**| .
3	-2059.31	-0.00906	. | .
4	-213.578	-0.00094	. | .
5	19566.4	0.08605	. |**.
6	-14683.5	-0.06458	. *| .
7	-1429.56	-0.00629	. | .
8	-2353.92	-0.01035	. | .
9	25318.2	0.11135	. |**.
10	-2347.93	-0.01033	. | .
11	-9031.69	-0.03972	. *| .
12	-605.489	-0.00266	. | .
13	-15058.1	-0.06623	. *| .
14	-13560.6	-0.05964	. *| .
15	2193.5	0.00965	. | .
16	-11640.4	-0.05119	. *| .
17	1438.36	0.00633	. | .
18	2779.28	0.01222	. | .
19	-9198.36	-0.04045	. *| .
20	-25441.6	-0.11189	.**| .
21	-14720.7	-0.06474	. *| .
22	10826.3	0.04761	. |* .
23	-11103.9	-0.04883	. *| .
24	-5925.68	-0.02606	. *| .
25	-15750.1	-0.06927	. *| .
26	-7400.01	-0.03255	. *| .
27	-1602.11	-0.00705	. | .
28	-12521.4	-0.05507	. *| .
29	-23080.7	-0.10151	.**| .
30	-24788.7	-0.10902	.**| .
31	9329.51	0.04103	. |* .
32	18795.5	0.08266	. |**.
33	-1412.85	-0.00621	. | .
34	13008.8	0.05721	. |* .
35	8539.98	0.03756	. |* .
36	8214.5	0.03613	. |* .
37	-6233.8	-0.02742	. *| .
38	-7795.27	-0.03428	. *| .
39	3736.63	0.01643	. | .
40	5880.07	0.02586	. |* .

'.' MARKS TWO STANDARD ERRORS

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT VF

TO AG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	2.76	4	0.599	0.018	-0.043	0.050	-0.013	-0.077	0.007
11	15.27	10	0.123	0.025	0.095	0.129	0.080	0.007	-0.128
17	19.61	16	0.238	-0.084	-0.002	0.009	-0.035	-0.028	-0.089
23	21.74	22	0.475	-0.022	0.071	-0.023	0.017	-0.005	0.044
29	27.85	28	0.472	0.009	-0.058	-0.088	-0.076	-0.065	-0.052
35	30.75	34	0.628	0.063	0.007	-0.084	-0.011	-0.009	-0.012
41	38.09	40	0.557	-0.014	-0.044	-0.126	0.031	0.069	0.071

Figure A2. Autocorrelation Plot of Transfer Function Residuals and Crosscorrelation Check of Residuals With Input Organic Loading (VF)

APPENDIX B

page

APPENDIX B1: Autocorrelation and Partial Autocorrelation of Original FCOD Time Series 153
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ARIMA Least Squares Estimation For FCOD's Model 155

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APPENDIX B3: Autocorrelation and Partial Autocorrelation of Original Feed Time Series 159
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NAME OF VARIABLE = IFOOD

MEAN OF WORKING SERIES= 13936
STANDARD DEVIATION = 4788.71
NUMBER OF OBSERVATIONS= 108

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0	0 1 2 3 4 5 6 7 8 9 1
0	22931789	1.00000		********************
1	20741686	0.90449		******************
2	18140939	0.79108		****************
3	15191308	0.66246		*************
4	11954506	0.52131		**********
5	8492320	0.37033		*******
6	4866456	0.21221		****
7	2998046	0.13074		***
8	1428151	0.06228		*
9	177096	0.00772		
10	-735071	-0.03205	*	
11	-1287941	-0.05616	*	
12	-1461201	-0.06372	*	
13	-1611594	-0.07028	*	
14	-1547982	-0.06750	*	
15	-1289898	-0.05625	*	
16	-856634	-0.03736	*	
17	-267348	-0.01166		
18	458410	0.01999		
19	1161439	0.05065		*
20	1743930	0.07605		**
21	2206615	0.09623		**
22	2550257	0.11121		**
23	2775613	0.12104		**
24	2883294	0.12573		***

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0	0 1 2 3 4 5 6 7 8 9 1
1	0.90449		******************
2	-0.14860	***	
3	-0.14052	***	
4	-0.13720	***	
5	-0.13788	***	
6	-0.14236	***	
7	0.34229		*******
8	-0.05064	*	
9	-0.04919	*	
10	-0.04693	*	
11	-0.04375	*	
12	-0.03994	*	
13	0.11861		**
14	0.00727		
15	0.01031		
16	0.01521		
17	0.02209		
18	0.03061		*
19	0.02643		*
20	-0.01546		
21	-0.00266		
22	0.01010		
23	0.02330		
24	0.03719		*

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	262.73	6	0.000	0.904	0.791	0.662	0.521	0.370	0.212
12	266.22	12	0.000	0.131	0.062	0.008	-0.032	-0.056	-0.064
18	268.07	18	0.000	-0.070	-0.068	-0.056	-0.037	-0.012	0.020
24	276.45	24	0.000	0.051	0.076	0.096	0.111	0.121	0.126

NAME OF VARIABLE = IFCOD
PERIODS OF DIFFERENCING= 1.

MEAN OF WORKING SERIES= 16.5888
STANDARD DEVIATION = 2010.98
NUMBER OF OBSERVATIONS= 107

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
0	4044030	1.00000	******************** (positive)
1	410485	0.10150	** (positive)
2	348134	0.08609	** (positive)
3	285830	0.07068	* (positive)
4	223450	0.05525	* (positive)
5	161155	0.03985	* (positive)
6	-1407643	-0.34808	******* (negative)
7	-304535	-0.07530	** (negative)
8	-325003	-0.08037	** (negative)
9	-345145	-0.08535	** (negative)
10	-365749	-0.09044	** (negative)
11	-386205	-0.09550	** (negative)
12	-479071	-0.11846	** (negative)
13	-198689	-0.04913	* (negative)
14	-178938	-0.04425	* (negative)
15	-159432	-0.03942	* (negative)
16	-140060	-0.03463	* (negative)
17	-120294	-0.02975	* (negative)
18	26832.6	0.00664	
19	183558	0.04539	* (positive)
20	182584	0.04515	* (positive)
21	181640	0.04492	* (positive)
22	180721	0.04469	* (positive)
23	179866	0.04448	* (positive)
24	1217020	0.30094	****** (positive)

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
1	0.10150	** (positive)
2	0.07657	** (positive)
3	0.03574	* (positive)
4	0.03786	* (positive)
5	0.02228	
6	-0.37203	******* (negative)
7	-0.02445	
8	-0.02526	* (negative)
9	-0.02736	* (negative)
10	-0.03063	* (negative)
11	-0.03449	* (negative)
12	-0.24713	***** (negative)
13	-0.03703	* (negative)
14	-0.04159	* (negative)
15	-0.04695	* (negative)
16	-0.05340	* (negative)
17	-0.06062	* (negative)
18	-0.14915	*** (negative)
19	0.00745	
20	-0.00755	
21	-0.02137	
22	-0.03463	* (negative)
23	-0.04736	* (negative)
24	0.25094	***** (positive)

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	17.04	6	0.009	0.102	0.086	0.071	0.055	0.040	-0.348
12	23.14	12	0.027	-0.075	-0.080	-0.085	-0.090	-0.096	-0.118
18	24.16	18	0.150	-0.049	-0.044	-0.039	-0.035	-0.030	0.007
24	38.25	24	0.033	0.045	0.045	0.045	0.045	0.044	0.301

ARIMA LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG
MA1, 1	0. 457212	0. 0903961	5. 06	6
AR1, 1	0. 303489	0. 094207	3. 22	24

VARIANCE ESTIMATE = 3098745
STD ERROR ESTIMATE = 1760 33
NUMBER OF RESIDUALS= 107

CORRELATIONS OF THE ESTIMATES

	MA1, 1	AR1, 1
MA1, 1	1. 000	0. 111
AR1, 1	0. 111	1. 000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	1. 96	4	0. 743	0. 087	0. 071	0. 055	0. 039	0. 022	-0. 000
12	5. 31	10	0 869	-0. 050	-0. 060	-0. 071	-0. 081	-0. 091	-0. 043
18	8. 19	16	0. 943	-0. 040	-0. 041	-0. 042	-0. 043	-0. 045	0. 116
24	8. 43	22	0. 996	0. 021	0. 018	0. 014	0. 010	0. 007	0. 026

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0    3098745    1.00000  |               .   |********************
  1     270671    0.08735  |               .   |** .
  2     220215    0.07107  |               .   |*  .
  3     169963    0.05485  |               .   |*  .
  4     119361    0.03852  |               .   |*  .
  5    69029.9    0.02228  |               .   |   .
  6   -550.176   -0.00018  |               .   |   .
  7    -155556   -0.05020  |               .  *|   .
  8    -187274   -0 06044  |               .  *|   .
  9    -218836   -0.07062  |               .  *|   .
 10    -250965   -0.08099  |               . **|   .
 11    -282596   -0.09120  |               . **|   .
 12    -134574   -0.04343  |               .  *|   .
 13    -122777   -0.03962  |               .  *|   .
 14    -126442   -0.04080  |               .  *|   .
 15    -130314   -0.04205  |               .  *|   .
 16    -134461   -0.04339  |               .  *|   .
 17    -138047   -0.04455  |               .  *|   .
 18     358225    0.11560  |               .   |** .
 19    65624.3    0.02118  |               .   |   .
 20    54388.8    0.01755  |               .   |   .
 21    43024.8    0.01388  |               .   |   .
 22    31466.3    0.01015  |               .   |   .
 23    20321.9    0.00656  |               .   |   .
 24    80697.6    0.02604  |               .   |*  .
                           '.' MARKS TWO STANDARD ERRORS
```

NAME OF VARIABLE = VF

MEAN OF WORKING SERIES= 8519.75
STANDARD DEVIATION = 3842.08
NUMBER OF OBSERVATIONS= 108

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
0	14761591	1.00000	********************
1	12598123	0.85344	*****************
2	10425214	0.70624	**************
3	8283375	0.56114	***********
4	6213296	0.42091	********
5	4255564	0.28829	******
6	2450626	0.16601	***
7	1564997	0.10602	**
8	750348	0.05083	*
9	5840.37	0.00040	
10	-669254	-0.04534	*
11	-1275632	-0.08642	**
12	-1814264	-0.12290	**
13	-2207981	-0.14958	***
14	-2665899	-0.18060	****
15	-3205279	-0.21714	****
16	-3843224	-0.26035	*****
17	-4596821	-0.31140	******
18	-5483311	-0.37146	*******
19	-4756974	-0.32225	******
20	-4079487	-0.27636	******
21	-3439721	-0.23302	*****
22	-2826742	-0.19149	****
23	-2229520	-0.15104	***
24	-1636956	-0.11089	**

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
1	0.85344	*****************
2	-0.08143	**
3	-0.07847	**
4	-0.07486	*
5	-0.07028	*
6	-0.06435	*
7	0.12959	***
8	-0.05274	*
9	-0.05090	*
10	-0.04868	*
11	-0.04606	*
12	-0.04309	*
13	0.01347	
14	-0.07398	*
15	-0.08307	**
16	-0.09448	**
17	-0.10906	**
18	-0.12817	***
19	0.34882	*******
20	-0.06001	*
21	-0.05548	*
22	-0.05037	*
23	-0.04420	*
24	-0.03652	*

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	205.43	6	0.000	0.853	0.706	0.561	0.421	0.288	0.166
12	210.09	12	0.000	0.106	0.051	0.000	-0.045	-0.086	-0.123
18	262.66	18	0.000	-0.150	-0.181	-0.217	-0.260	-0.311	-0.371
24	304.24	24	0.000	-0.322	-0.276	-0.233	-0.191	-0.151	-0.111

NAME OF VARIABLE = VF
PERIODS OF DIFFERENCING= 1.

MEAN OF WORKING SERIES= -89.7538
STANDARD DEVIATION = 1977.83
NUMBER OF OBSERVATIONS= 107

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
0	3911806	1.00000	********************
1	2069.07	0.00053	
2	-38880.6	-0.00994	
3	-80000.7	-0.02045	
4	-121057	-0.03095	*
5	-161912	-0.04139	*
6	-489463	-0.12512	***
7	-84420.7	-0.02158	
8	-83827	-0.02143	
9	-83354.9	-0.02131	
10	-82895.9	-0.02119	
11	-82169.5	-0.02101	
12	371276	0.09491	**
13	64369.1	0.01646	
14	81521.8	0.02084	
15	98514.1	0.02518	*
16	115491	0.02952	*
17	132623	0.03390	*
18	-1870500	-0.47817	**********
19	66824	0.01708	
20	55747	0.01425	
21	44809.6	0.01145	
22	33827.1	0.00865	
23	22777.6	0.00582	
24	476841	0.12190	**

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
1	0.00053	
2	-0.00994	
3	-0.02044	
4	-0.03104	*
5	-0.04186	*
6	-0.12666	***
7	-0.02530	*
8	-0.02937	*
9	-0.03139	*
10	-0.03428	*
11	-0.03690	*
12	0.07376	*
13	0.00592	
14	0.01204	
15	0.01903	
16	0.02710	*
17	0.03652	*
18	-0.47003	*********
19	0.02986	*
20	0.01584	
21	0.00254	
22	-0.01078	
23	-0.02485	
24	0.04108	*

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	2.17	6	0.903	0.001	-0.010	-0.020	-0.031	-0.041	-0.125
12	3.55	12	0.990	-0.022	-0.021	-0.021	-0.021	-0.021	0.095
18	33.94	18	0.013	0.016	0.021	0.025	0.030	0.034	-0.478
24	36.12	24	0.053	0.017	0.014	0.011	0.009	0.006	0.122

```
                        ARIMA. LEAST SQUARES ESTIMATION

            PARAMETER     ESTIMATE      STD ERROR    T RATIO   LAG
            AR1,1        -0.716145      0 096484       -7 42   18

            VARIANCE  ESTIMATE =    2603634
            STD ERROR ESTIMATE =    1613 58
            NUMBER OF RESIDUALS=   107

                         CORRELATIONS OF THE ESTIMATES

                                        AR1,1
                               AR1,1    1.000

                       AUTOCORRELATION CHECK OF RESIDUALS

   TO     CHI                                           AUTOCORRELATIONS
  LAG  SQUARE DF    PROB
    6    1 35  5   0.929       0.061  0.029 -0.003 -0.035 -0.067  0 042
   12    7.36 11   0.769      -0.094 -0.094 -0 094 -0.094 -0.093  0.078
   18   10 07 17   0.901      -0.005  0.016  0.038  0 059  0.081 -0 095
   24   11 64 23   0.976       0.051  0.032  0.013 -0.007 -0 026 -0 083


                              AUTOCORRELATION PLOT OF RESIDUALS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0    2603634     1 00000   |                   |********************
  1     158149     0.06074   |               .   |*  .
  2      75159     0.02987   |                   |*  .
  3   -7591.22    -0.00303   |                   |   .
  4   -90899.5    -0 03491   |               .  *|   .
  5    -173741    -0 06673   |               .  *|   .
  6     110482     0 04243   |               .   |*  .
  7    -246034    -0.09450   |               . **|   .
  8    -245281    -0 09421   |               . **|   .
  9    -244646    -0.09396   |               . **|   .
 10    -244044    -0.09373   |               . **|   .
 11    -243146    -0.09339   |               . **|   .
 12     203669     0.07823   |               .   |** .
 13   -13028.9    -0.00500   |               .   |   .
 14    42947.8     0 01650   |               .   |   .
 15    98754.7     0 03793   |               .   |*  .
 16     154550     0.05936   |               .   |*  .
 17     210549     0 08087   |               .   |** .
 18    -248636    -0 09550   |               . **|   .
 19     132778     0.05100   |               .   |*  .
 20      82945     0.03186   |               .   |*  .
 21    32910.8     0 01264   |               .   |   .
 22     -17078    -0 00656   |               .   |   .
 23   -66867.8    -0.02568   |               .  *|   .
 24    -215625    -0.08282   |               . **|   .
                             '.' MARKS TWO STANDARD ERRORS
```

```
                              NAME OF VARIABLE          =  FEED

                              MEAN OF WORKING SERIES=     363 611
                              STANDARD DEVIATION    =     206 527
                              NUMBER OF OBSERVATIONS=        108

                                          AUTOCORRELATIONS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0    42653.3     1 00000  !                   !********************
  1    36859.5     0 86417  !                   !*****************
  2    31065 8     0 72833  !                   !***************
  3      25272     0 59250  !                   !************
  4    19478 2     0 45666  !                   !*********
  5    13684 4     0. 32083 !                   !******
  6    7890. 61    0. 18499 !               .   !****     .
  7    5588. 66    0 13103  !               .   !***      .
  8    3286 71     0 07706  !               .   !**       .
  9    984 762     0. 02309 !               .   !         .
 10   -1317 19    -0 03088  !               .  *!         .
 11   -3619. 14   -0 08485  !               . **!         .
 12   -5921 08    -0 13882  !               .***!         .
 13   -7079 91    -0. 16599 !               .***!         .
 14   -8238 74    -0. 19316 !               ****!         .
 15   -9397 57    -0. 22032 !               ****!         .
 16   -10556. 4   -0. 24749 !              *****!         .
 17   -11715. 2   -0 27466  !              *****!         .
 18   -12874. 1   -0. 30183 !             ******!         .
 19   -8017 18    -0. 18796 !               ****!         .
 20   -3160 3     -0. 07409 !               .  *!         .
 21    1696. 58    0 03978  !                   !*        .
 22    6553 46     0. 15364 !                   !***      .
 23    11410 3     0 26751  !               .   !*****    .
 24    16267. 2    0 38138  !               .   !********.
                            ' MARKS TWO STANDARD ERRORS

                                  PARTIAL AUTOCORRELATIONS

                   LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
                    1    0. 86417  !                   !*****************
                    2   -0 07287   !                 . *!   .
                    3   -0. 07859  !                 .**!   .
                    4   -0. 08530  !                 .**!   .
                    5   -0. 09325  !                 .**!   .
                    6   -0 10284   !                 .**!   .
                    7    0. 22126  !                 .  !****
                    8   -0 06558   !                 . *!   .
                    9   -0. 07018  !                 . *!   .
                   10   -0. 07548  !                 .**!   .
                   11   -0. 08164  !                 .**!   .
                   12   -0. 08889  !                 .**!   .
                   13    0 13114   !                 .  !***.
                   14   -0. 06828  !                 . *!   .
                   15   -0. 07329  !                 . *!   .
                   16   -0. 07908  !                 .**!   .
                   17   -0. 08587  !                 .**!   .
                   18   -0. 09394  !                 .**!   .
                   19    0. 68041  !                 .  !**************
                   20   -0 01787   !                 .  !   .
                   21   -0. 01819  !                 .  !   .
                   22   -0. 01853  !                 .  !   .
                   23   -0. 01888  !                 .  !   .
                   24   -0. 01924  !                 .  !   .

                        AUTOCORRELATION CHECK FOR WHITE NOISE

 TO      CHI                                        AUTOCORRELATIONS
LAG   SQUARE DF   PROB
  6   221 76   6  0 000        0. 864   0 728   0. 592   0 457   0 321   0. 185
 12   227 94  12  0 000        0. 131   0 077   0. 023  -0. 031  -0 085  -0 139
 18   272 08  18  0 000       -0 166  -0 193  -0. 220  -0. 247  -0. 275  -0. 302
 24   311 59  24  0. 000      -0. 188  -0. 074   0. 040   0. 154   0. 268   0. 381
```

NAME OF VARIABLE = FEED
PERIODS OF DIFFERENCING= 1.

MEAN OF WORKING SERIES= -2.79439
STANDARD DEVIATION = 105.476
NUMBER OF OBSERVATIONS= 107

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
0	11125.2	1.00000	********************
1	-7.88161	-0.00071	
2	-7.95459	-0.00072	
3	-8.02756	-0.00072	
4	-8.10054	-0.00073	
5	-8.17352	-0.00073	
6	-3575.45	-0.32136	******
7	-9.96477	-0.00090	
8	-10.0377	-0.00090	
9	-10.1107	-0.00091	
10	-10.1837	-0.00092	
11	-10.2567	-0.00092	
12	-261.264	-0.02348	
13	7.25165	0.00065	
14	7.17868	0.00065	
15	7.1057	0.00064	
16	7.03272	0.00063	
17	6.95974	0.00063	
18	-6403.73	-0.57561	************
19	2.32187	0.00021	
20	2.24889	0.00020	
21	2.17591	0.00020	
22	2.10293	0.00019	
23	2.02996	0.00018	
24	6589.12	0.59227	************

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
1	-0.00071	
2	-0.00072	
3	-0.00072	
4	-0.00073	
5	-0.00074	
6	-0.32139	******
7	-0.00160	
8	-0.00161	
9	-0.00162	
10	-0.00164	
11	-0.00165	
12	-0.14139	***
13	-0.00047	
14	-0.00048	
15	-0.00050	
16	-0.00051	
17	-0.00052	
18	-0.71654	**************
19	-0.00527	
20	-0.00534	
21	-0.00540	
22	-0.00547	
23	-0.00554	
24	0.19403	****

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	11.93	6	0.064	-0.001	-0.001	-0.001	-0.001	-0.001	-0.321
12	12.00	12	0.446	-0.001	-0.001	-0.001	-0.001	-0.001	-0.023
18	55.41	18	0.000	0.001	0.001	0.001	0.001	0.001	-0.576
24	104.71	24	0.000	0.000	0.000	0.000	0.000	0.000	0.592

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG
MA1,1	0.331682	0.0946913	3.50	6
AR1,1	-0.197661	0.0721229	-2.74	12
AR1,2	-0.556275	0.0704698	-7.89	18
AR1,3	0.439903	0.0719226	6.12	24

VARIANCE ESTIMATE = 4351.16
STD ERROR ESTIMATE = 65.9633
NUMBER OF RESIDUALS= 107

CORRELATIONS OF THE ESTIMATES

	MA1,1	AR1,1	AR1,2	AR1,3
MA1,1	1.000	0.198	0.116	0.090
AR1,1	0.198	1.000	0.134	0.251
AR1,2	0.116	0.134	1.000	0.127
AR1,3	0.090	0.251	0.127	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	0.45	2	0.800	0.000	0.000	0.000	0.000	0.000	0.062
12	3.85	8	0.871	0.000	0.000	0.000	0.000	0.000	-0.166
18	3.96	14	0.996	0.000	0.000	0.000	0.000	0.000	-0.029
24	8.11	20	0.991	0.000	0.000	0.000	0.000	0.000	0.172

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0    4351.16     1.00000  !                   !********************!
  1          0     0.00000  !                .  !   .                !
  2          0     0.00000  !                .  !   .                !
  3          0     0.00000  !                .  !   .                !
  4          0     0.00000  !                .  !   .                !
  5          0     0.00000  !                .  !   .                !
  6    270.827     0.06224  !                .  !*  .                !
  7          0     0.00000  !                .  !   .                !
  8          0     0.00000  !                .  !   .                !
  9          0     0.00000  !                .  !   .                !
 10          0     0.00000  !                .  !   .                !
 11          0     0.00000  !                .  !   .                !
 12   -723.853    -0.16636  !                .***!   .                !
 13          0     0.00000  !                .  !   .                !
 14          0     0.00000  !                .  !   .                !
 15          0     0.00000  !                .  !   .                !
 16          0     0.00000  !                .  !   .                !
 17          0     0.00000  !                .  !   .                !
 18   -126.467    -0.02907  !                . *!   .                !
 19          0     0.00000  !                .  !   .                !
 20          0     0.00000  !                .  !   .                !
 21          0     0.00000  !                .  !   .                !
 22          0     0.00000  !                .  !   .                !
 23          0     0.00000  !                .  !   .                !
 24    747.862     0.17188  !                .  !***.                !
                           '.' MARKS TWO STANDARD ERRORS
```

NAME OF VARIABLE = EFCOD

MEAN OF WORKING SERIES= 4872.35
STANDARD DEVIATION = 1658.89
NUMBER OF OBSERVATIONS= 108

AUTOCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
0	2751904	1.00000	********************
1	2596358	0.94348	*******************
2	2375177	0.86310	*****************
3	2109859	0.76670	***************
4	1822729	0.66235	*************
5	1540752	0.55989	***********
6	1260270	0.45796	*********
7	960234	0.34893	*******
8	682321	0.24794	*****
9	408229	0.14834	***
10	148060	0.05380	*
11	-93796.1	-0.03408	*
12	-271538	-0.09867	**
13	-409370	-0.14876	***
14	-531003	-0.19296	****
15	-664161	-0.24135	*****
16	-782191	-0.28424	******
17	-872431	-0.31703	******
18	-934125	-0.33945	*******
19	-980745	-0.35639	*******
20	-1012773	-0.36803	*******
21	-1038684	-0.37744	********
22	-1062667	-0.38616	********
23	-1078147	-0.39178	********
24	-1111146	-0.40377	********

'.' MARKS TWO STANDARD ERRORS

PARTIAL AUTOCORRELATIONS

LAG	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
1	0.94348	*******************
2	-0.24621	*****
3	-0.15224	***
4	-0.08551	**
5	-0.01313	
6	-0.06235	*
7	-0.15004	***
8	0.01799	
9	-0.08032	**
10	-0.04990	*
11	-0.05193	*
12	0.12833	***
13	-0.00638	
14	-0.10713	**
15	-0.15117	***
16	0.00243	
17	0.03297	*
18	-0.03941	*
19	-0.06068	*
20	-0.03225	*
21	-0.04211	*
22	-0.09149	**
23	-0.01153	
24	-0.11277	**

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	359.53	6	0.000	0.943	0.863	0.767	0.662	0.560	0.458
12	385.49	12	0.000	0.349	0.248	0.148	0.054	-0.034	-0.099
18	439.17	18	0.000	-0.149	-0.193	-0.241	-0.284	-0.317	-0.339
24	558.97	24	0.000	-0.356	-0.368	-0.377	-0.386	-0.392	-0.404

```
NAME OF VARIABLE          =  EFCOD
PERIODS OF DIFFERENCING=     1.

MEAN OF WORKING SERIES=      8 03738
STANDARD DEVIATION     =     535 661
NUMBER OF OBSERVATIONS=        107
```

