GASIFICATION OF BIOMASS IN A DOWNDRAFT REACTOR

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Doctor of Philosophy

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SUMMARY

The objective of this study was to design, construct, commission and operate a laboratory scale gasifier system that could be used to investigate the parameters that influence the gasification process.

The gasifier is of the open-core variety and is fabricated from 7.5 cm bore quartz glass tubing. Gas cleaning is by a centrifugal contacting scrubber, with the product gas being flared. The system employs an on-line dedicated gas analysis system, monitoring the levels of H_2, CO, CO_2 and CH_4 in the product gas. The gas composition data, as well as the gas flowrate, temperatures throughout the system and pressure data is recorded using a BBC microcomputer based data-logging system.

Ten runs have been performed using the system of which six were predominately commissioning runs. The main emphasis in the commissioning runs was placed on the gas sample clean-up, the product gas cleaning and the reactor bed temperature measurement.

The reaction was observed to occur in a narrow band, of about 3 to 5 particle diameters thick. Initially the fuel was pyrolysed, with the volatiles produced being combusted and providing the energy to drive the process, and then the char product was gasified by reaction with the pyrolysis gases. Normally, the gasifier is operated with reaction zone supported on a bed of char, although it is has been operated for short periods without a char bed. At steady state the depth of char remains constant, but by adjusting the air inlet rate it has been shown that the depth of char can be increased or decreased. It has been shown that increasing the depth of the char bed effects some improvement in the product gas quality.

Key Words: Biomass; Downdraft; Gasification; Open-core; Stratified

DEDICATION

To my mother, Mrs Anita Earp and my grandmother, Mrs Doris Earp, neither of whom lived to see the completion of this work.

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CHAPTER 1
INTRODUCTION

The oil crisis of 1973 and the recognition that the world's non-renewable fossil energy resources are finite, has resulted in increased activity in the search for alternative energy sources. The major industrialised nations appeared to view nuclear power as the most likely alternative, despite the controversy surrounding its introduction. However, in recent years, a number of countries, notably the USA, Sweden and Italy, seem to have reassessed their future energy generation schemes and have cut back or shelved their nuclear programmes. In the UK, the government spends £200 million per annum on the UKAEA [1]. There is, however, expenditure on other alternatives including biomass, wind power, geothermal sources and solar power, although in 1985/86 this only totalled £14 million, of which 43 % was spent on land based wind power [2] and accounted for only about 1.4 % of the total expenditure on energy research and development [3].

Biomass, which is a generic name for a variety of materials including crops, wood, agricultural waste and both industrial and domestic waste, represents a large potential resource within the EEC. In 1982, 2070 million tons of waste were produced [4] and could provide an estimated 7% of the EEC's energy needs by the start of the next century [5].

One possible method of utilising biomass is by direct combustion. However, although combustion technology is well developed, only thermal energy is produced and is limited to the production of either steam, hot water or hot air. The value and usefulness of the biomass can be increased by converting it to more readily stored gaseous, liquid or solid fuels. These fuels can, in principle, be burned more efficiently, with only minor modifications being made to existing equipment.

Gaseous fuels have many advantages over solid fuels. Gas can be distributed easily; its combustion can be controlled to give high efficiency; it burns with low emissions, in particular smoke; and it burns at a high temperature thus making it suitable for many applications. In many modern manufacturing processes, gaseous fuels are a prerequisite. A given amount of energy is worth two to four times as much in the form of gas as it would be in the form of a solid fuel [6].

Biomass can be upgraded to either liquid or gaseous fuels by a variety of processes: biochemical techniques such as digestion and fermentation; or thermochemical methods including gasification, pyrolysis, flash pyrolysis or liquefaction. The thermochemical processes are generally more efficient than the biochemical routes. The biological processes can only convert a fraction of the biomass into energy as the organisms employed cannot attack all of the biomass components. Lignin, which is a component of many biomass materials, cannot be broken down using existing biological processes. The use of thermochemical conversion techniques is, therefore, seen by many to be the most sensible route to produce energy from biomass.

Of the thermochemical processes available, gasification is the most popular and has seen a considerable resurgence of interest over the last twenty years [7]. The technology of gasification is not new. The first gasifiers, using either peat or coal as fuel, were built about 150 years ago [8] and their use reached a peak during the Second World War. The actual process of gasification involves the heating of the biomass fuel with a gasifying agent, which may be either air, oxygen, steam or various combinations of these three reagents, so that the biomass undergoes 'oxygen starved combustion'. The main product is a gas of which the main components are generally, hydrogen, carbon monoxide, carbon dioxide and methane. Nitrogen will be present if air is employed as the gasifying agent and higher hydrocarbon gases are often present in small amounts. This gaseous product can be used , either directly as a fuel, for example to provide heat, electrical or mechanical power; or as a chemical precursor (syngas), for example to produce alcohols or synthetic gasoline.

A number of different reactor types and configurations are available in which to gasify the biomass. The oldest type of gasifier is the fixed bed which is available in co-current or counter-current varieties, with the gas flowing either up or down through the reactor. Other types of gasifier available include fluid bed and entrained flow and there are a variety of hybrids and specialised reactor types. The selection of reactor geometry depends on a number of criteria related to the size of the unit required, the end use of the product gas and properties of the biomass fuel.

However, although gasifiers have been used for many years, the approach to their design is still rather more of an art form than a scientific process, although a great deal of work is being performed worldwide to develop robust design procedures. Many of the parameters that influence the gasification process have been identified but have not, as yet, been quantified. In order to optimise the design of gasifiers and obtain systems that are both efficient and adaptable, these parameters must be quantified.

The objectives of this project, therefore, were to design, construct, commission and operate a gasifier system that could be used to investigate these parameters. In addition to the investigation of the controlling parameters, the system was also to be employed to investigate secondary processing techniques that could be employed to improve gas quality.

This thesis describes the work undertaken during this project. This includes a critical literature review in which the principles of gasification and the different types of gasifier available are discussed, and concentrates on a comparison of the design and performance of open-core and throated downdraft gasifiers. The literature review also includes details of the models available for open-core downdraft systems. A large portion of the project was dedicated to the design and the commissioning of the gasifier system and, therefore, this is discussed in detail. The feed materials employed for all the runs performed and the analysis of their properties, and experimental work undertaken including the selection of the variables investigated, are also described. The results of the experimentation and the conclusions and recommendations based on these results are presented at the end of the thesis.

CHAPTER 2
LITERATURE REVIEW AND GASIFICATION THEORY

2.1 INTRODUCTION

This chapter covers the literature review performed as part of this project. The theory of gasification is also discussed as it is closely linked to the developments in gasifier design. The literature review covers the following main topics:

1) An explanation of the basic principles of thermochemical gasification of biomass.

2) A discussion of the types of gasifier available outlining their advantages and disadvantages.

3) A description of downdraft gasifiers with particular reference to construction, performance differences and limitations.

4) The design and modelling of open-core downdraft gasifiers.

2.2 BIOMASS GASIFICATION

Gasification is the reaction, at an elevated temperature, of a carbonaceous material, such as biomass, coal or peat with an oxidising agent, the gasifying agent, which is usually either air, oxygen, steam or various mixtures of these three reagents. The carbonaceous material and the gasifying agent react so that 'partial' or 'oxygen starved' combustion occurs. Ideally, the carbonaceous fuel is entirely converted to a combustible gas, consisting of hydrogen, carbon monoxide, carbon dioxide, methane, water, nitrogen (when the gasifying agent contains air) and possibly higher hydrocarbons, such as, ethane, ethene and propane. However, in reality, in addition to the gaseous products, a solid residue of char, mainly carbon and inorganic ash present in the fuel, and an organic liquid or tar may also be produced. For many applications, the non-gaseous products and, in particular, the tars are undesirable and must be either removed and/or their production minimised.

The gasification process is not simple. A particle of biomass fuel that is being gasified will undergo a number of different processes. Initially, the fuel particle will dry, with moisture in the particle being evaporated; the particle will then pyrolyse, that is thermally decompose (see Section 2.2.1); and subsequently be gasified, the partial oxidation of the pyrolysis products (see Section 2.2.2). However, this process is extremely complicated as an individual particle in a gasifier may be drying, pyrolysing and gasifying simultaneously.

Gasification processes, as described above, are autothermal or energetically self-sufficient, thus requiring no external heat source. The energy to drive the drying and pyrolysis processes and endothermic reactions is provided effectively by combustion of part of the pyrolysis products, or the exothermic reactions in the partial oxidation step.

2.2.1 Pyrolysis

Pyrolysis is the irreversible but incomplete thermal degradation of the biomass fuel and generally occurs at temperatures in excess of 250 °C. Three main product groups are produced when a biomass fuel is pyrolysed:

i) Char - the solid residue of the fuel consisting mainly of carbon but also containing some hydrogen and oxygen. The char may also contain 'ash' from the biomass fuel, which is inorganic and generally contains: CaO, K_2O, Na_2O, MgO, SiO_2, Fe_2O_3, P_2O_5, SO_3 and Cl_2 [9].

ii) Condensibles - a complex mixture of up to 200 different compounds [10]. The liquid mixture contains two phases, an organic and an aqueous phase. The aqueous phase is acidic due to the presence of organic acids, but is up to 80 - 90 % water [11] which is produced by the drying of the feed and by reaction. The organic phase contains the water insoluble products and consists mainly of oxygenated hydrocarbons. The temperatures reached within a gasifier cause these condensibles to be produced in the vapour phase as both true vapours and a mist.

iii) Gases - a mixture of hydrogen, carbon monoxide, carbon dioxide and short chain hydrocarbons, notably methane, but also contain ethane, ethene, propane and propene.

The relative yields of the gaseous, liquid and solid products are a function of the pyrolysis reaction conditions such as: reaction temperature, particle heating rate, fuel moisture content, particle size, composition of the ambient atmosphere, pressure and vapour residence time (see Table 2.1 below).

Table 2.1 Influence of Reaction Conditions on Relative Yields of Pyrolysis Products

Increasing	Yield of: Char	High MW Liquids	Low MW Liquids	Gas
Reaction temperaure	Decreases	Decreases	Increases	Increases
Particle heating rate	Decreases	Increases*		Decreases
Feed moisture content	Increases	Decreases*		Decreases
Vapour residence time	Decreases	Decreases	Increases	Increases
Particle Size	Increases	Decreases*		Increases
Pressure	Increases	Decreases*		Decreases

* Total liquid products.

Based on data from [10], [12], [13] and [14].

2.2.2 Gasification

In the gasification stage, all the pyrolysis products undergo a series of reduction and oxidation reactions to produce the final product gas containing predominantly hydrogen, carbon monoxide, carbon dioxide, methane and water. Gasification generally occurs at temperatures in excess of 750 °C.

Much of the work in the literature does not cover the reaction of the tars in the gasification stage but concentrates on the reactions of the soiid and non-condensible pyrolysis products with each other and the gasifying agent. These reactions are usually summarised thus:

(a) Heterogeneous (gas-solid) reactions:

Oxidation of carbon:

(1) $C + 1/2O_2 \longrightarrow CO$ $\Delta H = -110.6$ KJ mol^{-1}

(2) $C + O_2 \longrightarrow CO_2$ $\Delta H = -393.8$ KJ mol^{-1}

(3) The Boudouard reaction

$C + CO_2 \longrightarrow 2CO$ $\Delta H = 172.6$ KJ mol^{-1}

(4) Water gas reaction

$C + H_2O \Longleftrightarrow H_2 + CO$ $\Delta H = 131.4$ KJ mol^{-1}

(5) Methane formation

$C + H_2 \longrightarrow CH_4$ $\Delta H = -74.93$ KJ mol^{-1}

(b) Homogeneous (gas phase) reactions:

(6) $CO + 1/2O_2 \longrightarrow CO_2$ $\Delta H = -283.8$ KJ mol^{-1}

(7) Water-Gas Shift Reaction

$CO + H_2O \Longleftrightarrow CO_2 + H_2$ $\Delta H = -41.2$ KJ mol^{-1}

(8) $CH_4 + H_2O \Longleftrightarrow CO + 3H_2$ $\Delta H = 201.9$ KJ mol^{-1}

(9) $H_2 + 1/2O_2 \longrightarrow H_2O$ $\Delta H = -241.8$ KJ mol^{-1}

(10) $2CO + 2H_2 \Longleftrightarrow CH_4 + CO_2$ $\Delta H = -247.3$ KJ mol^{-1}

(11) $CO_2 + 4H_2 \Longleftrightarrow CH_4 + 2H_2O$ $\Delta H = -164.7$ KJ mol^{-1}

The condensible and non-condensible organics formed during pyrolysis may be gasified in two ways: firstly, they may be thermally cracked; or they may be broken down by reaction with the gasifying agent and the other pyrolysis products (as above).

2.3 TYPES OF GASIFIER

Many different types of reactor have been developed for the gasification and pyrolysis of carbonaceous fuels. Types of reactor that have been developed include moving bed, fluidised bed, entrained flow, rotary kiln and molten salt. A variety of different techniques have been developed for the classification of the various reactor types.

In this thesis, gasifiers are classified by 'density factor', that is the ratio of the volume of biomass present in the reactor under normal operating conditions to the total reactor volume. The density factor is an important characteristic of gasifiers allowing them to be classified as either dense or lean phase reactors which distinguishes between the two main distinct gasifier types. Dense phase reactors tend to have distinct reaction zones (see Section 2.3.1) and lean phase reactors tend to be homogenous with no distinct reaction zones (see Section 2.3.2). Typical values for the density factor are in the range of 0.5 to 0.8 for dense phase reactors and 0.05 to 0.2 for lean phase systems [4].

2.3.1 Dense Phase Reactors

There are a variety of dense phase reactors of which the three main types recognised in the general literature are the counter-current updraft, co-current downdraft and crossdraft reactors However, in recent years, the updraft and downdraft reactors have seen much wider use than the crossdraft reactor [15]. In all these gasifier types, the fuel bed, which is generally supported by a grate, flows down the reactor due to gravity. However, the main difference between the gasifiers is determined by the relative motion of the gas phase to the solid phase within the reactor. In the counter-current updraft, the gas flows upwards through the reactor in a counter-current direction to the fuel; in the co-current downdraft reactor, both the fuel and the gas flow co-currently down through the reactor; whilst in the crossdraft reactor, the gas phase passes across the reactor at right angles to the flow of the fuel.

The main advantages of dense phase reactors is their simplicity in both construction and operation. As a result of their simplicity, they have had a long history, being the first gasifiers produced commercially. The first true gasifier, built in 1839 by

Bischoff, was of the updraft variety [8]. A characteristic of dense phase reactors is the existence of distinct reaction zones, that is drying, pyrolysis, oxidation and reduction, within the reactor [7][16].

The downdraft gasifier is characterised by the downward flow of gases through the reactor. The pyrolysis gases, therefore, pass through a bed of hot char which is supported by the grate, resulting in the cracking of the larger, more complex molecules into non-condensible gases and water. In order to aid this tar cracking process, the downdraft gasifier has generally been fitted with a restriction or 'throat' below the oxidant inlet, which ensures the passage of the tarry products through the hot oxidation zone under conditions of high turbulence to ensure good reaction of tars. This leads to a relatively clean product gas in terms of tar loadings and this type of gasifier is favoured for use with internal combustion engines, particularly in Third World countries for power generation. However, the throat also limits the gasifier's capacity. A more recent development of the downdraft gasifier, the open-core downdraft, eliminates the need for the throat, and air is drawn from the top of the bed. This should, therefore, remove scale-up limitations but may increase the tar emissions from the reactor. Downdraft gasifiers will be discussed in greater detail in Sections 2.4 and 2.5.

In the counter-current updraft reactor, the flow of gases and solids are in opposite directions. The pyrolysis gases, as a result, do not pass through a high temperature zone and thus the gas contains a high level of tars [16][17]. Therefore, although this type of reactor can be readily scaled-up, its use when using biomass as a fuel is limited to direct combustion unless extensive and expensive gas clean-up is employed. The updraft gasifier is more suitable for use with less volatile fuels and has been widely utilised for coal gasification.

The third main type of dense phase gasifier is the crossdraft reactor [18][19][20] which has not been as widely utilised as either the updraft or downdraft reactors. As with the other two types of reactor, the solid flows down the reactor, but with the gas flowing at right angles to the bed across the gasifier. This type of reactor tends to give a gas with high tar loadings unless charcoal is the fuel, but it is reported to have a quick response time to load changes, thus making it suitable for use with engines [4].

The operating principles, reactor temperature profiles and conversion profiles for the three types of gasifier discussed in this section are presented in Figure 2.1. In this figure, it can be seen that the temperatures in downdraft and updraft gasifiers may reach 1000 to 1200 °C and as high as 1500 °C for crossdraft reactors. The conversion of feedstock to product gas approaches 100 % for both downdraft and updraft reactors, but is noticeably less than 100 % in crossdraft systems. A feature of the dense phase reactors is their stringent restrictions on the size of the feedstocks they can accept, generally the fines content of the feed is limited, as they will result in the 'blinding' of the reactor which will result in excessive pressure drops across the reactor bed.

2.3.2 Lean Phase Gasifiers

There are two main varieties of lean phase reactor, fluidised bed and entrained flow reactors, both of which were developed for coal gasification, the fluidised bed gasifier by Winkler in 1926 and the entrained gasifier by Schmalfeld and Winterschall in 1940 [8]. Unlike the dense phase reactors discussed in Section 2.3.1, no distinct reaction zones exist within the reactor, with drying, oxidation, pyrolysis and reduction effectively occurring in the same region.

Features of the fluidised bed types of gasifier include high rates of heat and mass transfer and good mixing of the solid phase, thus reaction rates are high and the bed temperature distribution is more or less even. Generally, fluidised bed reactors contain either an inert material, such as sand, to act as a heat carrier or a reactive material, such as limestone, to act as both a heat carrier and catalyst. Fluidised beds generally require a feed with a relatively small particle size which, although it may require comminution of raw feed, means that a variety of feeding systems may be employed. Fluidised bed reactors are relatively simple to scale-up and can operate at lower temperatures than dense phase reactors, in the order of 700 - 850 °C [4]. However, they are reported to be difficult to control and operate [18].

These types of gasifier can be further classified by the number of reactors and the speed of the fluidising medium, see Figure 2.2. Developments of fluidised bed gasifiers include dual bed systems, one bed acting as a combustor (for example char) and the other as a pyrolyser [21] or as a steam gasifier [22][23]. The heat for the pyrolysis reactor is often provided by the circulation of hot sand from the

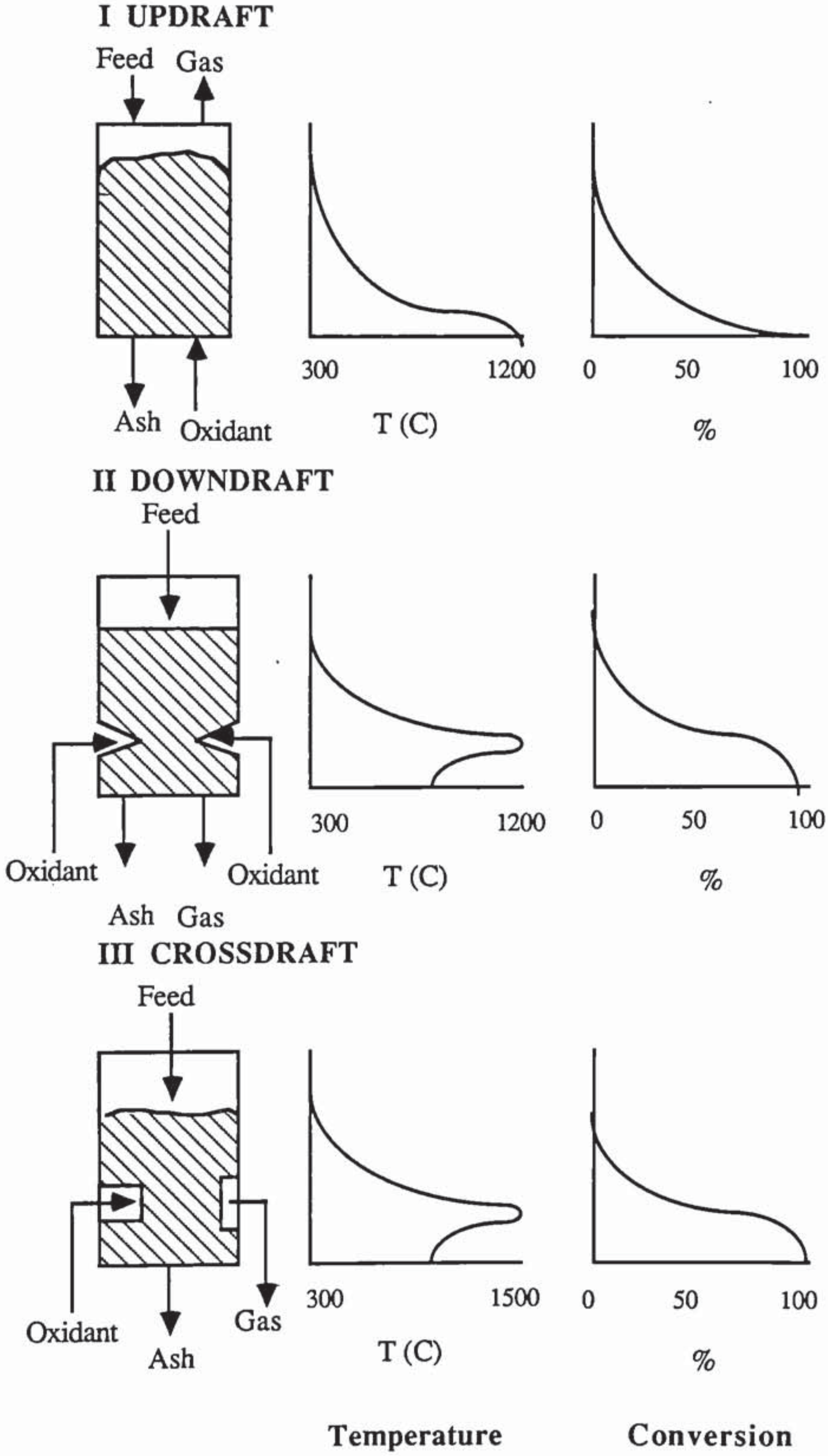


Figure 2.1 Principles of Dense Phase Gasifiers [4]][16][24]

combustor [17], although systems involving heat transfer walls have been developed [22]. Another variety of dual bed gasifier is the oxygen donor gasifier [25] where, in this system, calcium sulphate in the bed material is reduced to calcium sulphide in the gasifier to provide the neccesary oxygen for gasification of the feed. The calcium sulphate is recharged by reaction with air in the oxidiser section of the gasifier.

If a fluid bed gasifier is operated at high fluidising velocities, large amounts of solid are entrained with the gas. These systems have been developed so that the entrained material is recycled to the bed to improve the carbon conversion efficiency. Such systems are known as fast fluid or circulating fluid bed gasifiers and have been commercialised with systems in the order of 30 tonne/hr available [15][26][27]. A detailed treatise of fluidised gasifiers has been prepared by Maniatis [4].

Entrained flow gasifiers are still under development for use with biomass fuels, although they have been used for coal [28][29][30]. As with fluidised bed gasifiers, a small feed particle size is required, although no inert material is present in the reactor and no distinct 'bed' exists.

The principles of lean phase gasification with temperature and conversion profiles are shown in Figure 2.3. Fluidised bed gasifier systems are the only gasifiers that attain isothermal bed operation, typically in the range 700 - 800 °C. The majority of the conversion of the feedstock to gas takes place in the reactor bed, although conversion of entrained char to gas continues in the freeboard section and generally approaches 100 %, unless excessive carry over of fines occurs. Entrained flow gasifiers operate at very high temperatures, up to 1500 °C, thus ensuring low concentrations of tars and condensible gases in the product gas. However, the high temperature may create problems with materials of construction and ash melting. Conversion levels in entrained flow gasifiers may also approach 100 %.

Table 2.2 presents a summary of the disadvantages and advantages of the dense and lean phase gasifiers discussed in this section. Downdraft gasifiers will be discussed in greater detail in Sections 2.4 and 2.5.

2.3.3 Other Gasifier Types

In addition to the dense and lean phase reactors discussed in Section 2.3.1 and 2.3.2, many other reactor types have been developed. These other reactor types include horizontal moving bed [15][31], rotary kiln [15][32][33], multiple hearth [15][32][33][34], cyclonic [32][35][36], plasma [37] and molten salt reactors [38][39][40]. However, their usage has been generally to meet specific requirements and they have met with mixed success. A detailed study of these reactor types is beyond the scope of this thesis.

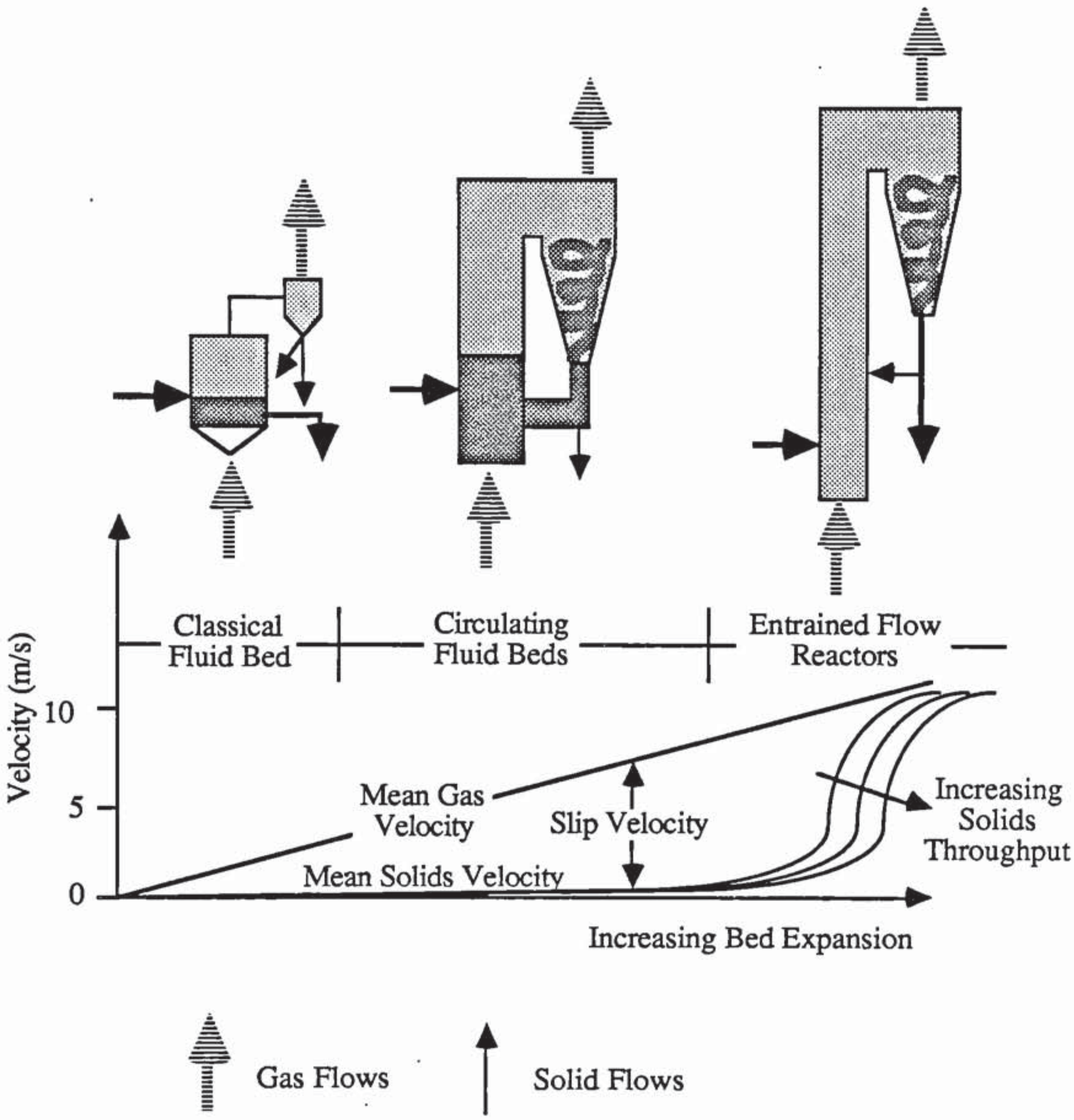


Figure 2.2 Basic Types of Lean Phase Gasifiers [30]

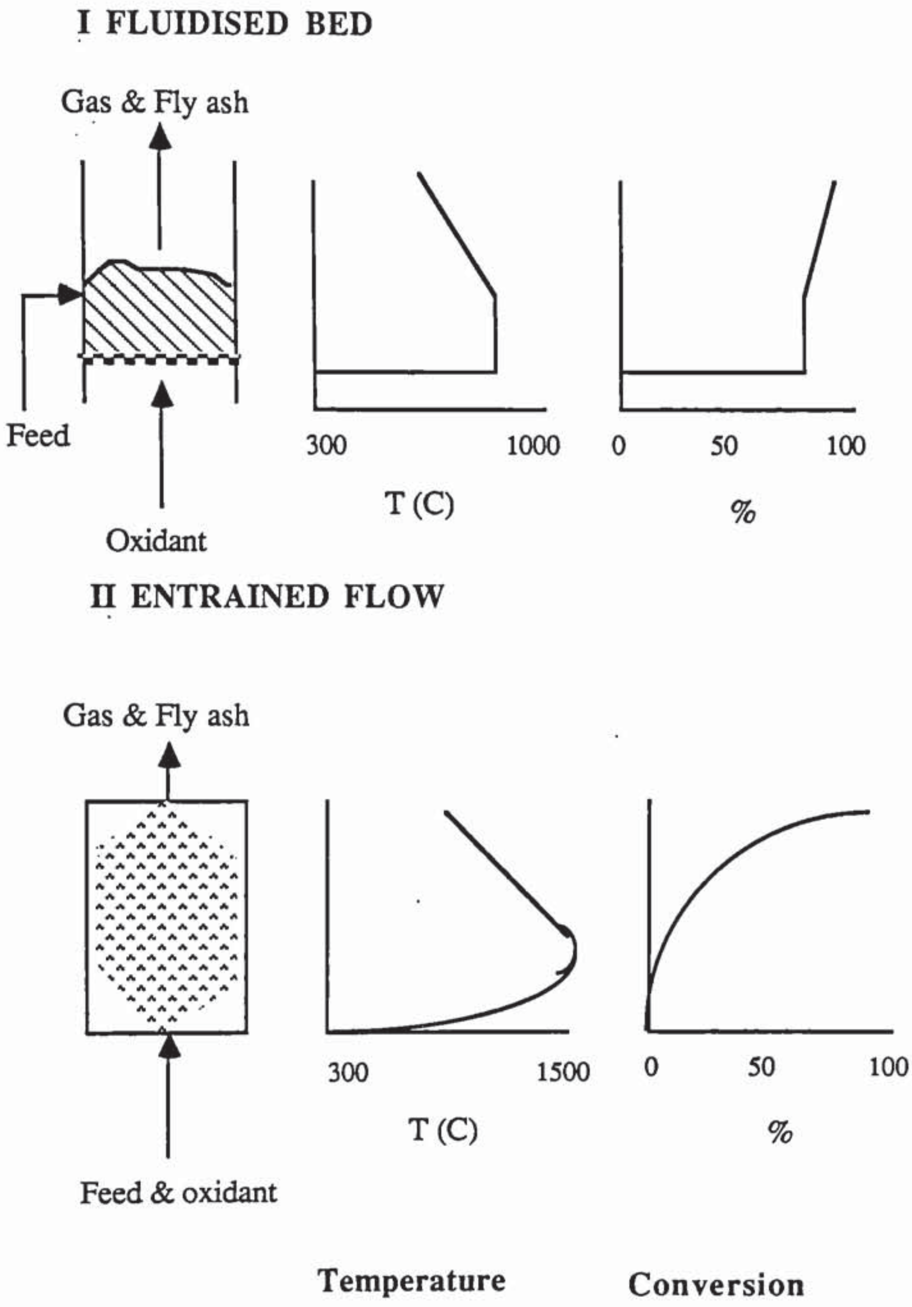


Figure 2.3 Principles of Lean Phase Gasifiers [4] [7] [16] [21]

Table 2.2 Advantages and Disadvantages of Various Gasifier Types

Advantages	Disadvantages
Updraft (counter-current)	
Low gas exit temperature High carbon conversion Low ash carry over Simple construction	High tar yield Low specific capacity Uniformly sized feedstock required- no fines Bridging or channelling of feed possible Ash fusion or clinkering on grate
Downdraft (co-current)	
Low tar yield High carbon conversion Low ash carry over Simple construction Quick response to load changes	High gas exit temperature # Low specific capacity Poor turn down capability Uniformly sized feedstock - no fines Bridging or channelling of feed possible Ash fusion or clinkering on grate Difficult to scale-up Limited moisture content of feed
Crossdraft	
Low reactor weight Low ash carry over Less sensitive to plugging Quick response to load changes	High tar yield except with wood char Low specific capacity Ash fusion or clinkering on grate Difficult to scale-up
Fluidised Bed	
Wide range of particle size can be accepted High ash fuels accepted Good temperature control High throughput Good turndown	High gas exit temperature # Tars and particulates in gas Difficult to control and operate Carbon loss with ash Low-operating temperature
Entrained Flow	
Tar free gas High feedstock utilisation due to rapid reaction rates	High temperatures require refractories or special materials of construction Very high gas exit temperature# Ash slagging Particulates in product gas

May be suitable for specific applications
Based on data of [4][18][41]

2.4 THROATED DOWNDRAFT GASIFIERS

As discussed in Section 2.3, updraft fixed bed gasifiers are the oldest variety of gasifiers in use. However, these types of gasifier produced a gas containing large amounts of tar, and in order to combat this problem, the downdraft gasifier was developed in Middlesborough by Howson in 1866 [42]. This gasifier worked with an air draft blown into the reactor. The first suction downdraft was produced around 1870 by Deschamps of Paris [42].

The downdraft gasifier now exists in two main varieties: the traditional throated gasifier which has seen near continuous use for 70 years and is described below; and the more recently developed open-core or stratified reactor, which is described in Section 2.5.

The name 'throated' is derived from a constriction, the throat (or alternatively the choke plate) near the base of the reactor (see Figure 2.3), into the vicinity of which the oxidant/gasifying agent, which is generally air, is injected, this being from either a central injection tube or wall mounted tuyeres. The gasifier is generally circular in cross-section, although gasifiers with a rectangular cross-section have been reported [43][44].

The throated downdraft gasifier is generally operated with air as the gasifying agent. Only two groups have been found using gasifying agents other than air: Makray et al. at the Universidade Estuadal de Campinas of Brazil who used pure oxygen, oxygen/steam mixtures and air/oxygen mixtures [45]; and Doner and Baillie of the University of Virginia who used a mixture of 60 % air/ 40 % oxygen [46].

The throated downdraft gasifier has been used for a variety of purposes including fueling internal combustion engines to generate electricity or to power vehicles, with usage peaking in World War II when it accounted for the majority of the reported one million gasifier powered vehicles in use [47][48].

The throated reactor produces a gas clean in terms of tar loadings, hence its use with engines, but its maximum practical size is limited to approximately 750 kg/hr [15] and the choice of fuel that can be used in the gasifier is also tightly constrained.

These points are discussed in detail in Sections 2.4.1 to 2.4.5.

2.4.1 Mode of Operation

As discussed in Section 2.2, a particle of biomass being gasified undergoes a number of processes in sequence: drying, pyrolysis and gasification. Although these processes cannot be entirely disassociated from each other, there is sufficient segregation of them so that a fixed bed gasifier can be conceptually divided into a series of zones. The zones commonly used to describe the throated downdraft gasifier are (see Figure 2.4):

a) Drying - moisture within the biomass feed is evaporated. This zone acts as a 'heat-sink' with energy generated within the gasifier being required to evaporate the moisture from the feed. Later reactions involving the water tend to be endothermic (see reduction zone) and, therefore, to prevent the moisture effectively quenching the gasifier, the moisture content of the feed is limited to approximately 40 % dry basis [15].

b) Pyrolysis - the dry biomass from the drying zone undergoes thermal degradation or pyrolysis, giving a gas rich in hydrocarbons; tar; water and a solid char (see Section 2.2.1).

The gasification reactions as discussed in Section 2.2.2 occur in two separate zones, which together constitute gasification or partial oxidation:

c) Combustion/oxidation - The reactions of the pyrolysis products with the oxygen in the gasifying agent are highly exothermic and result in a sharp rise in temperature within the reactor, up to a reported 1600 °C [8].

d) Reduction - the remaining char from the pyrolysis zone is gasified by reaction with the combustion gases from the combustion zone. In addition, reactions occur in the gas phase. Overall, this zone is endothermic, absorbing the sensible heat of both the combustion gases and char.

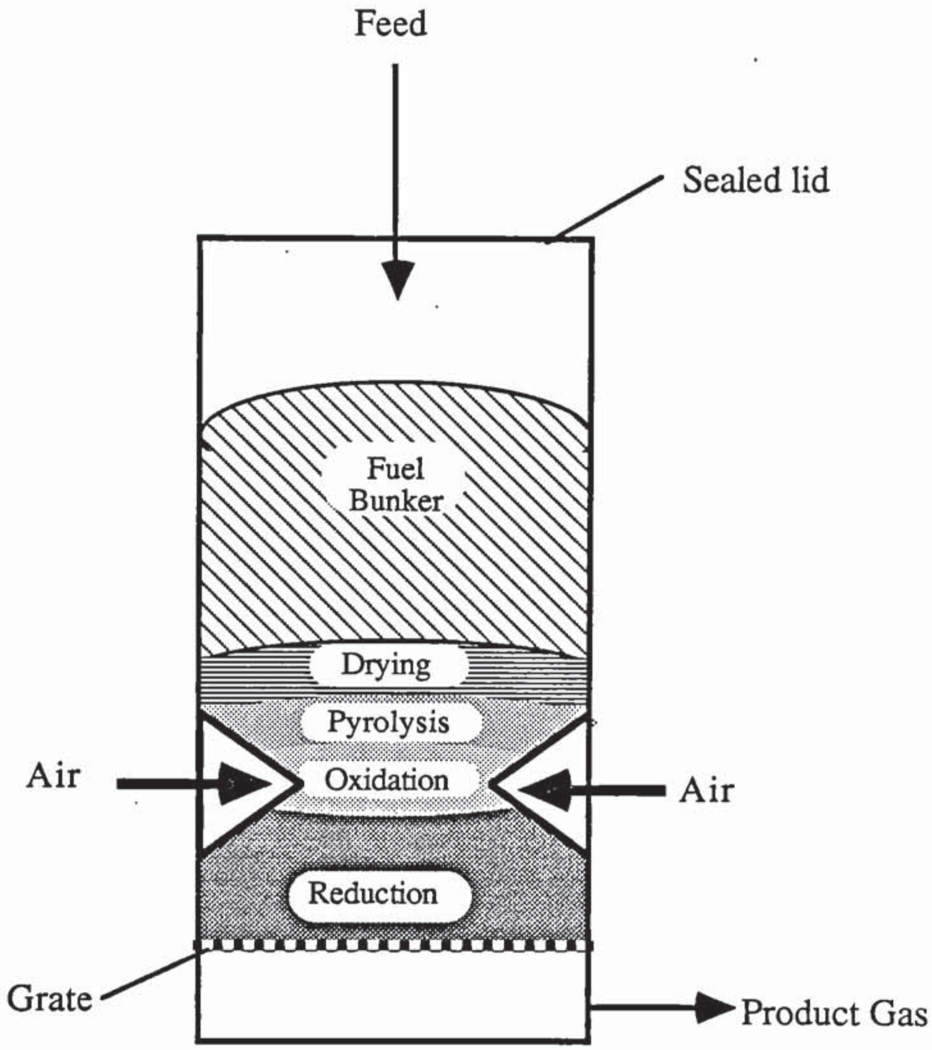


Figure 2.4 Zonal Model of Throated Downdraft Gasifier

2.4.2 Tar Cracking Mechanisms

Tar is converted or eliminated in the reactor either by thermal degradation at high temperature, or by partial oxidation with oxygen. Therefore, in order to minimise the tar content of the product gas, the primary tar laden gas should pass through an area of high temperature and high oxygen concentration.