AUTOCORRELATIONS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0     286933    1.00000   !                   !********************
  1      81335    0.28346   !                 . !******
  2    59887.7    0.20872   !                 . !****
  3    29087.1    0.10137   !                 . !**  .
  4     2113.4    0.00737   !                 . !    .
  5    912.644    0.00318   !                 . !    .
  6   -4365.99   -0.01522   !                 . !    .
  7   -8209.04   -0.02861   !                 .*!    .
  8   -12296.7   -0.04286   !                 .*!    .
  9   -20193.9   -0.07038   !                 .*!    .
 10   -19036.4   -0.06634   !                 .*!    .
 11   -58370.5   -0.20343   !               ****!    .
 12     -39939   -0.13919   !               . ***!    .
 13     -19570   -0.06820   !               .  *!    .
 14    12416.2    0.04327   !               .   !*   .
 15   -13895.8   -0.04843   !               .  *!    .
 16   -20538.2   -0.07158   !               .  *!    .
 17   -29998.6   -0.10455   !               . **!    .
 18   -11992.7   -0.04180   !               .  *!    .
 19   -18848.9   -0.06569   !               .  *!    .
 20   -12940.9   -0.04510   !               .  *!    .
 21   -6747.07   -0.02351   !               .   !    .
 22   -12204.4   -0.04253   !               .  *!    .
 23    14397.1    0.05018   !               .   !*   .
 24   -8296.09   -0.02891   !               .  *!    .
                            '.' MARKS TWO STANDARD ERRORS
```

PARTIAL AUTOCORRELATIONS

```
LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  1    0.28346   !                 . !******
  2    0.13958   !                 . !***.
  3    0.01209   !                 . !   .
  4   -0.05449   !                 .*!   .
  5   -0.00339   !                 . !   .
  6   -0.00834   !                 . !   .
  7   -0.01958   !                 . !   .
  8   -0.03036   !                 .*!   .
  9   -0.04934   !                 .*!   .
 10   -0.02798   !                 .*!   .
 11   -0.17847   !               ****!   .
 12   -0.03925   !                 .*!   .
 13    0.03803   !                 . !*  .
 14    0.11058   !                 . !** .
 15   -0.09507   !                 .**!   .
 16   -0.09164   !                 .**!   .
 17   -0.07971   !                 .**!   .
 18    0.03349   !                 . !*  .
 19   -0.04377   !                 .*!   .
 20   -0.03772   !                 .*!   .
 21   -0.01190   !                 . !   .
 22   -0.06421   !                 .*!   .
 23    0 05264   !                 . !*  .
 24   -0.06872   !                 .*!   .
```

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	14.87	6	0.021	0.283	0.209	0.101	0.007	0.003	-0.015
12	23.70	12	0.022	-0.029	-0.043	-0.070	-0.066	-0.203	-0.139
18	27.11	18	0.077	-0.068	0.043	-0.048	-0.072	-0.105	-0.042
24	28.75	24	0.230	-0.066	-0.045	-0.024	-0.043	0.050	-0.029

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG
MA1,1	0.219078	0.100003	2.19	11
AR1,1	0 2629	0 0942019	2.79	1

VARIANCE ESTIMATE = 258466
STD ERROR ESTIMATE = 508.395
NUMBER OF RESIDUALS= 107

CORRELATIONS OF THE ESTIMATES

	MA1,1	AR1,1
MA1,1	1.000	-0.030
AR1,1	-0.030	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	2.64	4	0.620	-0.036	0.115	0.075	-0.045	-0.015	-0.034
12	3.88	10	0.953	-0.034	-0.027	-0.034	-0.012	0.007	-0.084
18	7.92	16	0.951	-0.038	0.109	-0.063	-0.047	-0.109	-0.020
24	9.66	22	0.989	-0.065	-0.037	-0.003	-0.050	0.049	-0.048

AUTOCORRELATION PLOT OF RESIDUALS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1	STD
0	258466	1.00000	!********************	0
1	-9268.96	-0.03586	*!	0.0966736
2	29843.6	0.11546	!**	0.0967979
3	19288.6	0.07463	!*	0.0980766
4	-11655.4	-0.04509	*!	0.0986059
5	-3864.62	-0.01495	!	0.0987984
6	-8794.09	-0.03402	*!	0.0988196
7	-8777.58	-0.03396	*!	0.098929
8	-6925.13	-0.02679	*!	0.0990379
9	-8686.57	-0.03361	*!	0.0991056
10	-3123.03	-0.01208	!	0.0992121
11	1721.08	0.00666	!	0.0992258
12	-21747.1	-0.08414	**!	0.09923
13	-9943.7	-0 03847	*!	0.0998945
14	28145.4	0.10889	!**	0.100033
15	-16227.3	-0.06278	*!	0.101135
16	-12240.9	-0.04736	*!	0.101498
17	-28057.9	-0.10856	**!	0.101705
18	-5045.95	-0 01952	!	0.102782
19	-16682.5	-0.06454	*!	0.102816
20	-9652.81	-0.03735	*!	0.103194
21	-866.004	-0.00335	!	0.103321
22	-12896	-0.04989	*!	0.103322
23	12790.4	0.04949	!*	0.103547
24	-12395.4	-0.04796	*!	0.103767

'.' MARKS TWO STANDARD ERRORS

```
CORRELATION OF EFCOD AND FCOD
FCOD HAS BEEN DIFFERENCED.
PERIODS OF DIFFERENCING=1.
BOTH SERIES HAVE BEEN PREWHITENED.
VARIANCE OF TRANSFORMED SERIES=     364964    303819
NUMBER OF OBSERVATIONS=        107

                              CROSSCORRELATIONS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
-24   -179707   -0.17066    !                  .***!  .                  !
-23  -24525.2   -0.02329    !                  .   !  .                  !
-22   -114706   -0.10893    !                  . **!  .                  !
-21  -68318.9   -0.06488    !                  .  *!  .                  !
-20  -81687.3   -0.07757    !                  . **!  .                  !
-19  -69354.5   -0.06586    !                  .  *!  .                  !
-18   -181595   -0.17245    !                  .***!  .                  !
-17  -30132.1   -0.02862    !                  .  *!  .                  !
-16  -35983.6   -0.03417    !                  .  *!  .                  !
-15   14135.3    0.01342    !                  .   !  .                  !
-14   2750.85    0.00261    !                  .   !  .                  !
-13   7882.05    0.00749    !                  .   !  .                  !
-12   -109410   -0.10390    !                  . **!  .                  !
-11    123594    0.11737    !                  .   !** .                 !
-10   57308.6    0.05442    !                  .   !* .                  !
 -9   37393.9    0.03551    !                  .   !* .                  !
 -8   16107.3    0.01530    !                  .   !  .                  !
 -7    6065.1    0.00576    !                  .   !  .                  !
 -6   -162463   -0.15428    !                  .***!  .                  !
 -5  -30013.1   -0.02850    !                  .  *!  .                  !
 -4   -114389   -0.10863    !                  . **!  .                  !
 -3  -35746.2   -0.03395    !                  .  *!  .                  !
 -2   40920.3    0.03886    !                  .   !* .                  !
 -1   53616.2    0.05092    !                  .   !* .                  !
  0    221084    0.20995    !                  .   !****                 !
  1  -45381.1   -0.04310    !                  .  *!  .                  !
  2    172576    0.16389    !                  .   !***.                 !
  3    165336    0.15701    !                  .   !***.                 !
  4    215030    0.20420    !                  .   !****                 !
  5    141480    0.13436    !                  .   !***.                 !
  6    223236    0.21200    !                  .   !****                 !
  7   39695.7    0.03770    !                  .   !* .                  !
  8    127575    0.12115    !                  .   !** .                 !
  9     13720    0.01303    !                  .   !  .                  !
 10   42534.3    0.04039    !                  .   !* .                  !
 11   -6923.4   -0.00657    !                  .   !  .                  !
 12    157628    0.14969    !                  .   !***.                 !
 13  -85756.9   -0.08144    !                  . **!  .                  !
 14   25531.2    0.02425    !                  .   !  .                  !
 15  -95238.1   -0.09044    !                  . **!  .                  !
 16  -62764.7   -0.05960    !                  .  *!  .                  !
 17  -72585.5   -0.06893    !                  .  *!  .                  !
 18    157698    0.14976    !                  .   !***.                 !
 19   -221277   -0.21014    !                  ****!  .                  !
 20   33334.2    0.03166    !                  .   !* .                  !
 21   -137677   -0.13075    !                  .***!  .                  !
 22  -81340.2   -0.07725    !                  . **!  .                  !
 23   -100417   -0.09536    !                  . **!  .                  !
 24    -51856   -0.04925    !                  .  *!  .                  !
```

CROSSCORRELATION CHECK BETWEEN SERIES

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	16.82	6	0.010	0.210	-0.043	0.164	0.157	0.204	0.134
11	23.55	12	0.023	0.212	0.038	0.121	0.013	0.040	-0.007
17	28.48	18	0.055	0.150	-0.081	0.024	-0.090	-0.060	-0.069
23	39.16	24	0.026	0.150	-0.210	0.032	-0.131	-0.077	-0.095

BOTH VARIABLES HAVE BEEN PREWHITENED BY THE FOLLOWING FILTER

PREWHITENING FILTER
NO MEAN TERM IN THIS MODEL.

AUTOREGRESSIVE FACTORS
FACTOR 1
1-.303489B**(24)

MOVING AVERAGE FACTORS
FACTOR 1
1-.457212B**(6)

Figure B1. Crosscorrelation Function of Effluent Filtered COD and Influent Filtered COD Under Dynamic Conditions

```
CORRELATION OF EFCOD AND VF
VF HAS BEEN DIFFERENCED.
PERIODS OF DIFFERENCING=1.
BOTH SERIES HAVE BEEN PREWHITENED.
VARIANCE OF TRANSFORMED SERIES=     389160   257194(
NUMBER OF OBSERVATIONS=        107

                         CROSSCORRELATIONS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
-24    -155996    -0.15593 !                .***!   .               :
-23    12916.9     0.01291 !                .   !   .               :
-22   -40621.3    -0.04060 !                .  *!   .               :
-21    19945.8     0.01994 !                .   !   .               :
-20    913.264     0.00091 !                .   !   .               :
-19    15494.4     0.01549 !                .   !   .               :
-18    -163353    -0.16328 !                .***!   .               :
-17   -73695.3    -0.07366 !                .  *!   .               :
-16    14599.4     0.01459 !                .   !   .               :
-15    80164.8     0.08013 !                .   !** .               :
-14     118608     0.11856 !                .   !** .               :
-13     117049     0.11700 !                .   !** .               :
-12    60565.2     0.06054 !                .   !*  .               :
-11     129024     0.12897 !                .   !***.               :
-10    38389.4     0.03837 !                .   !*  .               :
 -9     -11409    -0.01140 !                .   !   .               :
 -8     -21899    -0.02189 !                .   !   .               :
 -7   -190.146    -0.00019 !                .   !   .               :
 -6   -56950.3    -0.05692 !                .  *!   .               :
 -5    -266486    -0.26637 !               *****!   .               :
 -4    -150958    -0.15089 !                .***!   .               :
 -3    -136544    -0.13648 !                .***!   .               :
 -2   -61559.9    -0.06153 !                .  *!   .               :
 -1   -58855.5    -0.05883 !                .  *!   .               :
  0    52613.6     0.05259 !                .   !*  .               :
  1    -110419    -0.11037 !                . **!   .               :
  2     221688     0.22159 !                .   !****               :
  3     163592     0.16352 !                .   !***.               :
  4     224083     0.22398 !                .   !****               :
  5     166248     0.16617 !                .   !***.               :
  6     144596     0.14453 !                .   !***.               :
  7    85504.6     0.08547 !                .   !** .               :
  8     118818     0.11876 !                .   !** .               :
  9   -73008.3    -0.07298 !                .  *!   .               :
 10   -66102.2    -0.06607 !                .  *!   .               :
 11   -37125.4    -0.03711 !                .  *!   .               :
 12    22329.4     0.02232 !                .   !   .               :
 13   -81109.2    -0 08107 !                . **!   .               :
 14   -64781.8    -0.06475 !                .  *!   .               :
 15    -133354    -0.13329 !                .***!   .               :
 16   -71098.5    -0.07107 !                .  *!   .               :
 17   -65220.4    -0.06519 !                .  *!   .               :
 18    80709.8     0.08067 !                .   !** .               :
 19    -257323    -0.25721 !               *****!   .               :
 20      15727     0.01572 !                .   !   .               :
 21   -62245.9    -0.06222 !                .  *!   .               :
 22    2563.17     0.00256 !                .   !   .               :
 23    25491.6     0.02548 !                .   !*  .               :
 24    27400.2     0.02739 !                .   !*  .               :

              CROSSCORRELATION CHECK BETWEEN SERIES

 TO    CHI                               CROSSCORRELATIONS
LAG  SQUARE DF   PROB
  5   18.04   6  0.006       0.053 -0.110  0.222  0.164  0.224  0.166
 11   23.75  12  0.022       0.145  0.085  0.119 -0.073 -0.066 -0.037
 17   27.85  18  0.064       0.022 -0.081 -0.065 -0.133 -0.071 -0.065
 23   36.13  24  0.053       0.081 -0.257  0.016 -0.062  0.003  0.025
    BOTH VARIABLES HAVE BEEN PREWHITENED BY THE FOLLOWING FILTER

           PREWHITENING FILTER
           NO MEAN TERM IN THIS MODEL.

            AUTOREGRESSIVE FACTORS
                        FACTOR 1
           1+0.716145B**(18)
```

Figure B2. Crosscorrelation Function of Effluent Filtered COD and Volumetric Organic Loading Under Dynamic Conditions

CORRELATION OF EFCOD AND FEED
FEED HAS BEEN DIFFERENCED.
PERIODS OF DIFFERENCING=1.
BOTH SERIES HAVE BEEN PREWHITENED.
VARIANCE OF TRANSFORMED SERIES= 411041 4185.7
NUMBER OF OBSERVATIONS= 107

CROSSCORRELATIONS

LAG	COVARIANCE	CORRELATION	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
-24	-9095.26	-0.21927	****|
-23	7091.81	0.17097	|***
-22	-811.375	-0.01956	|
-21	997.805	0.02406	|
-20	-370.823	-0.00894	|
-19	2147.94	0.05178	|*
-18	-7960.03	-0.19190	****|
-17	-2140.49	-0.05160	*|
-16	-5621.79	-0.13553	***|
-15	775	0.01868	|
-14	852.852	0.02056	|
-13	2719.22	0.06556	|*
-12	-608.184	-0.01466	|
-11	-4151.45	-0.10009	**|
-10	747.966	0.01803	|
-9	3533.6	0.08519	|**
-8	3851.41	0.09285	|**
-7	2396.52	0.05778	|*
-6	-1284.15	-0.03096	*|
-5	4336.51	0.10455	|**
-4	4198.03	0.10121	|**
-3	3821.47	0.09213	|**
-2	3002.89	0.07240	|*
-1	1843.68	0.04445	|*
0	1169.46	0.02819	|*
1	-6937.69	-0.16726	***|
2	239.449	0.00577	|
3	-758.34	-0.01828	|
4	1595.58	0.03847	|*
5	1296.28	0.03125	|*
6	3851.39	0.09285	|**
7	-10198.2	-0.24586	*****|
8	468.093	0.01129	|
9	-2239.43	-0.05399	*|
10	-876.316	-0.02113	|
11	-1221.25	-0.02944	*|
12	2305.71	0.05559	|*
13	3843.94	0.09267	|**
14	9120.01	0.21987	|****
15	-531.678	-0.01282	|
16	2831.97	0.06827	|*
17	1165.93	0.02811	|*
18	-590.091	-0.01423	|
19	-2419.15	-0.05832	*|
20	302.936	0.00730	|
21	-5547.94	-0.13375	***|
22	-1426.68	-0.03440	*|
23	2179.58	0.05255	|*
24	206.437	0.00498	|

CROSSCORRELATION CHECK BETWEEN SERIES

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	3.38	6	0.760	0.028	-0.167	0.006	-0.018	0.038	0.031
11	11.24	12	0.509	0.093	-0.246	0.011	-0.054	-0.021	-0.029
17	18.26	18	0.439	0.056	0.093	0.220	-0.013	0.068	0.028
23	20.99	24	0.639	-0.014	-0.058	0.007	-0.134	-0.034	0.053

BOTH VARIABLES HAVE BEEN PREWHITENED BY THE FOLLOWING FILTER

PREWHITENING FILTER
NO MEAN TERM IN THIS MODEL.

AUTOREGRESSIVE FACTORS
FACTOR 1
1+0.197661B**(12)+0.556275B**(18)-.439903B**(24)

MOVING AVERAGE FACTORS
FACTOR 1
1-.331682B**(6)

Figure B3. Crosscorrelation Function of Effluent Filtered COD and Feed Rate Under Dynamic Conditions

APPENDIX C

Table C1. Statistics of Transfer Function Noise Model For Effluent Filtered COD, Model 2

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG	VARIABLE
MA1,1	0.214799	0.102648	2.09	11	EFCOD
AR1,1	0.185423	0.0980935	1.89	1	EFCOD
NUM1	0.0625306	0.0167213	3.76	0	IFCOD
DEN1,1	0.822737	0.0720789	11.41	2	IFCOD

VARIANCE ESTIMATE = 222025
STD ERROR ESTIMATE = 471.195
NUMBER OF RESIDUALS= 105

CORRELATIONS OF THE ESTIMATES

	MA1,1	AR1,1	NUM1	DEN1,1
MA1,1	1.000	-0.076	0.087	-0.007
AR1,1	-0.076	1.000	-0.069	0.049
NUM1	0.087	-0.069	1.000	-0.411
DEN1,1	-0.007	0.049	-0.411	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	1.02	4	0.906	-0.012	0.042	0.071	-0.033	0.020	-0.030
12	3.57	10	0.965	0.045	-0.002	-0.019	-0.046	-0.009	-0.129
18	6.25	16	0.985	-0.053	0.066	-0.070	-0.064	-0.073	-0.006
24	6.59	22	0.999	-0.013	-0.023	-0.039	0.006	-0.005	-0.016

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0     222025     1.00000                      |********************|
  1   -2597.51    -0.01170                   .  |   .                |
  2    9321.99     0.04199                   .  |*  .                |
  3    15654.5     0.07051                   .  |*  .                |
  4   -7328.95    -0.03301                   . *|   .                |
  5    4338.67     0.01954                   .  |   .                |
  6   -6703.15    -0.03019                   . *|   .                |
  7    9953.02     0.04483                   .  |*  .                |
  8   -403.322    -0.00182                   .  |   .                |
  9   -4181.81    -0.01883                   .  |   .                |
 10     -10132    -0.04563                   . *|   .                |
 11   -1914.95    -0.00862                   .  |   .                |
 12    -28701.4   -0.12927                   .***|  .                |
 13   -11745.8    -0.05290                   . *|   .                |
 14      14638     0.06593                   .  |*  .                |
 15   -15492.4    -0.06978                   . *|   .                |
 16   -14188.7    -0.06391                   . *|   .                |
 17   -16144.9    -0.07272                   . *|   .                |
 18   -1231.34    -0.00555                   .  |   .                |
 19   -2818.67    -0.01270                   .  |   .                |
 20   -5115.85    -0.02304                   .  |   .                |
 21   -8666.94    -0.03904                   . *|   .                |
 22    1371.92     0.00618                   .  |   .                |
 23   -1047.25    -0.00472                   .  |   .                |
 24   -3525.02    -0.01588                   .  |   .                |
                           '.' MARKS TWO STANDARD ERRORS
```

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT IFCOD

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	5.94	4	0.204	0.087	-0.118	0.059	0.169	0.012	0.054
11	6.92	10	0.733	0.061	0.049	0.025	-0.039	-0.033	-0.001
17	8.63	16	0.928	0.062	-0.026	0.059	-0.079	-0.047	-0.024
23	[illegible]	22	[illegible]	[illegible]	-0.247	-0.025	-0.147	[illegible]	[illegible]

Table C2. Statistics of Transfer Function Noise Model For Effluent Filtered COD, Model 3

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG	VARIABLE
MA1,1	0.317218	0.0949609	3.34	11	EFCOD
NUM1	0.0719654	0.0183775	3.92	0	VF
DEN1,1	0.705684	0.148688	4.75	1	VF

VARIANCE ESTIMATE = 224838
STD ERROR ESTIMATE = 474.171
NUMBER OF RESIDUALS= 104

CORRELATIONS OF THE ESTIMATES

	MA1,1	NUM1	DEN1,1
MA1,1	1.000	-0.015	-0.018
NUM1	-0.015	1.000	-0.429
DEN1,1	-0.018	-0.429	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	2.39	5	0.793	0.091	0.039	0.072	-0.018	-0.032	-0.075
12	4.98	11	0.932	0.093	0.026	-0.048	-0.071	-0.000	-0.075
18	9.97	17	0.905	-0.079	0.070	-0.085	-0.102	-0.101	-0.034
24	11.29	23	0.980	-0.081	-0.037	-0.007	-0.021	0.039	-0.012

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0     224838     1.00000  |                    |********************
  1    20468.2     0.09104  |                .   |**  .
  2    8679.06     0.03860  |                .   |*   .
  3    16242.7     0.07224  |                .   |*   .
  4   -3980.21    -0.01770  |                .   |    .
  5   -7163.49    -0.03186  |                .  *|    .
  6   -16759.3    -0.07454  |                .  *|    .
  7    20970.6     0.09327  |                .   |**  .
  8    5944.48     0.02644  |                .   |*   .
  9   -10862.6    -0.04831  |                .  *|    .
 10   -15858.1    -0.07053  |                .  *|    .
 11   -76.2732    -0.00034  |                .   |    .
 12     -16807    -0.07475  |                .  *|    .
 13   -17776.2    -0.07906  |                . **|    .
 14    15667.6     0.06968  |                .   |*   .
 15   -19014.3    -0.08457  |                . **|    .
 16   -23023.8    -0.10240  |                . **|    .
 17   -22698.5    -0.10095  |                . **|    .
 18   -7589.39    -0.03375  |                .  *|    .
 19   -18292.2    -0.08136  |                . **|    .
 20   -8250.78    -0.03670  |                .  *|    .
 21   -1665.26    -0.00741  |                .   |    .
 22   -4636.77    -0.02062  |                .   |    .
 23    8701.34     0.03870  |                .   |*   .
 24   -2644.64    -0.01176  |                .   |    .
                             '.' MARKS TWO STANDARD ERRORS
```

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT VF

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	1.73	4	0.786	-0.029	-0.039	0.086	0.075	0.033	-0.009
11	4.07	10	0.944	0.121	-0.046	-0.063	0.031	0.005	0.027
17	10.20	16	0.856	0.002	-0.112	-0.066	-0.032	-0.017	-0.202
23	12.63	22	0.943	0.015	-0.094	-0.041	-0.001	-0.029	0.108

Table C3. Statistics of Transfer Function Noise Model For Effluent Filtered COD, Model 4

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG	VARIABLE
MA1,1	0.255076	0.105414	2.46	11	EFCOD
AR1,1	0.355806	0.0948306	3.75	1	EFCOD
NUM1	-0.512445	0.38428	-1.33	0	FEED

VARIANCE ESTIMATE = 210136
STD ERROR ESTIMATE = 458.406
NUMBER OF RESIDUALS= 100

CORRELATIONS OF THE ESTIMATES

	MA1,1	AR1,1	NUM1
MA1,1	1.000	0.032	0.039
AR1,1	0.032	1.000	-0.019
NUM1	0.039	-0.019	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	0.65	4	0.953	-0.013	0.013	0.060	-0.045	0.023	0.001
12	2.10	10	0.996	0.003	-0.020	-0.035	0.045	0.014	-0.089
18	7.12	16	0.971	-0.114	0.087	-0.080	-0.040	-0.114	-0.020
24	8.53	22	0.995	-0.055	-0.026	0.044	-0.070	0.017	0.011

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0     210136     1.00000  |                   |********************
  1   -2835.41    -0.01349  |                 . |  .
  2    2765.84     0.01316  |                 . |  .
  3    12603.9     0.05998  |                 . |* .
  4   -9467.88    -0.04506  |                 .*|  .
  5     4838.5     0.02303  |                 . |  .
  6    252.781     0.00120  |                 . |  .
  7    729.635     0.00347  |                 . |  .
  8   -4238.56    -0.02017  |                 . |  .
  9   -7325.71    -0.03486  |                 .*|  .
 10    10401.3     0.04950  |                 . |* .
 11    2892.52     0.01376  |                 . |  .
 12   -18775.1    -0.08935  |                 **|  .
 13   -23875.8    -0.11362  |                 **|  .
 14    18362.9     0.08739  |                 . |** .
 15   -16788.4    -0.07989  |                 **|  .
 16   -8446.49    -0.04020  |                 .*|  .
 17   -23934.1    -0.11390  |                 **|  .
 18   -4191.26    -0.01995  |                 . |  .
 19   -11542.9    -0.05493  |                 .*|  .
 20   -5436.65    -0.02587  |                 .*|  .
 21    9148.31     0.04354  |                 . |* .
 22   -14802.1    -0.07044  |                 .*|  .
 23     3543.4     0.01686  |                 . |  .
 24    2238.02     0.01065  |                 . |  .
                            '.' MARKS TWO STANDARD ERRORS
```

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT FEED

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	1.31	5	0.934	-0.061	0.026	-0.075	-0.045	-0.067	-0.033
11	5.61	11	0.898	0.064	0.102	-0.121	0.099	0.046	-0.045
17	6.64	17	0.988	0.025	0.000	-0.057	0.007	0.080	-0.003
23	25.06	23	0.347	-0.418	-0.038	-0.064	-0.046	0.036	0.016

Table C4. Statistics of Transfer Function Noise Model For Effluent Filtered COD, Model 5

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG	VARIABLE
MA1.1	0.356751	0.10352	3.45	11	EFCOD
NUM1	0.041408	0.0145575	2.84	0	FCOD
DEN1.1	0.785785	0.132032	5.95	1	FCOD
NUM2	0.0661877	0.0163919	4.04	0	VF
DEN1.1	0.700936	0.115977	6.04	1	VF
NUM3	-0.43628	0.395473	-1.10	0	FEED