The injection of the gasifying agent into the reactor bed provides the necessary oxygen for the partial combustion of all the pyrolysis products, including the tar. The various components of the pyrolysis products react with the oxygen in the gasifying agent at different rates in the following order: hydrocarbons > hydrogen > methane > carbon monoxide > solid carbon [49]. These reactions are exothermic [50] and thus raise the temperature within the gasifier to a level in excess of 850 °C [21] which will cause the tars to thermally degrade. Further tar cracking may also occur in the char within the reduction zone if it is at a sufficiently high temperature, ie in excess of 850 °C.

However, due to the rapid rate of reaction of the oxygen with the pyrolysis products, the air jets have only a limited penetration in the bed [21][51] resulting in an uneven temperature distribution across the reactor bed, ie it is hottest next to the injectors. Groeneveld found that in the experimental combustion of charcoal, all the oxygen was consumed within two particle diameters [21], which would suggest a maximum throat diameter of four particle diameters to prevent oxygen free areas in the throat area. This could result in the occurrence of 'cold-spots' within the reactor which would allow tar laden gas to escape the gasifier uncracked. The throat minimises these bed penetration problems by reducing the cross-sectional area of the reactor and thus reducing the required penetration distance of the air jet and also increases gas turbulence to ensure side or back mixing. Ideally, there should, therefore, be a 'hot' zone across the reactor cross-section through which all the tar laden gas must pass which should result in the complete cracking of the tar. This oxidant distribution problem could also be rectified by using more air injection points across the reactor. However, this could result in disturbances in the flow of solids through the reactor, causing channels or voids which could also allow the product gas to escape uncracked.

Important criteria in the design of throated downdraft gasifiers are reported to be the positioning of the air injector(s) relative to the throat and the size of the throat itself [21][52]. The Swedish [52] state that these criteria have an important effect on the product gas quality and Groeneveld [21] reports that increasing the distance between the throat wall and injector causes an increase in the tar loading of the product gas. Taking into account the penetration limits of the air jet into the bed, these findings are not surprising.

Groeneveld also states that the angle of injection of the air into the reactor is also an important factor in the amount of tar cracking, the most efficient tar cracking occurring when the air is injected horizontally into the reactor. This, he attributes, to the occurrence of gas recirculation flows within the gasifier which carry the tar laden gas back to the hot zones in the vicinity of the injectors and thus greatly enhance the tar cracking of the gas. In his particular geometry, these flows followed a figure of eight pattern (see Figure 2.5). Groeneveld suggests that these recirculation flows are very important to the performance of the gasifier, obtaining a tar free gas when the temperature at the throat wall was as low as 527 °C, which would not support tar cracking. This, he believed, indicated that the tar laden gas was being carried back to the hot zone in the vicinity of the air injector.

Other techniques for improving the tar cracking ability of the gasifier include insulating the reactor wall to minimise heat loss to the surroundings and thus ensure a high temperature at the wall. This insulation may be provided by either refractory bricks and/or passing the hot product gas in an annulus surrounding the reactor. The hot product gas can also be used to preheat the gasifying air prior to injection into the reactor which will result in an increase in temperature in the oxidation zone due to the increased sensible heat of the oxidant. However, this may create problems with ash sintering (see Section 2.4.4) or with materials of construction.

2.4.3 Reactor Scale-up Limitations

Despite its ability to produce a clean gas, the downdraft gasifier has seen limited use due to limitations on its maximum throughput, which is generally thought to be around 750 kg/hr [15], although Groeneveld reports the maximum practical size for tar free operation is approximately 250 kg/hr [21]. For applications requiring a high throughput, multiple gasifier systems have been employed [53][54].

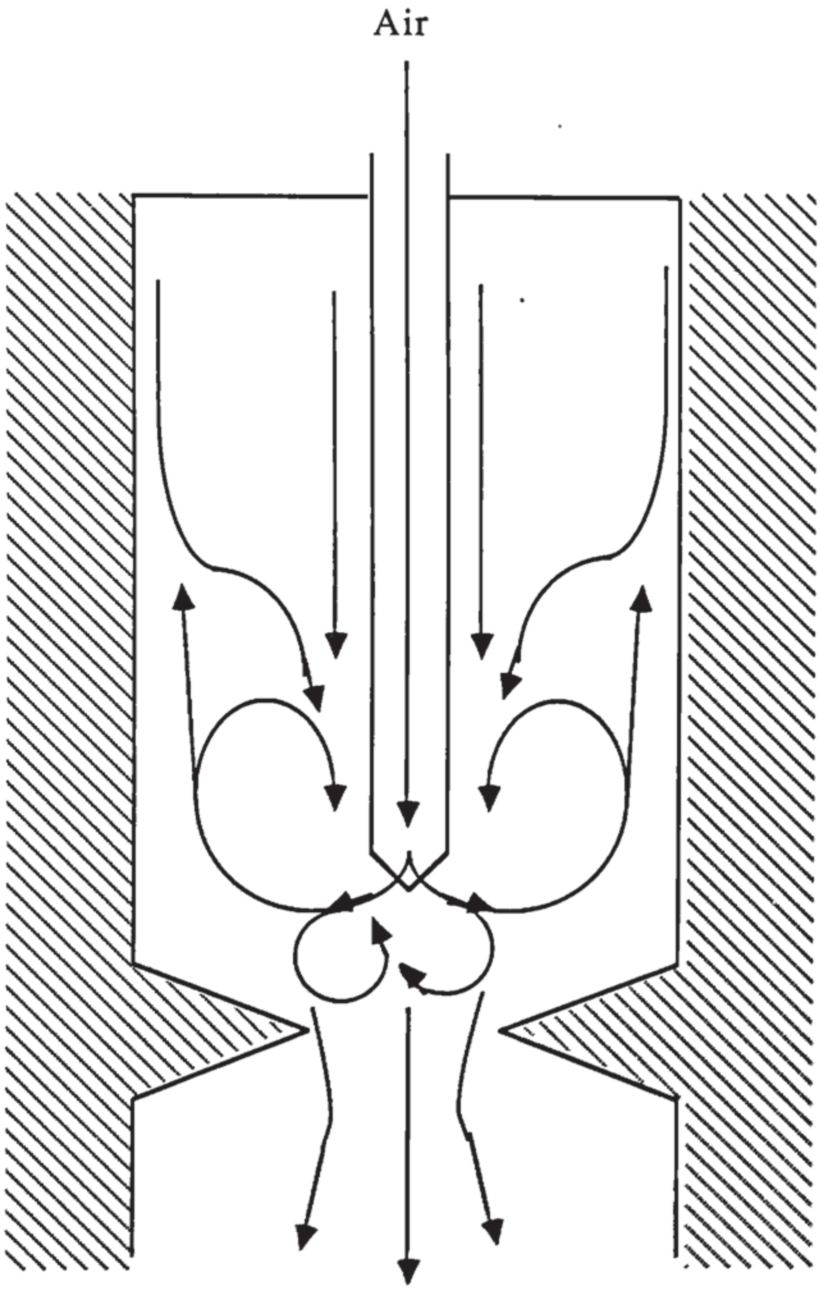


Figure 2.5 Gas Circulation Patterns in a Throated Downdraft Gasifier with Central Air Injector [21]

This lack of scale-up-ability is generally attributed to problems associated with the mal-distribution of the gasifying agent from the injectors across the reactor bed [55][56]. This results in an uneven temperature distribution across the reactor bed and thus, as discussed in Section 2.4.2, results in a high tar content in the product gas. This may also result in a lowering of the overall efficiency (to cold clean gas) of the gasifier. At larger reactor diameters, the recirculation patterns discussed in Section 2.4.2 also become less effective. A possible way to overcome this poor distribution of air in the reactor would be to add further air injectors across the reactor. However, this could result in disturbances in the flow of solids through the bed which could further exacerbate tar cracking problems.

Another reason suggested for the inability to scale-up this reactor geometry, is that the 'reacting mass' in the throat is supported by a bridging mechanism [57]. This method of support is only effective over small distances and will not work efficiently at larger throat diameters, thus preventing the formation of a stable reactor bed. The degree of bridging is also a function of feed size and shape. However, although the throat may provide some bed support, the majority of the bed support is provided by the grate, and, therefore, the breakdown of the throat supporting mechanism is not a serious factor in limiting the scale-up of throated reactors.

At least one design has been proposed for the scaling-up of this reactor type to approximately 100 tonne/day by the use of an annular throat [21], although the design has yet to be built or tested.

2.4.4 Feedstock Limitations

Further disadvantages of this reactor geometry are the constraints placed upon the properties of the fuel to be gasified. Work by Beenackers and Manurung [58], Kaupp [59] and Bonino [60] has identified a number of the fuel properties which may create difficulties in a throated gasifier. A particular problem may be associated with the flow of the fuel through the reactor bed which may be hindered by the throat and/or air injectors. This problem will be exacerbated if the fuel exhibits poor flow characteristics, for example, low bulk density, lack of shrinkage or even expansion under pyrolysis. The high temperatures in the vicinity of the air injectors prevents the use of fuels with a low ash fusion temperature.

There are also limits placed on the particle size and particle size distribution of the fuel. A fuel consisting of, or containing, small particles, for example sawdust, decreases the penetration of the air jet into the reactor bed which in turn leads to higher tar loading of the product gas (see Section 2.4.2). A further problem associated with small fuel particles, although not exclusive to this reactor geometry, is the 'blinding' of the reactor and subsequent elevated reactor pressure drop. Upper particle size is limited by the physical size of the reactor and by the fuel's reaction time, in that for tar free operation the feed particles must be completely devolatised before entering the reduction zone. Feed shape must also be considered as a constraint, as a feed containing mixed particle shapes can promote bridging in the reactor. This may prevent the even flow of fuel through the bed, or form channels which could allow tar laden gas to bypass the hot zone and escape the reactor uncracked.

The moisture content of the fuel is generally considered to be limited to approximately 40 % dry basis [15]. As discussed in Section 2.4.1, water in the feed acts as a heat sink and could, at high levels, effectively 'kill' the gasification process by absorbing more heat than is generated, by the exothermic combustion/partial oxidation reactions (see Section 2.2). High moisture fuels also lead to a high tar content in the product gas. This may be due to a lowering of reactor temperatures or due to the inhibition of the pyrolysis of the biomass, thus allowing fuel that has not been completely devolatised to pass from the pyrolysis zone. Further pyrolysis can then occur in the oxidation zone and this may result in tar passing through this zone uncracked and, therefore, escaping the reactor.

2.4.5 Reactor Feeding

In order to avoid egress of pyrolysis and gasification products, notably carbon monoxide, and to prevent ingress of air into the reactor, this type of reactor generally requires a sealed solids feeding device, such as a lockhopper or screw auger. On small scale systems, the reactor may be hand fed, batches of feed being regularly added to the reactor. However, the gasifier will still require a sealed lid.

The gasifying agent can be introduced to the gasifier by two methods, either suction or injection. In suction mode, the gasifier is operated under vacuum with the product gas withdrawn from the gasifier either by a gas pump placed downstream of the reactor or, when used with engines, due to the suction applied by the engine, which induces a flow of oxidant into the reactor. When operated in injection mode, a gas pump is placed upstream of the gasifier and injects the oxidant into the reactor, so generally the system will, therefore, be operating under pressure. In most cases, throated gasifiers are operated in suction mode. This may be due to their widespread use with engines or the fact that they operate under a vacuum, thus reducing the risk of explosion and carbon monoxide poisoning [48][61]. However, systems in the injection mode have been constructed and operated [62][63].

2.5 OPEN-CORE DOWNDRAFT GASIFIERS

The open-core variant of downdraft reactor has been promoted by the Solar Energy Research Institute of Colorado [55][61][64][65][66], although other devices have been found in various locations [58][59][67][68][69]. In its basic form, the open-core gasifier is an open-topped tube with a grate to support the bed and operates with air pulled downwards through the reactor. However, the open-core concept has been developed in a variety of forms, from atmospheric air systems, as above, to a pressurised oxygen gasifier [70], and a number of variants have been commercialised such as the Buck Rogers 'air-blown' version of which eighteen have been sold and the Syngas air gasifier of which three have been sold [15]. The open-core geometry has less stringent size limitations placed upon it, possibly up to 10 tonne/hr, and can accept a wider variety of fuels than the throated downdraft reactor, although it may produce a more heavily tar laden product gas. These points are discussed in detail in Sections 2.5.1 to 2.5.5.

2.5.1 Mode of Operation

As a recently developed, and as yet not widely used reactor type, there is only a limited amount of literature relating to the open-core gasifier. Only Reed et al. at SERI have attempted to describe the processes occurring in the gasifier [55][64][65][66]. They divide the gasifer into four zones, two reaction zones and two non-reacting or inert zones (see Figure 2.6):

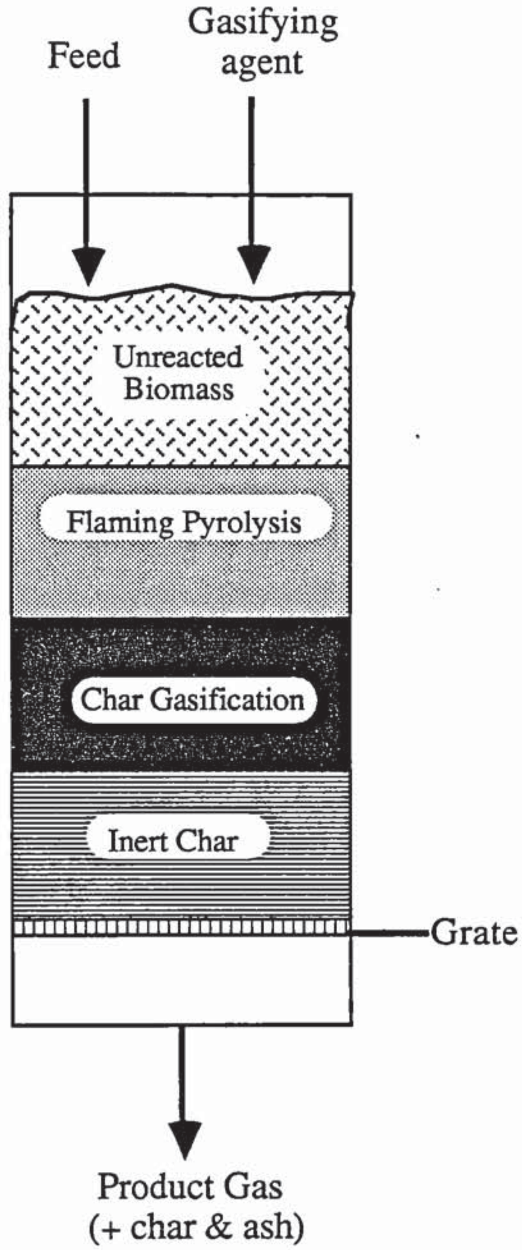


Figure 2.6 Reed's Schematic of the Zones in an Open-Core Downdraft Gasifier [64]

a) Unreacted Biomass

Initially, the biomass fuel and oxidant enter the top of the reactor forming a non-reacting fuel/oxidant reservoir which should, ideally, homogenise the gas flows to provide an even oxidant distribution across the reactor, although the oxidant distribution across the reactor is, in fact, dependent on the reactor bed properties. This zone also provides a reservoir of unreacted fuel which can allow for intermittent, rather than continuous, feeding and, as Reed and Markson [61] report, insulation to minimise heat loss from the flaming pyrolysis zone. As with the drying zone in throated downdraft gasifiers, there may be some drying of the biomass fuel in this zone, although due to the limited gas recirculation (see Section 2.5.2), this will only occur within a limited distance of the flaming pyrolysis zone (see below). However, it is reported [55] that the gasifier may be operated without a zone of unreacted biomass in 'top-stabilised' mode with the flaming pyrolysis reaction zone at the top of the bed (see later in this section), and both oxygen and air 'blown' gasifiers have been developed which operate in this way [71][72][73].

b) Flaming Pyrolysis zone

The first reaction zone is described by Reed [64] as the flaming pyrolysis zone and accounts for a claimed 85 to 90 % of the biomass conversion [55][74]. Here, Reed et al propose that the biomass undergoes pyrolysis with energy provided by partial combustion of the pyrolysis products, making the overall process autothermal or energetically self sufficient. They suggest that the heat transfer mechanism to the pyrolysing particle is by conduction or radiation, although they also suggest that, as all the particles in the zone are at approximately the same temperature, the radiative heat transfer will be minimal. However, they neglect to consider the possibility of radiation from the burning gases, although they do say that air or oxygen flames are powerful heat transfer mechanisms. Large amounts of gas are evolved as a result of the pyrolysis process, which they report forms a boundary layer around the reacting particle which controls its surface temperature to approximately 800 - 900 °C and also prevents reaction between the pyrolysis gases and the char product until flaming pyrolysis is complete, that is the thermal wave reaches the centre of the particle. This effect creates a distinct interface between the flaming pyrolysis zone and the char gasification zone (see below).

Reed also reports that, although the gas temperature may rise well above that of the surface of the particle, the temperature at the centre of the particle will 'lag' behind due to the delay in conduction of the heat from the surface of the particle to its centre. The time-temperature history for the surface and centre of the particle and the flame temperature was verified experimentally by Reed and Markson [64]. The gas entering the flaming pyrolysis zone is predominantly air/oxygen (depending on the gasifying agent), but reacts completely within the zone to form a gas consisting predominantly of H_2, CO, CO_2 and H_2O, as well as the char residue. Reed claims that the oxygen in this zone is in excess for complete gasification, which results in high temperatures and the near complete destruction of the volatile components.

In order for the biomass feed to undergo flaming pyrolysis, it must be heated to a temperature in excess of 250 °C for pyrolysis to commence. However, due to the downward flow of the char and gas from the flaming pyrolysis zone, much of the 'heat' produced in the zone is also carried by forced convection downwards through the reactor away from the incoming fuel. Therefore, reaction propagation is by a different mechanism. Reed and Markson [55] suggest that the reverse heat transfer necessary to propagate the reaction, may take place by radiation from the hot reacting material. However, they believe that the main mechanism of propagation is by the combustion of the pyrolysis gases causing a flame to climb upwards at velocities of 10 to 100 cm/s, which is much greater than the downward velocity of the biomass and thus propagating the flaming pyrolysis reaction. They do not, however, support this theory with any experimental data and/or observations and it was, therefore, decided that this was an area for further investigation. Heat conduction through the reactor walls and natural convection may also play lesser roles in reaction propagation.

c) Char Gasification Zone

On completion of flaming pyrolysis, the hot gases from the flaming pyrolysis zone, which may be at temperatures in the order of 1000 °C, can begin to react with the char produced by the biomass pyrolysis. The char is consumed by reaction with carbon dioxide and steam, in the Boudouard and Water Gas reaction respectively (see Section 2.2.2). As with the reaction zone in a throated gasifier, gas-phase reactions also occur, see Section 2.4.1, although Reed and co-workers consider the water gas shift reaction as the dominant reaction. The modelling work performed by Reed et al at SERI (see Section 2.6) suggests that a certain time, and hence length, of char gasification zone is required in order for the char to be gasified. This would suggest that the char passing downwards through the char gasification zone is progressively gasified on its journey down through the zone.

Again, as with the reduction zone in the throated downdraft gasifier, this zone is endothermic and the reactions are claimed to be quenched by the following four mechanisms [64]:

- The sensible heat of the gas and char is converted to chemical energy. Reed and Markson report that this cools the gas at the rate of 24 °C per 0.01 degree of reaction. Thus a gas at 240 °C above the equilibrium temperature could only attain 0.1 of the complete char gasification. The mole fractions of CO and CO_2 are related to the degree of reaction X by:

  Equation 2.1 : $M_{CO} = 2X / (1+X)$

  and:

  Equation 2.2 : $M_{CO_2} = (1-X) / (1+X)$

- The char gasification reactions cannot proceed past equilibrium, which will occur at temperatures between 600 and 800 °C. The equilibrium temperature will depend on the composition of the gas entering the char gasification zone.

- The reaction rates drop rapidly as the gas cools and, therefore, may not reach equilibrium.

- Reed also suggests that there is a 'mechanical' limit to char gasification. As gasification proceeds to a reported 95 to 99 % conversion of the biomass [75], the char begins to 'dissolve' into a fine dust. This char dust is entrained in the gas stream and will either escape the reactor entirely or move to the inert char zone where the temperature is too low to support further reaction thus limiting the overall char conversion. If this dust does not escape the reactor, it could result in an increase in the reactor pressure drop and thus limit the operating time of the gasifier (see below). Walawender and co-workers report a loss of approximately 3 kg of char per 100 kg of dry feed [76].

Reed and Markson report that it is possible to vary the height of the char bed (see below) and that this may also affect the gas quality. Increasing the height of the char zone increases the contact time of the gas with the char and, therefore, if the gas and char temperatures are sufficiently high, will allow for greater char gasification. If the temperatures are sufficiently high, of the order of 850 °C, the char bed may also aid tar cracking.

d) Inert Char Zone

There may be a zone of unreacted charcoal below the char gasification zone which is too cool to react with the flaming pyrolysis gases, and is, therefore, not necessary for gasifier operation. However, Reed reports, it can both absorb heat from the gases cooling them further, although he does not explain how; or absorb oxygen if conditions change, presumably by reaction, although he is not clear in this. It, therefore, acts as a 'buffer' and a charcoal storage zone. It may also prevent the passage of char and ash from the char gasification zone to the grate thus hindering their removal. This could result in excessive bed pressure drop if the reactor is operated for long periods. This problem could be lessened by mechanically removing some of the ash and char whilst the gasifier is in operation. However, this would lower the overall carbon conversion efficiency of the gasifier.

At steady state, the gasifier is operating so that the rate of char production by the flaming pyrolysis zone is equal to the rate of char gasification in the char gasification zone, thus the reaction zone remains constant relative to the grate. However, Reed and Markson [55] report that it is possible for the rates of char gasification and flaming pyrolysis to be adjusted relative to each other so that they are no longer equal and, therefore, the reaction zone will move either up or down. If the rate of flaming pyrolysis is greater than the rate of char gasification, the reaction zone will move upwards. However, if the opposite is true and the rate of char gasification is greater than the rate of flaming pyrolysis, the reaction zone will move down.

The work of Reed and Markson [55] indicates that the stability and position of the reaction zone depends on the air:fuel ratio, the degree of reactor insulation and the gasifying agent used. They found that at a specific gas flowrate, the reaction zone will remain stable. However, they also found that increasing the gas flowrate will cause the reaction zone to move down and approach the grate, whereas decreasing the gas flowrate will cause the reaction zone to move upwards towards the top of the reactor, ie through the unreacted biomass feed. They found that increasing the amount of insulation on the reactor tends to cause the flaming pyrolysis to dominate and will either cause the reaction zone to advance up the reactor or slow down the downward motion through the reactor. However, they do not attempt to explain this phenomenon.

Where char gasification is controlling, that is the reaction zone is moving downwards, Reed and Markson claim that the position of the reaction zone can be restabilised. This, they attribute, to the reduction in the height of the char bed decreasing the contact time between the char and the gas and, therefore, effectively reducing the rate of char gasification. The rate of char gasification will eventually equal the rate of flaming pyrolysis and thus the reaction front will restabilise in what they term 'grate-stabilisation'. There appears to be no experimental evidence to support this supposition. They also add that the reduced height of char will result in a poorer gas quality, due to the shorter zone lowering the conversion of CO_2 and H_2O.

In operation with oxygen, the reaction front moves rapidly up through the unreacted biomass so that it is all consumed and the reaction zone is, therefore, at the top of the bed and cannot be controlled in any other way. Reed et al [70] describe this as 'top-stabilised'. This type of stabilisation is only suitable for oxygen gasifiers or gasifiers with a sealed top, as there is considerable radiative heat loss from the uncovered reaction zone, thus lowering the conversion efficiency, and may also represent a fire hazard. In this mode of stabilisation, fuel must be added at a steady rate in order to prevent alternate pyrolysis and char gasification operation which is reported to promote high tar levels [61]. The feed rate will determine the position of the reaction zone: if large amounts of feed are added, the reaction zone will climb up through the unreacted feed, but if insufficient feed is added, the reaction front will begin to move down through the char bed towards the grate.

Although Reed and Markson list techniques for reaction zone stabilisation, they do not attempt to explain why or how they work. They do not discuss that in changing reaction parameters such as the degree of reactor insulation or the air/fuel ratio whether these just effect the rate of char gasification or flaming pyrolysis or both to differing degrees.

Reed and Markson also list other methods of stabilising the reaction zone. These include, varying the degree of insulation up the reactor; agitating the bed; and injecting secondary air into the bed at the desired level, that is tuyere stabilisation which is the technique successfully employed by Buck Rogers [76][77].

2.5.2 Tar Cracking Mechanisms

As discussed earlier (see Section 2.4.2), the extent of tar cracking is greater at high temperatures and at high oxygen concentrations. In an air blown open-core reactor, the gasifying agent is drawn through the bed from the top of the reactor, which should result in an even temperature and oxygen distribution across the reactor. In reality, the actual distribution of oxidant across the reactor will be dependent on bed properties, such as the degree of channelling and voiding, and, therefore, there are likely to be variations in both temperature and oxygen across the reactor. In most cases, as the gasifying agent is introduced across the complete cross-section of the reactor, there should be relatively even oxygen and temperature distributions across the reactor bed giving a near uniform tar cracking ability across the reactor, unlike the throated variety. However, in the vicinity of the reactor wall, local variations may occur in the oxygen, and hence temperature, distributions due to the occurrence of 'wall effects'. Typical reaction zone temperatures for the open-core gasifier are reported to be in the region of 700 to 1100 °C [58][59]. This may be lower than in the throated reactor, as the gasification air is generally not pre-heated in an open-core reactor. Reed claims that there is sufficient oxygen, when using both air and oxygen as the gasifying agent, in the flaming pyrolysis zone to result in virtually complete combustion of the tar, although he does not provide any experimental evidence to back this up.

The overall tar cracking efficiency of the throated reactor is reported to be greatly enhanced by the gas circulation flows set up as a result of the throat and oxidant injection (see Section 2.4.2). In the open-core reactor, the removal of the throat and injection systems considerably reduce the degree of gas mixing, hence this may lower the overall efficiency of tar cracking and increase the tar loading of the product gas. It is noticeable that in the reported data for an open-core reactor with additional in-bed air injection [76], the tar loading of the product gas is significantly reduced relative to those reactors without in-bed injection systems (see Chapter 6).

As discussed in Section 2.5.1, the open-core gasifier can be divided into a number of zones. The tar is produced in the flaming pyrolysis zone and this must generally pass through a bed of char before exiting the reactor. If this char is in excess of 850 °C [21], it may also effect some further tar cracking.

2.5.3 Reactor Scale-up Limitations

As discussed previously (see Section 2.4.3), the scale up potential of the throated downdraft reactor is limited due to worsening oxygen distribution across the reaction zone as size increases with subsequent uneven temperature distribution across the reactor and breakdown of the reaction zone bridging support mechanism. In the open-core reactor, these problems are of little significance as, ideally, there is uniform oxygen and temperature distribution and no support is required.

The oxidant is not injected directly into the fuel bed at a number of points, but is drawn through the reactor from the top of the bed. This should result in an even oxidant and temperature distribution across the reactor (see Section 2.5.1) and, therefore, prevent the formation of cold spots across the reactor thus minimising the problems associated with these cold spots in the throated reactor. Variations may occur in the oxidant and temperature distributions as a result of irregularities in the reactor bed, for instance the occurrence of voids and channels. These are formed by the bridging of the particles in the reactor feed. However, this bridging support mechanism is only effective over a limited distance (see Section 2.4.2) and, therefore, the size of these voids and channels is restricted. Therefore, as the reactor diameter is increased, the effect of voiding and channelling on the gasifier performance is likely to be of less significance.

The reaction zone in the open-core reactor is supported on a bed of char which is in turn supported on a metallic or ceramic grate. There are, therefore, no problems associated with the breakdown of support that may occur at larger reactor diameters in the throat of the throated gasifier (see Section 2.4.3).

The mode of operation is similar to that of the updraft counter-current gasifiers, ie it is plug flow with the oxidant being introduced across the complete cross-section of the reactor. It is, therefore, fair to assume the maximum practicable size will be in the same order as updraft gasifiers which is generally in the region of

10 tonne/hour [15]. The largest open-core gasifier so far constructed is that of Syngas Inc. [73] which is 0.762 m in diameter with a throughput of up to 900 kg/hr with oxygen as the gasifying agent and 670 kg/hr with air.

2.5.4 Feedstock Limitations

The open-core gasifier, unlike the throated downdraft reactor, is far less constrained in the fuels it can accept. The flow of solids through the throated downdraft reactor may be adversely effected by the presence of the throat and oxidant injectors. The open-core reactor is essentially an open tube without, in most cases, in-bed oxidant injection; therefore, the flow problems are largely removed (see Section 2.4.4).

Fuels with high ash content and/or low ash fusion temperatures may not be successfully gasified in a throated reactor due to the occurrence of hot spots in the vicinity of the oxidant injectors. The temperature distribution across the reaction zone of the open-core reactor is generally more even without any very hot areas thus reducing problems associated with the fuel ash properties.

The size and size range constraints placed on reactor fuel for the open-core gasifier are very similar to that for the throated gasifier. The upper particle size limit is set by particle reaction times as in the throated reactor. In the throated gasifier, the lower particle limit is set by the bed pressure drop and the degree of oxidant penetration across the reactor bed (see Section 2.4.4). In the open-core reactor with the oxidant being pulled through the bed, the problem of oxidant penetration across the bed is largely removed. However, the lower particle size will be constrained by the maximum bed pressure drop allowed which will be set by the gas suction pump. Widely different particle sizes may require a different grate design: a grate for small particle sizes will also increase the overall bed pressure drop.

The suitability of the open-core reactor for the gasification of poor fuels has been demonstrated by Manurung and Beenackers at Twente University [58]. They have developed an open-core reactor which has successfully gasified rice husks, which is one of the most difficult fuels to gasify. This is of a relatively standard design, but employs a rotating grate with scraper for char and ash removal. At the University of California, a batch open-core gasifier was developed for rice husk gasification [59]. This concept has been developed to a 'continuous' gasifier engine system. This employs two batch reactors which are operated alternately with the non-operating gasifier being cleaned and recharged [78].

2.5.5 Reactor Feeding

An air 'blown' open-core reactor is a simple open tube with air drawn into the reactor from the top of the bed and, therefore, does not require a sealed feeding device unlike most other gasifier types. This must be seen as a major advantage of this particular reactor type, as the fibrous nature of much biomass makes the design and operation of suitable feeders a difficult and troublesome task. On a small reactor, the reactor can be fed manually, larger reactors would probably require a mechanical feeding system such as an open screw feeder, a conveyer or a bucket elevator. The 'Buck Rogers' gasifier tested at Kansas State University employs a screw feeder system, the feeder being actuated by an 'electric eye' operated level controller [76].

In order to prevent the egress of oxygen and maintain the reactor pressure, the SERI high pressure oxygen gasifier needs a more complex sealed feeding device. The feeder on the SERI gasifier employs a series of lock hoppers [70]. The open-core gasifier developed by Syngas Inc [73] as a result of the SERI work, although an air gasifier, is 'top-stabilised' (see Section 2.5.1) and requires a sealed feeding system. A metered screw feeder feeds into a lock-hopper with a rotary valve.

As with the throated variety of downdraft gasifier, the gasifying agent may be introduced to the reactor by either suction or injection. In oxygen or 'top-stabilised' air systems, the oxidant is injected into the reactor [70][73]. However, in most cases, where the gasifying agent is air, the reactor has an open type and, therefore, the oxidant is sucked into the reactor by a gas pump placed downstream of the reactor [55][58][59][76].

2.6 DESIGN AND MODELLING OF OPEN-CORE GASIFIERS

As discussed previously in Section 2.5.1, of the limited amount of literature available relating to open-core gasifiers, much has been produced by Reed and co-workers at SERI. This is particularly true for literature covering the design and modelling of open-core gasifiers. Of the modelling work so far performed at SERI, the major emphasis appears to have been to develop a 'quantitative' model of the open-core gasifier to predict the gasifier dimensions, that is the length of the reaction zones, and 'operating characteristics'. This is discussed in Section 2.6.1, although further modelling work has also been performed (see Section 2.6.2).

A detailed treatise on the modelling of all aspects of pyrolysis and gasification mechanisms and reactions was felt to be beyond the scope of this thesis as the main thrust of the work was to design, construct, commission and run a gasifier system. However, it was decided to study the 'quantitative' model of SERI (see Section 2.6.1) as this would help in the analysis of the Aston system.

2.6.1 SERI's Quantitative Model of the Open-Core Downdraft Gasifier

The model is claimed to predict the dimensions of the gasifier as a function of feed properties and operating conditions [65][66][75][79]. The model developed only considers the two reacting zones, that is the flaming pyrolysis and char gasification zones. They do not discuss either the unreacted feed or inert char zones. The two zones are considered as separate models, each being discussed in turn in Sections 2.6.1.1 and 2.6.1.2, together with general observations in Section 2.6.1.3.

2.6.1.1 Flaming Pyrolysis Zone

In order to predict the height of the flaming pyrolysis zone, it is first necessary to calculate the time required for the reaction. The time could be calculated from the following equation:

Equation 2.3 : $$t_p = \frac{0.21\rho D(1 + 0.61D)F_S(1 + 1.76F_m)e^{-4700/RT}}{(1 + 3.4F_o)}$$ [64]

This equation was based on the work of Huff [80] who derived empirical relationships for the combustion of wood, and which was modified for the lower oxygen availability in gasification. However, this equation was empirically based and further work was performed to develop a further model to improve the understanding of the flaming pyrolysis process. This 'new' model (see Equation

2.4) was based on what Reed reports as observed heat transfer rates, that is the pyrolysis time is calculated by dividing the energy for flaming pyrolysis by the rate at which it is supplied.

$$\text{Equation 2.4}: t_p = \frac{(h_p + h_w\ F_M)\rho V}{A q} \qquad [75]$$

In order for the model to be utilised, values for h_p, h_w and q had to be estimated, the variables relating to the physical properties of the feed, that is F_M feed moisure fraction, V the particle volume, A the particle area and ρ the particle density, can be found by direct measurement.

The heat of pyrolysis, h_P or $h_P(T_s)$,used in Equation 2.4 is not merely a heat of reaction, but includes a contribution for the energy necessary to raise the particle to the pyrolysis temperature, T_P, from its initial temperature, T_0, and the energy required to raise the products from T_P to T_s the surface temperature of the particle. The value of T_s is taken to be greater than T_P in order to drive the reaction at a 'reasonable' rate. The heat of pyrolysis is represented algebraically in Equation 2.5:

$$\text{Equation 2.5}: h_p(T_s) = \int_{T_o}^{T_p} C_{pw}\, dT + \Delta h_p + \sum \int_{T_p}^{T_s} C_{pi}\, dT \qquad [75]$$

The detailed evaluation of this equation was not feasible, due to the large number of pyrolysis products. However, it was possible to calculate h_P, from h_w (also known as $h_w(T_s)$), the 'heat for water vaporisation at T_s'. This is not just an 'ordinary' heat of vaporisation but includes contributions to raise liquid water from the initial temperature T_0 to 100 °C and the water vapour from 100 °C to T_s, see Equation 2.6. Reed and Levie report that Huff found that 1.76 times as much energy was required to vaporise a given amount of water at T_s than was required to pyrolyse the same weight of biomass. Reed ana Levie, therefore, used this as a basis to calculate the heat of pyrolysis, as the thermodynamic properties are well documented.

$$\text{Equation 2.6} : h_w(T_s) = C_p(l)\,(100 - T_o) + h_v + C_p(g)\,(T_s - 100) \qquad [75]$$

Reed and Levie calculated values for h_w and h_p over the temperature range 600 to 800 °C with h_w covering 3664 to 4115 kJ/kg and h_p 2081 to 2338 kJ/kg. They claim that a value of 2200 kJ/kg for h_p closely models the conditions in a downdraft gasifier. This is based on experimental observation in which the surface temperature was measured to never exceed 800 °C and the surface of the particle was claimed to appear black, therefore in the region of 700 °C.

The value for q, the average heat transfer rate to the biomass over the whole time period required for flaming pyrolysis, was obtained by using the modified Huff equation (Equation 2.3). The estimated value for h_p of 2200 kJ/kg was used, and a wide range of feed properties considered. The values of q calculated covered the range 30 to 130 kW/m^2, with an average of 40 kW/m^2. However, when they utilise the model, the value they select for q is 20 kW/m^2, no explanation is offered for this.

The calculation of the height of the flaming pyrolysis zone can then be calculated thus:

$$\text{Equation 2.7} : l_p = \frac{t_p\, m\, A_g}{F_d\,(1 - F_v)}$$

Reed and Levie report that the 'new' model (Equation 2.4) is less accurate than the original model based on the modified Huff equation, (Equation 2.3), although they do not quantify the difference. In the original model, actual times measured for flaming combustion were used to estimate the time for flaming pyrolysis. In the 'new' model, the pyrolysis time is derived from the ratio of a mean observed value for pyrolysis energy to the rate at which heat is supplied. The simplifications involved in the model make it inherently less accurate. However, this makes the model less complicated to apply. Reed and Levie report that they are investigating methods of relating particle size, moisture content, gas velocity, and combustion conditions (although they do not explain what they mean by combustion conditions) to the heat transfer rate in order to improve the estimate of the heat transfer rate and thus the accuracy of the model. They are also working on improving the accuracy of the value of h_p.

2.6.1.2 Char Gasification Zone

The model proposed for the prediction of the length of the char gasification zone is simpler and is taken to be the length of reactor that the fuel will travel through in 100 seconds, as shown in Equation 2.8:

Equation 2.8: $l_g = 100 F_d (1 - F_v)$

This value of a time of 100 seconds was derived from kinetic studies of the char gasification zone performed by Reed and co-workers [66][75] who suggest that the reaction will be 90 % complete after this time. Doubling the length/residence time in the char gasification zone would only increase the degree of char gasification by 1 to 2 % However, there does appear to be some discrepancies in the work as one paper reports that the reaction is effectively complete when the temperature, presumably of the gas, reaches 850 °C [75] and another when the temperature reaches 800 °C [66].

2.6.1.3 General Comments

Reed et al [66] report that the model for the two reaction zones discussed in Sections 2.6.1.1 and 2.6.1.2 has been combined in a 'dynamic' computer spread sheet based model. This has been used to predict the zone lengths for a variety of different feed materials. The accuracy of the model is claimed to be within a factor of 2 to 3 [75], although no comparison to actual measured zone lengths are presented. The simplicity of the model is acknowledged by Reed and Levie but they reported that the model was being refined, although no new information relating to these improvements appears to have been published. Areas that might be included are the reactor heat loss, the air/fuel ratio and the use of different gasifying agents.

2.6.2 Other SERI Modelling Work

In addition to the modelling work discussed above, Reed and co-workers have also reported, although only briefly, on another model developed at SERI [81]. The purpose of the model is to help in the optimisation of gasifier performance and cost and, as with the 'quantitative' model discussed in Section 2.6.1, is divided into two separate reaction zones, the flaming pyrolysis zone and the char gasification zone. Each separate zone is modelled by considering combined mass and energy balances across the zone to give the outlet stream composition and temperature.

The flaming pyrolysis is considered first with the following inputs specified: the gasifying agent (air or oxygen); the oxidant/fuel ratio; and the feed composition. From this data, an adiabatic reaction calculation around the reaction zone is performed to yield temperature gas composition, gas flowrate and char yield.

The outputs of the flaming pyrolysis zone model are used to provide the input conditions to the char gasification zone model. Char gasification kinetics are employed to calculate the conversion/length profile and heat balances on the gas and solid are employed to determine temperature profiles.

Only limited results from the model are presented by Reed and co-workers [81], these include the CO/CO_2 ratio along the char gasification zone and the reactor temperature profile for the same zone. Reed reports that there is close agreement between these predicted profiles and those determined experimentally. However, although there appears to be close agreement for the predicted and actual temperature profiles, this does not appear to be the case for the predicted and actual CO/CO_2 ratios, although this could be attributed to the difficulties in gas sampling. The model is claimed to demonstrate the buffering effect of the endothermic gasification reactions on the char temperature and the results presented for the temperature distibrutions through the char gasification zone for both air and O_2 are similar. This effect is reported by Double[82] with his carbon boundary gasifier model.