VARIANCE ESTIMATE = 181494
STD ERROR ESTIMATE = 426.021
NUMBER OF RESIDUALS= 100

CORRELATIONS OF THE ESTIMATES

	MA1.1	NUM1	DEN1.1	NUM2	DEN1.1	NUM3
MA1.1	1.000	-0.040	-0.007	-0.025	-0.005	0.023
NUM1	-0.040	1.000	-0.455	-0.148	0.005	-0.062
DEN1.1	-0.007	-0.455	1.000	0.141	-0.201	0.267
NUM2	-0.025	-0.148	0.141	1.000	-0.429	0.056
DEN1.1	-0.005	0.005	-0.201	-0.429	1.000	-0.296
NUM3	0.023	-0.062	0.267	0.056	-0.296	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	3.68	5	0.597	0.125	-0.048	-0.014	-0.107	-0.061	-0.029
12	5.30	11	0.916	0.095	0.034	-0.017	0.008	0.021	-0.061
18	8.27	17	0.960	-0.070	0.083	-0.063	-0.084	-0.036	-0.024
24	9.80	23	0.992	-0.020	0.020	0.043	-0.066	-0.035	0.059

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0     181494     1.00000  |                    |********************
  1    22462.7     0.12528  |                  . |***.
  2   -8727.76    -0.04809  |                  . *|   .
  3   -2468.11    -0.01360  |                  .  |   .
  4   -19361.5    -0.10668  |                  .**|   .
  5   -10994.3    -0.06058  |                  . *|   .
  6   -5282.32    -0.02910  |                  . *|   .
  7    17181.1     0.09466  |                  .  |** .
  8    6147.75     0.03387  |                  .  |*  .
  9   -3034.58    -0.01672  |                  .  |   .
 10    1525.01     0.00840  |                  .  |   .
 11    3777.52     0.02081  |                  .  |   .
 12   -11016.7    -0.06070  |                  . *|   .
 13   -12651.7    -0.06971  |                  . *|   .
 14    15148.8     0.08347  |                  .  |** .
 15     -11430    -0.06298  |                  . *|   .
 16   -15232.6    -0.08393  |                  .**|   .
 17    -6612.3    -0.03643  |                  . *|   .
 18    -4434.6    -0.02443  |                  .  |   .
 19   -3610.47    -0.01989  |                  .  |   .
 20    3634.57     0.02003  |                  .  |   .
 21    7760.71     0.04276  |                  .  |*  .
 22   -11978.9    -0.06600  |                  . *|   .
 23   -6367.26    -0.03508  |                  . *|   .
 24    10695.2     0.05893  |                  .  |*  .
                             '.' MARKS TWO STANDARD ERRORS
```

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT FOOD

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	0.70	4	0.951	-0.043	-0.069	0.064	0.011	0.029	0.069
11	3.30	10	0.974	0.053	-0.030	0.011	0.022	0.142	0.037
17	11.01	16	0.809	0.014	-0.076	-0.076	-0.059	0.052	-0.231
23	21.99	22	0.460	-0.043	-0.181	-0.100	-0.082	-0.116	0.212

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT VF

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	1.64	4	0.802	-0.056	-0.070	0.074	0.048	0.022	0.011
11	4.82	10	0.903	0.160	-0.018	-0.039	-0.002	0.043	0.050
17	11.13	16	0.801	0.024	-0.113	-0.071	-0.027	-0.014	-0.209
23	14.07	22	0.899	-0.002	-0.127	-0.084	-0.008	-0.042	0.066

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT FEED

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	4.28	5	0.510	-0.019	0.010	-0.057	-0.112	-0.079	-0.119
11	7.75	11	0.736	0.006	0.103	-0.101	0.062	0.091	-0.041
17	11.80	17	0.812	0.001	0.053	-0.006	0.052	0.146	0.116
23	25.75	23	0.313	-0.333	-0.138	-0.082	-0.045	0.026	0.023

Table C5. Statistics of Transfer Function Noise Model For Effluent Filtered COD, Model 6

ARIMA: LEAST SQUARES ESTIMATION

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG	VARIABLE
MA1,1	0.296871	0.100165	2.96	11	EFCOD
NUM1	0.0595097	0.0157153	3.79	0	IFCOD
DEN1,1	0.793313	0.0804109	9.87	2	IFCOD
NUM2	0.0633893	0.0176478	3.59	0	VF
DEN1,1	0.721553	0.125576	5.75	1	VF

VARIANCE ESTIMATE = 199676
STD ERROR ESTIMATE = 446.851
NUMBER OF RESIDUALS= 104

CORRELATIONS OF THE ESTIMATES

	MA1,1	NUM1	DEN1,1	NUM2	DEN1,1
MA1,1	1.000	0.054	-0.025	-0.046	-0.019
NUM1	0.054	1.000	-0.404	-0.113	0.018
DEN1,1	-0.025	-0.404	1.000	0.033	-0.063
NUM2	-0.046	-0.113	0.033	1.000	-0.433
DEN1,1	-0.019	0.018	-0.063	-0.433	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	1.85	5	0.869	0.043	-0.040	0.034	-0.089	-0.036	-0.055
12	5.20	11	0.921	0.091	0.049	-0.020	-0.075	-0.011	-0.109
18	7.60	17	0.974	-0.060	0.084	-0.055	-0.070	-0.029	-0.010
24	7.68	23	0.999	0.004	0.013	-0.006	0.014	0.009	0.009

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  0     199676     1.00000  |                    |********************|
  1    8603.51     0.04309  |                  . |*  .                 |
  2   -7995.98    -0.04004  |                  . *|   .                |
  3    6722.73     0.03367  |                  . |*  .                 |
  4   -17808.5    -0.08919  |                  .**|   .                |
  5   -7142.45    -0.03577  |                  . *|   .                |
  6   -10941.9    -0.05480  |                  . *|   .                |
  7    18098.2     0.09064  |                  . |** .                 |
  8    9855.82     0.04936  |                  . |*  .                 |
  9   -4039.42    -0.02023  |                  .  |   .                |
 10   -14961.2    -0.07493  |                  . *|   .                |
 11   -2277.43    -0.01141  |                  .  |   .                |
 12   -21674.7    -0.10855  |                  .**|   .                |
 13   -11916.4    -0.05968  |                  . *|   .                |
 14    16766.6     0.08397  |                  . |** .                 |
 15   -10894.4    -0.05456  |                  . *|   .                |
 16   -14062.6    -0.07043  |                  . *|   .                |
 17   -5732.44    -0.02871  |                  . *|   .                |
 18   -1904.65    -0.00954  |                  .  |   .                |
 19    713.473     0.00357  |                  .  |   .                |
 20    2606.56     0.01305  |                  .  |   .                |
 21   -1160.37    -0.00581  |                  .  |   .                |
 22    2891.96     0.01448  |                  .  |   .                |
 23    1784.17     0.00894  |                  .  |   .                |
 24     1892.5     0.00948  |                  .  |   .                |
                            '.' MARKS TWO STANDARD ERRORS
```

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT IFCOD

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	5.04	4	0.283	0.122	-0.104	-0.045	0.131	0.036	0.047
11	7.71	10	0.657	0.108	0.100	0.036	-0.038	-0.023	0.023
17	10.36	16	0.847	0.090	-0.010	0.030	-0.095	-0.077	-0.039
23	24.07	22	0.344	0.068	-0.264	-0.068	-0.178	-0.110	-0.094

CROSSCORRELATION CHECK OF RESIDUALS WITH INPUT VF

TO LAG	CHI SQUARE	DF	PROB	CROSSCORRELATIONS					
5	1.64	4	0.802	-0.063	-0.025	0.046	0.066	0.066	-0.017
11	4.93	10	0.896	0.160	-0.045	-0.036	0.026	0.036	0.026
17	12.28	16	0.725	0.025	-0.130	-0.065	-0.030	-0.031	-0.217
23	15.54	22	0.838	-0.014	-0.112	-0.067	-0.003	-0.029	0.115

APPENDIX D

The experimental data presented in this Appendix together with Figures 4 - 18 and 21 - 33 were provided by Dr. Eric R. Hall, Process Development Engineer of the Wastewater Technology Center, Canada Center for Inland Waters, Burlington, Ontario.

MCFEED T=00004 IS ON CR00049 USING 00078 BLKS R=0000

	McFEED HR.	FHR.	TS	TVS	SS	VSS	COD	FCOD	TKN	FTKN	NH4	TP	FTP	BOD	FBOD	Note
0003	165	15														
0004	000	000	-1	-1	61	58	6820	5920	-1	-1	-1	-1	-1	-1	-1	
0005	020	020	-1	-1	72	71	6620	6320	-1	-1	-1	-1	-1	-1	-1	
0006	024	024	-1	-1	50	48	6140	5800	-1	-1	-1	-1	-1	-1	-1	
0007	045	045	-1	-1	80	76	6040	5820	-1	-1	-1	-1	-1	-1	-1	
0008	049	049	-1	-1	53	50	6340	6040	-1	-1	-1	-1	-1	-1	-1	
0009	068	068	-1	-1	85	83	6560	6340	-1	-1	-1	-1	-1	-1	-1	
0010	072	072	-1	-1	55	51	6420	6180	-1	-1	-1	-1	-1	-1	-1	
0011	092	092	-1	-1	126	115	6360	6220	-1	-1	-1	-1	-1	-1	-1	
0012	096	096	-1	-1	86	82	5940	5700	-1	-1	-1	-1	-1	-1	-1	
0013	118	118	-1	-1	161	155	6020	5760	-1	-1	-1	-1	-1	-1	-1	
0014	119	119	-1	-1	64	60	5740	5540	-1	-1	-1	-1	-1	-1	-1	
0015	143	143	-1	-1	156	145	6060	5900	-1	-1	-1	-1	-1	-1	-1	
0016	144	144	-1	-1	56	53	6300	6020	-1	-1	-1	-1	-1	-1	-1	
0017	164	164	-1	-1	97	90	6060	5780	-1	-1	-1	-1	-1	-1	-1	
0018	171	171	-1	-1	53	49	6380	6020	-1	-1	-1	-1	-1	-1	-1	
0019	188	188	-1	-1	91	85	6400	5940	-1	-1	-1	-1	-1	-1	-1	
0020	194	194	-1	-1	52	51	6540	6100	-1	-1	-1	-1	-1	-1	-1	
0021	212	212	-1	-1	77	72	6400	6020	-1	-1	-1	-1	-1	-1	-1	
0022	218	218	-1	-1	103	102	6460	5860	-1	-1	-1	-1	-1	-1	-1	
0023	236	236	-1	-1	108	104	6360	5860	-1	-1	-1	-1	-1	-1	-1	
0024	242	242	-1	-1	75	66	6380	5960	-1	-1	-1	-1	-1	-1	-1	
0025	260	260	-1	-1	106	94	6120	5600	-1	-1	-1	-1	-1	-1	-1	
0026	266	266	-1	-1	102	102	6900	6360	-1	-1	-1	-1	-1	-1	-1	
0027	287	287	-1	-1	94	91	5940	5780	-1	-1	-1	-1	-1	-1	-1	
0028	288	288	-1	-1	109	98	5900	5540	-1	-1	-1	-1	-1	-1	-1	
0029	309	309	-1	-1	105	102	6180	6160	-1	-1	-1	-1	-1	-1	-1	
0030	310	310	-1	-1	121	115	6140	5820	-1	-1	-1	-1	-1	-1	-1	Run #1 (0-332hrs)
0031	332	332	-1	-1	190	170	6540	6340	-1	-1	-1	-1	-1	-1	-1	
0032	337	337	-1	-1	284	260	18020	16520	-1	-1	-1	-1	-1	-1	-1	
0033	356	356	-1	-1	260	170	17220	16440	-1	-1	-1	-1	-1	-1	-1	
0034	363	363	-1	-1	292	244	18000	16040	-1	-1	-1	-1	-1	-1	-1	
0035	385	385	-1	-1	300	269	17860	17180	-1	-1	-1	-1	-1	-1	-1	
0036	405	405	-1	-1	472	460	19180	17620	-1	-1	-1	-1	-1	-1	-1	
0037	409	409	-1	-1	488	460	20900	19750	-1	-1	-1	-1	-1	-1	-1	
0038	428	428	-1	-1	380	375	21550	20554	-1	-1	-1	-1	-1	-1	-1	
0039	476	476	-1	-1	575	530	21350	18450	-1	-1	-1	-1	-1	-1	-1	
0040	482	482	-1	-1	600	590	20950	19450	-1	-1	-1	-1	-1	-1	-1	
0041	500	500	-1	-1	680	660	21450	19200	-1	-1	-1	-1	-1	-1	-1	
0042	506	506	-1	-1	670	590	21450	18850	-1	-1	-1	-1	-1	-1	-1	
0043	524	524	-1	-1	640	-1	19400	16600	-1	-1	-1	-1	-1	-1	-1	
0044	526	526	-1	-1	580	560	18650	18250	-1	-1	-1	-1	-1	-1	-1	
0045	548	548	-1	-1	660	560	21400	20100	-1	-1	-1	-1	-1	-1	-1	
0046	554	554	-1	-1	490	390	20900	19900	-1	-1	-1	-1	-1	-1	-1	
0047	572	572	-1	-1	670	660	21900	19700	-1	-1	-1	-1	-1	-1	-1	
0048	579	579	-1	-1	510	500	20050	18700	-1	-1	-1	-1	-1	-1	-1	
0049	596	596	-1	-1	810	750	20300	17650	-1	-1	-1	-1	-1	-1	-1	
0050	622	622	-1	-1	780	750	17450	15600	-1	-1	-1	-1	-1	-1	-1	Run #2 (336-696hrs)
0051	623	623	-1	-1	750	670	16450	15900	-1	-1	-1	-1	-1	-1	-1	
0052	697	697	-1	-1	240	230	16850	15100	-1	-1	-1	-1	-1	-1	-1	
0053	717	717	-1	-1	220	200	15450	14950	-1	-1	-1	-1	-1	-1	-1	
0054	723	723	-1	-1	155	150	16250	14000	-1	-1	-1	-1	-1	-1	-1	
0055	740	740	-1	-1	160	80	15400	14150	-1	-1	-1	-1	-1	-1	-1	
0056	746	746	-1	-1	332	292	17200	14750	-1	-1	-1	-1	-1	-1	-1	
0057	762	762	-1	-1	248	204	16100	15500	-1	-1	-1	-1	-1	-1	-1	
0058	772	772	-1	-1	216	192	14250	12200	-1	-1	-1	-1	-1	-1	-1	
0059	792	792	-1	-1	244	240	13300	12500	-1	-1	-1	-1	-1	-1	-1	
0060	812	812	-1	-1	200	192	12850	11650	-1	-1	-1	-1	-1	-1	-1	
0061	816	816	-1	-1	240	208	13500	11800	-1	-1	-1	-1	-1	-1	-1	
0062	838	838	-1	-1	160	140	14250	12950	-1	-1	-1	-1	-1	-1	-1	
0063	844	844	-1	-1	130	115	16900	15500	-1	-1	-1	-1	-1	-1	-1	
0064	866	866	-1	-1	145	-1	17700	16800	-1	-1	-1	-1	-1	-1	-1	
0065	891	891	-1	-1	188	148	16450	15500	-1	-1	-1	-1	-1	-1	-1	
0066	908	908	-1	-1	160	104	15550	14150	-1	-1	-1	-1	-1	-1	-1	
0067	915	915	-1	-1	196	112	15550	14800	-1	-1	-1	-1	-1	-1	-1	
0068	960	960	-1	-1	212	144	15700	14200	-1	-1	-1	-1	-1	-1	-1	
0069	980	980	-1	-1	212	152	15200	13700	-1	-1	-1	-1	-1	-1	-1	
0070	984	984	-1	-1	180	144	15200	13650	-1	-1	-1	-1	-1	-1	-1	
0071	1004	1004	-1	-1	176	120	14350	13150	-1	-1	-1	-1	-1	-1	-1	Run #3 (700-1032hrs)
0072	1009	1009	-1	-1	168	152	15550	14150	-1	-1	-1	-1	-1	-1	-1	
0073	1028	1028	-1	-1	112	100	9650	8450	-1	-1	-1	-1	-1	-1	-1	
0074	1034	1034	-1	-1	60	40	9050	7800	-1	-1	-1	-1	-1	-1	-1	
0075	1052	1052	-1	-1	58	42	8800	7900	-1	-1	-1	-1	-1	-1	-1	
0076	1057	1057	-1	-1	66	52	8850	8150	-1	-1	-1	-1	-1	-1	-1	
0077	1076	1076	-1	-1	70	46	8800	7850	-1	-1	-1	-1	-1	-1	-1	
0078	1081	1081	-1	-1	34	-1	7600	7050	-1	-1	-1	-1	-1	-1	-1	

0079	[illegible]	[illegible]	-1	-1	[illegible]	[illegible]	[illegible]	[illegible]	-1	-1	-1	-1	-1	-1	-1	
0080	1105	1105	-1	-1	50	48	7250	6450	-1	-1	-1	-1	-1	-1	-1	
0081	1128	1428	-1	-1	58	56	6750	5700	-1	-1	-1	-1	-1	-1	-1	
0082	1151	1151	-1	-1	50	42	5800	5700	-1	-1	-1	-1	-1	-1	-1	
0083	1152	1152	-1	-1	48	42	5520	5180	-1	-1	-1	-1	-1	-1	-1	
0084	1172	1172	-1	-1	44	42	5680	5280	-1	-1	-1	-1	-1	-1	-1	
0085	1180	1180	-1	-1	78	58	8960	8320	-1	-1	-1	-1	-1	-1	-1	
0086	1196	1196	-1	-1	74	54	9400	8780	-1	-1	-1	-1	-1	-1	-1	
0087	1201	1201	-1	-1	66	62	9820	9420	-1	-1	-1	-1	-1	-1	-1	
0088	1220	1220	-1	-1	58	54	9760	9620	-1	-1	-1	-1	-1	-1	-1	
0089	1225	1225	-1	-1	76	-1	11400	10300	-1	-1	-1	-1	-1	-1	-1	
0090	1244	1244	-1	-1	70	68	10600	9950	-1	-1	-1	-1	-1	-1	-1	
0091	1249	1249	-1	-1	28	26	11600	10650	-1	-1	-1	-1	-1	-1	-1	
0092	1268	1268	-1	-1	38	18	11150	10800	-1	-1	-1	-1	-1	-1	-1	
0093	1273	1273	-1	-1	70	52	12250	10850	-1	-1	-1	-1	-1	-1	-1	
0094	1295	1295	-1	-1	62	46	10750	10550	-1	-1	-1	-1	-1	-1	-1	
0095	1320	1320	-1	-1	34	24	10750	9950	-1	-1	-1	-1	-1	-1	-1	
0096	1321	1321	-1	-1	44	40	10350	9150	-1	-1	-1	-1	-1	-1	-1	
0097	1340	1340	-1	-1	42	36	10600	10100	-1	-1	-1	-1	-1	-1	-1	
0098	1346	1346	-1	-1	42	38	10150	9800	-1	-1	-1	-1	-1	-1	-1	Run #4 (1034-1364hrs
0099	1364	1364	-1	-1	44	40	10900	9300	-1	-1	-1	-1	-1	-1	-1	
0100	1372	1372	-1	-1	56	50	16800	15250	-1	-1	-1	-1	-1	-1	-1	
0101	1388	1388	-1	-1	50	46	16200	15400	-1	-1	-1	-1	-1	-1	-1	
0102	1392	1392	-1	-1	54	-1	17400	16700	-1	-1	-1	-1	-1	-1	-1	
0103	1412	1412	-1	-1	64	-1	20650	20650	-1	-1	-1	-1	-1	-1	-1	
0104	1418	1418	-1	-1	1030	970	22700	17750	-1	-1	-1	-1	-1	-1	-1	
0105	1436	1436	-1	-1	1080	1030	20600	15600	-1	-1	-1	-1	-1	-1	-1	
0106	1441	1441	-1	-1	1480	1420	17900	14650	-1	-1	-1	-1	-1	-1	-1	
0107	1461	1461	-1	-1	1460	1400	17300	14900	-1	-1	-1	-1	-1	-1	-1	
0108	1487	1487	-1	-1	1460	1420	20200	16300	-1	-1	-1	-1	-1	-1	-1	
0109	1488	1488	-1	-1	1340	1260	18900	14600	-1	-1	-1	-1	-1	-1	-1	
0110	1508	1508	-1	-1	1520	1480	17650	14100	-1	-1	-1	-1	-1	-1	-1	
0111	1513	1513	-1	-1	1780	1440	17000	13000	-1	-1	-1	-1	-1	-1	-1	
0112	1532	1532	-1	-1	276	-1	12500	8500	-1	-1	-1	-1	-1	-1	-1	
0113	1561	1561	-1	-1	595	575	22000	20900	-1	-1	-1	-1	-1	-1	-1	
0114	1580	1580	-1	-1	555	545	21800	20050	-1	-1	-1	-1	-1	-1	-1	
0115	1586	1586	-1	-1	400	380	25350	23100	-1	-1	-1	-1	-1	-1	-1	
0116	1604	1604	-1	-1	-1	-1	25250	23950	-1	-1	-1	-1	-1	-1	-1	
0117	1609	1609	-1	-1	-1	-1	21750	21050	-1	-1	-1	-1	-1	-1	-1	
0118	1631	1631	-1	-1	-1	-1	22250	21450	-1	-1	-1	-1	-1	-1	-1	
0119	1632	1632	-1	-1	205	195	23950	22700	-1	-1	-1	-1	-1	-1	-1	
0120	1657	1657	-1	-1	-1	-1	24800	23450	-1	-1	-1	-1	-1	-1	-1	
0121	1658	1658	-1	-1	-1	-1	23300	21900	-1	-1	-1	-1	-1	-1	-1	
0122	1676	1676	-1	-1	-1	-1	22850	21800	-1	-1	-1	-1	-1	-1	-1	
0123	1707	1707	-1	-1	378	364	23600	22600	-1	-1	-1	-1	-1	-1	-1	
0124	1724	1724	-1	-1	-1	-1	22600	22000	-1	-1	-1	-1	-1	-1	-1	
0125	1729	1729	-1	-1	424	400	21150	18750	-1	-1	-1	-1	-1	-1	-1	Run #5 (1368-1748hrs)
0126	1748	1748	-1	-1	780	732	19450	17650	-1	-1	-1	-1	-1	-1	-1	
0127	1756	1756	-1	-1	-1	-1	14650	13950	-1	-1	-1	-1	-1	-1	-1	
0128	1772	1772	-1	-1	536	516	15150	13850	-1	-1	-1	-1	-1	-1	-1	
0129	1777	1777	-1	-1	636	584	15000	13900	-1	-1	-1	-1	-1	-1	-1	
0130	1798	1798	-1	-1	876	800	14150	13150	-1	-1	-1	-1	-1	-1	-1	
0131	1822	1822	-1	-1	928	856	16600	15050	-1	-1	-1	-1	-1	-1	-1	
0132	1846	1846	-1	-1	795	780	14350	12050	-1	-1	-1	-1	-1	-1	-1	
0133	1850	1850	-1	-1	564	516	13350	11500	-1	-1	-1	-1	-1	-1	-1	
0134	1868	1868	-1	-1	840	756	13650	12150	-1	-1	-1	-1	-1	-1	-1	
0135	1874	1874	-1	-1	555	485	16250	13350	-1	-1	-1	-1	-1	-1	-1	
0136	1892	1892	-1	-1	775	690	15800	13950	-1	-1	-1	-1	-1	-1	-1	
0137	1898	1898	-1	-1	900	830	13300	12500	-1	-1	-1	-1	-1	-1	-1	
0138	1916	1916	-1	-1	940	865	13750	12900	-1	-1	-1	-1	-1	-1	-1	
0139	1944	1944	-1	-1	-1	-1	13100	11700	-1	-1	-1	-1	-1	-1	-1	
0140	1966	1966	-1	-1	-1	-1	12900	11800	-1	-1	-1	-1	-1	-1	-1	
0141	1992	1992	-1	-1	715	665	11500	10200	-1	-1	-1	-1	-1	-1	-1	
0142	2012	2012	-1	-1	705	635	10600	10150	-1	-1	-1	-1	-1	-1	-1	
0143	2016	2016	-1	-1	470	440	14300	13100	-1	-1	-1	-1	-1	-1	-1	
0144	2037	2037	-1	-1	535	455	14300	12800	-1	-1	-1	-1	-1	-1	-1	Run #6 (1752-2061hrs)
0145	2061	2061	-1	-1	585	535	13600	11650	-1	-1	-1	-1	-1	-1	-1	
0146	2066	2066	-1	-1	505	475	18850	17450	-1	-1	-1	-1	-1	-1	-1	
0147	2089	2089	-1	-1	570	500	18300	17450	-1	-1	-1	-1	-1	-1	-1	
0148	2090	2090	-1	-1	440	436	7650	6400	-1	-1	-1	-1	-1	-1	-1	
0149	2113	2113	-1	-1	444	-1	8650	7550	-1	-1	-1	-1	-1	-1	-1	
0150	2114	2114	-1	-1	404	392	23500	21750	-1	-1	-1	-1	-1	-1	-1	
0151	2137	2137	-1	-1	436	420	22100	21400	-1	-1	-1	-1	-1	-1	-1	
0152	2138	2138	-1	-1	480	464	23900	21750	-1	-1	-1	-1	-1	-1	-1	
0153	2162	2162	-1	-1	328	316	13950	12950	-1	-1	-1	-1	-1	-1	-1	
0154	2186	2186	-1	-1	180	178	8800	7200	-1	-1	-1	-1	-1	-1	-1	
0155	2209	2209	-1	-1	184	182	7100	7000	-1	-1	-1	-1	-1	-1	-1	
0156	2210	2210	-1	-1	390	348	17200	14700	-1	-1	-1	-1	-1	-1	-1	
0157	2234	2234	-1	-1	488	472	20300	19300	-1	-1	-1	-1	-1	-1	-1	
0158	2258	2258	-1	-1	284	268	15050	12900	-1	-1	-1	-1	-1	-1	-1	