A range of data from the pyrolysis model is presented. This consists of the adiabatic flame temperature for the zone for both oxygen and air gasifying agents at various oxidant/fuel ratios for different fractions of fixed carbon. These results are as might be anticipated, that is increasing the oxidant/fuel ratio to near stoichiometric levels, increases the flame temperature, as does the degree of carbon conversion and the use of oxygen rather than air as the oxidant.

As discussed above, only few results are presented and the model is only discussed briefly, therefore it is not possible to draw any detailed conclusions on its value. It is assumed that the model is still under development, although no futher work relating to it has been published.

2.7 NOMENCLATURE

Symbol	Description	Units (SI)
A	Biomass particle area	m^2
Ag	Cross-sectional area of gasifier	m
$C_p(g)$	Average heat capacity at constant pressure for steam over temperature range 100 to T_s °C	kJ kg^{-1} K^{-1}
C_{pi}	Specific heat capacity of the ith product of combustion	kJ kg^{-1} K^{-1}
$C_p(l)$	Average heat capacity at constant pressure for liquid water over temperature range T_o to 100 °C	kJ kg^{-1} K^{-1}
C_{pw}	Specific heat capacity of the biomass	kJ kg^{-1} K^{-1}
D	Characteristic size (cubic root of particle volume)	m
F_d	Feed particle density	kg m^{-3}
F_m	Feed moisture fraction dry basis	-
F_o	Fraction of energy in gaseous surround	-
F_s	Sphericity (Ratio of the surface area of a sphere of same volume as particle to actual surface area of particle	-
F_v	Fractional voidage	-
M_X	Mole fraction component X	-
T_o	Initial biomass temperature	°C
T_p	Pyrolysis temperature	°C
T_s	Surface temperature of biomass	°C
V	Particle volume	m^3
X	Degree of reaction	-
$h_p(T_s)$ (or h_p)	Heat of pyrolysis	kJ kg^{-1} K^{-1}
h_v	Heat of vaporisation of water	kJ kg^{-1}
$h_w(T_s)$ (or h_w)	Heat of vaporisation of water at T_s	kJ kg^{-1}
k	Constant	-

l_g	Length of char gasification zone	m
l_p	Length of pyrolysis zone	m
m	Biomass feedrate	kg s^{-1}
q	Heat transfer rate	W m^{-2}
t	Time	s
ρ	Density	kg m^{-3}

CHAPTER 3
EXPERIMENTAL APPARATUS

3.1 INTRODUCTION

The objectives of this project were to design, build, commission and operate a gasifier that could be used to investigate the parameters that influence the gasification process. The design process can be summarised as follows:

a) The selection of the reactor geometry to be employed.

b) The identification of the items of ancillary equipment required, that is: reactor feeding; gas cooling; gas cleaning; gas pump; method of product disposal; gas burner; instrumentation; data-logging and safety equipment.

c) The specific design, that is sizing and selection of materials of construction of equipment.

d) Modifications and/or redesign as a result of experience gained during commissioning. The commissioning experiments are discussed in Chapter 5.

This chapter describes the design of the complete gasifier system. This is presented in a 'flow' order, that is the equipment is described in the order through which the biomass, and subsequently the product gas, passes through it. The design of each individual item of equipment is dealt with in chronological order, starting with the initial design and then dealing with the redesign or modifications required, if any. These modifications are also summarised in Chapter 5. A P and I diagram of the complete system is presented in Appendix III, and Figure 3.1 illustrates the complete system, excluding the lean gas burner. The system costs are itemised in Appendix V.

3.2 REACTOR FEEDING

To prevent the ingress of air into the gasifier and the egress of gasification products from the reactor, reactor feeding systems need to be gas tight. However, the

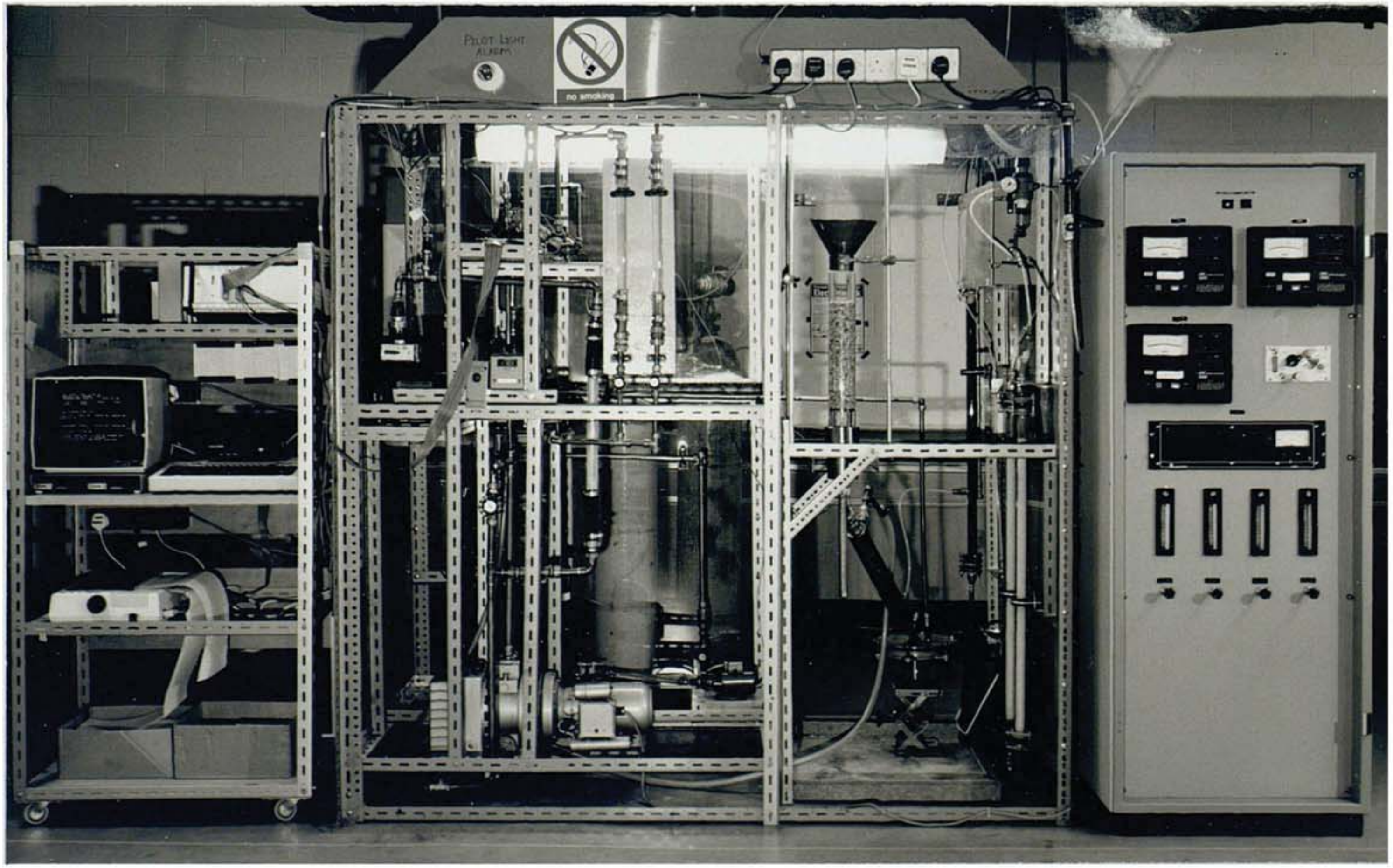


Figure 3.1 Complete Gasifier System

fibrous nature of biomass, makes the design of suitable biomass feeding systems a difficult task [83]. The feeders that have been developed are generally complex, costly and often unreliable. However, the choice of the open-core downdraft reactor geometry (see Section 3.3) with its open top allows for direct feeding of the reactor and, at the scale of operation chosen, hand feeding. The technique chosen was a hand batch system and is discussed in Chapter 5. The feed was introduced via a funnel, the same funnel being used as with the previous Aston gasifier, in order to allow access to the reactor for the bed thermocouple array (see Section 3.8.2). The flow of solids through this funnel had proved adequate, as it did not block even when used with a feed consisting entirely of pins [84].

3.3 REACTOR

The first stage in the design of the gasifier system was to select the reactor geometry to be employed. The types of gasifier available and their advantages and disadvantages are discussed in Chapter 2. From consideration of the factors described in that chapter, notably its ease of construction and operation particularly related to reactor feeding; and the novelty of the gasifier geometry, it was decided to employ a reactor of the open-core downdraft geometry.

Transparent quartz glass tubing was selected as the material of construction as it would allow the gasification process to be observed and monitored while the reactor was in operation. The principle of a transparent quartz glass open-core reactor had already been established at Aston [84] and SERI [55]. However, the principle was not studied in detail, although its potential as a research tool was clearly demonstrated by these groups.

3.3.1 Diameter

As a result of experience gained at Aston using a 3.75 cm diameter reactor [84], it was decided to build a reactor of larger diameter to give lower heat losses from wall effects, and a greater ability to accept a wider variety of feed materials. However, an upper size limit on the reactor diameter had also to be set, this being constrained by a number of factors, including:

- the range of quartz tubing commercially available which was sold in a range based on internal diameter and included the following sizes 5.0, 7.5, 10.0, 12.5 and 15.0 cm.

- increasing the reactor diameter would increase the reactor throughput which would subsequently effect the rate of reactor feeding, possibly occupying a greater amount of the operators' time, and due to the increased product gas throughput, increase the size and cost of the ancillary equipment required.

In order to select the appropriate diameter, it was, therefore, necessary to estimate the throughputs of both the product gas and biomass feed. These estimates were based on limited data available in the literature for 'air-blown' open-core downdraft reactors which is summarised in Table 3.1. Of the data available, that of Bright, Cloney and Fan [84] and Reed and Markson [55] was taken as most indicative of the performance of the proposed reactor due to the similarity in construction and feed materials employed. In order to scale the biomass throughput to the proposed reactor diameters, the feed rate was taken to be directly proportional to the reactor cross-sectional area or the square of the reactor diameter and, therefore, doubling the reactor diameter would quadruple the reactor throughput. The biomass throughputs estimated are shown in Table 3.2, the scaling factor being cross-sectional area. The anticipated product gas throughputs are shown in Table 3.3 with the calculations presented in Appendix II.

Table 3.1 Performance Data for 'Air-Blown' Open-Core Downdraft Gasifiers

Author	Bright, Fan & Cloney	Reed & Markson	Manurung & Beenackers	Reines
Reference	[84]	[55]	[58]	[67]
Group	Aston University	SERI	Twente University	Open University
REACTOR				
Diameter (cm)	3.75	5.4	45	12
Construction	Quartz glass	Quartz glass	Not known	Refractory
FEED				
Rate (kg/m^{2}hr)	192	540	157	209
Type	Wood chips	Wood chips	Rice Husks	Carrot Fibre
PRODUCT				
Yield (Nm3/daf kg)	4.18	2.68	1.6	1.51

Table 3.2 Biomass Throughputs for a Variety of Reactor Diameters Estimated from Data in Literature

Reactor Diameter (cm)	Estimated Throughput (kg/hr) Bright et al data	Reed & Markson data
5.0	0.38	1.06
7.5	0.85	2.39
10.0	1.51	4.24
12.5	2.36	6.63
15.0	3.40	9.56

Table 3.3 Gas Throughputs for a Variety of Reactor Diameters Estimated from Data in Literature

Reactor Diameter (cm)	Estimated Gas Rate Range (Nm^3/hr)
5.0	1.01 - 2.86
7.5	2.27 - 6.40
10.0	4.03 - 11.39
12.5	6.30 - 17.79
15.0	9.08 - 25.62

Calculations are shown in Appendix II.

It was found from the throughput data, as presented in Tables 3.2 and 3.3, that although reactors of 5.0 cm and 7.5 cm could utilise much the same equipment, increasing the reactor diameter from 7.5 cm to 10.0 cm would require ancillary equipment of greater capacity and, therefore, cost. A reactor of 10.0 cm or greater in diameter would have required a pump of greater capacity and possibly a larger capacity scrubber, lean gas burner and piping. The larger capacity of pump required at these higher reactor diameters would have required a 3 phase electrical supply being installed in the laboratory. Furthermore, it was felt that the maximum acceptable feed rate for a hand fed reactor, at the feed rate calculated from Reed and Markson, would be for a reactor of 7.5 cm diameter which would require feeding approximately every 75 seconds if using batches of 50 g. On consideration of this throughput data, it was decided to employ a reactor of 7.5 cm in diameter.

3.3.2 Height

The height of the reactor to be employed was based on three main criteria:

i) The height available within the fumehood which was 2.05 m. However, this had to accommodate, as well as the reactor, access for feeding, the funnel, the connecting collar, the heat exchanger, the catchpot and access at floor level. The total height required for the equipment, excluding the reactor and the heat exchanger, was 0.6 m, thus limiting the height for the reactor and exchanger to 1.55 m. Some flexibility was allowed in the length of the exchanger, but the experience with the previous Aston reactor [84] suggested that a cooled length of at least 0.5 m would be required, thus limiting the maximum reactor height to approximately 0.8 m.

ii) The fragility of the tubing. The quartz tubing of the reactor was relatively fragile, this fragility being qualitatively proportional to the reactor height. In view of the reactor fragility (and the clumsiness of the author), it was decided to have a spare tube.

iii) Furthermore, the quartz tubing could only be purchased in standard lengths of one metre at a cost of approximately £125/metre, although these could be cut as desired.

On consideration of all these points, it was decided to employ a reactor of 0.5 m, so that two reactors could be cut from one standard length of tube.

3.3.3 Grate

The purpose of the grate is both to support the reactor bed and to allow the product gas to exit the reactor at minimum pressure drop and, therefore, normally takes the form of a perforated plate. The overall diameter of the grate is 7.3 cm with a tolerance of 0.2 cm on the reactor internal diameter to allow for thermal expansion, this being an adequate allowance for temperatures as high as 1500 °C and was calculated from the coefficient of linear expansion for type 304 stainless steel [85]. This design is a direct scale-up, on hole to reactor diameter ratio, of the grate that had been successfully used on the previous Aston reactor. The size of hole in the grate is dependent on the particle size of the feed, which in turn may be taken to be proportional to the reactor diameter and, therefore, the grate was drilled with sixtytwo 0.5 cm diameter holes. Stainless steel (type 304) was selected as the material of construction on consideration of the elevated temperatures, in the order of 1000 °C or more, and attack by reactive products, that is pyroligneous tars and acids, steam and possibly hydrogen and carbon monoxide, that the grate would be subjected to.

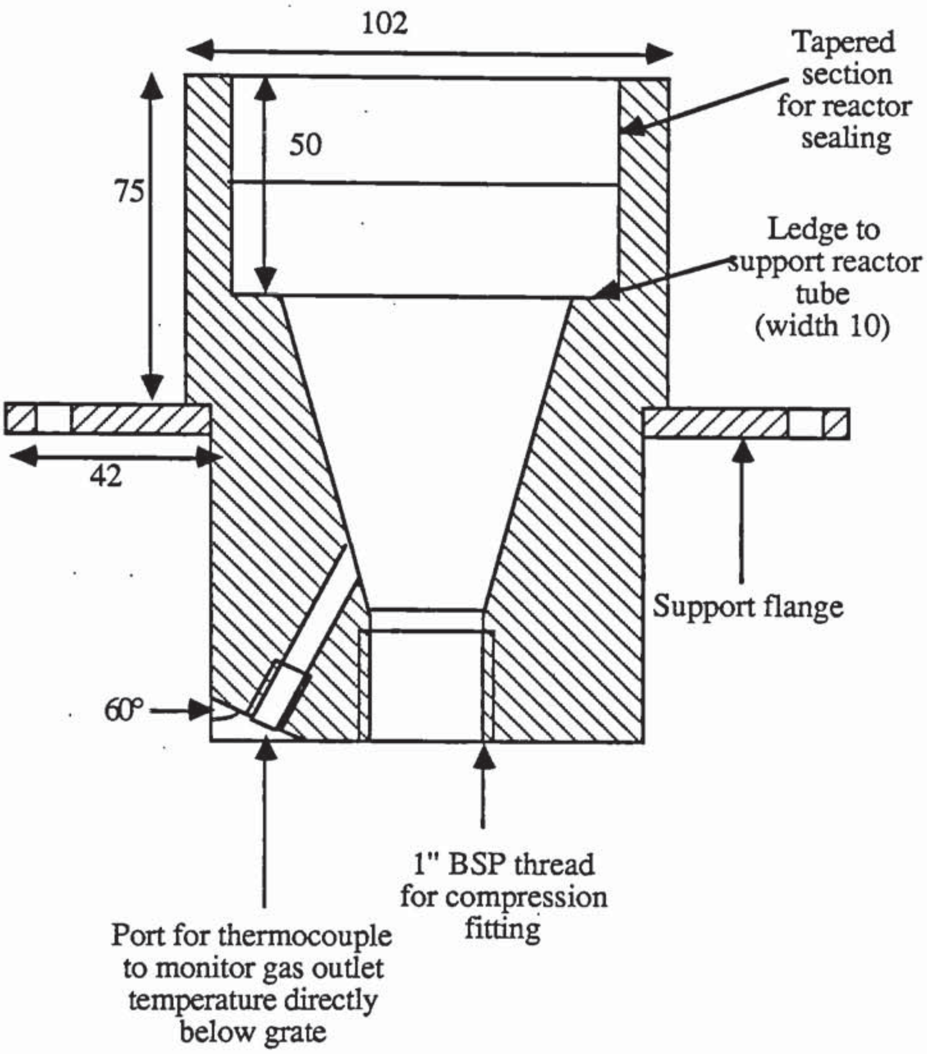
3.3.4 Connecting Collar

The quartz glass tubing selected as the material of construction offered a number of advantages (see Section 3.3), although it did create a difficulty in connecting the reactor to the downstream equipment. This problem was overcome by mounting the reactor in a steel 'collar' (see Figure 3.2), which could be connected to the downstream equipment via a standard compression fitting. A port was included to allow for the mounting of a thermocouple to measure the temperature of the product gas directly below the grate. The thermocouple was mounted using a compression fitting. The collar was fabricated in stainless steel (type 304), this material being selected on the same criteria as for the grate (see Section 3.3.3).

Variations in the outer diameter of the quartz tube and a thermal expansion allowance between its external diameter and the internal diameter of the collar meant that this 'bond' was not gas tight and thus a sealant was required. The selection of this sealant is discussed in the next section.

3.3.5 Reactor Sealing

The sealant selected had to be able to withstand high temperature, possible attack by reactive products (see Section 3.3.3) and be easily removed in order for the reactor to be cleaned. The use of rubber and polymer sealants was discounted due to their temperature limitations and fire cements were excluded on the basis that they would not allow the reactor to be easily removed. Evidence collected on the previous Aston reactor [84], suggested that fire cement might crack, and hence leak, or worse crack the reactor under the stress created by the difference in the thermal expansion of the steel and the quartz. The final possibility was the use of a fibrous material packed into the gap between the collar and the tubing. The traditional choice for this packing material would be asbestos. However, University regulations prohibited the use of asbestos and an alternative had to be found. The



Not to scale
All dimensions in mm (unless stated otherwise)

Figure 3.2 Section of Stainless Steel Connecting Collar

alternative selected was a fibrous ceramic material with specification shown in Table 3.4. This was available in a variety of forms, loose fibre, string and paper. For this sealing purpose, the 2 or 3 mm paper was found to be most suitable, as this allowed the reactor to be sealed by placing the tubing on a 'gasket' of the paper as well as by the packing technique. In order to make the sealing process easier, a slight taper (wide end at the top), was machined into the collar (see Figure 3.3).

Table 3.4 Properties of Kaowool [86]

Chemical Composition	
Component	**Composition %**
Al_2O_3	43 to 47
SiO_2	53 to 57
Fe_2O_3	0.02 to 0.08
TiO_2	0.02 to 0.05
MgO CaO	<0.1
Alkalis Na_2O K_2O	0.05 to 0.4
B_2O_3	<0.02
Leachable chlorides	<20ppm
Physical Properties	
Density (kg m^{-3})	230
Max.continuous service temp (°C)	1260
Melting point (°C)	1760

3.4 PRODUCT GAS TREATMENT

Previous experience at Aston and information gained from the literature, suggested that the product gas leaving the reactor would be both hot, up to a possible 1000 °C and 'dirty' containing a number of contaminants (see Section 3.4.2). The analysis and metering of the product gas and the requirement to place the gas pump downstream of the reactor precluded direct flaring of the product gas. However, the temperature and 'dirtiness' of the gas exiting the reactor, would either damage or be outside the operating conditions of a number of items of equipment, such as the gas pump (depending upon the type of pump employed), the flowmeter, pressure transducers, gasmeter and gas analysers. Furthermore, the expansion of the gas due to the raised temperature could also limit the pump's capacity. Therefore, it was decided that the product gas leaving the reactor required both cooling and cleaning prior to the gas pump and instrumentation.