0159	2282	2282	-1	-1	170	164	7400	7150	-1	-1	-1	-1	-1	-1	-1
0160	2306	2306	-1	-1	126	118	10950	10700	-1	-1	-1	-1	-1	-1	-1
0161	2330	2330	-1	-1	116	106	7800	6550	-1	-1	-1	-1	-1	-1	-1
0162	2354	2354	-1	-1	140	138	11700	10550	-1	-1	-1	-1	-1	-1	-1
0163	2378	2378	-1	-1	180	168	16250	14200	-1	-1	-1	-1	-1	-1	-1
0164	2402	2402	-1	-1	168	160	16800	15550	-1	-1	-1	-1	-1	-1	-1
0165	2426	2426	-1	-1	182	180	19950	17150	-1	-1	-1	-1	-1	-1	-1
0166	2450	2450	-1	-1	190	188	20800	18950	-1	-1	-1	-1	-1	-1	-1
0167	2474	2474	-1	-1	204	198	20850	19600	-1	-1	-1	-1	-1	-1	-1
0168	2498	2498	-1	-1	204	200	21450	19150	-1	-1	-1	-1	-1	-1	-1

Dynamic Run

(2066-2498hrs)

MCFTOP T=00004 IS ON CR00049 USING 00065 BLKS R=0000

	McFTOP HR.	FHR.	PH	TEMP	C2	C3	C4	TVA	
0001									
0002									
0003	164	0							
0004	000	000	4.2	-1	146	-1	-1	-1	
0005	020	020	4.3	-1	162	-1	-1	-1	
0006	024	024	4.4	-1	179	-1	-1	-1	
0007	045	045	4.3	-1	143	-1	-1	-1	
0008	049	049	4.3	-1	141	-1	-1	-1	
0009	068	068	4.3	-1	141	-1	-1	-1	
0010	072	072	4.4	-1	143	-1	-1	-1	
0011	092	092	4.2	-1	143	-1	-1	-1	
0012	096	096	4.4	-1	143	-1	-1	-1	
0013	118	118	4.3	-1	146	-1	-1	-1	
0014	119	119	4.2	-1	146	-1	-1	-1	
0015	143	143	4.3	-1	146	-1	-1	-1	
0016	144	144	4.2	-1	162	-1	-1	-1	
0017	164	164	4.4	-1	146	-1	-1	-1	
0018	171	171	4.3	-1	146	-1	-1	-1	
0019	188	188	4.3	-1	162	-1	-1	-1	
0020	194	194	4.3	-1	141	-1	-1	-1	
0021	212	212	4.4	-1	141	-1	-1	-1	
0022	218	218	4.4	-1	229	-1	-1	-1	
0023	236	236	4.4	-1	229	-1	-1	-1	
0024	242	242	4.3	-1	306	-1	-1	-1	
0025	260	260	4.4	-1	234	10	10	-1	
0026	266	266	4.3	-1	306	8	-1	-1	
0027	287	287	4.4	-1	215	19	15	-1	
0028	288	288	4.3	-1	194	18	21	-1	
0029	309	309	4.4	-1	272	22	12	-1	
0030	310	310	4.3	-1	267	16	25	-1	Run #1 (0-332hrs)
0031	332	332	4.4	-1	306	13	10	-1	
0032	356	356	4.5	-1	578	33	37	-1	
0033	363	363	4.4	-1	735	20	33	-1	
0034	385	385	4.4	-1	556	14	40	-1	
0035	405	405	4.4	-1	615	18	25	-1	
0036	409	409	4.1	-1	914	29	34	-1	
0037	428	428	3.9	-1	926	22	35	-1	
0038	476	476	4.0	-1	685	37	33	-1	
0039	482	482	4.1	-1	596	48	25	-1	
0040	500	500	4.0	-1	884	34	31	-1	
0041	506	506	4.0	-1	727	35	27	-1	
0042	524	524	3.9	-1	1141	53	28	-1	
0043	526	526	4.0	-1	1099	40	19	-1	
0044	548	548	4.0	-1	1175	25	22	-1	
0045	554	554	4.0	-1	855	24	27	-1	
0046	572	572	4.0	-1	1104	76	53	-1	
0047	579	579	4.0	-1	1257	50	40	-1	
0048	596	596	4.0	-1	1326	43	36	-1	
0049	622	622	4.1	-1	1030	44	23	-1	Run #2 (336-696hrs)
0050	623	623	4.0	-1	909	30	26	-1	
0051	697	697	3.8	-1	910	34	10	-1	
0052	717	717	3.8	-1	834	26	25	-1	
0053	723	723	3.8	-1	431	38	23	-1	
0054	740	740	3.8	-1	730	22	4	-1	
0055	746	746	3.5	-1	486	21	37	-1	
0056	762	762	3.5	-1	827	17	42	-1	
0057	772	772	3.5	-1	640	-1	-1	-1	
0058	792	792	3.5	-1	739	-1	-1	-1	
0059	812	812	3.5	-1	764	-1	-1	-1	
0060	816	816	3.5	-1	876	10	34	-1	
0061	838	838	3.5	-1	784	17	20	-1	
0062	844	844	3.5	-1	1031	102	26	-1	
0063	866	866	3.5	-1	662	32	40	-1	
0064	891	891	3.8	-1	692	19	38	-1	
0065	908	908	3.8	-1	649	13	22	-1	
0066	915	915	3.8	-1	711	5	58	-1	
0067	960	960	3.6	-1	794	10	39	-1	
0068	980	980	3.5	-1	761	22	30	-1	
0069	984	984	3.7	-1	702	23	40	-1	
0070	1004	1004	3.6	-1	703	24	45	-1	
0071	1009	1009	3.8	-1	305	32	38	-1	Run #3 (700-1032hrs)
0072	1028	1028	3.8	-1	278	13	20	-1	
0073	1034	1034	3.7	-1	465	30	14	-1	
0074	1052	1052	3.7	-1	301	4	7	-1	
0075	1057	1057	3.7	-1	492	13	10	-1	
0076	1076	1076	3.8	-1	434	-1	-1	-1	
0077	1081	1081	3.7	-1	298	10	9	-1	
0078	1100	1100	3.7	-1	306	9	9	-1	

0079	1105	1105	4.0	-1	437	9	39	-1	
0080	1128	1128	4.0	-1	348	4	-1	-1	
0081	1151	1151	3.7	-1	380	21	3	-1	
0082	1152	1152	3.7	-1	361	-1	-1	-1	
0083	1172	1172	3.8	-1	324	-1	-1	-1	
0084	1180	1180	3.8	-1	538	-1	-1	-1	
0085	1196	1196	3.8	-1	523	-1	-1	-1	
0086	1201	1201	3.7	-1	547	-1	-1	-1	
0087	1220	1220	3.7	-1	524	-1	-1	-1	
0088	1225	1225	3.9	-1	544	12	-1	-1	
0089	1244	1244	3.9	-1	552	-1	-1	-1	
0090	1249	1249	3.8	-1	520	18	7	-1	
0091	1268	1268	3.8	-1	566	7	19	-1	
0092	1273	1273	3.8	-1	568	6	22	-1	
0093	1295	1295	3.8	-1	556	4	20	-1	
0094	1320	1320	3.9	-1	601	26	12	-1	
0095	1321	1321	3.9	-1	510	6	12	-1	
0096	1340	1340	3.9	-1	513	7	13	-1	
0097	1346	1346	3.8	-1	690	6	32	-1	Run #4 (1034-1364hrs)
0098	1364	1364	3.8	-1	564	19	40	-1	
0099	1372	1372	3.8	-1	899	26	46	-1	
0100	1388	1388	3.8	-1	880	11	42	-1	
0101	1392	1392	3.7	-1	900	22	26	-1	
0102	1412	1412	3.7	-1	928	22	44	-1	
0103	1418	1418	3.7	-1	996	33	49	-1	
0104	1436	1436	3.7	-1	806	2	7	-1	
0105	1441	1441	3.7	-1	692	21	42	-1	
0106	1461	1461	3.7	-1	682	21	31	-1	
0107	1487	1487	4.0	-1	682	19	21	-1	
0108	1488	1488	3.7	-1	1012	40	81	-1	
0109	1508	1508	3.8	-1	1012	42	48	-1	
0110	1513	1513	3.9	-1	1012	36	50	-1	
0111	1532	1532	4.1	-1	-1	-1	-1	-1	
0112	1561	1561	6.1	-1	332	32	-1	-1	
0113	1580	1580	5.1	-1	149	-1	-1	-1	
0114	1586	1586	5.0	-1	141	-1	-1	-1	
0115	1604	1604	4.5	-1	141	-1	-1	-1	
0116	1609	1609	4.3	-1	92	-1	-1	-1	
0117	1631	1631	4.3	-1	92	-1	-1	-1	
0118	1632	1632	4.3	-1	222	44	-1	-1	
0119	1657	1657	4.4	-1	205	-1	-1	-1	
0120	1658	1658	4.5	-1	222	23	-1	-1	
0121	1676	1676	4.5	-1	205	-1	-1	-1	
0122	1707	1707	4.6	-1	272	32	-1	-1	
0123	1724	1724	4.6	-1	401	-1	-1	-1	
0124	1729	1729	4.7	-1	361	14	-1	-1	Run #5 (1368-1748hrs)
0125	1748	1748	4.7	-1	226	-1	-1	-1	
0126	1756	1756	4.6	-1	117	-1	-1	-1	
0127	1772	1772	4.7	-1	170	-1	-1	-1	
0128	1777	1777	4.4	-1	288	16	26	-1	
0129	1798	1798	4.3	-1	318	9	-1	-1	
0130	1822	1822	4.2	-1	352	11	27	-1	
0131	1846	1846	4.3	-1	320	3	73	-1	
0132	1850	1850	4.4	-1	292	17	66	-1	
0133	1868	1868	4.3	-1	365	-1	46	-1	
0134	1874	1874	4.3	-1	280	20	57	-1	
0135	1892	1892	4.2	-1	352	12	57	-1	
0136	1898	1898	4.1	-1	402	-1	57	-1	
0137	1916	1916	4.1	-1	493	5	56	-1	
0138	1944	1944	4.0	-1	337	34	126	-1	
0139	1966	1966	4.0	-1	396	25	118	-1	
0140	1992	1992	3.9	-1	349	-1	121	-1	
0141	2012	2012	3.0	-1	346	15	132	-1	
0142	2016	2016	3.0	-1	414	167	412	-1	
0143	2037	2037	2.8	-1	354	187	422	-1	Run #6 (1752-2061hrs)
0144	2061	2061	3.0	-1	360	181	416	-1	
0145	2066	2066	2.9	-1	1122	432	610	-1	
0146	2089	2089	2.9	-1	414	271	611	-1	
0147	2090	2090	2.9	-1	498	230	289	-1	
0148	2113	2113	3.1	-1	234	123	287	-1	
0149	2114	2114	2.9	-1	543	398	875	-1	
0150	2137	2137	3.0	-1	484	377	875	-1	
0151	2138	2138	3.2	-1	556	378	825	-1	
0152	2162	2162	3.0	-1	294	245	503	-1	
0153	2186	2186	2.9	-1	240	122	263	-1	
0154	2209	2209	2.9	-1	150	106	228	-1	
0155	2210	2210	2.8	-1	515	280	537	-1	
0156	2234	2234	3.6	-1	524	359	694	-1	
0157	2258	2258	3.5	-1	538	329	537	-1	
0158	2282	2282	3.6	-1	176	136	460	-1	

0159	2306	2306	3.7	-1	210	185	402	-1
0160	2330	2330	3.3	-1	208	144	241	-1
0161	2354	2354	3.3	-1	169	200	387	-1
0162	2378	2378	3.4	-1	603	306	558	-1
0163	2402	2402	3.3	-1	287	262	549	-1
0164	2426	2426	3.2	-1	624	457	861	-1
0165	2450	2450	3.2	-1	547	428	944	-1
0166	2474	2474	3.5	-1	481	327	717	-1
0167	2498	2498	3.5	-1	434	322	614	-1

Dynamic Run (2066-2498hrs)

MCOPER T=00004 IS ON CR00049 USING 00188 BLKS R=0000

0001 0002	McOPER HR.	FHR.	FEED	RECYC	GAS	PH	TEMP	CO2	CH4	O2	N2	C2	C3	C4	TVA	NaOH
0003	517	16														
0004	004	004	1377	0	1247	6.6	32.0	-1	-1	-1	-1	1359	513	498	-1	1710
0005	008	008	1377	0	932	6.6	32.0	-1	-1	-1	-1	841	329	142	-1	1710
0006	012	012	1377	0	900	6.6	32.0	-1	-1	-1	-1	647	156	80	-1	1710
0007	016	016	1377	0	900	6.6	32.0	-1	-1	-1	-1	680	409	44	-1	1710
0008	020	020	1377	0	886	6.6	32.0	-1	-1	-1	-1	647	457	44	-1	1710
0009	024	024	1195	0	775	6.4	33.0	-1	-1	-1	-1	822	651	103	-1	1962
0010	028	028	1195	0	720	6.4	33.0	-1	-1	-1	-1	679	584	69	-1	1962
0011	032	032	1195	0	775	6.4	33.0	-1	-1	-1	-1	643	567	36	-1	1962
0012	036	036	1195	0	840	6.4	33.0	-1	-1	-1	-1	714	634	54	-1	1962
0013	040	040	1195	0	886	6.4	33.0	-1	-1	-1	-1	714	634	54	-1	1962
0014	044	044	1195	0	886	6.4	33.0	-1	-1	-1	-1	643	567	54	-1	1962
0015	048	048	1212	0	755	6.5	33.0	-1	-1	-1	-1	942	976	108	-1	2124
0016	052	052	1212	0	886	6.5	33.0	-1	-1	-1	-1	879	864	108	-1	2124
0017	056	056	1212	0	960	6.5	33.0	-1	-1	-1	-1	816	880	90	-1	2124
0018	060	060	1212	0	840	6.5	33.0	-1	-1	-1	-1	816	784	108	-1	2124
0019	064	064	1212	0	886	6.5	33.0	-1	-1	-1	-1	754	.16	90	-1	2124
0020	068	068	1221	0	960	6.3	33.0	-1	-1	-1	-1	1000	1163	114	-1	2214
0021	072	072	1221	0	960	6.3	33.0	-1	-1	-1	-1	1000	1180	95	-1	2214
0022	076	076	1221	0	916	6.3	33.0	-1	-1	-1	-1	857	990	95	-1	2214
0023	080	080	1221	0	916	6.3	33.0	-1	-1	-1	-1	786	903	76	-1	2214
0024	084	084	1221	0	840	6.3	33.0	-1	-1	-1	-1	714	781	57	-1	2214
0025	088	088	1221	0	840	6.3	33.0	-1	-1	-1	-1	643	694	57	-1	2214
0026	092	092	1352	0	886	6.3	32.0	-1	-1	-1	-1	710	738	156	-1	2280
0027	100	100	1352	0	916	6.3	32.0	-1	-1	-1	-1	770	958	123	-1	2280
0028	104	104	1352	0	916	6.3	32.0	-1	-1	-1	-1	681	769	88	-1	2280
0029	108	108	1352	0	886	6.3	32.0	-1	-1	-1	-1	710	832	107	-1	2280
0030	112	112	1352	0	651	6.3	32.0	-1	-1	-1	-1	651	738	107	-1	2280
0031	116	116	1352	0	775	6.3	32.0	-1	-1	-1	-1	592	644	162	-1	2280
0032	120	120	1339	0	916	6.6	32.0	-1	-1	-1	-1	829	958	193	-1	2364
0033	124	124	1339	0	840	6.6	32.0	-1	-1	-1	-1	681	675	144	-1	2364
0034	128	128	1339	0	785	6.6	32.0	-1	-1	-1	-1	503	440	107	-1	2364
0035	132	132	1339	0	785	6.6	32.0	-1	-1	-1	-1	503	440	107	-1	2364
0036	144	144	1343	0	720	6.6	32.0	-1	-1	-1	-1	710	377	162	-1	2400
0037	148	148	1343	0	785	6.6	32.0	-1	-1	-1	-1	651	345	162	-1	2400
0038	152	152	1343	0	785	6.6	32.0	-1	-1	-1	-1	533	471	144	-1	2400
0039	156	156	1343	0	864	6.6	32.0	-1	-1	-1	-1	533	440	144	-1	2400
0040	160	160	1343	0	785	6.6	32.0	-1	-1	-1	-1	562	424	162	-1	2400
0041	164	164	1343	0	864	6.6	32.0	-1	-1	-1	-1	474	377	144	-1	2400
0042	168	168	1355	0	864	6.5	32.0	-1	-1	-1	-1	744	584	229	-1	2454
0043	172	172	1355	0	864	6.5	32.0	-1	-1	-1	-1	712	534	208	-1	2454
0044	176	176	1355	0	864	6.5	32.0	-1	-1	-1	-1	680	500	212	-1	2454
0045	180	180	1355	0	864	6.5	32.0	-1	-1	-1	-1	647	417	191	-1	2454
0046	184	184	1355	0	864	6.5	32.0	-1	-1	-1	-1	712	467	229	-1	2454
0047	188	188	1355	0	785	6.5	32.0	-1	-1	-1	-1	615	384	208	-1	2454
0048	192	192	1330	0	785	6.6	32.0	-1	-1	-1	-1	754	625	280	-1	2334
0049	196	196	1330	0	785	6.6	32.0	-1	-1	-1	-1	754	625	280	-1	2334
0050	200	200	1330	0	864	6.6	32.0	-1	-1	-1	-1	754	608	280	-1	2334
0051	204	204	1330	0	864	6.6	32.0	-1	-1	-1	-1	785	608	280	-1	2334
0052	208	208	1330	0	864	6.6	32.0	-1	-1	-1	-1	722	521	301	-1	2334
0053	212	212	1330	0	800	6.6	32.0	-1	-1	-1	-1	754	521	301	-1	2334
0054	216	216	1398	0	864	6.6	32.0	-1	-1	-1	-1	1189	954	419	-1	2460
0055	220	220	1398	0	800	6.6	32.0	-1	-1	-1	-1	945	767	360	-1	2460
0056	224	224	1398	0	800	6.6	32.0	-1	-1	-1	-1	1189	886	419	-1	2460
0057	228	228	1398	0	864	6.6	32.0	-1	-1	-1	-1	1128	852	398	-1	2460
0058	232	232	1398	0	864	6.6	32.0	-1	-1	-1	-1	1158	903	376	-1	2460
0059	236	236	1398	0	864	6.6	32.0	-1	-1	-1	-1	1006	801	355	-1	2460
0060	240	240	1220	0	864	6.6	32.0	-1	-1	-1	-1	909	484	202	-1	2208
0061	244	244	1220	0	864	6.6	32.0	-1	-1	-1	-1	609	334	123	-1	2208
0062	248	248	1220	0	960	6.6	32.0	-1	-1	-1	-1	626	404	138	-1	2208
0063	252	252	1220	0	960	6.6	32.0	-1	-1	-1	-1	559	392	105	-1	2208
0064	256	256	1220	0	960	6.6	32.0	-1	-1	-1	-1	491	336	107	-1	2208
0065	260	260	1220	0	864	6.6	32.0	-1	-1	-1	-1	367	194	65	-1	2208
0066	264	264	1330	0	960	6.5	33.0	-1	-1	-1	-1	832	458	417	-1	2100
0067	268	268	1330	0	960	6.5	33.0	-1	-1	-1	-1	904	700	233	-1	2100
0068	272	272	1330	0	960	6.5	33.0	-1	-1	-1	-1	1012	685	[illegible]	-1	2100
0069	276	276	1330	0	960	6.5	33.0	-1	-1	-1	-1	966	702	217	-1	2100
0070	280	280	1330	0	800	6.5	33.0	-1	-1	-1	-1	1020	674	228	-1	2100
0071	284	284	1330	0	800	6.5	33.0	-1	-1	-1	-1	844	562	240	-1	2100
0072	288	288	1298	0	864	6.4	33.0	-1	-1	-1	-1	992	718	267	-1	2094
0073	292	292	1298	0	800	6.4	33.0	-1	-1	-1	-1	997	653	184	-1	2094
0074	296	296	1298	0	864	6.4	33.0	-1	-1	-1	-1	804	646	162	-1	2094
0075	300	300	1298	0	800	6.4	33.0	-1	-1	-1	-1	742	557	140	-1	2094
0076	304	304	1298	0	800	6.4	33.0	-1	-1	-1	-1	793	521	216	-1	2094
0077	308	308	1298	0	720	6.4	33.0	-1	-1	-1	-1	659	375	151	-1	2094
0078	312	312	1314	0	720	6.6	33.0	-1	-1	-1	-1	1040	770	165	-1	2160

Run #1 (0-332hrs)

0079	316	316	1314	0	900	6.6	33.0	-1	-1	-1	-1	1001	713	173	-1	2160
0080	320	320	1314	0	800	6.6	33.0	-1	-1	-1	-1	901	625	133	-1	2160
0081	324	324	1314	0	864	6.6	33.0	-1	-1	-1	-1	819	498	150	-1	2160
0082	328	328	1314	0	785	6.6	33.0	-1	-1	-1	-1	833	554	158	-1	2160
0083	332	332	1314	0	800	6.6	33.0	-1	-1	-1	-1	760	443	158	-1	2160
0084	340	340	143	0	1120	6.6	33.0	-1	-1	-1	-1	971	635	125	-1	294
0085	344	344	143	0	1440	6.6	33.0	-1	-1	-1	-1	939	664	108	-1	294
0086	348	348	143	0	1296	6.6	33.0	-1	-1	-1	-1	919	705	121	-1	294
0087	352	352	143	0	1120	6.6	33.0	-1	-1	-1	-1	936	666	67	-1	294
0088	356	356	150	0	1584	6.7	36.0	-1	-1	-1	-1	1034	796	101	-1	414
0089	364	364	150	0	1440	6.7	36.0	-1	-1	-1	-1	1284	867	191	-1	414
0090	368	368	150	0	1296	6.7	36.0	-1	-1	-1	-1	1222	779	103	-1	414
0091	372	372	150	0	1280	6.7	36.0	-1	-1	-1	-1	1354	813	113	-1	414
0092	376	376	150	0	1440	6.7	36.0	-1	-1	-1	-1	1371	823	128	-1	414
0093	384	384	108	0	1490	6.6	35.0	-1	-1	-1	-1	1394	842	164	-1	288
0094	388	388	108	0	1490	6.6	35.0	-1	-1	-1	-1	1287	796	184	-1	288
0095	392	392	108	0	1490	6.6	35.0	-1	-1	-1	-1	1223	721	110	-1	288
0096	396	396	108	0	1490	6.6	35.0	-1	-1	-1	-1	1165	724	147	-1	288
0097	400	400	108	0	1490	6.6	35.0	-1	-1	-1	-1	1238	847	192	-1	288
0098	404	404	108	0	1490	6.6	35.0	-1	-1	-1	-1	1255	808	177	-1	306
0099	408	408	145	0	1392	6.5	35.0	-1	-1	-1	-1	1482	803	176	-1	306
0100	412	412	145	0	1392	6.5	35.0	-1	-1	-1	-1	1461	821	138	-1	306
0101	416	416	145	0	1392	6.5	35.0	-1	-1	-1	-1	1433	802	137	-1	306
0102	420	420	145	0	1392	6.5	35.0	-1	-1	-1	-1	1318	763	139	-1	306
0103	424	424	145	0	1392	6.5	35.0	-1	-1	-1	-1	1345	766	138	-1	306
0104	428	428	228	0	1496	6.6	35.0	-1	-1	-1	-1	1299	738	138	-1	120
0105	432	432	228	0	1496	6.6	35.0	-1	-1	-1	-1	1252	721	139	-1	120
0106	436	436	228	0	1496	6.6	35.0	-1	-1	-1	-1	1417	846	213	-1	120
0107	440	440	228	0	1496	6.6	35.0	-1	-1	-1	-1	1122	666	134	-1	120
0108	444	444	228	0	1496	6.6	35.0	-1	-1	-1	-1	1310	792	167	-1	120
0109	448	448	228	0	1496	6.6	35.0	-1	-1	-1	-1	1241	714	106	-1	120
0110	452	452	-1	0	1432	6.5	35.0	-1	-1	-1	-1	1333	756	207	-1	141
0111	456	456	-1	0	1432	6.5	35.0	-1	-1	-1	-1	1179	620	86	-1	141
0112	460	460	-1	0	1432	6.5	35.0	-1	-1	-1	-1	1179	633	87	-1	141
0113	464	464	-1	0	1432	6.5	35.0	-1	-1	-1	-1	992	548	94	-1	141
0114	480	480	141	0	1432	6.6	38.0	-1	-1	-1	-1	1249	627	175	-1	114
0115	484	484	141	0	1432	6.6	38.0	-1	-1	-1	-1	1103	535	92	-1	114
0116	488	488	141	0	1432	6.6	38.0	-1	-1	-1	-1	1092	558	75	-1	114
0117	492	492	141	0	1432	6.6	38.0	-1	-1	-1	-1	1088	589	114	-1	114
0118	496	496	141	0	1432	6.6	38.0	-1	-1	-1	-1	1126	541	75	-1	114
0119	504	504	142	0	1361	6.5	35.0	-1	-1	-1	-1	1158	553	122	-1	90
0120	508	508	142	0	1361	6.5	35.0	-1	-1	-1	-1	1161	570	112	-1	90
0121	512	512	142	0	1361	6.5	35.0	-1	-1	-1	-1	1134	553	71	-1	90
0122	516	516	142	0	1361	6.5	35.0	-1	-1	-1	-1	1289	537	62	-1	90
0123	520	520	142	0	1361	6.5	35.0	-1	-1	-1	-1	1213	513	54	-1	90
0124	528	528	144	0	1440	6.7	35.0	-1	-1	-1	-1	1033	470	78	-1	66
0125	532	532	144	0	1296	6.7	35.0	-1	-1	-1	-1	1032	474	63	-1	66
0126	536	536	144	0	1008	6.7	35.0	-1	-1	-1	-1	1022	459	42	-1	66
0127	540	540	144	0	1296	6.7	35.0	-1	-1	-1	-1	1107	506	99	-1	66
0128	544	544	144	0	1440	6.7	35.0	-1	-1	-1	-1	1213	560	79	-1	66
0129	548	548	144	0	1584	6.7	35.0	-1	-1	-1	-1	1378	632	86	-1	66
0130	552	552	133	0	1440	6.6	35.0	-1	-1	-1	-1	1413	627	120	-1	239
0131	556	556	133	0	1440	6.6	35.0	-1	-1	-1	-1	1164	540	90	-1	239
0132	560	560	133	0	1152	6.6	35.0	-1	-1	-1	-1	1256	578	76	-1	239
0133	564	564	133	0	1440	6.6	35.0	-1	-1	-1	-1	1282	619	102	-1	239
0134	568	568	133	0	1440	6.6	35.0	-1	-1	-1	-1	1222	619	118	-1	239
0135	576	576	137	0	1371	6.6	35.0	-1	-1	-1	-1	1148	595	76	-1	162
0136	580	580	137	0	1371	6.6	35.0	-1	-1	-1	-1	1132	574	60	-1	162
0137	584	584	137	0	1371	6.6	35.0	-1	-1	-1	-1	1192	582	51	-1	162
0138	588	588	137	0	1371	6.6	35.0	-1	-1	-1	-1	1187	586	52	-1	162
0139	592	592	137	0	1371	6.6	35.0	-1	-1	-1	-1	1216	625	140	-1	162
0140	596	596	114	0	1238	6.7	37.0	-1	-1	-1	-1	1129	567	104	-1	60
0141	600	570	114	0	1238	6.7	37.0	-1	-1	-1	-1	1011	497	46	-1	60
0142	604	604	114	0	1238	6.7	37.0	-1	-1	-1	-1	1129	581	117	-1	60
0143	608	608	114	0	1258	6.7	37.0	-1	-1	-1	-1	1155	590	88	-1	60
0144	612	612	114	0	1238	6.7	37.0	-1	-1	-1	-1	1133	598	93	-1	60
0145	616	616	114	0	1238	6.7	37.0	-1	-1	-1	-1	1113	551	105	-1	60
0146	700	700	427	0	1238	7.1	34.0	-1	-1	-1	-1	2174	1028	142	-1	318
0147	704	704	427	0	1238	7.2	34.0	-1	-1	-1	-1	2501	1202	164	-1	318
0148	708	708	427	0	1238	6.4	34.0	-1	-1	-1	-1	2517	1096	193	-1	318
0149	712	712	427	0	1238	6.0	34.0	-1	-1	-1	-1	2302	754	176	-1	318
0150	716	716	434	0	1238	5.5	34.0	-1	-1	-1	-1	1670	376	90	-1	0
0151	720	720	434	0	1238	7.0	35.0	-1	-1	-1	-1	1687	451	100	-1	0
0152	724	724	434	0	1728	7.0	35.0	-1	-1	-1	-1	1584	324	78	-1	0
0153	728	728	434	0	1728	6.8	35.0	-1	-1	-1	-1	1519	367	90	-1	0
0154	732	732	434	0	1728	6.0	35.0	-1	-1	-1	-1	1694	569	245	-1	0
0155	740	740	435	0	2160	6.0	34.0	-1	-1	-1	-1	1126	68	1208	-1	0
0156	748	748	435	0	1728	5.3	34.0	-1	-1	-1	-1	1082	77	1167	-1	0
0157	752	752	435	0	1728	5.3	34.0	-1	-1	-1	-1	1169	72	1121	-1	0
0158	756	756	435	0	1728	5.3	34.0	-1	-1	-1	-1	1089	65	1132	-1	0

Run #2 (336-696hrs)

0159	768	768	431	0	1728	5.3	34.0	-1	-1	-1	-1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0160	772	772	431	0	2592	5.3	34.0	-1	-1	-1	-1	1076	74	1057	-1	0
0161	776	776	431	0	2160	5.3	34.0	-1	-1	-1	-1	1034	52	1077	-1	0
0162	784	784	431	0	2160	5.3	36.0	-1	-1	-1	-1	880	50	1009	-1	0
0163	788	788	431	0	2160	5.3	36.0	-1	-1	-1	-1	849	46	964	-1	0
0164	792	792	431	0	2160	5.3	35.0	-1	-1	-1	-1	1130	98	1064	-1	-1
0165	796	796	431	0	2160	5.3	35.0	-1	-1	-1	-1	997	61	1034	-1	-1
0166	800	800	431	0	2160	5.3	35.0	-1	-1	-1	-1	999	-1	1012	-1	-1
0167	804	804	431	0	2160	5.3	35.0	-1	-1	-1	-1	990	-1	943	-1	-1
0168	808	808	431	0	2160	5.3	35.0	-1	-1	-1	-1	1012	-1	938	-1	-1
0169	816	816	437	0	2160	5.3	35.0	-1	-1	-1	-1	1046	72	931	-1	-1
0170	820	820	437	0	1728	5.3	35.0	-1	-1	-1	-1	981	74	941	-1	-1
0171	824	824	437	0	2160	5.3	35.0	-1	-1	-1	-1	965	48	982	-1	-1
0172	828	828	437	0	2160	5.3	35.0	-1	-1	-1	-1	961	70	980	-1	-1
0173	832	832	437	0	2160	5.3	35.0	-1	-1	-1	-1	944	-1	927	-1	-1
0174	836	836	437	0	1728	5.3	35.0	-1	-1	-1	-1	796	-1	886	-1	-1
0175	840	840	436	0	2160	5.3	35.0	-1	-1	-1	-1	1011	71	861	-1	-1
0176	844	844	436	0	2160	5.3	35.0	-1	-1	-1	-1	1004	60	1001	-1	-1
0177	848	848	436	0	2160	5.3	35.0	-1	-1	-1	-1	875	-1	952	-1	-1
0178	860	860	215	0	2160	5.4	34.0	-1	-1	-1	-1	917	-1	862	-1	78
0179	864	864	215	0	2592	5.4	34.0	-1	-1	-1	-1	918	-1	978	-1	78
0180	868	868	215	0	2592	5.4	34.0	-1	-1	-1	-1	909	50	954	-1	78
0181	872	872	215	0	2592	5.4	34.0	-1	-1	-1	-1	1007	72	1075	-1	78
0182	876	876	215	0	2592	5.4	34.0	-1	-1	-1	-1	958	-1	954	-1	78
0183	880	880	215	0	2592	5.4	34.0	-1	-1	-1	-1	935	-1	943	-1	78
0184	884	884	342	0	2160	5.4	36.0	-1	-1	-1	-1	1129	102	1004	-1	-1
0185	888	888	342	0	2160	5.4	35.0	-1	-1	-1	-1	1139	82	924	-1	-1
0186	892	892	342	0	2045	5.4	35.0	-1	-1	-1	-1	1023	66	860	-1	-1
0187	896	896	342	0	2045	5.4	35.0	-1	-1	-1	-1	1040	60	833	-1	-1
0188	900	900	342	0	2045	5.4	35.0	-1	-1	-1	-1	1065	68	814	-1	-1
0189	908	908	314	0	1694	5.5	35.0	-1	-1	-1	-1	948	61	803	-1	780
0190	912	912	314	0	1694	6.7	35.0	-1	-1	-1	-1	1178	98	850	-1	780
0191	916	916	314	0	1694	6.7	35.0	-1	-1	-1	-1	1173	90	794	-1	780
0192	960	960	441	0	2214	6.8	35.0	-1	-1	-1	-1	1206	387	385	-1	780
0193	964	964	441	0	2214	6.8	35.0	-1	-1	-1	-1	1398	370	647	-1	780
0194	968	968	441	0	2214	6.8	35.0	-1	-1	-1	-1	1288	241	642	-1	780
0195	972	972	441	0	2214	6.8	35.0	-1	-1	-1	-1	1276	254	564	-1	780
0196	976	976	441	0	2214	6.8	35.0	-1	-1	-1	-1	1408	327	557	-1	780
0197	980	980	440	0	2214	6.8	35.0	-1	-1	-1	-1	1429	410	480	-1	780
0198	984	984	440	0	1909	6.8	37.0	-1	-1	-1	-1	1537	797	292	-1	600
0199	988	988	440	0	1909	6.8	37.0	-1	-1	-1	-1	1580	671	400	-1	600
0200	992	992	440	0	1909	6.8	37.0	-1	-1	-1	-1	1576	758	380	-1	600
0201	996	996	440	0	1909	6.8	37.0	-1	-1	-1	-1	1636	859	380	-1	600
0202	1000	1000	406	0	1909	6.8	37.0	-1	-1	-1	-1	1620	841	359	-1	600
0203	1004	1004	393	0	1315	7.1	35.0	-1	-1	-1	-1	1997	1082	401	-1	360
0204	1008	1008	393	0	1315	7.1	35.0	-1	-1	-1	-1	1854	1008	308	-1	360
0205	1016	1016	393	0	1315	7.1	35.0	-1	-1	-1	-1	1992	958	268	-1	360
0206	1020	1020	393	0	1315	7.1	35.0	-1	-1	-1	-1	1568	771	231	-1	360
0207	1032	1032	385	0	1296	6.5	34.0	-1	-1	-1	-1	1354	490	256	-1	534
0208	1036	1036	385	0	894	6.5	34.0	-1	-1	-1	-1	1500	472	258	-1	534
0209	1040	1040	385	0	864	6.5	34.0	-1	-1	-1	-1	1382	438	246	-1	534
0210	1044	1044	385	0	864	6.5	34.0	-1	-1	-1	-1	1344	450	202	-1	534
0211	1048	1048	385	0	864	6.5	34.0	-1	-1	-1	-1	1308	433	177	-1	534
0212	1052	1052	414	0	864	6.6	34.0	-1	-1	-1	-1	1410	454	221	-1	360
0213	1056	1056	414	0	1296	6.6	34.0	-1	-1	-1	-1	1328	444	176	-1	360
0214	1060	1060	414	0	864	6.6	34.0	-1	-1	-1	-1	1356	460	176	-1	360
0215	1064	1064	414	0	864	6.6	34.0	-1	-1	-1	-1	1244	410	167	-1	360
0216	1068	1068	414	0	1296	6.6	34.0	-1	-1	-1	-1	1295	422	186	-1	360
0217	1072	1072	414	0	1295	6.6	34.0	-1	-1	-1	-1	1269	384	179	-1	360
0218	1076	1076	413	0	1296	6.5	34.0	-1	-1	-1	-1	1296	418	287	-1	216
0219	1080	1080	413	0	864	6.5	34.0	-1	-1	-1	-1	1265	453	245	-1	216
0220	1084	1084	413	0	1296	6.5	34.0	-1	-1	-1	-1	1184	408	209	-1	216
0221	1088	1088	413	0	864	7.0	34.0	-1	-1	-1	-1	1268	436	212	-1	216
0222	1092	1092	413	0	1296	7.0	34.0	-1	-1	-1	-1	1158	354	219	-1	216
0223	1096	1096	413	0	1296	7.0	34.0	-1	-1	-1	-1	1104	297	246	-1	216
0224	1100	1100	394	0	864	7.0	34.0	-1	-1	-1	-1	1218	264	335	-1	-1
0225	1104	1104	394	0	864	7.0	34.0	-1	-1	-1	-1	1002	192	271	-1	-1
0226	1108	1108	394	0	864	7.0	34.0	-1	-1	-1	-1	921	162	311	-1	-1
0227	1112	1112	394	0	864	7.0	34.0	-1	-1	-1	-1	931	132	300	-1	-1
0228	1116	1116	394	0	864	7.0	34.0	-1	-1	-1	-1	848	128	250	-1	-1
0229	1120	1120	394	0	864	7.0	35.0	-1	-1	-1	-1	744	68	344	-1	-1
0230	1124	1124	394	0	864	7.0	35.0	-1	-1	-1	-1	770	94	311	-1	-1
0231	1128	1128	408	0	864	6.9	34.0	-1	-1	-1	-1	727	107	274	-1	210
0232	1132	1132	408	0	864	6.9	34.0	-1	-1	-1	-1	699	92	344	-1	210
0233	1136	1136	408	0	864	6.9	34.0	-1	-1	-1	-1	604	54	295	-1	210
0234	1140	1140	408	0	864	6.9	34.0	-1	-1	-1	-1	571	90	301	-1	210
0235	1144	1144	408	0	864	6.0	34.0	-1	-1	-1	-1	552	49	240	-1	210
0236	1148	1148	408	0	864	6.9	34.0	-1	-1	-1	-1	555	43	258	-1	210
0237	1156	1156	352	0	864	6.9	34.0	-1	-1	-1	-1	538	46	250	-1	66
0238	1160	1160	352	0	864	6.9	34.0	-1	-1	-1	-1	521	46	251	-1	66

Run #3 (700-1032hrs)

0239	1164	1164	352	0	864	6.9	34.0	-1	-1	-1	-1	483	45	245	-1	66	
0240	1172	1172	352	0	864	6.9	34.0	-1	-1	-1	-1	508	64	230	-1	66	
0241	1176	1176	382	0	864	7.0	34.0	-1	-1	-1	-1	698	41	429	-1	-1	
0242	1180	1180	382	0	864	7.0	34.0	-1	-1	-1	-1	665	52	459	-1	-1	
0243	1184	1184	382	0	864	7.0	34.0	-1	-1	-1	-1	670	40	480	-1	-1	
0244	1188	1188	382	0	864	7.0	34.0	-1	-1	-1	-1	510	40	256	-1	-1	
0245	1192	1192	382	0	864	7.0	34.0	-1	-1	-1	-1	564	41	356	-1	-1	
0246	1200	1200	356	0	1296	7.3	32.0	-1	-1	-1	-1	696	35	543	-1	-1	
0247	1204	1204	356	0	1296	7.3	32.0	-1	-1	-1	-1	724	54	540	-1	-1	
0248	1208	1208	356	0	1296	7.3	32.0	-1	-1	-1	-1	662	52	498	-1	-1	
0249	1212	1212	356	0	1296	7:3	32.0	-1	-1	-1	-1	604	52	502	-1	-1	
0250	1216	1216	356	0	1296	7.3	32.0	-1	-1	-1	-1	584	52	477	-1	-1	
0251	1224	1224	280	0	1080	6.5	33.0	-1	-1	-1	-1	721	99	464	-1	-1	
0252	1236	1236	280	0	1080	-6.5	33.0	-1	-1	-1	-1	676	52	410	-1	372	
0253	1240	1240	280	0	864	6.5	33.0	-1	-1	-1	-1	800	116	491	-1	372	
0254	1244	1244	280	0	864	6.5	33.0	-1	-1	-1	-1	714	82	365	-1	372	
0255	1248	1248	405	0	864	6.6	33.0	-1	-1	-1	-1	914	137	513	-1	432	
0256	1252	1252	405	0	1080	6.6	33.0	-1	-1	-1	-1	820	92	389	-1	432	
0257	1256	1256	405	0	1296	6.6	33.0	-1	-1	-1	-1	827	134	376	-1	432	
0258	1260	1260	405	0	1512	6.6	33.0	-1	-1	-1	-1	923	130	464	-1	432	
0259	1264	1264	405	0	1296	6.6	33.0	-1	-1	-1	-1	869	119	380	-1	432	
0260	1272	1272	400	0	1080	6.6	35.0	-1	-1	-1	-1	946	156	446	-1	-1	
0261	1276	1276	400	0	1296	6.6	35.0	-1	-1	-1	-1	975	188	337	-1	-1	
0262	1280	1280	400	0	1296	6.6	35.0	-1	-1	-1	-1	1074	198	359	-1	-1	
0263	1284	1284	400	0	1296	6.6	35.0	-1	-1	-1	-1	1031	242	308	-1	-1	
0264	1288	1288	400	0	1296	6.6	35.0	-1	-1	-1	-1	1154	279	332	-1	-1	
0265	1296	1296	408	0	1296	-1	35.0	-1	-1	-1	-1	1008	190	449	-1	-1	
0266	1300	1300	408	0	1296	-1	35.0	-1	-1	-1	-1	1044	180	443	-1	60	
0267	1304	1304	408	0	1296	-1	35.0	-1	-1	-1	-1	974	187	315	-1	60	
0268	1308	1308	408	0	1296	-1	35.0	-1	-1	-1	-1	959	192	403	-1	60	
0269	1320	1320	206	0	1080	-1	34.0	-1	-1	-1	-1	861	152	338	-1	-1	
0270	1324	1324	206	0	1080	-1	34.0	-1	-1	-1	-1	931	174	404	-1	-1	
0271	1328	1328	206	0	864	-1	34.0	-1	-1	-1	-1	873	154	316	-1	-1	
0272	1332	1332	206	0	864	-1	34.0	-1	-1	-1	-1	838	138	292	-1	-1	
0273	1336	1336	206	0	1080	-1	34.0	-1	-1	-1	-1	780	132	267	-1	-1	
0274	1340	1340	206	0	864	-1	34.0	-1	-1	-1	-1	902	172	313	-1	-1	
0275	1348	1348	183	0	864	6.6	35.0	-1	-1	-1	-1	821	145	280	-1	222	
0276	1352	1352	183	0	864	6.6	35.0	-1	-1	-1	-1	840	149	294	-1	222	
0277	1356	1356	183	0	864	6.6	35.0	-1	-1	-1	-1	868	178	249	-1	222	
0278	1360	1360	183	0	864	6.6	35.0	-1	-1	-1	-1	874	200	186	-1	222	Run #4 (1034-1364hrs)
0279	1364	1364	183	0	864	6.6	35.0	-1	-1	-1	-1	756	187	130	-1	222	
0280	1372	1372	472	0	1080	6.5	35.0	-1	-1	-1	-1	1153	293	278	-1	762	
0281	1376	1376	472	0	1512	6.5	35.0	-1	-1	-1	-1	1732	564	346	-1	672	
0282	1380	1380	472	0	1728	6.5	35.0	-1	-1	-1	-1	1957	718	382	-1	762	
0283	1384	1384	472	0	3024	6.5	35.0	-1	-1	-1	-1	1926	737	355	-1	762	
0284	1388	1388	472	0	2592	6.5	35.0	-1	-1	-1	-1	1798	692	319	-1	762	
0285	1392	1392	344	0	2160	6.8	34.0	-1	-1	-1	-1	1822	557	348	-1	162	
0286	1396	1396	344	0	2160	6.8	34.0	-1	-1	-1	-1	1977	570	538	-1	162	
0287	1400	1400	344	0	2376	6.8	34.0	-1	-1	-1	-1	1808	446	601	-1	162	
0288	1404	1404	344	0	2808	6.8	34.0	-1	-1	-1	-1	1804	366	833	-1	162	
0289	1408	1408	344	0	2808	6.8	34.0	-1	-1	-1	-1	1800	357	872	-1	162	
0290	1412	1412	433	0	2808	6.9	32.0	-1	-1	-1	-1	1450	152	1131	-1	0	
0291	1416	1416	433	0	2592	6.9	32.0	-1	-1	-1	-1	1469	155	1045	-1	0	
0292	1420	1420	433	0	2592	6.9	32.0	-1	-1	-1	-1	1550	152	1079	-1	0	
0293	1424	1424	433	0	2376	6.9	32.0	-1	-1	-1	-1	1408	137	1141	-1	0	
0294	1428	1428	433	0	2376	6.9	32.0	-1	-1	-1	-1	1252	120	1052	-1	0	
0295	1432	1432	433	0	2802	6.9	32.0	-1	-1	-1	-1	1178	103	1115	-1	0	
0296	1436	1436	420	0	2592	6.6	33.0	-1	-1	-1	-1	1550	152	1033	-1	1008	
0297	1444	1444	420	0	2160	6.6	33.0	-1	-1	-1	-1	1300	166	677	-1	1008	
0298	1448	1448	420	0	1944	6.6	33.0	-1	-1	-1	-1	1226	131	786	-1	1008	
0299	1452	1452	420	0	2376	6.6	33.0	-1	-1	-1	-1	1256	165	654	-1	1008	
0300	1456	1456	420	0	2376	6.6	33.0	-1	-1	-1	-1	1226	166	568	-1	1008	
0301	1468	1468	419	0	1728	6.6	32.0	-1	-1	-1	-1	1564	211	873	-1	672	
0302	1472	1472	419	0	1728	6.6	32.0	-1	-1	-1	-1	1679	233	1075	-1	672	
0303	1476	1476	419	0	2160	6.6	32.0	-1	-1	-1	-1	1699	318	816	-1	672	
0304	1480	1480	419	0	2376	6.6	32.0	-1	-1	-1	-1	1873	302	867	-1	672	
0305	1484	1484	419	0	2160	6.6	32.0	-1	-1	-1	-1	1495	278	583	-1	672	
0306	1488	1488	419	0	1944	6.7	32.0	-1	-1	-1	-1	1442	339	474	-1	534	
0307	1492	1492	419	0	1728	6.7	32.0	-1	-1	-1	-1	1580	302	785	-1	534	
0308	1496	1496	419	0	2160	6.7	32.0	-1	-1	-1	-1	1520	331	653	-1	534	
0309	1500	1500	419	0	2160	6.7	32.0	-1	-1	-1	-1	1573	323	730	-1	534	
0310	1504	1504	419	0	1944	6.7	32.0	-1	-1	-1	-1	1595	357	662	-1	534	
0311	1508	1508	419	0	-1	6.7	32.0	-1	-1	-1	-1	1488	355	576	-1	534	
0312	1512	1512	442	0	1944	6.6	33.0	-1	-1	-1	-1	1409	359	498	-1	75	
0313	1516	1516	442	0	1296	6.6	33.0	-1	-1	-1	-1	1268	349	371	-1	75	
0314	1520	1520	442	0	864	6.6	33.0	-1	-1	-1	-1	977	305	231	-1	75	
0315	1524	1524	442	0	648	6.6	33.0	-1	-1	-1	-1	734	273	135	-1	75	
0316	1528	1528	442	0	648	6.6	33.0	-1	-1	-1	-1	216	60	2	-1	1188	
0317	1564	1564	388	0	-1	6.8	36.0	-1	-1	-1	-1	554	60	2	-1	1188	
0318	1568	1568	388	0	1944	6.8	36.0	-1	-1	-1	-1	186	52	22	-1	1188	