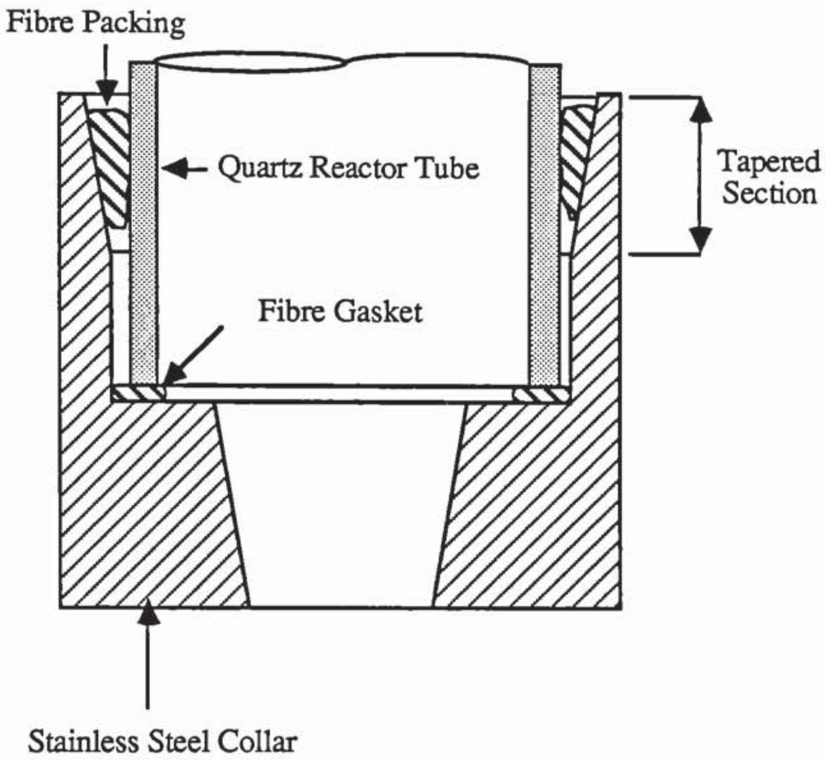


Figure 3.3 Schematic of Stainless Steel Collar Illustrating Reactor Sealing Technique

3.4.1 Gas Cooling

It was decided to employ a wet scrubbing system as this would act as both a gas cooler and cleaner (see Section 3.4.2.2). However, it was anticipated that the gas exit temperature from the reactor would be in the range 700 to 1000 °C [65] and it was felt that this gas temperature was too high to pass directly to the scrubber. The scrubber was to be built of QVF and such a temperature would be outside its operating temperature range and problems might be encountered with excessive evaporation of the scrubber water. Therefore, it was decided to install a primary heat exchanger to act as a gas pre-cooler, the construction of which is described below.

In order to avoid blockage of the primary heat exchanger with particles of char, unreacted feed, tar or combinations of these materials, and to allow for drainage of any condensate to the catchpot, it was decided to employ a concentric tube water cooled exchanger, mounted vertically below the reactor. To facilitate ready access to the reactor for feeding, the total length of the exchanger was limited to 1.0 m (see Section 3.3). To allow provision for a gas sampling port and to provide access to the compression fittings, which were employed to enable the exchanger to be easily removed for cleaning and modification, the cooled length of the exchanger was limited to 0.75 m. However, this also entailed that the hot gas from the reactor would be entering an un-cooled section of the exchanger. As the gas could be at a temperature in the order of 1000 °C, this precluded the use of copper and, due to the possibly corrosive nature of the gas (see Section 3.3.3), it was decided to fabricate the exchanger from type 304 stainless steel. In order to minimise the risk of blockage, the gas tube was fabricated from 2.54 cm diameter tube.

The heat transfer coefficient could not be accurately calculated due to uncertainties in the gas composition, although it was known that the gas side coefficient would be controlling. However, an estimate of the gas exit temperature from the exchanger could be obtained and was based on the data from the exchanger used with the previous Aston reactor [84]. This estimate indicated that, although the heat load over the exchanger would be increased, both the exchanger area and heat transfer coefficient would increase, the latter due to the increased gas velocity through the exchanger. Therefore, it was concluded that the gas exit temperature from the exchanger would be of the same order as the previous reactor, that is between 100 and 200 °C [84] which was felt to be acceptable. When the gasifier was operated, the actual temperature measured at the end of the cooler was in the region of 150 °C.

After the first commissioning run (see Chapter 5), it was decided to lower the reactor in order to improve access to the reactor. To facilitate this alteration, the heat exchanger was remounted to run diagonally from the reactor (see Figure 3.4).

The solid's catchpot (see Section 3.4.2.1) placed directly after the exchanger also acted as a gas cooler due to its ice cooling. However, the ice cooling was not intended to act as a gas cooler but to maintain the QVF from which the catchpot was constructed within its safe operating temperature. When the gasifier was operated, the actual temperature measured after the catchpot was in the region of 80 °C. In addition, it was anticipated that the gas would be further cooled in the pipe between the catchpot and the scrubber.

3.4.2 Gas Cleaning

As discussed above, it was anticipated that the gas leaving the reactor would be 'dirty' and that in order to protect the instrumentation, some form of gas cleaning would be required. At the initial design stage, the combined scrubber/gas pump was considered (see Section 3.5). However, when it was decided to employ a vacuum pump of the positive displacement type, a separate gas cleaning system was necessitated.

On the basis of the previous experience gained at Aston [84][87] and the literature review, it was anticipated that the dirt in the gas would comprise of two main types of contaminant: a 'mist' of fine droplets of pyroligneous tars and acids; and entrained particles of ash and char. It was also anticipated that particles of char and unreacted feed would fall through the grate and, although not entrained in the product gas stream, had to be collected in order to avoid blockage of the piping.

3.4.2.1 Solid's Catchpot

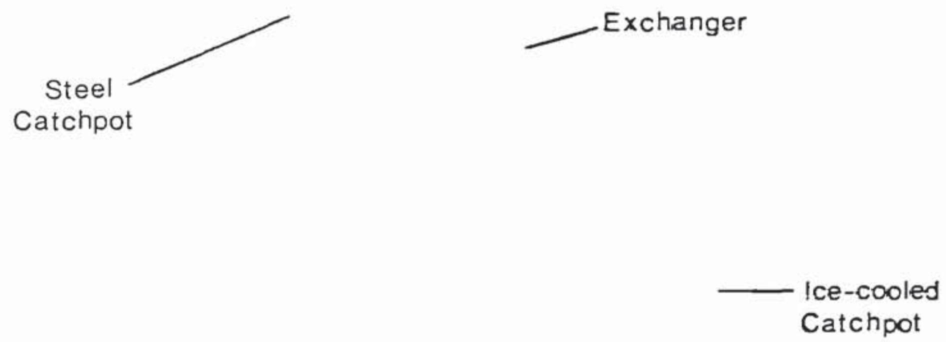
The first stage of gas cleaning was a solid's catchpot. In the original layout, this was placed directly below the reactor (after the heat exchanger) and was designed to remove any large solid particles (ie >0.5 mm) that were entrained in the product gas and those particles falling through the grate. In order to allow the quantity of removed particles to be observed, the catchpot was made from a section of QVF column. To maintain the QVF within its permitted operating temperature range, the catchpot was cooled in a salt/ice bath which also meant that the catchpot acted as a gas cooler.

The realignment of the heat exchanger (see Section 3.4.1) meant that the catchpot was no longer directly below the reactor, therefore, in order to catch any particles falling through the grate, a secondary catchpot was placed directly below the reactor prior to the heat exchanger fabricated from stainless steel. The catchpots are illustrated in Figure 3.4.

3.4.2.2 Gas Scrubber Device One

A wide variety of equipment is used for gas cleaning in industry, including wet scrubbers, cyclones, electrostatic precipitators and filters. For this particular application, it was decided to employ a wet scrubbing system. This decision was made after a review of the relevant literature which indicated that wet scrubbing systems were the type most commonly employed with other gasifiers. Further reference to the literature suggested that the efficiency of cyclones, in the region of 85 % [88], would not be adequate and had only been used for the removal of char and ash entrained in the gas [77][89]; and the 'sticky' nature of the tarry contaminants would tend to clog filters thus limiting their operating life. The use of an electrostatic precipitator was discounted as, due to their complexity, a system would have to be purchased and insufficient funds were available for this, and no data was available relating to their use with gasifiers.

A further factor included in the selection of a wet scrubbing system was its ability to act as a gas cooler, as had been demonstrated by Nielson and Nielson [90] in the cooling and cleaning of the flue gas from a straw furnace using a packed scrubber. As discussed in Section 3.4, the product gas required both cooling and cleaning and, therefore, a system that could perform both these tasks was felt to be desirable. The particular advantages of a combined cooler/cleaner were that it would minimise the number of items of equipment required and, therefore, ease


Exchanger
Steel Catchpot
Ice-cooled Catchpot

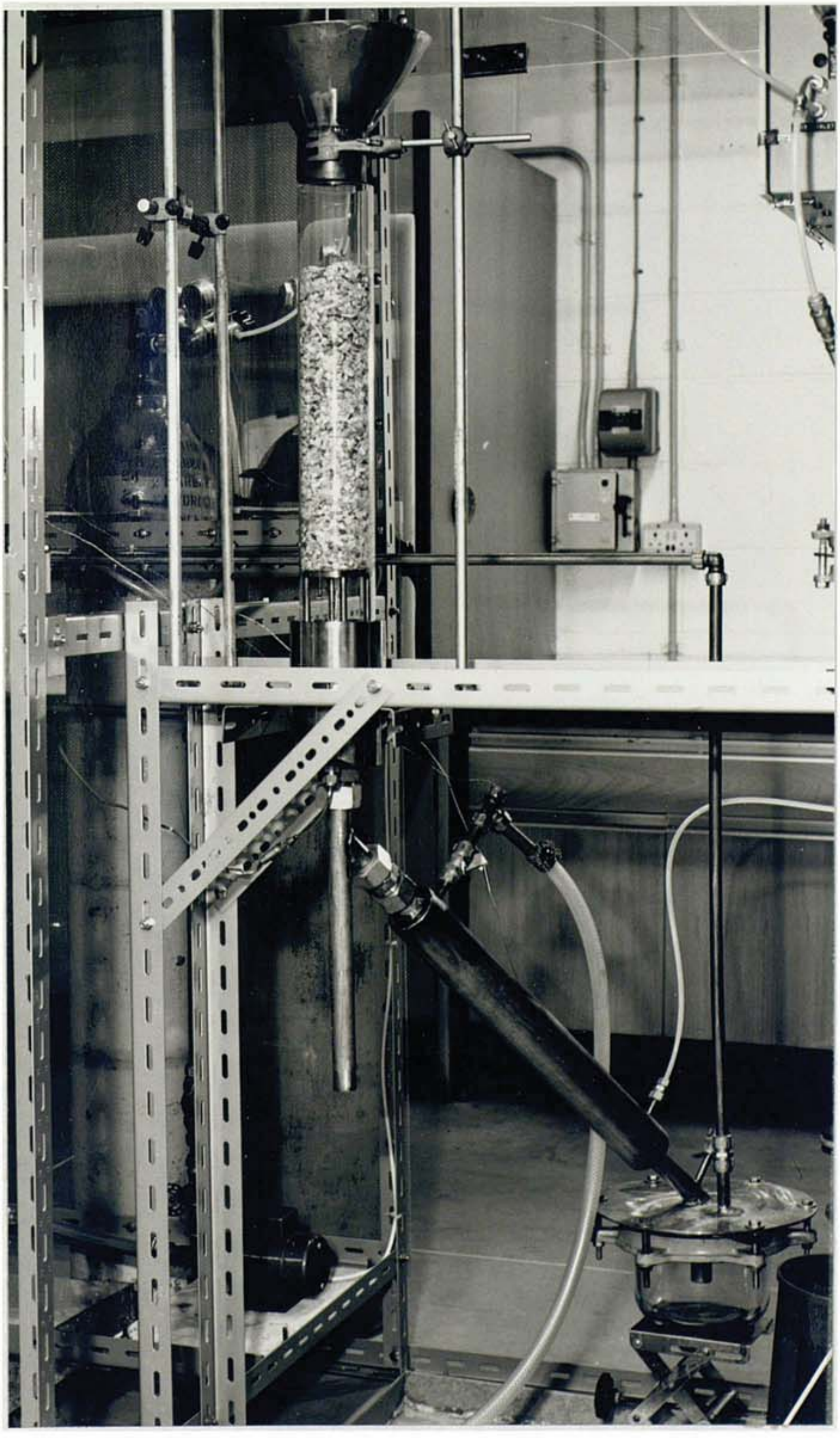


Figure 3.4 View of Reactor Showing Catchpots and Heat Exchanger

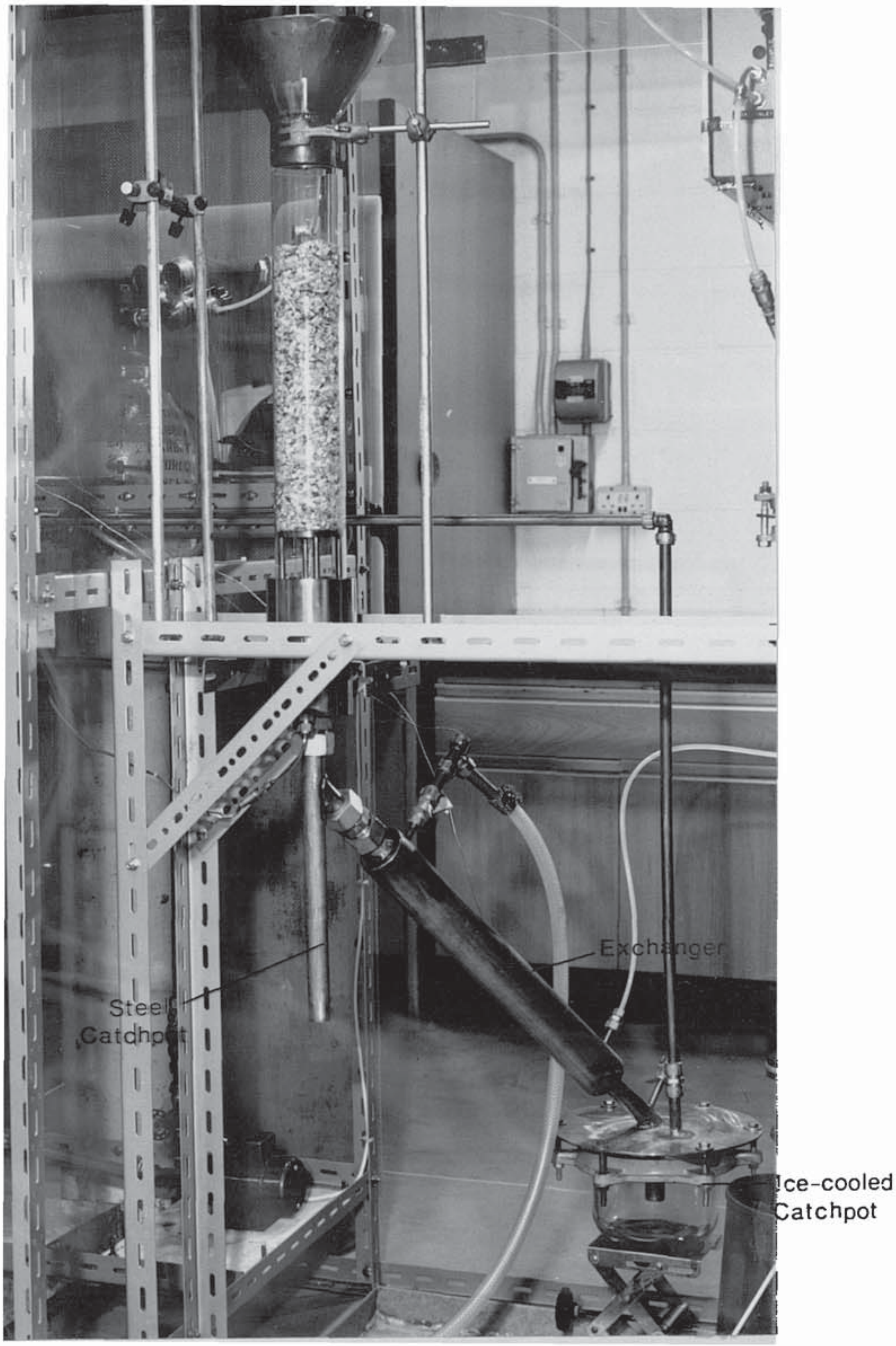


Figure 3.4 View of Reactor Showing Catchpots and Heat Exchanger

problems associated with the layout of equipment within the confines of the fumehood.

There is, however, a wide variety of different types of wet scrubber (see Table 3.5) and it was, therefore, necessary to perform a selection process in order to identify the most appropriate scrubbing system for use with the gasifier.

The choice of scrubbing system was based on the following criteria:

a) Scrubbing Efficiency - the purpose of the scrubbing system was to remove as many contaminants from the gas as possible, therefore, the efficiency of the apparatus was an important criterion. The efficiency of a scrubber is generally considered as a grade efficiency, which expresses the efficiency of the scrubber at a particular particle size or size range and is represented algebraically in Equation 3.1.

Equation 3.1: $\eta_{ig} = [\ 1 - C_2/C_1\ ] * 100$ [91]

No information was available in the literature on the particle size of the gas contaminants from a downdraft gasifier. However, it was reported from the previous Aston work that tar droplets were 'very small' [87], although the size was not quantified. Only limited data was available for the comparison of the performance of wet scrubbers, and it was decided to employ the data of Marchello and Kelly [91] which covered the smallest particle size and is detailed in Table 3.5.

b) Scrubber Pressure Drop - although the pump was selected to maintain its capacity at low inlet pressures (see Section 3.4), it was desired to employ a scrubber with a low pressure drop in order to minimise its effect on the pump capacity and thus allow a sufficient safety margin for other items upstream of the gas pump.

Also considered in the selection of the scrubber system was its simplicity of construction. Cost and time limitations meant that it would be desirable to select the most simple system possible without adversely effecting either the pressure drop or efficiency considerations. A simple construction would also allow the utilisation of equipment already available in the Department, thus saving both cost and time.

Table 3.5 Data Used in the Selection of the Gas Cleaning System

Design	Approx. grade efficiency at 5 μm [91]	Pressure drop ($cm\ H_20$) [91]	Simplicity of construction rating*
Gravity Spray	80	1.3 - 5.1	1
Centrifugal or wet cyclone	87	2.5 - 38.1	1
Self-induced spray	93	5.1 - 38.1	3
Impingement plate	97	2.5 - 20.3	3
Packed bed	99	0.5 - 2.5	1
Venturi	99+	12.7 - 88.9	2
Mechanically induced spray	99+	3.8 - 10.2	3

* Rating 1- Simple to 3 - Difficult

The data on which the selection of the scrubbing system was based is presented in Table 3.5. On consideration of this data, it was decided to employ a packed bed system. This decision was based on the fact that the packed bed type of scrubber had the lowest pressure drop, was considered to be one of the simplest types of scrubber to construct and its efficiency, although not as high as the venturi or mechanical induced spray scrubber, was felt to be sufficient.

It was decided to construct the scrubber from QVF as this would allow the internals of the scrubber to be monitored whilst in operation. However, only a limited number of suitable columns were available so it was decided to select the largest diameter of column available, that is 10.16 cm, in order to give the greatest gas/liquid contacting area. This would allow a maximum packing size of between 0.677 and 1.27 cm. In order to maximise the packing area, it was decided to employ 0.635 cm glass Raschig rings. The scrubber is shown in Figures 3.5 and 3.6.