0319	1572	1572	388	0	2160	6.8	36.0	-1	-1	-1	-1	[illegible]	[illegible]	[illegible]	-1	[illegible]	
0320	1576	1576	388	0	2160	6.8	36.0	-1	-1	-1	-1	960	167	509	-1	1188	
0321	1580	1580	400	0	2376	6.5	35.0	-1	-1	-1	-1	1213	256	589	-1	1140	
0322	1584	1584	400	0	2160	6.5	35.0	-1	-1	-1	-1	1394	522	518	-1	1140	
0323	1588	1588	400	0	3672	6.5	35.0	-1	-1	-1	-1	1589	858	391	-1	1140	
0324	1592	1592	400	0	-3240	6.5	35.0	-1	-1	-1	-1	1770	1025	295	-1	1140	
0325	1596	1596	400	0	3024	6.5	35.0	-1	-1	-1	-1	2118	1256	310	-1	1140	
0326	1600	1600	401	0	2808	6.5	35.0	-1	-1	-1	-1	2352	1339	346	-1	1140	
0327	1612	1612	395	0	3024	6.6	34.0	-1	-1	-1	-1	2442	1598	450	-1	2022	
0328	1616	1616	395	0	3024	6.6	34.0	-1	-1	-1	-1	2411	1578	482	-1	2022	
0329	1620	1620	395	0	3024	6.6	34.0	-1	-1	-1	-1	2624	1477	547	-1	2022	
0330	1624	1624	395	0	2808	6.6	34.0	-1	-1	-1	-1	2770	1450	682	-1	2022	
0331	1628	1628	395	0	2808	6.6	34.0	-1	-1	-1	-1	2522	1256	539	-1	2022	
0332	1632	1632	395	0	2376	6.6	34.0	-1	-1	-1	-1	2685	1290	580	-1	2022	
0333	1636	1636	381	0	2808	6.6	35.0	-1	-1	-1	-1	2302	1086	510	-1	-1	
0334	1640	1640	381	0	2808	6.6	35.0	-1	-1	-1	-1	2586	1198	558	-1	-1	
0335	1644	1644	381	0	2808	6.6	35.0	-1	-1	-1	-1	2955	1112	678	-1	-1	
0336	1648	1648	381	0	2808	6.6	35.0	-1	-1	-1	-1	2982	932	668	-1	-1	
0337	1652	1652	381	0	2808	6.6	35.0	-1	-1	-1	-1	2603	749	626	-1	-1	
0338	1656	1656	381	0	2808	6.6	35.0	-1	-1	-1	-1	2415	679	649	-1	-1	
0339	1660	1660	285	0	2018	6.6	35.0	-1	-1	-1	-1	2433	575	470	-1	-1	
0340	1664	1664	285	0	2018	6.6	35.0	-1	-1	-1	-1	2647	883	543	-1	-1	
0341	1668	1668	285	0	2018	6.6	35.0	-1	-1	-1	-1	2519	630	463	-1	-1	
0342	1672	1672	285	0	2018	6.6	35.0	-1	-1	-1	-1	2991	676	493	-1	-1	
0343	1676	1676	285	0	2018	6.6	35.0	-1	-1	-1	-1	2586	693	475	-1	-1	
0344	1708	1708	283	0	2045	6.5	34.0	-1	-1	-1	-1	2829	1117	410	-1	960	
0345	1712	1712	283	0	2045	6.5	34.0	-1	-1	-1	-1	2880	1078	364	-1	960	
0346	1716	1716	283	0	2045	6.5	34.0	-1	-1	-1	-1	2929	1167	394	-1	960	
0347	1720	1720	283	0	2045	6.5	34.0	-1	-1	-1	-1	2801	1056	339	-1	960	
0348	1728	1728	189	0	2160	7.5	39.0	-1	-1	-1	-1	2315	904	321	-1	678	
0349	1732	1732	189	0	2160	7.5	35.0	-1	-1	-1	-1	2498	830	382	-1	678	
0350	1736	1736	189	0	2160	7.5	35.0	-1	-1	-1	-1	2427	770	534	-1	678	
0351	1740	1740	189	0	1296	7.1	35.0	-1	-1	-1	-1	2500	780	515	-1	678	
0352	1744	1744	189	0	1296	7.1	39.0	-1	-1	-1	-1	2532	846	513	-1	678	Run #5 (1368-1748hrs)
0353	1748	1748	395	0	2592	6.6	35.0	-1	-1	-1	-1	2171	802	421	-1	86	
0354	1752	1752	395	0	2160	6.6	35.0	-1	-1	-1	-1	2377	722	424	-1	864	
0355	1756	1756	395	0	2160	6.6	35.0	-1	-1	-1	-1	2587	775	490	-1	864	
0356	1760	1760	395	0	1728	6.6	35.0	-1	-1	-1	-1	2369	746	550	-1	864	
0357	1764	1764	395	0	2592	6.6	35.0	-1	-1	-1	-1	2226	718	596	-1	864	
0358	1768	1768	395	0	2160	6.6	35.0	-1	-1	-1	-1	2243	700	568	-1	864	
0359	1772	1772	359	0	2160	6.6	35.0	-1	-1	-1	-1	2168	679	436	-1	726	
0360	1780	1780	359	0	2160	6.6	35.0	-1	-1	-1	-1	2386	733	401	-1	726	
0361	1784	1784	359	0	2592	6.6	35.0	-1	-1	-1	-1	2398	685	402	-1	726	
0362	1788	1788	359	0	2160	6.6	35.0	-1	-1	-1	-1	2477	685	445	-1	726	
0363	1792	1792	359	0	2160	6.6	35.0	-1	-1	-1	-1	2477	565	396	-1	726	
0364	1796	1796	359	0	2160	6.6	35.0	-1	-1	-1	-1	2635	560	385	-1	726	
0365	1804	1804	328	0	2160	6.5	35.0	-1	-1	-1	-1	2309	417	271	-1	486	
0366	1808	1808	328	0	2160	6.5	35.0	-1	-1	-1	-1	2144	338	233	-1	486	
0367	1812	1812	328	0	2160	6.5	35.0	-1	-1	-1	-1	2092	301	211	-1	486	
0368	1816	1816	328	0	2160	6.5	35.0	-1	-1	-1	-1	2138	286	260	-1	486	
0369	1820	1820	328	0	2592	6.5	35.0	-1	-1	-1	-1	2137	278	229	-1	486	
0370	1824	1824	346	0	2160	6.5	35.0	-1	-1	-1	-1	1982	254	204	-1	354	
0371	1828	1828	346	0	2160	6.5	34.0	-1	-1	-1	-1	2144	288	235	-1	354	
0372	1832	1832	346	0	2160	6.5	34.0	-1	-1	-1	-1	1862	232	220	-1	354	
0373	1836	1836	346	0	1728	6.5	34.0	-1	-1	-1	-1	1894	258	249	-1	354	
0374	1840	1840	346	0	1728	6.5	34.0	-1	-1	-1	-1	1813	264	272	-1	354	
0375	1844	1844	346	0	1728	6.5	34.0	-1	-1	-1	-1	1877	272	290	-1	354	
0376	1848	1848	370	0	1728	6.6	34.0	-1	-1	-1	-1	2025	340	412	-1	739	
0377	1852	1852	370	0	1728	6.6	34.0	-1	-1	-1	-1	1933	406	450	-1	739	
0378	1856	1856	370	0	1728	6.6	34.0	-1	-1	-1	-1	1711	526	420	-1	739	
0379	1860	1860	370	0	1728	6.6	34.0	-1	-1	-1	-1	1710	540	436	-1	739	
0380	1864	1864	370	0	1728	6.6	34.0	-1	-1	-1	-1	1704	538	424	-1	939	
0381	1868	1868	387	0	2160	6.6	35.0	-1	-1	-1	-1	1779	528	432	-1	960	
0382	1872	1872	387	0	2160	6.6	35.0	-1	-1	-1	-1	1968	523	445	-1	960	
0383	1876	1876	387	0	1728	6.6	35.0	-1	-1	-1	-1	2064	604	412	-1	960	
0384	1880	1880	387	0	-1728	6.6	35.0	-1	-1	-1	-1	2116	663	392	-1	960	
0385	1884	1884	387	0	-1728	6.6	35.0	-1	-1	-1	-1	2009	661	348	-1	960	
0386	1896	1896	352	0	1728	6.5	33.0	-1	-1	-1	-1	2165	642	286	-1	558	
0387	1900	1900	352	0	1728	6.5	33.0	-1	-1	-1	-1	1868	548	287	-1	558	
0388	1940	1940	453	0	-1728	6.5	35.0	-1	-1	-1	-1	2368	1034	323	-1	950	
0389	1944	1944	453	0	1728	6.5	35.0	-1	-1	-1	-1	1704	790	266	-1	950	
0390	1952	1952	453	0	1728	6.5	35.0	-1	-1	-1	-1	1539	747	286	-1	950	
0391	1956	1956	453	0	1728	6.5	35.0	-1	-1	-1	-1	1508	769	286	-1	950	
0392	1960	1960	453	0	1728	6.5	35.0	-1	-1	-1	-1	1690	854	301	-1	950	
0393	1968	1968	430	0	1728	6.5	35.0	-1	-1	-1	-1	1840	702	314	-1	648	
0394	1972	1972	430	0	1294	6.5	35.0	-1	-1	-1	-1	1568	675	263	-1	648	
0395	1976	1976	430	0	1728	6.5	35.0	-1	-1	-1	-1	1540	678	310	-1	648	
0396	1980	1980	430	0	1728	6.5	35.0	-1	-1	-1	-1	1425	624	299	-1	648	
0397	1984	1984	430	0	1728	6.5	35.0	-1	-1	-1	-1	1380	607	315	-1	648	
0398	1988	1988	430	0	1728	6.5	35.0	-1	-1	-1	-1	1320	588	321	-1	648	

0399	1992	1992	421	0	1728	6.5	36.0	-1	-1	-1	-1	1104	477	301	-1	366
0400	1996	1996	421	0	1296	6.5	36.0	-1	-1	-1	-1	1076	464	317	-1	366
0401	2000	2000	421	0	1296	6.5	36.0	-1	-1	-1	-1	1056	429	298	-1	366
0402	2004	2004	421	0	1728	6.5	36.0	-1	-1	-1	-1	975	440	328	-1	366
0403	2008	2008	421	0	1728	6.5	36.0	-1	-1	-1	-1	904	407	302	-1	366
0404	2012	2012	320	0	864	6.6	34.0	-1	-1	-1	-1	1048	477	439	-1	822
0405	2016	2016	320	0	864	6.6	34.0	-1	-1	-1	-1	842	430	252	-1	822
0406	2020	2020	320	0	864	6.6	34.0	-1	-1	-1	-1	1025	604	282	-1	822
0407	2024	2024	320	0	1296	6.6	34.0	-1	-1	-1	-1	1343	844	370	-1	822
0408	2028	2028	320	0	1296	6.6	34.0	-1	-1	-1	-1	1369	956	328	-1	822
0409	2032	2032	320	0	1296	6.6	34.0	-1	-1	-1	-1	1369	979	361	-1	822
0410	2036	2036	430	0	-1 1728	6.9	35.0	-1	-1	-1	-1	1549	1156	386	-1	822
0411	2040	2040	430	0	-1 1728	6.9	35.0	-1	-1	-1	-1	1564	1163	358	-1	822
0412	2044	2044	430	0	1728	6.9	35.0	-1	-1	-1	-1	1532	1052	341	-1	822
0413	2048	2048	430	0	2160	6.9	35.0	-1	-1	-1	-1	1566	1161	352	-1	822
0414	2052	2052	430	0	1728	6.9	35.0	-1	-1	-1	-1	1572	1171	412	-1	822
0415	2056	2056	430	0	864	6.9	35.0	-1	-1	-1	-1	1665	1212	420	-1	822
0416	2066	2066	425	0	1080	6.7	36.0	-1	-1	-1	-1	1038	654	144	-1	1020
0417	2070	2070	425	0	1944	6.7	36.0	-1	-1	-1	-1	1497	865	256	-1	1020
0418	2074	2074	425	0	1944	6.7	36.0	-1	-1	-1	-1	1810	1060	344	-1	1020
0419	2078	2078	425	0	2160	6.7	36.0	-1	-1	-1	-1	2050	1194	358	-1	1020
0420	2082	2082	425	0	2592	6.7	36.0	-1	-1	-1	-1	2230	1267	395	-1	1020
0421	2086	2086	425	0	2160	6.7	36.0	-1	-1	-1	-1	2388	1302	394	-1	1020
0422	2090	2090	485	0	2160	6.7	35.0	-1	-1	-1	-1	2077	1056	401	-1	486
0423	2094	2094	485	0	1512	6.7	35.0	-1	-1	-1	-1	2160	1108	332	-1	486
0424	2098	2098	485	0	1512	6.7	35.0	-1	-1	-1	-1	1911	966	296	-1	486
0425	2102	2102	485	0	1080	6.7	35.0	-1	-1	-1	-1	1570	768	230	-1	486
0426	2106	2106	485	0	-1	6.7	35.0	-1	-1	-1	-1	1444	751	226	-1	-1
0427	2110	2110	485	0	864	6.7	35.0	-1	-1	-1	-1	1336	638	237	-1	486
0428	2114	2114	111	0	865	6.5	36.0	-1	-1	-1	-1	1190	584	244	-1	60
0429	2118	2118	111	0	864	6.5	36.0	-1	-1	-1	-1	1238	617	257	-1	60
0430	2138	2138	140	0	1416	6.7	37.0	-1	-1	-1	-1	1530	822	383	-1	180
0431	2142	2142	140	0	-1	6.7	37.0	-1	-1	-1	-1	1559	758	386	-1	180
0432	2146	2146	140	0	-1	6.7	37.0	-1	-1	-1	-1	1938	1002	372	-1	180
0433	2150	2150	140	0	-1	6.7	37.0	-1	-1	-1	-1	1838	961	334	-1	180
0434	2154	2154	140	0	-1	6.7	37.0	-1	-1	-1	-1	1918	1023	329	-1	180
0435	2158	2158	140	0	1416	6.7	37.0	-1	-1	-1	-1	1819	1012	288	-1	180
0436	2162	2162	396	0	1944	6.7	35.0	-1	-1	-1	-1	1716	911	266	-1	546
0437	2166	2166	396	0	1944	6.7	35.0	-1	-1	-1	-1	1690	891	332	-1	546
0438	2170	2170	396	0	1944	6.7	35.0	-1	-1	-1	-1	1528	703	518	-1	546
0439	2174	2174	396	0	1728	6.7	35.0	-1	-1	-1	-1	1535	568	606	-1	546
0440	2178	2178	396	0	1728	6.7	35.0	-1	-1	-1	-1	1462	496	663	-1	546
0441	2182	2182	396	0	1728	6.7	35.0	-1	-1	-1	-1	1659	501	575	-1	546
0442	2186	2186	924	0	1944	6.6	35.0	-1	-1	-1	-1	1625	491	549	-1	876
0443	2190	2190	924	0	1728	6.6	35.0	-1	-1	-1	-1	935	252	488	-1	87
0444	2194	2194	924	0	1512	6.6	35.0	-1	-1	-1	-1	948	210	601	-1	876
0445	2198	2198	924	0	1512	6.6	35.0	-1	-1	-1	-1	1032	219	670	-1	876
0446	2202	2202	924	0	1296	6.6	35.0	-1	-1	-1	-1	994	241	609	-1	876
0447	2206	2206	924	0	1296	6.6	35.0	-1	-1	-1	-1	981	220	615	-1	876
0448	2210	2210	430	0	1086	6.8	40.0	-1	-1	-1	-1	1084	184	593	-1	660
0449	2214	2214	430	0	2376	6.8	40.0	-1	-1	-1	-1	1316	205	772	-1	660
0450	2218	2218	430	0	2376	6.8	40.0	-1	-1	-1	-1	1336	170	850	-1	660
0451	2222	2222	430	0	2376	6.8	40.0	-1	-1	-1	-1	1595	207	996	-1	660
0452	2226	2226	430	0	2592	6.8	40.0	-1	-1	-1	-1	1547	200	925	-1	660
0453	2230	2230	430	0	2808	6.8	40.0	-1	-1	-1	-1	1749	239	887	-1	660
0454	2234	2234	424	0	3024	6.0	35.0	-1	-1	-1	-1	1743	256	763	-1	600
0455	2238	2238	424	0	2808	6.0	35.0	-1	-1	-1	-1	1687	212	1137	-1	600
0456	2242	2242	424	0	2592	6.0	35.0	-1	-1	-1	-1	1557	218	1254	-1	600
0457	2250	2250	424	0	2592	6.0	35.0	-1	-1	-1	-1	1502	180	1473	-1	600
0458	2250	2250	424	0	2376	6.0	35.0	-1	-1	-1	-1	1456	184	1464	-1	600
0459	2252	2252	424	0	2376	6.0	35.0	-1	-1	-1	-1	1552	179	1598	-1	600
0460	2258	2258	316	0	2808	6.5	35.0	-1	-1	-1	-1	2076	256	1553	-1	955
0461	2262	2262	316	0	2160	6.5	35.0	-1	-1	-1	-1	1908	226	1481	-1	955
0462	2266	2266	316	0	1944	6.5	35.0	-1	-1	-1	-1	1850	233	1316	-1	955
0463	2270	2270	316	0	1944	6.5	35.0	-1	-1	-1	-1	1752	230	1266	-1	955
0464	2274	2274	316	0	2160	6.5	35.0	-1	-1	-1	-1	1871	275	986	-1	955
0465	2278	2278	316	0	1944	6.5	35.0	-1	-1	-1	-1	1794	291	1002	-1	955
0466	2282	2282	700	0	1512	6.5	35.0	-1	-1	-1	-1	1828	301	779	-1	800
0467	2286	2286	700	0	1512	6.5	35.0	-1	-1	-1	-1	1377	312	618	-1	800
0468	2290	2290	700	0	1080	6.5	35.0	-1	-1	-1	-1	1208	318	499	-1	800
0469	2294	2294	700	0	-1	6.5	35.0	-1	-1	-1	-1	1061	339	514	-1	800
0470	2302	2302	700	0	-1	6.5	35.0	-1	-1	-1	-1	1026	340	416	-1	800
0471	2302	2302	700	0	-1	6.5	35.0	-1	-1	-1	-1	1020	382	369	-1	800
0472	2306	2306	421	0	1080	6.8	35.0	-1	-1	-1	-1	1111	460	384	-1	120
0473	2310	2310	421	0	1296	6.8	35.0	-1	-1	-1	-1	1189	556	374	-1	120
0474	2314	2314	421	0	1512	6.8	35.0	-1	-1	-1	-1	1330	594	412	-1	120
0475	2330	2330	420	0	1728	6.9	35.0	-1	-1	-1	-1	728	140	525	-1	0
0476	2334	2334	420	0	1296	6.9	35.0	-1	-1	-1	-1	942	185	573	-1	0
0477	2338	2338	420	0	1296	6.9	35.0	-1	-1	-1	-1	788	161	575	-1	0
0478	2342	2342	420	0	1296	6.9	35.0	-1	-1	-1	-1	766	134	575	-1	0

Run #6 (1752-2061hrs)

	0479	2346	2346	420	0	1080	6.9	35.0	-1	-1	-1	-1	771	108	480	-1	0
	0480	2350	2350	420	0	1080	6.9	35.0	-1	-1	-1	-1	696	89	539	-1	0
	0481	2358	2358	124	0	864	6.6	35.0	-1	-1	-1	-1	570	93	382	-1	258
	0482	2362	2362	124	0	848	6.6	35.0	-1	-1	-1	-1	647	101	373	-1	258
	0483	2366	2366	124	0	648	6.6	35.0	-1	-1	-1	-1	604	96	324	-1	258
	0484	2370	2370	124	0	648	6.6	35.0	-1	-1	-1	-1	601	82	265	-1	258
	0485	2374	2374	124	0	648	6.6	35.0	-1	-1	-1	-1	634	107	212	-1	258
	0486	2378	2378	273	0	1512	6.4	35.0	-1	-1	-1	-1	576	115	244	-1	522
	0487	2382	2382	273	0	-1	6.4	35.0	-1	-1	-1	-1	852	143	490	-1	522
	0488	2386	2386	273	0	-1	6.4	35.0	-1	-1	-1	-1	904	136	653	-1	522
	0489	2390	2390	273	0	1512	6.4	35.0	-1	-1	-1	-1	962	154	754	-1	522
	0490	2394	2394	273	0	-1	6.4	35.0	-1	-1	-1	-1	992	145	820	-1	522
	0491	2398	2398	273	0	864	6.4	35.0	-1	-1	-1	-1	982	152	838	-1	522
	0492	2406	2406	282	0	648	6.7	37.0	-1	-1	-1	-1	1246	226	508	-1	378
	0493	2410	2410	282	0	648	6.7	37.0	-1	-1	-1	-1	1274	198	350	-1	378
	0494	2414	2414	282	0	-1	6.7	37.0	-1	-1	-1	-1	1042	208	268	-1	378
	0495	2418	2418	282	0	648	6.7	37.0	-1	-1	-1	-1	862	202	262	-1	378
	0496	2422	2422	282	0	-1	6.7	37.0	-1	-1	-1	-1	961	250	254	-1	378
	0497	2426	2426	425	0	2376	6.8	35.0	-1	-1	-1	-1	2036	1862	372	-1	954
	0498	2430	2430	425	0	2808	6.8	35.0	-1	-1	-1	-1	2031	2004	467	-1	954
	0499	2434	2434	425	0	2592	6.8	35.0	-1	-1	-1	-1	1896	2014	574	-1	954
	0500	2438	2438	425	0	2376	6.8	35.0	-1	-1	-1	-1	1600	1632	870	-1	954
	0501	2442	2442	425	0	2592	6.8	35.0	-1	-1	-1	-1	1345	1148	1603	-1	954
	0502	2446	2446	425	0	2376	6.8	35.0	-1	-1	-1	-1	1585	1028	1183	-1	954
	0503	2450	2450	123	0	2376	6.8	35.0	-1	-1	-1	-1	1796	1085	1113	-1	0
	0504	2454	2454	123	0	2160	6.8	35.0	-1	-1	-1	-1	1704	971	835	-1	0
	0505	2458	2458	123	0	1944	6.8	35.0	-1	-1	-1	-1	1546	858	578	-1	0
	0506	2462	2462	123	0	1944	6.8	35.0	-1	-1	-1	-1	1430	836	540	-1	0
	0507	2466	2466	123	0	1944	6.8	35.0	-1	-1	-1	-1	1299	709	472	-1	0
	0508	2470	2470	123	0	1944	6.8	35.0	-1	-1	-1	-1	1150	768	350	-1	0
	0509	2474	2474	126	0	1512	6.9	35.0	-1	-1	-1	-1	1254	882	321	-1	0
	0510	2478	2478	126	0	1512	6.9	35.0	-1	-1	-1	-1	1149	850	273	-1	0
	0511	2482	2482	126	0	1296	6.9	35.0	-1	-1	-1	-1	1182	946	268	-1	0
	0512	2486	2486	126	0	1296	6.9	35.0	-1	-1	-1	-1	1196	908	242	-1	0
	0513	2490	2490	126	0	1296	6.9	35.0	-1	-1	-1	-1	1135	898	221	-1	0
	0514	2494	2494	126	0	1512	6.9	35.0	-1	-1	-1	-1	1236	997	240	-1	0
	0515	2498	2498	137	0	1296	6.9	35.0	-1	-1	-1	-1	1195	910	230	-1	0
	0516	2502	2502	137	0	1296	6.9	35.0	-1	-1	-1	-1	1164	920	241	-1	0
NO	0517	2506	2506	137	0	1296	6.9	35.0	-1	-1	-1	-1	1165	929	231	-1	0
	0518	2510	2510	137	0	1512	6.9	35.0	-1	-1	-1	-1	1084	820	197	-1	0
	0519	2514	2514	137	0	1512	6.9	35.0	-1	-1	-1	-1	1217	956	227	-1	0
	0520	2518	2518	137	0	1296	6.9	35.0	-1	-1	-1	-1	1188	896	194	-1	0

Dynamic Run
(2066-2498hrs)

MCEFF T=00004 IS ON CR00049 USING 00088 BLKS R=0000

Run #1 (0-332hrs)

0001	McEFF														
0002	HR.	FHR.	TS	TVS	SS	VSS	COD	FCOD	TKN	FTKN	NH4	TP	FTP	BOD	FBOD
0003	519	15													
0004	004	004	-1	-1	2700	2150	7310	4120	-1	-1	-1	-1	-1	-1	-1
0005	008	008	-1	-1	1540	1240	5210	3850	-1	-1	-1	-1	-1	-1	-1
0006	012	012	-1	-1	630	570	4780	3830	-1	-1	-1	-1	-1	-1	-1
0007	016	016	-1	-1	690	680	4760	4020	-1	-1	-1	-1	-1	-1	-1
0008	020	020	-1	-1	1020	1010	5060	3960	-1	-1	-1	-1	-1	-1	-1
0009	024	024	-1	-1	650	590	5100	3960	-1	-1	-1	-1	-1	-1	-1
0010	028	028	-1	-1	710	650	5040	4100	-1	-1	-1	-1	-1	-1	-1
0011	032	032	-1	-1	640	540	4980	3960	-1	-1	-1	-1	-1	-1	-1
0012	036	036	-1	-1	810	740	4840	3920	-1	-1	-1	-1	-1	-1	-1
0013	040	040	-1	-1	740	720	5220	3960	-1	-1	-1	-1	-1	-1	-1
0014	044	044	-1	-1	720	630	5240	4600	-1	-1	-1	-1	-1	-1	-1
0015	048	048	-1	-1	690	590	4760	3700	-1	-1	-1	-1	-1	-1	-1
0016	052	052	-1	-1	840	730	4840	3960	-1	-1	-1	-1	-1	-1	-1
0017	056	056	-1	-1	630	600	4620	4400	-1	-1	-1	-1	-1	-1	-1
0018	060	060	-1	-1	740	620	5120	4360	-1	-1	-1	-1	-1	-1	-1
0019	064	064	-1	-1	900	760	5240	4340	-1	-1	-1	-1	-1	-1	-1
0020	068	068	-1	-1	580	470	5040	4040	-1	-1	-1	-1	-1	-1	-1
0021	072	072	-1	-1	1270	1090	5540	3960	-1	-1	-1	-1	-1	-1	-1
0022	076	076	-1	-1	600	480	5020	4000	-1	-1	-1	-1	-1	-1	-1
0023	080	080	-1	-1	740	630	4960	3940	-1	-1	-1	-1	-1	-1	-1
0024	084	084	-1	-1	690	570	4680	3720	-1	-1	-1	-1	-1	-1	-1
0025	088	088	-1	-1	710	560	4560	3880	-1	-1	-1	-1	-1	-1	-1
0026	092	092	-1	-1	670	650	4880	3680	-1	-1	-1	-1	-1	-1	-1
0027	100	100	-1	-1	490	470	4640	3820	-1	-1	-1	-1	-1	-1	-1
0028	104	104	-1	-1	600	510	4900	4040	-1	-1	-1	-1	-1	-1	-1
0029	108	108	-1	-1	610	520	4660	3720	-1	-1	-1	-1	-1	-1	-1
0030	112	112	-1	-1	680	650	4620	3640	-1	-1	-1	-1	-1	-1	-1
0031	116	116	-1	-1	690	600	4480	3660	-1	-1	-1	-1	-1	-1	-1
0032	120	120	-1	-1	700	580	4900	3760	-1	-1	-1	-1	-1	-1	-1
0033	124	124	-1	-1	1960	1730	5800	3820	-1	-1	-1	-1	-1	-1	-1
0034	128	128	-1	-1	870	730	4820	3880	-1	-1	-1	-1	-1	-1	-1
0035	132	132	-1	-1	890	770	4600	3840	-1	-1	-1	-1	-1	-1	-1
0036	144	144	-1	-1	920	860	4380	3640	-1	-1	-1	-1	-1	-1	-1
0037	148	148	-1	-1	700	600	4860	3860	-1	-1	-1	-1	-1	-1	-1
0038	152	152	-1	-1	830	710	4640	3980	-1	-1	-1	-1	-1	-1	-1
0039	156	156	-1	-1	720	560	5760	4200	-1	-1	-1	-1	-1	-1	-1
0040	160	160	-1	-1	700	550	4700	3940	-1	-1	-1	-1	-1	-1	-1
0041	164	164	-1	-1	890	750	4720	4140	-1	-1	-1	-1	-1	-1	-1
0042	168	168	-1	-1	760	610	5100	4300	-1	-1	-1	-1	-1	-1	-1
0043	172	172	-1	-1	760	650	5080	4500	-1	-1	-1	-1	-1	-1	-1
0044	176	176	-1	-1	850	750	5040	4100	-1	-1	-1	-1	-1	-1	-1
0045	180	180	-1	-1	760	630	5060	4180	-1	-1	-1	-1	-1	-1	-1
0046	184	184	-1	-1	1780	1530	5080	4260	-1	-1	-1	-1	-1	-1	-1
0047	188	188	-1	-1	1940	1650	5940	4380	-1	-1	-1	-1	-1	-1	-1
0048	192	192	-1	-1	1240	1080	5520	3760	-1	-1	-1	-1	-1	-1	-1
0049	196	196	-1	-1	1390	1230	6280	3880	-1	-1	-1	-1	-1	-1	-1
0050	200	200	-1	-1	1580	1380	6860	4180	-1	-1	-1	-1	-1	-1	-1
0051	204	204	-1	-1	1960	1740	7800	4120	-1	-1	-1	-1	-1	-1	-1
0052	208	208	-1	-1	3560	3200	9640	4520	-1	-1	-1	-1	-1	-1	-1
0053	212	212	-1	-1	4000	3540	8620	4220	-1	-1	-1	-1	-1	-1	-1
0054	216	216	-1	-1	5050	4500	12600	4520	-1	-1	-1	-1	-1	-1	-1
0055	220	220	-1	-1	2450	2350	8700	4340	-1	-1	-1	-1	-1	-1	-1
0056	224	224	-1	-1	5200	4700	13720	4580	-1	-1	-1	-1	-1	-1	-1
0057	228	228	-1	-1	6900	6550	17380	4340	-1	-1	-1	-1	-1	-1	-1
0058	232	232	-1	-1	9150	8200	14780	4680	-1	-1	-1	-1	-1	-1	-1
0059	236	236	-1	-1	9500	8350	15920	4860	-1	-1	-1	-1	-1	-1	-1
0060	240	240	-1	-1	19350	16450	15220	4280	-1	-1	-1	-1	-1	-1	-1
0061	244	244	-1	-1	9000	6900	15460	4180	-1	-1	-1	-1	-1	-1	-1
0062	248	248	-1	-1	7900	6300	15000	4320	-1	-1	-1	-1	-1	-1	-1
0063	252	252	-1	-1	7100	5500	15060	4340	-1	-1	-1	-1	-1	-1	-1
0064	256	256	-1	-1	6100	4700	12320	4100	-1	-1	-1	-1	-1	-1	-1
0065	260	260	-1	-1	1800	800	5560	3840	-1	-1	-1	-1	-1	-1	-1
0066	264	264	-1	-1	950	850	5050	4040	-1	-1	-1	-1	-1	-1	-1
0067	268	268	-1	-1	1650	1650	5650	4060	-1	-1	-1	-1	-1	-1	-1
0068	272	272	-1	-1	3650	3350	7100	4320	-1	-1	-1	-1	-1	-1	-1
0069	276	276	-1	-1	2800	2300	5700	4340	-1	-1	-1	-1	-1	-1	-1
0070	280	280	-1	-1	4300	4300	8900	4380	-1	-1	-1	-1	-1	-1	-1
0071	284	284	-1	-1	3500	3100	5500	4240	-1	-1	-1	-1	-1	-1	-1
0072	288	288	-1	-1	2800	2600	9700	3980	-1	-1	-1	-1	-1	-1	-1
0073	292	292	-1	-1	5400	5300	12300	4100	-1	-1	-1	-1	-1	-1	-1
0074	296	296	-1	-1	1200	1200	6800	3720	-1	-1	-1	-1	-1	-1	-1
0075	300	300	-1	-1	500	400	6650	3800	-1	-1	-1	-1	-1	-1	-1
0076	304	304	-1	-1	400	-1	6000	3860	-1	-1	-1	-1	-1	-1	-1
0077	308	308	-1	-1	650	-1	4900	3680	-1	-1	-1	-1	-1	-1	-1
0078	312	312	-1	-1	1500	1200	6950	4060	-1	-1	-1	-1	-1	-1	-1

0079	316	316	-1	-1	900	300	6650	4300	-1	-1	-1	-1	-1	-1	-1	
0080	320	320	-1	-1	700	700	4950	3960	-1	-1	-1	-1	-1	-1	-1	
0081	324	324	-1	-1	700	510	4900	3980	-1	-1	-1	-1	-1	-1	-1	
0082	328	328	-1	-1	500	400	4950	3960	-1	-1	-1	-1	-1	-1	-1	
0083	332	332	-1	-1	500	300	5450	4280	-1	-1	-1	-1	-1	-1	-1	
0084	340	340	-1	-1	2200	1700	4860	2700	-1	-1	-1	-1	-1	-1	-1	
0085	344	344	-1	-1	1900	1500	5960	2900	-1	-1	-1	-1	-1	-1	-1	
0086	348	348	-1	-1	5700	4900	11140	3120	-1	-1	-1	-1	-1	-1	-1	Run #2 (336-696hrs)
0087	352	352	-1	-1	8500	6900	12000	3120	-1	-1	-1	-1	-1	-1	-1	
0088	356	356	-1	-1	5900	4800	11440	3600	-1	-1	-1	-1	-1	-1	-1	
0089	360	360	-1	-1	6300	5100	12260	3300	-1	-1	-1	-1	-1	-1	-1	
0090	364	364	-1	-1	5300	5200	11760	3640	-1	-1	-1	-1	-1	-1	-1	
0091	368	368	-1	-1	4300	3200	9640	3540	-1	-1	-1	-1	-1	-1	-1	
0092	372	372	-1	-1	2400	1900	7880	3340	-1	-1	-1	-1	-1	-1	-1	
0093	376	376	-1	-1	1600	600	6440	3540	-1	-1	-1	-1	-1	-1	-1	
0094	384	384	-1	-1	7800	6900	6240	3180	-1	-1	-1	-1	-1	-1	-1	
0095	388	388	-1	-1	3000	2800	6180	3180	-1	-1	-1	-1	-1	-1	-1	
0096	392	392	-1	-1	3900	3800	6120	3060	-1	-1	-1	-1	-1	-1	-1	
0097	396	376	-1	-1	3000	2900	5640	2900	-1	-1	-1	-1	-1	-1	-1	
0098	400	400	-1	-1	3200	3100	5100	3120	-1	-1	-1	-1	-1	-1	-1	
0099	404	404	-1	-1	2900	2800	5860	3100	-1	-1	-1	-1	-1	-1	-1	
0100	408	408	-1	-1	1900	1800	6660	3800	-1	-1	-1	-1	-1	-1	-1	
0101	412	412	-1	-1	1800	-1	6160	3640	-1	-1	-1	-1	-1	-1	-1	
0102	416	416	-1	-1	2100	1900	6060	3640	-1	-1	-1	-1	-1	-1	-1	
0103	420	420	-1	-1	1800	1700	6360	3380	-1	-1	-1	-1	-1	-1	-1	
0104	424	424	-1	-1	1500	-1	6140	3600	-1	-1	-1	-1	-1	-1	-1	
0105	428	428	-1	-1	3000	-1	6580	3600	-1	-1	-1	-1	-1	-1	-1	
0106	432	432	-1	-1	1900	1800	6640	3260	-1	-1	-1	-1	-1	-1	-1	
0107	436	436	-1	-1	2000	1400	6260	3340	-1	-1	-1	-1	-1	-1	-1	
0108	440	440	-1	-1	2300	1900	7240	3200	-1	-1	-1	-1	-1	-1	-1	
0109	444	444	-1	-1	1900	1700	5180	3920	-1	-1	-1	-1	-1	-1	-1	
0110	448	448	-1	-1	2400	2300	6340	2980	-1	-1	-1	-1	-1	-1	-1	
0111	452	452	-1	-1	1100	1000	6460	3540	-1	-1	-1	-1	-1	-1	-1	
0112	456	456	-1	-1	2000	1900	5960	3520	-1	-1	-1	-1	-1	-1	-1	
0113	460	460	-1	-1	1000	-1	5740	3220	-1	-1	-1	-1	-1	-1	-1	
0114	464	464	-1	-1	1100	-1	5540	2880	-1	-1	-1	-1	-1	-1	-1	
0115	468	468	-1	-1	800	700	5320	2780	-1	-1	-1	-1	-1	-1	-1	
0116	480	480	-1	-1	1000	-1	5740	3420	-1	-1	-1	-1	-1	-1	-1	
0117	484	484	-1	-1	2000	1900	5540	3240	-1	-1	-1	-1	-1	-1	-1	
0118	488	488	-1	-1	2100	2000	5340	2760	-1	-1	-1	-1	-1	-1	-1	
0119	492	492	-1	-1	1200	-1	5240	2760	-1	-1	-1	-1	-1	-1	-1	
0120	496	496	-1	-1	1000	700	5940	2720	-1	-1	-1	-1	-1	-1	-1	
0121	504	504	-1	-1	700	500	4620	2860	-1	-1	-1	-1	-1	-1	-1	
0122	508	508	-1	-1	700	-1	4380	2900	-1	-1	-1	-1	-1	-1	-1	
0123	512	512	-1	-1	560	460	4500	2740	-1	-1	-1	-1	-1	-1	-1	
0124	516	516	-1	-1	200	-1	4660	2740	-1	-1	-1	-1	-1	-1	-1	
0125	520	520	-1	-1	300	-1	4720	2920	-1	-1	-1	-1	-1	-1	-1	
0126	528	528	-1	-1	800	600	3760	3620	-1	-1	-1	-1	-1	-1	-1	
0127	532	532	-1	-1	400	300	3620	2260	-1	-1	-1	-1	-1	-1	-1	
0128	536	536	-1	-1	500	-1	3800	2460	-1	-1	-1	-1	-1	-1	-1	
0129	540	540	-1	-1	200	-1	3880	2700	-1	-1	-1	-1	-1	-1	-1	
0130	544	544	-1	-1	400	300	4040	2860	-1	-1	-1	-1	-1	-1	-1	
0131	548	548	-1	-1	1100	900	3980	2760	-1	-1	-1	-1	-1	-1	-1	
0132	552	552	-1	-1	800	700	3840	3060	-1	-1	-1	-1	-1	-1	-1	
0133	556	556	-1	-1	1400	1300	3920	2900	-1	-1	-1	-1	-1	-1	-1	
0134	560	560	-1	-1	1000	900	4180	2760	-1	-1	-1	-1	-1	-1	-1	
0135	564	564	-1	-1	1500	1400	4380	2760	-1	-1	-1	-1	-1	-1	-1	
0136	568	568	-1	-1	1000	700	4360	2880	-1	-1	-1	-1	-1	-1	-1	
0137	576	576	-1	-1	1100	700	3960	2660	-1	-1	-1	-1	-1	-1	-1	
0138	580	580	-1	-1	1400	1300	4340	2780	-1	-1	-1	-1	-1	-1	-1	
0139	584	584	-1	-1	1400	1000	4640	3000	-1	-1	-1	-1	-1	-1	-1	
0140	588	588	-1	-1	1300	960	3940	2540	-1	-1	-1	-1	-1	-1	-1	
0141	592	592	-1	-1	1300	600	3780	2460	-1	-1	-1	-1	-1	-1	-1	
0142	596	596	-1	-1	1700	700	3700	2800	-1	-1	-1	-1	-1	-1	-1	
0143	600	600	-1	-1	1800	1200	3720	2660	-1	-1	-1	-1	-1	-1	-1	
0144	604	604	-1	-1	1800	800	3800	2840	-1	-1	-1	-1	-1	-1	-1	
0145	608	608	-1	-1	1800	1200	3780	2380	-1	-1	-1	-1	-1	-1	-1	
0146	612	612	-1	-1	1800	1200	3840	2360	-1	-1	-1	-1	-1	-1	-1	
0147	616	616	-1	-1	1800	1500	4300	2820	-1	-1	-1	-1	-1	-1	-1	
0148	700	700	-1	-1	850	850	6700	4680	-1	-1	-1	-1	-1	-1	-1	
0149	704	704	-1	-1	1050	850	7250	5180	-1	-1	-1	-1	-1	-1	-1	
0150	708	708	-1	-1	1000	900	7080	5640	-1	-1	-1	-1	-1	-1	-1	Run #3 (700-1032hrs)
0151	712	712	-1	-1	1000	900	7440	6330	-1	-1	-1	-1	-1	-1	-1	
0152	716	716	-1	-1	1050	800	7740	6320	-1	-1	-1	-1	-1	-1	-1	
0153	720	720	-1	-1	820	640	8040	6500	-1	-1	-1	-1	-1	-1	-1	
0154	724	724	-1	-1	880	760	7960	6520	-1	-1	-1	-1	-1	-1	-1	
0155	728	728	-1	-1	820	700	7820	6380	-1	-1	-1	-1	-1	-1	-1	
0156	732	732	-1	-1	1120	840	8100	6980	-1	-1	-1	-1	-1	-1	-1	
0157	740	740	-1	-1	980	860	12140	7760	-1	-1	-1	-1	-1	-1	-1	
0158	748	748	-1	-1	1020	780	9160	7940	-1	-1	-1	-1	-1	-1	-1	

0159	752	752	-1	-1	1500	1452	11100	7740	-1	-1	-1	-1	-1	-1	-1
0160	756	756	-1	-1	1660	1400	11420	8820	-1	-1	-1	-1	-1	-1	-1
0161	768	768	-1	-1	1220	1020	8980	6860	-1	-1	-1	-1	-1	-1	-1
0162	772	772	-1	-1	2120	1800	9160	7500	-1	-1	-1	-1	-1	-1	-1
0163	776	776	-1	-1	1540	1280	10120	7100	-1	-1	-1	-1	-1	-1	-1
0164	784	784	-1	-1	2080	1680	9600	6560	-1	-1	-1	-1	-1	-1	-1
0165	788	788	-1	-1	1480	1200	10460	6520	-1	-1	-1	-1	-1	-1	-1
0166	792	792	-1	-1	-1	-1	8920	7160	-1	-1	-1	-1	-1	-1	-1
0167	796	796	-1	-1	2080	1880	10340	6620	-1	-1	-1	-1	-1	-1	-1
0168	800	800	-1	-1	1400	1380	9080	6540	-1	-1	-1	-1	-1	-1	-1
0169	804	804	-1	-1	-1	-1	10240	6100	-1	-1	-1	-1	-1	-1	-1
0170	808	808	-1	-1	1750	1650	9040	6120	-1	-1	-1	-1	-1	-1	-1
0171	816	816	-1	-1	1350	1300	9420	6380	-1	-1	-1	-1	-1	-1	-1
0172	820	820	-1	-1	1650	1550	10860	5920	-1	-1	-1	-1	-1	-1	-1
0173	824	824	-1	-1	1950	1850	10020	6360	-1	-1	-1	-1	-1	-1	-1
0174	828	828	-1	-1	1800	1700	9140	6460	-1	-1	-1	-1	-1	-1	-1
0175	832	832	-1	-1	1850	1750	10080	6220	-1	-1	-1	-1	-1	-1	-1
0176	836	836	-1	-1	1100	1000	9060	6120	-1	-1	-1	-1	-1	-1	-1
0177	840	840	-1	-1	1200	1150	9080	5840	-1	-1	-1	-1	-1	-1	-1
0178	844	844	-1	-1	-1	-1	11040	7060	-1	-1	-1	-1	-1	-1	-1
0179	848	848	-1	-1	1000	900	10440	6580	-1	-1	-1	-1	-1	-1	-1
0180	860	860	-1	-1	1450	-1	10220	7580	-1	-1	-1	-1	-1	-1	-1
0181	864	864	-1	-1	900	850	10580	7560	-1	-1	-1	-1	-1	-1	-1
0182	868	868	-1	-1	1100	1050	10740	7140	-1	-1	-1	-1	-1	-1	-1
0183	872	872	-1	-1	1000	-1	10400	7380	-1	-1	-1	-1	-1	-1	-1
0184	876	876	-1	-1	700	600	11640	7160	-1	-1	-1	-1	-1	-1	-1
0185	880	880	-1	-1	1200	1100	13760	6900	-1	-1	-1	-1	-1	-1	-1
0186	884	884	-1	-1	2200	1600	9700	6960	-1	-1	-1	-1	-1	-1	-1
0187	888	888	-1	-1	2050	1200	9540	7180	-1	-1	-1	-1	-1	-1	-1
0188	892	892	-1	-1	1700	1250	10740	7140	-1	-1	-1	-1	-1	-1	-1
0189	896	896	-1	-1	2650	1050	10460	7000	-1	-1	-1	-1	-1	-1	-1
0190	900	900	-1	-1	2800	1950	15980	7380	-1	-1	-1	-1	-1	-1	-1
0191	908	908	-1	-1	2100	1250	9840	6980	-1	-1	-1	-1	-1	-1	-1
0192	912	912	-1	-1	4500	3800	11080	7000	-1	-1	-1	-1	-1	-1	-1
0193	916	916	-1	-1	-1	-1	13340	7040	-1	-1	-1	-1	-1	-1	-1
0194	960	960	-1	-1	1650	900	7680	6780	-1	-1	-1	-1	-1	-1	-1
0195	964	964	-1	-1	2800	1750	10220	6640	-1	-1	-1	-1	-1	-1	-1
0196	968	968	-1	-1	1100	500	8280	6720	-1	-1	-1	-1	-1	-1	-1
0197	972	972	-1	-1	1650	900	8100	6400	-1	-1	-1	-1	-1	-1	-1
0198	976	976	-1	-1	1350	600	7600	6340	-1	-1	-1	-1	-1	-1	-1
0199	980	980	-1	-1	1150	350	7480	6640	-1	-1	-1	-1	-1	-1	-1
0200	984	984	-1	-1	1250	400	7380	5980	-1	-1	-1	-1	-1	-1	-1
0201	988	988	-1	-1	1350	550	8240	5960	-1	-1	-1	-1	-1	-1	-1
0202	992	992	-1	-1	1650	1050	8740	6360	-1	-1	-1	-1	-1	-1	-1
0203	996	996	-1	-1	1100	500	7660	6300	-1	-1	-1	-1	-1	-1	-1
0204	1000	1000	-1	-1	1250	450	7100	6060	-1	-1	-1	-1	-1	-1	-1
0205	1004	1004	-1	-1	1300	1250	7100	5540	-1	-1	-1	-1	-1	-1	-1
0206	1008	1008	-1	-1	1150	850	7480	5700	-1	-1	-1	-1	-1	-1	-1
0207	1016	1016	-1	-1	1200	750	6160	4960	-1	-1	-1	-1	-1	-1	-1
0208	1020	1020	-1	-1	750	550	5640	4100	-1	-1	-1	-1	-1	-1	-1
0209	1032	1032	-1	-1	1300	650	5600	3820	-1	-1	-1	-1	-1	-1	-1
0210	1036	1036	-1	-1	950	300	5160	4140	-1	-1	-1	-1	-1	-1	-1
0211	1040	1040	-1	-1	450	-1	4740	3780	-1	-1	-1	-1	-1	-1	-1
0212	1044	1044	-1	-1	550	-1	5200	3520	-1	-1	-1	-1	-1	-1	-1
0213	1048	1048	-1	-1	550	-1	4160	3560	-1	-1	-1	-1	-1	-1	-1
0214	1052	1052	-1	-1	720	380	4140	3720	-1	-1	-1	-1	-1	-1	-1
0215	1056	1056	-1	-1	620	400	4100	3760	-1	-1	-1	-1	-1	-1	-1
0216	1060	1060	-1	-1	640	380	4200	3520	-1	-1	-1	-1	-1	-1	-1
0217	1064	1064	-1	-1	400	160	4140	3620	-1	-1	-1	-1	-1	-1	-1
0218	1068	1068	-1	-1	580	240	4260	3640	-1	-1	-1	-1	-1	-1	-1
0219	1072	1072	-1	-1	1000	540	4280	3500	-1	-1	-1	-1	-1	-1	-1
0220	1076	1076	-1	-1	-1	-1	4100	3400	-1	-1	-1	-1	-1	-1	-1
0221	1080	1080	-1	-1	-1	-1	4860	3180	-1	-1	-1	-1	-1	-1	-1
0222	1084	1084	-1	-1	220	200	5520	3060	-1	-1	-1	-1	-1	-1	-1
0223	1088	1088	-1	-1	260	-1	4840	3160	-1	-1	-1	-1	-1	-1	-1
0224	1092	1092	-1	-1	-1	-1	4240	3040	-1	-1	-1	-1	-1	-1	-1
0225	1096	1096	-1	-1	-1	-1	4860	3320	-1	-1	-1	-1	-1	-1	-1
0226	1100	1100	-1	-1	860	660	4580	3280	-1	-1	-1	-1	-1	-1	-1
0227	1104	1104	-1	-1	500	460	3880	2780	-1	-1	-1	-1	-1	-1	-1
0228	1108	1108	-1	-1	840	780	3820	2600	-1	-1	-1	-1	-1	-1	-1
0229	1112	1112	-1	-1	480	380	3740	2540	-1	-1	-1	-1	-1	-1	-1
0230	1116	1116	-1	-1	780	760	4420	2420	-1	-1	-1	-1	-1	-1	-1
0231	1120	1120	-1	-1	480	460	3600	2220	-1	-1	-1	-1	-1	-1	-1
0232	1124	1124	-1	-1	720	680	3380	2300	-1	-1	-1	-1	-1	-1	-1
0233	1128	1128	-1	-1	560	540	3900	2420	-1	-1	-1	-1	-1	-1	-1
0234	1132	1132	-1	-1	540	460	4160	2340	-1	-1	-1	-1	-1	-1	-1
0235	1136	1136	-1	-1	500	420	3580	2380	-1	-1	-1	-1	-1	-1	-1
0236	1140	1140	-1	-1	560	400	3440	2540	-1	-1	-1	-1	-1	-1	-1
0237	1144	1144	-1	-1	440	400	3400	2540	-1	-1	-1	-1	-1	-1	-1
0238	1148	1148	-1	-1	440	400	4960	2440	-1	-1	-1	-1	-1	-1	-1

Run #4
(1034-1364hrs)

0239	1156	1156	-1	-1	440	340	3410	2650	-1	-1	-1	-1	-1	-1	-1
0240	1160	1160	-1	-1	580	560	3480	2270	-1	-1	-1	-1	-1	-1	-1
0241	1164	1164	-1	-1	510	440	3210	2230	-1	-1	-1	-1	-1	-1	-1
0242	1172	1172	-1	-1	340	320	3300	2270	-1	-1	-1	-1	-1	-1	-1
0243	1176	1176	-1	-1	1420	1280	5790	3830	-1	-1	-1	-1	-1	-1	-1
0244	1180	1180	-1	-1	1360	1320	5960	3960	-1	-1	-1	-1	-1	-1	-1
0245	1184	1184	-1	-1	980	960	5470	4230	-1	-1	-1	-1	-1	-1	-1
0246	1188	1188	-1	-1	400	300	3190	2590	-1	-1	-1	-1	-1	-1	-1
0247	1192	1192	-1	-1	900	-1	4380	3040	-1	-1	-1	-1	-1	-1	-1
0248	1200	1200	-1	-1	1020	960	5800	4440	-1	-1	-1	-1	-1	-1	-1
0249	1204	1204	-1	-1	840	820	5230	4290	-1	-1	-1	-1	-1	-1	-1
0250	1208	1208	-1	-1	1000	-1	7200	4230	-1	-1	-1	-1	-1	-1	-1
0251	1212	1212	-1	-1	900	840	5360	4230	-1	-1	-1	-1	-1	-1	-1
0252	1216	1216	-1	-1	1400	1380	6600	4190	-1	-1	-1	-1	-1	-1	-1
0253	1224	1224	-1	-1	420	340	5040	4080	-1	-1	-1	-1	-1	-1	-1
0254	1236	1236	-1	-1	360	340	5120	4360	-1	-1	-1	-1	-1	-1	-1
0255	1240	1240	-1	-1	340	320	4840	4320	-1	-1	-1	-1	-1	-1	-1
0256	1244	1244	-1	-1	440	380	4880	4200	-1	-1	-1	-1	-1	-1	-1
0257	1248	1248	-1	-1	280	100	5040	4080	-1	-1	-1	-1	-1	-1	-1
0258	1252	1252	-1	-1	500	260	4560	3620	-1	-1	-1	-1	-1	-1	-1
0259	1256	1256	-1	-1	400	200	5000	4180	-1	-1	-1	-1	-1	-1	-1
0260	1260	1260	-1	-1	500	360	5420	4300	-1	-1	-1	-1	-1	-1	-1
0261	1264	1264	-1	-1	380	180	5540	4200	-1	-1	-1	-1	-1	-1	-1
0262	1272	1272	-1	-1	620	400	4800	4100	-1	-1	-1	-1	-1	-1	-1
0263	1276	1276	-1	-1	740	540	5240	3780	-1	-1	-1	-1	-1	-1	-1
0264	1280	1280	-1	-1	660	440	5060	3700	-1	-1	-1	-1	-1	-1	-1
0265	1284	1284	-1	-1	600	420	4820	3780	-1	-1	-1	-1	-1	-1	-1
0266	1288	1288	-1	-1	360	280	4780	3940	-1	-1	-1	-1	-1	-1	-1
0267	1296	1296	-1	-1	720	700	4680	3360	-1	-1	-1	-1	-1	-1	-1
0268	1300	1300	-1	-1	420	360	5100	3620	-1	-1	-1	-1	-1	-1	-1
0269	1304	1304	-1	-1	660	580	4900	3600	-1	-1	-1	-1	-1	-1	-1
0270	1308	1308	-1	-1	480	340	4800	3800	-1	-1	-1	-1	-1	-1	-1
0271	1320	1320	-1	-1	600	580	5660	3040	-1	-1	-1	-1	-1	-1	-1
0272	1324	1324	-1	-1	600	640	5660	3040	-1	-1	-1	-1	-1	-1	-1
0273	1328	1328	-1	-1	500	340	4520	2920	-1	-1	-1	-1	-1	-1	-1
0274	1332	1332	-1	-1	-1	-1	4400	3040	-1	-1	-1	-1	-1	-1	-1
0275	1336	1336	-1	-1	520	360	3820	2960	-1	-1	-1	-1	-1	-1	-1
0276	1340	1340	-1	-1	300	-1	4220	2920	-1	-1	-1	-1	-1	-1	-1
0277	1348	1348	-1	-1	420	380	4280	3040	-1	-1	-1	-1	-1	-1	-1
0278	1352	1352	-1	-1	280	260	3640	2760	-1	-1	-1	-1	-1	-1	-1
0279	1356	1356	-1	-1	200	180	3000	2620	-1	-1	-1	-1	-1	-1	-1
0280	1360	1360	-1	-1	240	200	3520	2440	-1	-1	-1	-1	-1	-1	-1
0281	1364	1364	-1	-1	200	180	3020	2360	-1	-1	-1	-1	-1	-1	-1
0282	1372	1372	-1	-1	520	460	5180	3820	-1	-1	-1	-1	-1	-1	-1
0283	1376	1376	-1	-1	660	640	5920	4820	-1	-1	-1	-1	-1	-1	-1
0284	1380	1380	-1	-1	540	500	6520	5220	-1	-1	-1	-1	-1	-1	-1
0285	1384	1384	-1	-1	180	160	6160	5160	-1	-1	-1	-1	-1	-1	-1
0286	1388	1388	-1	-1	270	250	5860	5320	-1	-1	-1	-1	-1	-1	-1
0287	1392	1392	-1	-1	540	-1	7240	6100	-1	-1	-1	-1	-1	-1	-1
0288	1396	1396	-1	-1	500	420	7280	6260	-1	-1	-1	-1	-1	-1	-1
0289	1400	1400	-1	-1	440	400	8340	7120	-1	-1	-1	-1	-1	-1	-1
0290	1404	1404	-1	-1	560	-1	8580	7240	-1	-1	-1	-1	-1	-1	-1
0291	1408	1408	-1	-1	620	540	8620	7500	-1	-1	-1	-1	-1	-1	-1
0292	1412	1412	-1	-1	1080	1060	9420	8260	-1	-1	-1	-1	-1	-1	-1
0293	1416	1416	-1	-1	620	560	8520	7960	-1	-1	-1	-1	-1	-1	-1
0294	1420	1420	-1	-1	780	660	8780	7560	-1	-1	-1	-1	-1	-1	-1
0295	1424	1424	-1	-1	1160	1120	9580	7520	-1	-1	-1	-1	-1	-1	-1
0296	1428	1428	-1	-1	1200	1160	9860	7940	-1	-1	-1	-1	-1	-1	-1
0297	1432	1432	-1	-1	1220	1140	9580	7640	-1	-1	-1	-1	-1	-1	-1
0298	1436	1436	-1	-1	960	940	10040	8520	-1	-1	-1	-1	-1	-1	-1
0299	1444	1444	-1	-1	1560	1400	7360	7240	-1	-1	-1	-1	-1	-1	-1
0300	1448	1448	-1	-1	800	700	9400	7920	-1	-1	-1	-1	-1	-1	-1
0301	1452	1452	-1	-1	1520	1340	9720	7740	-1	-1	-1	-1	-1	-1	-1
0302	1456	1456	-1	-1	1600	1460	9800	7900	-1	-1	-1	-1	-1	-1	-1
0303	1468	1468	-1	-1	1300	1140	9440	7620	-1	-1	-1	-1	-1	-1	-1
0304	1472	1472	-1	-1	820	800	9160	7340	-1	-1	-1	-1	-1	-1	-1
0305	1476	1476	-1	-1	1120	-1	8400	7160	-1	-1	-1	-1	-1	-1	-1
0306	1480	1480	-1	-1	1300	1260	8300	6300	-1	-1	-1	-1	-1	-1	-1
0307	1484	1484	-1	-1	1380	1320	9160	6640	-1	-1	-1	-1	-1	-1	-1
0308	1488	1488	-1	-1	2420	2300	9060	6500	-1	-1	-1	-1	-1	-1	-1
0309	1492	1492	-1	-1	1700	1600	9580	5720	-1	-1	-1	-1	-1	-1	-1
0310	1496	1496	-1	-1	1500	1350	8740	6420	-1	-1	-1	-1	-1	-1	-1
0311	1500	1500	-1	-1	1500	1450	9080	6260	-1	-1	-1	-1	-1	-1	-1
0312	1504	1504	-1	-1	1650	1600	8660	6420	-1	-1	-1	-1	-1	-1	-1
0313	1508	1508	-1	-1	1150	1050	9060	6160	-1	-1	-1	-1	-1	-1	-1
0314	1512	1512	-1	-1	2000	1600	8580	5860	-1	-1	-1	-1	-1	-1	-1
0315	1516	1516	-1	-1	-1	-1	9100	5840	-1	-1	-1	-1	-1	-1	-1
0316	1520	1520	-1	-1	5150	4000	8200	5380	-1	-1	-1	-1	-1	-1	-1
0317	1524	1524	-1	-1	5150	-1	11090	3720	-1	-1	-1	-1	-1	-1	-1
0318	1528	1528	-1	-1	3950	2950	12020	2040	-1	-1	-1	-1	-1	-1	-1