Percentage flood calculations were performed for the maximum anticipated gas flowrate, ie 6.5 Nm^3/hr, over the gas temperature range 0 to 273 °C, the higher temperature used was chosen to give an adequate allowance for the gas entering the scrubber at an elevated temperature and to simplify the calculations (see Appendix II). The water flowrate was calculated to be between 1.8 and 2.95 l/min, at 80 % flood. Tests prior to start-up using ambient air at a liquid rate of 2 l/min, showed that the column would flood at 10 m^3/hr, which showed close agreement with the calculated value.

In order to prevent 'clogging' of the packing with contaminants removed from the gas and to prevent saturation of the scrubber water with the removed contaminants, the scrubber was designed to work on a once-through water system. However, as the system would be under vacuum, a gravity drainage system could not be employed due to the danger of air leakage into the system. This potential problem was overcome by the installation of a reservoir below the scrubber column which was drained in batches by a level switch activated centrifugal pump. A high water level in the reservoir activated the pump and at low level caused it to be turned off. A non-return valve in the drain line prevented leakage of air back into the reservoir and a tun dish in this line prevented the reservoir from emptying further than desired due to siphoning. A sample point was placed in the drain line so that used wash water could be drawn off for analysis.

3.4.2.3 Gas Scrubber Device Two

Although no quantitative evidence was available, qualitative observations made during and after the first commissioning run, suggested that the packed bed scrubber was not as efficient as required. The gas pump's lubricating oil collected after the run was black and opaque, as opposed to its normal golden and transparent appearance. This colour change was attributed to the absorption of contaminants from the gas as no such discolouration had occurred when the pump had been run in 'cold' commissioning runs. This contamination of the pump oil resulted in the pump requiring a service. There was little evidence of absorption of contaminants in the scrubber water which was only marginally discoloured. Further evidence for the poor performance of the scrubber was provided by the occurrence of a 'smoke' of tar particles in the 'knockout' pot downstream of the scrubber and the discolouration of the water in the gas burner flame trap. On this evidence, it was decided that the packed bed scrubber's performance was unsatisfactory and it was, therefore, decided that a more effective gas cleaning system was required.

It was concluded that in order to obtain effective removal of the tar droplets from the product gas, the efficiency had to be considerably improved by increasing the gas/liquid contacting. As it had been seen that the necessary degree of gas/liquid mixing required for an efficient gas cleaning system appeared to have occurred in

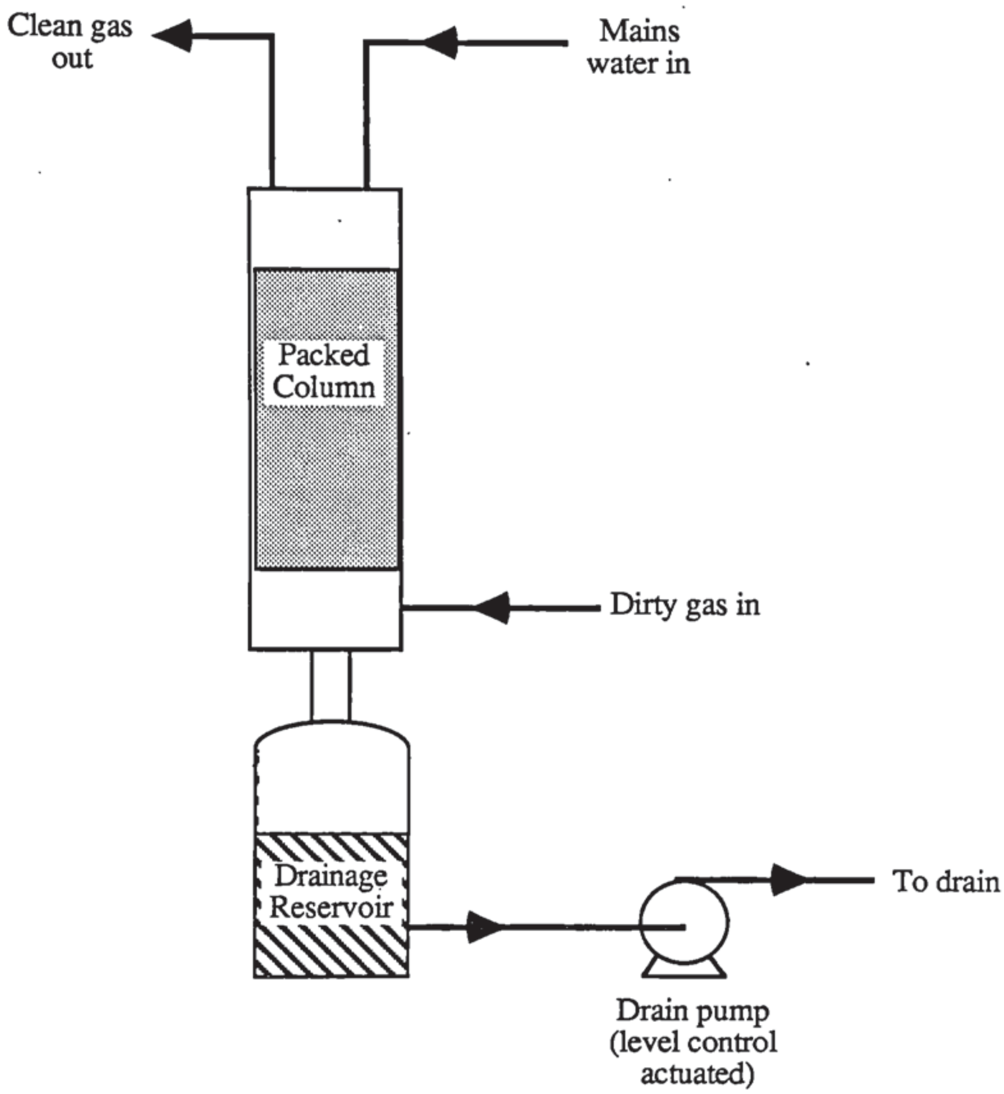
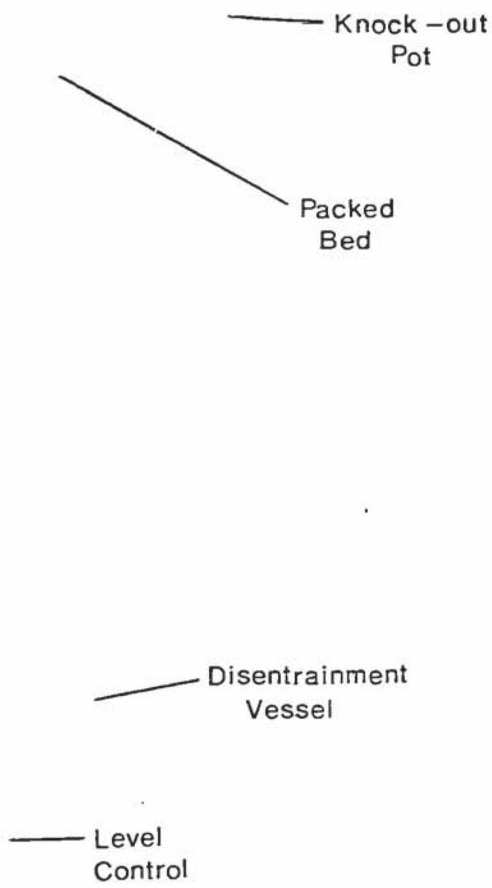


Figure 3.5 Flow Diagram of Scrubber Device One


Knock -out Pot
Packed Bed
Disentrainment Vessel
Level Control

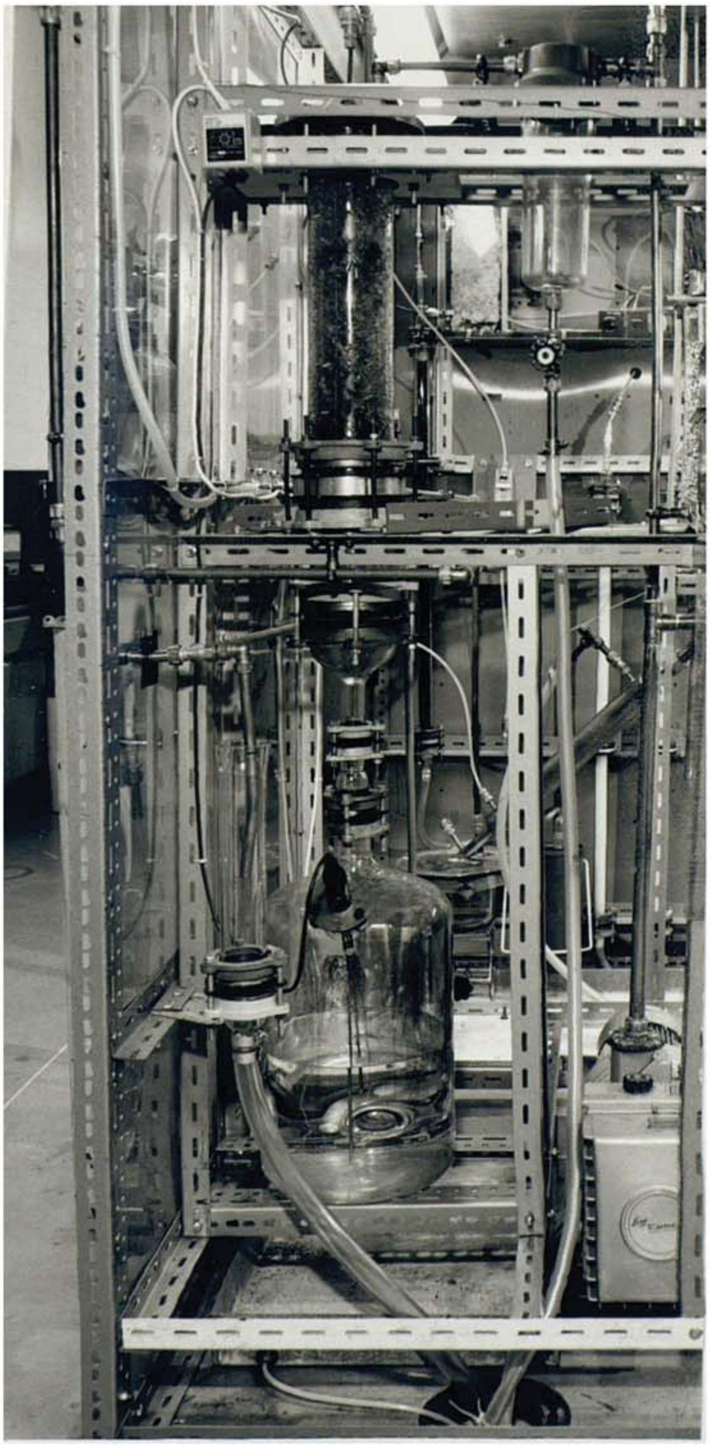


Figure 3.6 Scrubber Device One

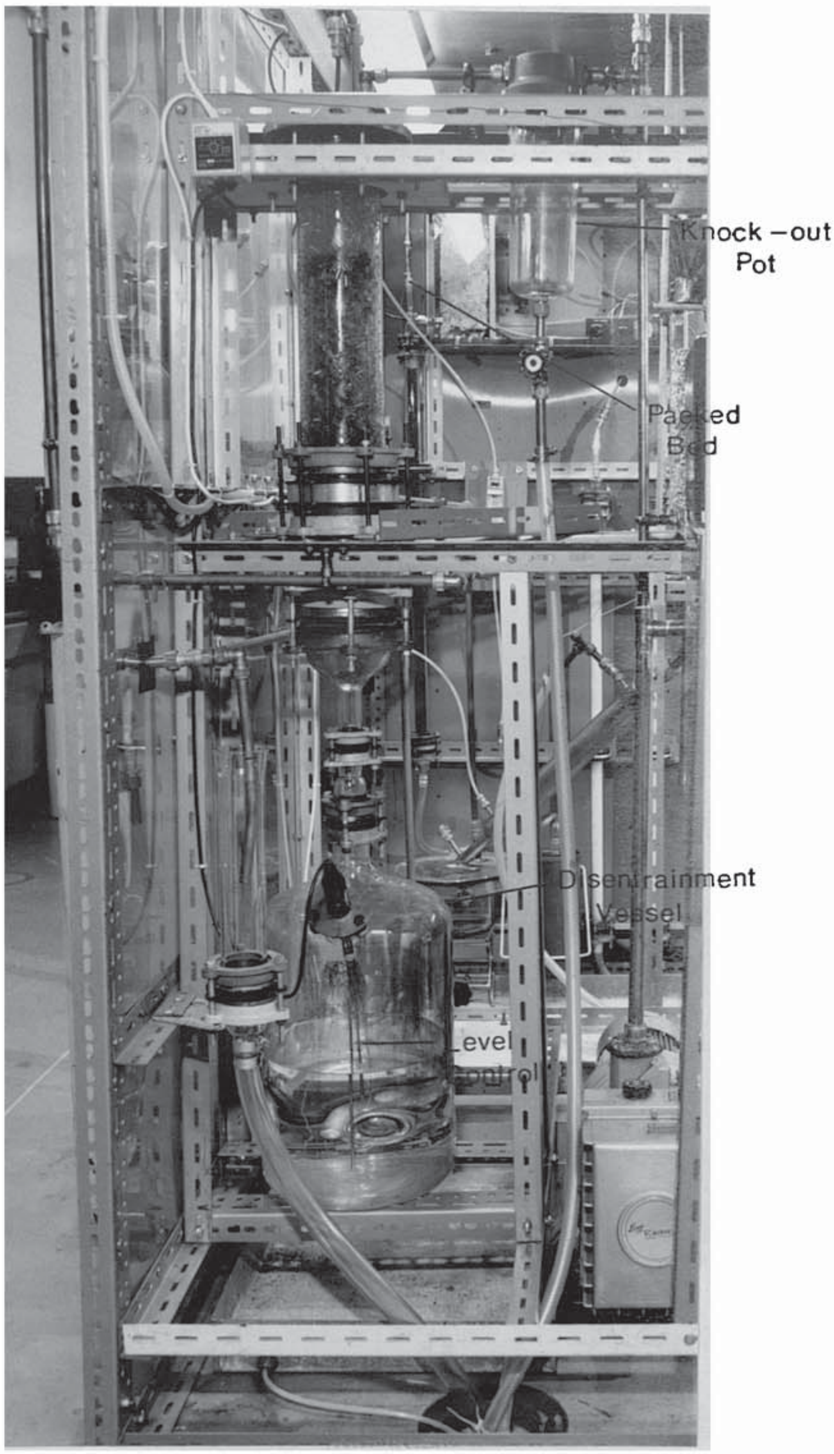


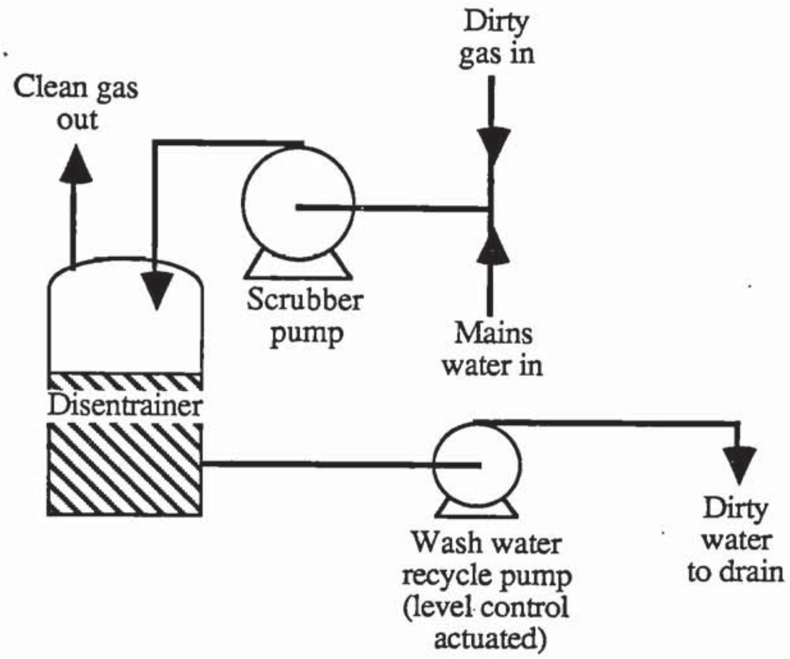
Figure 3.6 Scrubber Device One

the gas pump, it was decided to follow this example and employ a high energy centrifugal contacting scrubber.

A Stuart-Turner No.12 pump was used as the scrubber, providing intimate mixing of the gas and scrubber water occurring in the impeller head of the pump. Initial mixing of the gas and scrubbing water occurred prior to entering the pump. The reservoir system was retained both to prevent air leakage into the system and to act as a disentrainment vessel to separate the scrubber water and the cleaned gas. Tests indicated that the optimum wash water rate was approximately 3 l/min (see Chapter 5), this being a balance between the reduction in pump capacity due the scrubber pressure drop and the gas/liquid mixing.

Initially, this scrubber system was also operated in the once-through water mode, clean water being fed directly to the scrubber from the mains supply and the used water being drained using the level control system. The scrubber efficiency was observed to have improved as evidenced by the colouration of the scrubber water, which was much darker than with the packed bed scrubber; by the presence of tar agglomerations floating on the water surface in the disentrainment vessel; and the absence of the tarry smoke in the knockout pot. However, the increased efficiency of the scrubber caused the failure of the level control system, due to tars coating the sensor electrodes, even when they were sheathed to prevent this. Therefore, in order to overcome this problem and in order to minimise any product gas dissolution in the scrubber water when the gas analysis sample point was placed after the scrubber, it was decided to operate the scrubber with a continuous water recycle. The degree of dissolution of the product gas in the scrubber water would not be the same for all the components, carbon dioxide being significantly more soluble and this would, therefore, effect the accuracy of the mass balance However, with continual water recycle, the scrubber water would become saturated with carbon dioxide and the other components which would minimise this problem. This required a modification so that the reservoir drainage pump was used to inject water into the scrubber pump. Flow diagrams of the scrubber system, in both recycle and once-through water modes, are presented in Figure 3.7 and the system is illustrated in Figures 3.8 and 3.9.