Run #5 (1368-1748hrs)

0319	1564	1564	-1	-1	1700	1550	6460	1740	-1	-1	-1	-1	-1	-1	-1
0320	1568	1568	-1	-1	400	350	4860	1520	-1	-1	-1	-1	-1	-1	-1
0321	1572	1572	-1	-1	850	-1	6260	4540	-1	-1	-1	-1	-1	-1	-1
0322	1576	1576	-1	-1	1250	1200	8740	5680	-1	-1	-1	-1	-1	-1	-1
0323	1580	1580	-1	-1	1250	1200	9020	6620	-1	-1	-1	-1	-1	-1	-1
0324	1584	1584	-1	-1	1550	1500	9060	6340	-1	-1	-1	-1	-1	-1	-1
0325	1588	1588	-1	-1	1400	1300	8460	6800	-1	-1	-1	-1	-1	-1	-1
0326	1592	1592	-1	-1	2050	2000	9440	7580	-1	-1	-1	-1	-1	-1	-1
0327	1596	1596	-1	-1	2300	2200	10280	7580	-1	-1	-1	-1	-1	-1	-1
0328	1600	1600	-1	-1	2300	2250	11680	8080	-1	-1	-1	-1	-1	-1	-1
0329	1612	1612	-1	-1	-1	-1	11660	8360	-1	-1	-1	-1	-1	-1	-1
0330	1616	1616	-1	-1	-1	-1	11300	8840	-1	-1	-1	-1	-1	-1	-1
0331	1620	1620	-1	-1	-1	-1	11100	8200	-1	-1	-1	-1	-1	-1	-1
0332	1624	1624	-1	-1	-1	-1	11080	8160	-1	-1	-1	-1	-1	-1	-1
0333	1628	1628	-1	-1	-1	-1	11180	7860	-1	-1	-1	-1	-1	-1	-1
0334	1632	1632	-1	-1	-1	-1	11160	7800	-1	-1	-1	-1	-1	-1	-1
0335	1636	1636	-1	-1	1500	1450	11720	8160	-1	-1	-1	-1	-1	-1	-1
0336	1640	1640	-1	-1	1900	1750	11300	8800	-1	-1	-1	-1	-1	-1	-1
0337	1644	1644	-1	-1	1500	1300	11660	9020	-1	-1	-1	-1	-1	-1	-1
0338	1648	1648	-1	-1	1500	1050	12820	9380	-1	-1	-1	-1	-1	-1	-1
0339	1652	1652	-1	-1	1300	1200	13620	9300	-1	-1	-1	-1	-1	-1	-1
0340	1656	1656	-1	-1	1650	1400	10600	7740	-1	-1	-1	-1	-1	-1	-1
0341	1660	1660	-1	-1	2050	1850	10780	8320	-1	-1	-1	-1	-1	-1	-1
0342	1664	1664	-1	-1	2050	1900	11020	7900	-1	-1	-1	-1	-1	-1	-1
0343	1668	1668	-1	-1	1800	1600	11460	7700	-1	-1	-1	-1	-1	-1	-1
0344	1672	1672	-1	-1	2000	1800	10960	7000	-1	-1	-1	-1	-1	-1	-1
0345	1676	1676	-1	-1	-1	-1	10980	6720	-1	-1	-1	-1	-1	-1	-1
0346	1708	1708	-1	-1	-1	-1	11500	6640	-1	-1	-1	-1	-1	-1	-1
0347	1712	1712	-1	-1	-1	-1	11700	8100	-1	-1	-1	-1	-1	-1	-1
0348	1716	1716	-1	-1	-1	-1	10840	7620	-1	-1	-1	-1	-1	-1	-1
0349	1720	1720	-1	-1	-1	-1	10540	6800	-1	-1	-1	-1	-1	-1	-1
0350	1728	1728	-1	-1	1350	1300	8860	5880	-1	-1	-1	-1	-1	-1	-1
0351	1732	1732	-1	-1	2400	2350	8980	6100	-1	-1	-1	-1	-1	-1	-1
0352	1736	1736	-1	-1	2400	2350	9620	6640	-1	-1	-1	-1	-1	-1	-1
0353	1740	1740	-1	-1	2250	2100	9340	6140	-1	-1	-1	-1	-1	-1	-1
0354	1744	1744	-1	-1	2600	2400	9360	5860	-1	-1	-1	-1	-1	-1	-1
0355	1748	1748	-1	-1	1020	960	7060	5600	-1	-1	-1	-1	-1	-1	-1
0356	1752	1752	-1	-1	1550	1450	7580	5520	-1	-1	-1	-1	-1	-1	-1
0357	1756	1756	-1	-1	1660	1550	7280	5240	-1	-1	-1	-1	-1	-1	-1
0358	1760	1760	-1	-1	2200	2050	7760	5260	-1	-1	-1	-1	-1	-1	-1
0359	1764	1764	-1	-1	2050	1950	7500	5260	-1	-1	-1	-1	-1	-1	-1
0360	1768	1768	-1	-1	2200	1950	7520	5180	-1	-1	-1	-1	-1	-1	-1
0361	1772	1772	-1	-1	1860	1720	7120	5320	-1	-1	-1	-1	-1	-1	-1
0362	1780	1780	-1	-1	1900	1850	8060	5060	-1	-1	-1	-1	-1	-1	-1
0363	1784	1784	-1	-1	2200	2100	7520	5080	-1	-1	-1	-1	-1	-1	-1
0364	1788	1788	-1	-1	2000	1900	7740	5060	-1	-1	-1	-1	-1	-1	-1
0365	1792	1792	-1	-1	2500	-1	7860	5160	-1	-1	-1	-1	-1	-1	-1
0366	1796	1796	-1	-1	1800	1700	7100	4940	-1	-1	-1	-1	-1	-1	-1
0367	1804	1804	-1	-1	1150	1100	6360	4920	-1	-1	-1	-1	-1	-1	-1
0368	1808	1808	-1	-1	950	800	6140	4740	-1	-1	-1	-1	-1	-1	-1
0369	1812	1812	-1	-1	900	-1	5740	4640	-1	-1	-1	-1	-1	-1	-1
0370	1816	1816	-1	-1	800	750	5760	4640	-1	-1	-1	-1	-1	-1	-1
0371	1820	1820	-1	-1	650	600	5720	4520	-1	-1	-1	-1	-1	-1	-1
0372	1824	1824	-1	-1	900	850	5520	4140	-1	-1	-1	-1	-1	-1	-1
0373	1828	1828	-1	-1	360	-1	4660	4340	-1	-1	-1	-1	-1	-1	-1
0374	1832	1832	-1	-1	400	300	4480	4000	-1	-1	-1	-1	-1	-1	-1
0375	1836	1836	-1	-1	320	260	4700	4100	-1	-1	-1	-1	-1	-1	-1
0376	1840	1840	-1	-1	380	360	4580	4180	-1	-1	-1	-1	-1	-1	-1
0377	1844	1844	-1	-1	400	380	4940	4460	-1	-1	-1	-1	-1	-1	-1
0378	1848	1848	-1	-1	500	560	4900	4400	-1	-1	-1	-1	-1	-1	-1
0379	1852	1852	-1	-1	540	440	5360	4300	-1	-1	-1	-1	-1	-1	-1
0380	1856	1856	-1	-1	740	600	5120	4260	-1	-1	-1	-1	-1	-1	-1
0381	1860	1860	-1	-1	1100	900	5700	4320	-1	-1	-1	-1	-1	-1	-1
0382	1864	1864	-1	-1	1450	1350	6280	4700	-1	-1	-1	-1	-1	-1	-1
0383	1868	1868	-1	-1	1350	950	6920	4580	-1	-1	-1	-1	-1	-1	-1
0384	1872	1872	-1	-1	1150	950	7000	5220	-1	-1	-1	-1	-1	-1	-1
0385	1876	1876	-1	-1	950	800	6440	4920	-1	-1	-1	-1	-1	-1	-1
0386	1880	1880	-1	-1	1600	1150	6280	4740	-1	-1	-1	-1	-1	-1	-1
0387	1884	1884	-1	-1	1150	1050	6700	4940	-1	-1	-1	-1	-1	-1	-1
0388	1896	1896	-1	-1	1550	1350	6780	4800	-1	-1	-1	-1	-1	-1	-1
0389	1900	1900	-1	-1	1000	750	6800	4920	-1	-1	-1	-1	-1	-1	-1
0390	1940	1940	-1	-1	-1	-1	5900	4860	-1	-1	-1	-1	-1	-1	-1
0391	1944	1944	-1	-1	-1	-1	8720	5540	-1	-1	-1	-1	-1	-1	-1
0392	1952	1952	-1	-1	-1	-1	6580	4960	-1	-1	-1	-1	-1	-1	-1
0393	1956	1956	-1	-1	-1	-1	6920	4960	-1	-1	-1	-1	-1	-1	-1
0394	1960	1960	-1	-1	-1	-1	7160	5260	-1	-1	-1	-1	-1	-1	-1
0395	1968	1968	-1	-1	800	350	7160	5360	-1	-1	-1	-1	-1	-1	-1
0396	1972	1972	-1	-1	820	620	7200	5400	-1	-1	-1	-1	-1	-1	-1
0397	1976	1976	-1	-1	750	650	5460	4220	-1	-1	-1	-1	-1	-1	-1
0398	1980	1980	-1	-1	750	730	5740	4020	-1	-1	-1	-1	-1	-1	-1

Run #6 (1752-2061hrs)

0399	1984	1984	-1	-1	350	150	5300	3900	-1	-1	-1	-1	-1	-1	-1
0400	1988	1988	-1	-1	750	600	5600	4020	-1	-1	-1	-1	-1	-1	-1
0401	1992	1992	-1	-1	500	300	5460	3900	-1	-1	-1	-1	-1	-1	-1
0402	1996	1996	-1	-1	750	700	5260	3900	-1	-1	-1	-1	-1	-1	-1
0403	2000	2000	-1	-1	200	-1	5000	3820	-1	-1	-1	-1	-1	-1	-1
0404	2004	2004	-1	-1	300	-1	5100	4280	-1	-1	-1	-1	-1	-1	-1
0405	2008	2008	-1	-1	350	-1	5260	4320	-1	-1	-1	-1	-1	-1	-1
0406	2012	2012	-1	-1	500	150	5280	4360	-1	-1	-1	-1	-1	-1	-1
0407	2016	2016	-1	-1	700	500	5140	3960	-1	-1	-1	-1	-1	-1	-1
0408	2020	2020	-1	-1	950	700	4640	4100	-1	-1	-1	-1	-1	-1	-1
0409	2024	2024	-1	-1	400	350	3160	2680	-1	-1	-1	-1	-1	-1	-1
0410	2028	2028	-1	-1	850	600	3820	3100	-1	-1	-1	-1	-1	-1	-1
0411	2032	2032	-1	-1	350	200	4300	3540	-1	-1	-1	-1	-1	-1	-1
0412	2036	2036	-1	-1	800	500	4560	3820	-1	-1	-1	-1	-1	-1	-1
0413	2040	2040	-1	-1	1050	900	5260	4060	-1	-1	-1	-1	-1	-1	-1
0414	2044	2044	-1	-1	750	600	5360	4440	-1	-1	-1	-1	-1	-1	-1
0415	2048	2048	-1	-1	400	150	5400	4000	-1	-1	-1	-1	-1	-1	-1
0416	2052	2052	-1	-1	550	250	5500	4220	-1	-1	-1	-1	-1	-1	-1
0417	2056	2056	-1	-1	650	350	5220	3820	-1	-1	-1	-1	-1	-1	-1
0418	2066	2066	-1	-1	420	320	4160	3320	-1	-1	-1	-1	-1	-1	-1
0419	2070	2070	-1	-1	740	720	5320	4280	-1	-1	-1	-1	-1	-1	-1
0420	2074	2074	-1	-1	620	560	6820	5300	-1	-1	-1	-1	-1	-1	-1
→ 0421	2078	2078	-1	-1	580	560	7300	5740	-1	-1	-1	-1	-1	-1	-1
0422	2082	2082	-1	-1	640	560	7660	5940	-1	-1	-1	-1	-1	-1	-1
0423	2086	2086	-1	-1	400	440	7720	6120	-1	-1	-1	-1	-1	-1	-1
0424	2090	2090	-1	-1	480	-1	5340	4480	-1	-1	-1	-1	-1	-1	-1
0425	2094	2094	-1	-1	500	480	6280	5100	-1	-1	-1	-1	-1	-1	-1
0426	2098	2098	-1	-1	380	360	5480	4280	-1	-1	-1	-1	-1	-1	-1
0427	2102	2102	-1	-1	380	-1	4440	3660	-1	-1	-1	-1	-1	-1	-1
0428	2106	2106	-1	-1	320	300	4280	3280	-1	-1	-1	-1	-1	-1	-1
0429	2110	2110	-1	-1	320	-1	3580	3300	-1	-1	-1	-1	-1	-1	-1
0430	2114	2114	-1	-1	200	-1	3780	3440	-1	-1	-1	-1	-1	-1	-1
0431	2118	2118	-1	-1	280	-1	3560	3220	-1	-1	-1	-1	-1	-1	-1
0432	2138	2138	-1	-1	820	800	5700	4940	-1	-1	-1	-1	-1	-1	-1
0433	2142	2142	-1	-1	580	560	5340	4580	-1	-1	-1	-1	-1	-1	-1
0434	2146	2146	-1	-1	520	500	5560	4480	-1	-1	-1	-1	-1	-1	-1
0435	2150	2150	-1	-1	560	-1	5700	4520	-1	-1	-1	-1	-1	-1	-1
0436	2154	2154	-1	-1	880	860	6100	4540	-1	-1	-1	-1	-1	-1	-1
0437	2158	2158	-1	-1	840	800	6160	4480	-1	-1	-1	-1	-1	-1	-1
0438	2162	2162	-1	-1	860	820	6640	4440	-1	-1	-1	-1	-1	-1	-1
0439	2166	2166	-1	-1	960	940	6260	4800	-1	-1	-1	-1	-1	-1	-1
0440	2170	2170	-1	-1	820	800	6840	4960	-1	-1	-1	-1	-1	-1	-1
0441	2174	2174	-1	-1	860	820	7060	5100	-1	-1	-1	-1	-1	-1	-1
0442	2178	2178	-1	-1	920	900	6700	5000	-1	-1	-1	-1	-1	-1	-1
0443	2182	2182	-1	-1	1020	-1	6460	4940	-1	-1	-1	-1	-1	-1	-1
0444	2186	2186	-1	-1	1000	-1	6820	5700	-1	-1	-1	-1	-1	-1	-1
0445	2190	2190	-1	-1	880	860	5720	4620	-1	-1	-1	-1	-1	-1	-1
0446	2194	2194	-1	-1	780	760	5200	4580	-1	-1	-1	-1	-1	-1	-1
0447	2198	2198	-1	-1	680	660	5140	4240	-1	-1	-1	-1	-1	-1	-1
0448	2202	2202	-1	-1	760	-1	4940	4120	-1	-1	-1	-1	-1	-1	-1
0449	2206	2206	-1	-1	540	520	4840	3820	-1	-1	-1	-1	-1	-1	-1
0450	2210	2210	-1	-1	370	340	4360	3760	-1	-1	-1	-1	-1	-1	-1
0451	2214	2214	-1	-1	380	370	6100	4760	-1	-1	-1	-1	-1	-1	-1
0452	2218	2218	-1	-1	430	420	6800	5360	-1	-1	-1	-1	-1	-1	-1
0453	2222	2222	-1	-1	410	400	7440	5420	-1	-1	-1	-1	-1	-1	-1
0454	2226	2226	-1	-1	420	410	7320	5600	-1	-1	-1	-1	-1	-1	-1
0455	2230	2230	-1	-1	450	400	7600	5380	-1	-1	-1	-1	-1	-1	-1
0456	2234	2234	-1	-1	800	780	7600	5540	-1	-1	-1	-1	-1	-1	-1
0457	2238	2238	-1	-1	1080	940	8360	6660	-1	-1	-1	-1	-1	-1	-1
0458	2242	2242	-1	-1	1000	960	9180	7520	-1	-1	-1	-1	-1	-1	-1
0459	2246	2246	-1	-1	1160	1100	9640	7540	-1	-1	-1	-1	-1	-1	-1
0460	2250	2250	-1	-1	1120	1060	10340	8160	-1	-1	-1	-1	-1	-1	-1
0461	2254	2254	-1	-1	1200	-1	10820	8620	-1	-1	-1	-1	-1	-1	-1
0462	2258	2258	-1	-1	660	640	10040	9120	-1	-1	-1	-1	-1	-1	-1
0463	2262	2262	-1	-1	580	460	8960	7600	-1	-1	-1	-1	-1	-1	-1
0464	2266	2266	-1	-1	340	320	8300	6800	-1	-1	-1	-1	-1	-1	-1
0465	2270	2270	-1	-1	520	380	7760	6200	-1	-1	-1	-1	-1	-1	-1
0466	2274	2274	-1	-1	320	280	7240	5560	-1	-1	-1	-1	-1	-1	-1
0467	2278	2278	-1	-1	380	340	7780	5380	-1	-1	-1	-1	-1	-1	-1
0468	2282	2282	-1	-1	320	300	6420	5340	-1	-1	-1	-1	-1	-1	-1
0469	2286	2286	-1	-1	340	240	5120	4340	-1	-1	-1	-1	-1	-1	-1
0470	2290	2290	-1	-1	240	200	4520	4000	-1	-1	-1	-1	-1	-1	-1
0491	2294	2294	-1	-1	320	240	4260	3640	-1	-1	-1	-1	-1	-1	-1
0472	2298	2298	-1	-1	280	240	3760	3320	-1	-1	-1	-1	-1	-1	-1
0473	2302	2302	-1	-1	320	240	3580	2980	-1	-1	-1	-1	-1	-1	-1
0474	2306	2306	-1	-1	300	240	4080	3400	-1	-1	-1	-1	-1	-1	-1
0475	2310	2310	-1	-1	320	300	4480	3700	-1	-1	-1	-1	-1	-1	-1
0476	2314	2314	-1	-1	320	300	4580	3900	-1	-1	-1	-1	-1	-1	-1
0477	2330	2330	-1	-1	400	380	3640	2960	-1	-1	-1	-1	-1	-1	-1
0478	2334	2334	-1	-1	380	300	4320	3580	-1	-1	-1	-1	-1	-1	-1

Dynamic Run
(2066-2498hrs)

0479	2338	2338	-1	-1	200	190	3800	3240	-1	-1	-1	-1	-1	-1	-1
0480	2342	2342	-1	-1	230	180	3640	2940	-1	-1	-1	-1	-1	-1	-1
0481	2346	2346	-1	-1	230	180	3640	2760	-1	-1	-1	-1	-1	-1	-1
0482	2350	2350	-1	-1	210	190	3560	2660	-1	-1	-1	-1	-1	-1	-1
0483	2358	2358	-1	-1	270	200	3420	2760	-1	-1	-1	-1	-1	-1	-1
0484	2362	2362	-1	-1	280	220	3180	2420	-1	-1	-1	-1	-1	-1	-1
0485	2366	2366	-1	-1	260	190	3020	2140	-1	-1	-1	-1	-1	-1	-1
0486	2370	2370	-1	-1	290	240	3060	2020	-1	-1	-1	-1	-1	-1	-1
0487	2374	2374	-1	-1	300	280	2960	1980	-1	-1	-1	-1	-1	-1	-1
0488	2378	2378	-1	-1	310	240	3360	2320	-1	-1	-1	-1	-1	-1	-1
0489	2382	2382	-1	-1	310	270	4260	3620	-1	-1	-1	-1	-1	-1	-1
0490	2386	2386	-1	-1	360	270	4920	3740	-1	-1	-1	-1	-1	-1	-1
0491	2390	2390	-1	-1	380	280	5240	4180	-1	-1	-1	-1	-1	-1	-1
0492	2394	2394	-1	-1	370	310	5620	4220	-1	-1	-1	-1	-1	-1	-1
0493	2398	2398	-1	-1	390	360	5620	4220	-1	-1	-1	-1	-1	-1	-1
0494	2406	2406	-1	-1	550	460	5940	4760	-1	-1	-1	-1	-1	-1	-1
0495	2410	2410	-1	-1	420	330	6380	5360	-1	-1	-1	-1	-1	-1	-1
0496	2414	2414	-1	-1	400	390	7160	6180	-1	-1	-1	-1	-1	-1	-1
0497	2418	2418	-1	-1	390	340	8260	6980	-1	-1	-1	-1	-1	-1	-1
0498	2422	2422	-1	-1	390	340	7700	6780	-1	-1	-1	-1	-1	-1	-1
0499	2426	2426	-1	-1	440	420	7140	6380	-1	-1	-1	-1	-1	-1	-1
0500	2430	2430	-1	-1	460	440	8100	7560	-1	-1	-1	-1	-1	-1	-1
0501	2434	2434	-1	-1	580	-1	9140	7700	-1	-1	-1	-1	-1	-1	-1
0502	2438	2438	-1	-1	600	560	9580	8540	-1	-1	-1	-1	-1	-1	-1
0503	2442	2442	-1	-1	720	700	10320	8640	-1	-1	-1	-1	-1	-1	-1
0504	2446	2446	-1	-1	760	740	10060	8580	-1	-1	-1	-1	-1	-1	-1
0505	2450	2450	-1	-1	620	520	9700	8780	-1	-1	-1	-1	-1	-1	-1
0506	2454	2454	-1	-1	580	560	9340	7780	-1	-1	-1	-1	-1	-1	-1
0507	2458	2458	-1	-1	460	440	7080	6960	-1	-1	-1	-1	-1	-1	-1
0508	2462	2462	-1	-1	360	320	7320	6400	-1	-1	-1	-1	-1	-1	-1
0509	2466	2466	-1	-1	260	240	6580	5740	-1	-1	-1	-1	-1	-1	-1
0510	2470	2470	-1	-1	300	280	6000	5120	-1	-1	-1	-1	-1	-1	-1
0511	2474	2474	-1	-1	460	440	5800	5160	-1	-1	-1	-1	-1	-1	-1
0512	2478	2478	-1	-1	360	320	5640	5200	-1	-1	-1	-1	-1	-1	-1
0513	2482	2482	-1	-1	360	340	5580	4520	-1	-1	-1	-1	-1	-1	-1
0514	2486	2486	-1	-1	380	360	5440	4440	-1	-1	-1	-1	-1	-1	-1
0515	2490	2490	-1	-1	420	400	5460	4360	-1	-1	-1	-1	-1	-1	-1
0516	2494	2494	-1	-1	400	380	5620	4100	-1	-1	-1	-1	-1	-1	-1
0517	2498	2498	-1	-1	560	500	5160	4160	-1	-1	-1	-1	-1	-1	-1
0518	2502	2502	-1	-1	480	460	5060	4540	-1	-1	-1	-1	-1	-1	-1
0519	2506	2506	-1	-1	440	420	5560	3800	-1	-1	-1	-1	-1	-1	-1
0520	2510	2510	-1	-1	560	540	5300	3860	-1	-1	-1	-1	-1	-1	-1
0521	2514	2514	-1	-1	480	460	5420	3800	-1	-1	-1	-1	-1	-1	-1
0522	2518	2518	-1	-1	480	-1	5500	3900	-1	-1	-1	-1	-1	-1	-1