a) Once Through Operation



b) Recycle Operation

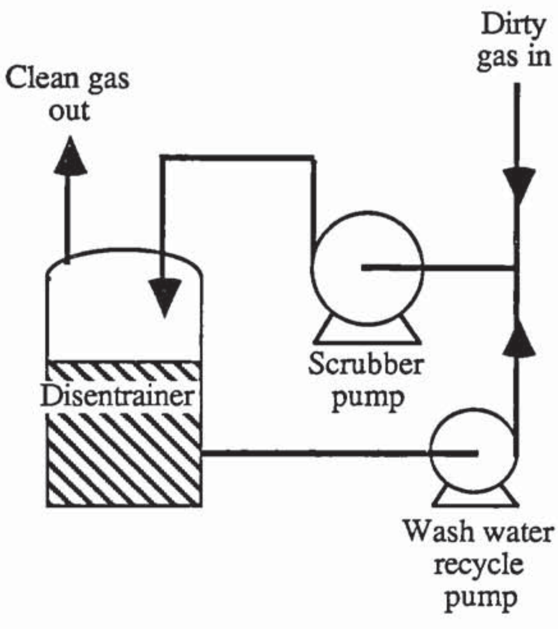


Figure 3.7 Flow Diagrams of Different Set-ups for Scrubber Device Two

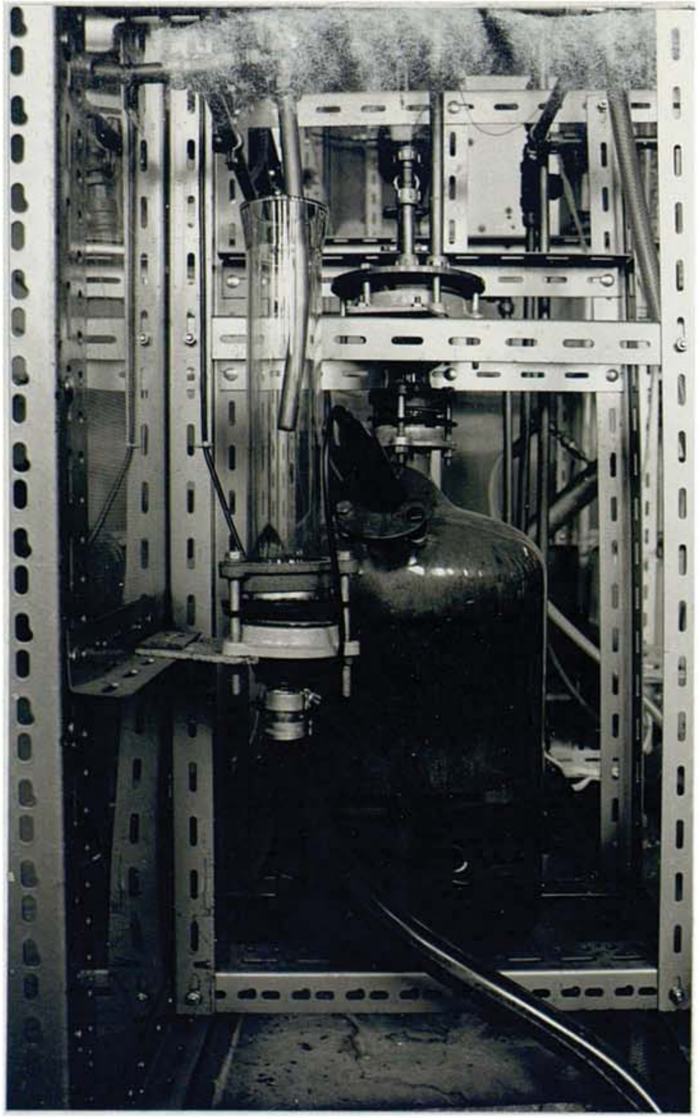


Figure 3.8 Scrubber Device Two Disentrainment Vessel

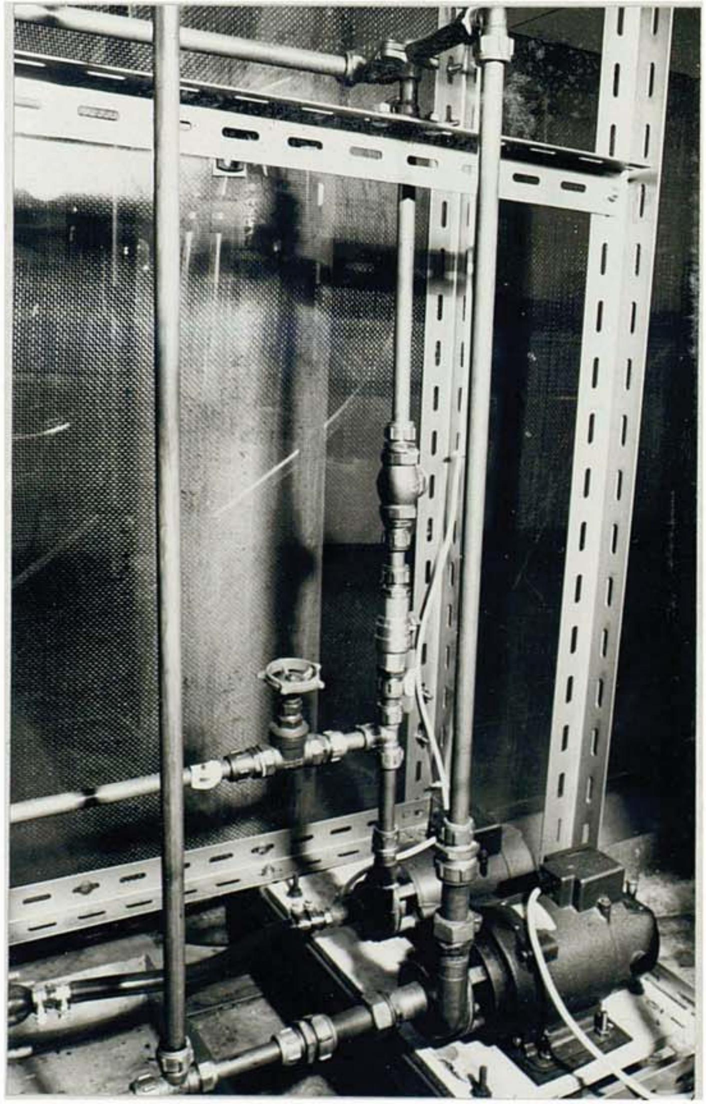


Figure 3.9 Scrubber Device Two Scrubber Pump and Recirculator Pump

3.4.2.4 Pump Filters

Further clean-up stages included a filter on the gas pump inlet after the scrubber to remove any contaminants that had passed through the scrubber and thus further protected the pump. A result of the pumps once-through oil lubricating system was that oil droplets were entrained in the outlet gas stream, and in order to prevent damage to the gas flowmeter in particular, the droplets were removed with an oil mist filter in the pump outlet line but within the recycle loop.

3.5 GAS PUMP

To provide the necessary flow of gasifying agent into the reactor a pump was required. A number of alternatives were available for the type of pump to be employed, that is centrifugal or positive displacement gas pumps; gas or liquid ejectors or venturi systems. However, the first stage in the selection of the gas pump was to estimate the product gas throughput and the system pressure drop.

The total product gas throughput was estimated for a variety of reactor diameters. These calculations were based on gas throughput data of Reed and Markson [55] and Aston gas data, although reported to be inaccurate [84][87]. A further estimate was based on the biomass throughput data of both Reed and Markson [55] and Bright et al [84] and was calculated from the gas yield versus heating value data of Shand and Bridgwater [17]. The calculations are shown in Appendix II and the estimates of gas throughput so obtained are summarised in Table 3.3.

The design of the reactor with an open top necessitated the pump being placed downstream of the reactor, so that the pump operated in the suction mode with air being pulled through the reactor (see P and I Diagram in Appendix III). This meant that the inlet of the pump would be under vacuum whilst the outlet would, due to equipment downstream of the pump, be at slightly greater than atmospheric pressure. On consideration of potential future applications of the gasifier system, for example the use of secondary reactors, and the possible need for gas cleaning equipment, it was estimated that an inlet pressure of 50 kN/m^2 might be required without there being a significant loss of pump capacity.

A choice was, therefore, presented between the purchase of a suitable pump of any type or the in-house manufacture of an ejector or venturi system. However, on consideration of the time limitations of the project, it was felt, as with the feeder (see Section 3.2), that the difficulties associated with the design, construction, commissioning and operation of an in-house built system, would be too time consuming. It was, therefore, decided to purchase a pump and quotations were sought on the basis of the pressure drop and flowrate required; details of anticipated gas composition; and the application of the pump. However, the response was poor and only one quotation that met the specification was received, from Werner Rietschle (UK) Ltd., for two vacuum pumps rated at 10 and 25 m^3/hr (at ATP). As discussed previously (see Section 3.3.1), a reactor diameter of 7.5 cm was selected and on consideration of the anticipated throughputs, it was decided to purchase the pump rated at 10 m^3/hr as it was felt that this would have sufficient capacity. The pump is shown in Figure 3.10.

The pump works on a once-through oil lubrication system. The lubricating system was specified by the manufacturers due to concern over the contamination of the lubricating oil with tars, moisture and other components of the product gas. The pump was of the positive displacement variety and, therefore, the flowrate had to be controlled by the use of a valved recycle loop which gave a flowrate over the range ~ 0.5 to 10 m^3/hr.

3.6 LEAN GAS BURNER

The carbon monoxide content and the explosive nature of the product gas meant that it had to be disposed of by flaring. A lean gas burner with a propane gas pilot light had been developed for the previous Aston reactor and it was decided to adapt this for use with the proposed reactor by altering the pilot light to accept natural gas; altering the interconnecting pipework and burner head to accommodate the greater gas throughputs; installing a sheathed thermocouple for the pilot light alarm sensor and shortening the pipe between the flame trap and the burner. The burner 'jet' itself consists of a flattened 28 mm copper pipe contained in a stainless steel gauze covered 'cowl'. The burner is shown in Figures 3.11 and 3.12.

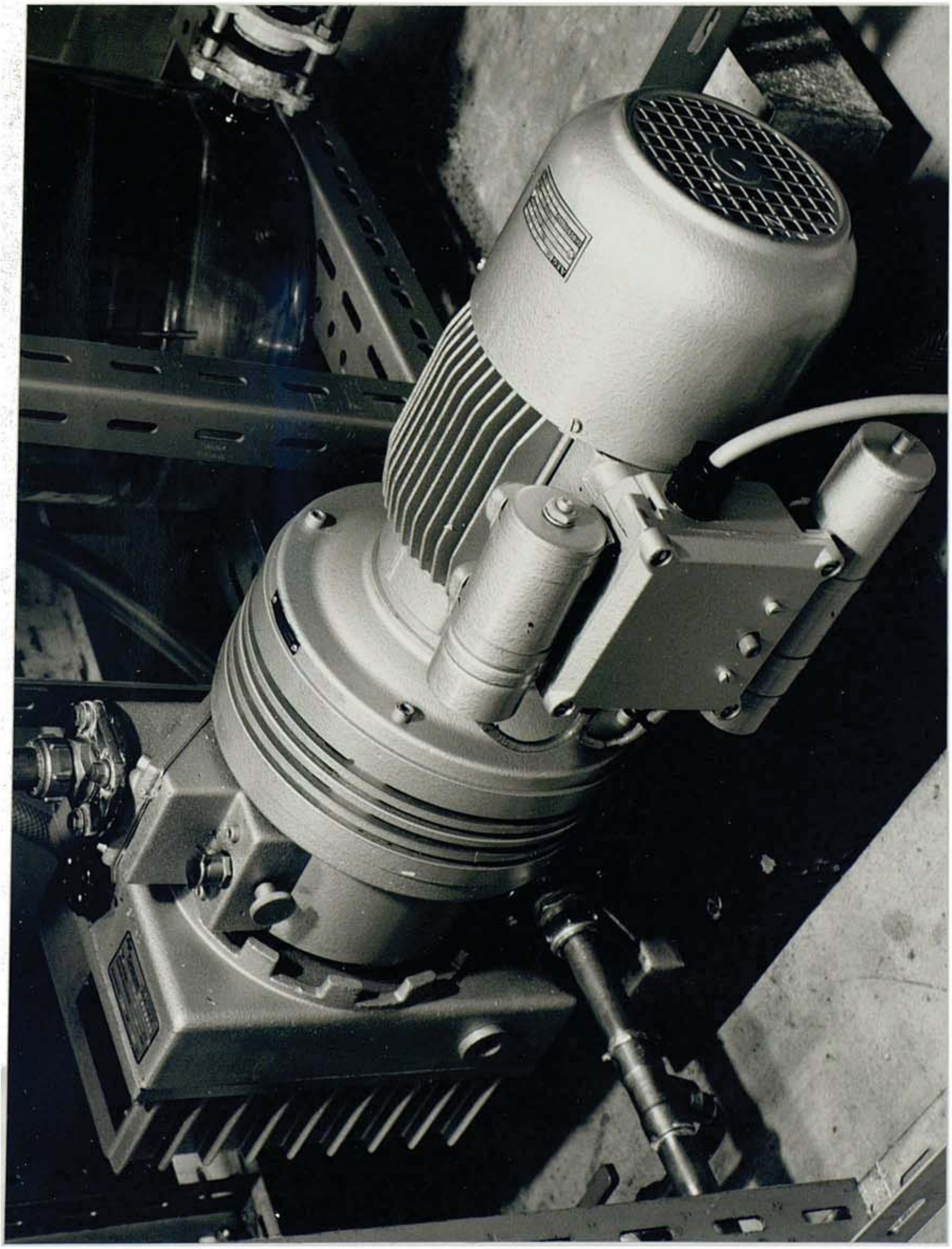


Figure 3.10 Gas Pump

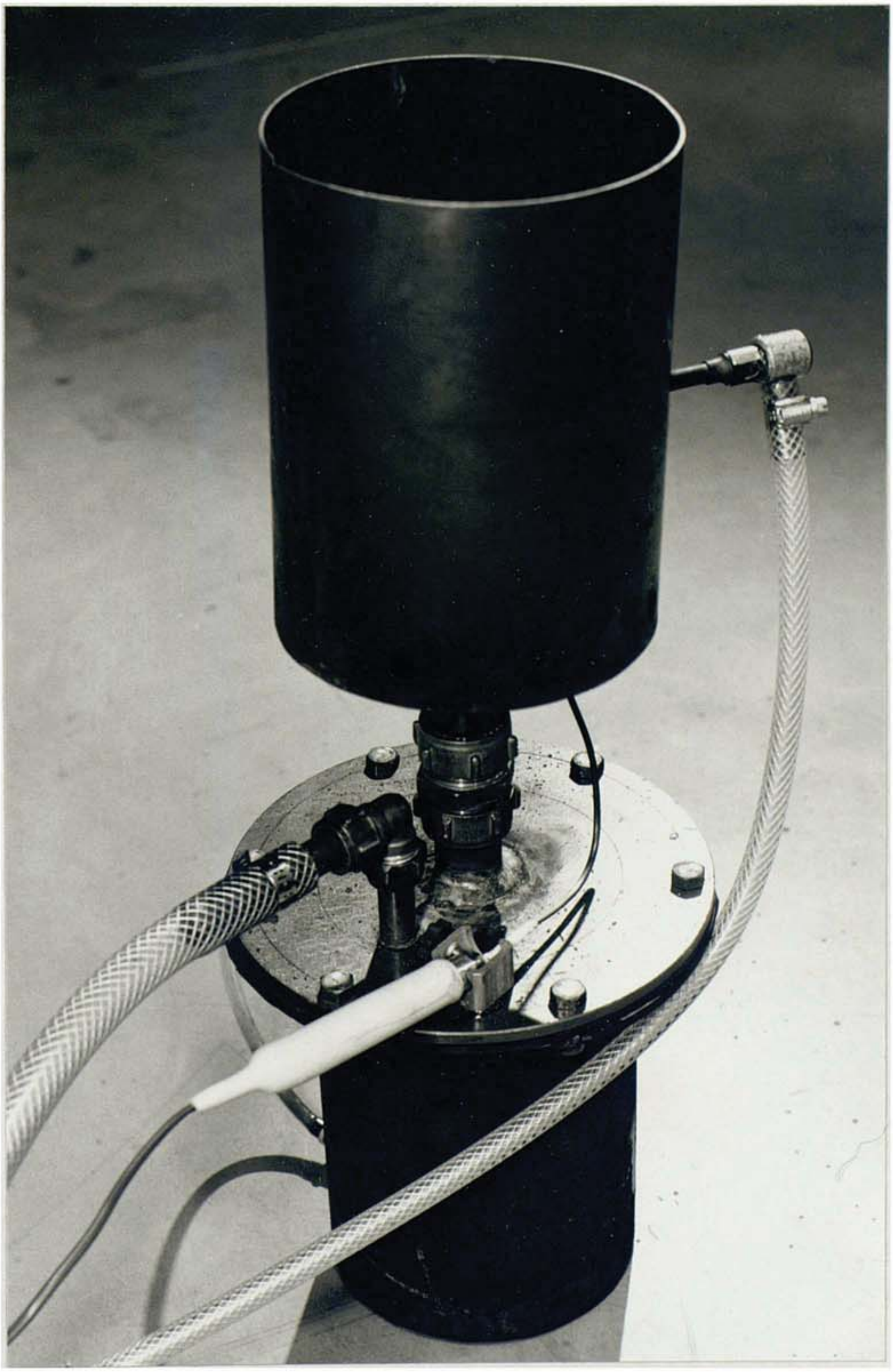
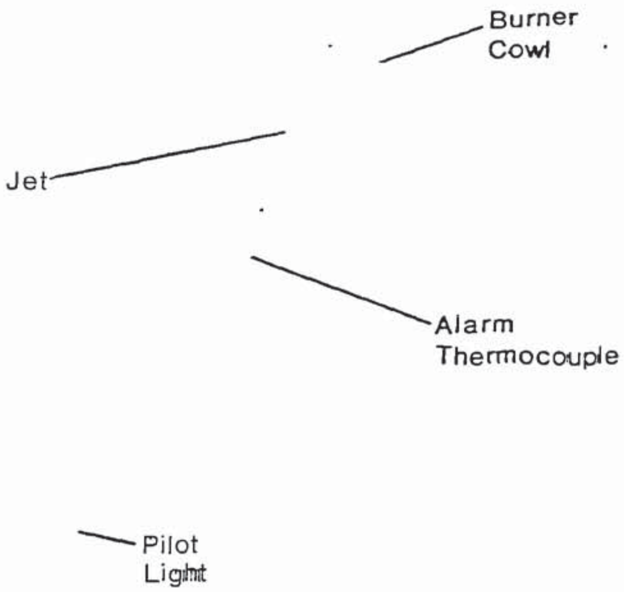


Figure 3.11 Lean Gas Burner



Burner
Cowl
Jet
Alarm
Thermocouple
Pilot
Light

Figure 3.12 Top View Burner Assembly

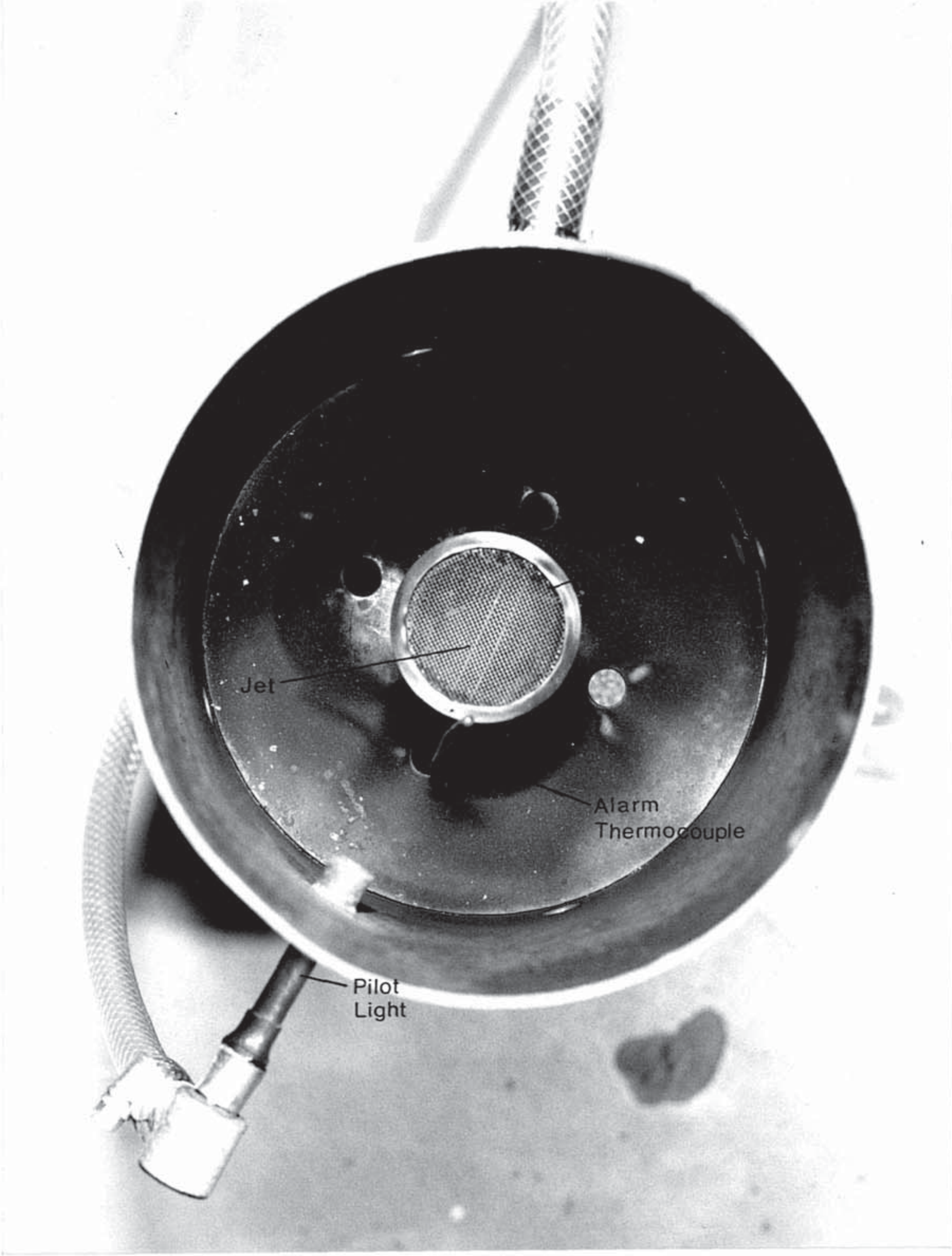


Figure 3.12 Top View Burner Assembly

3.7 PIPING

The two criteria to be considered in the design of the gasifier pipework, were the pipe diameter and its material of construction. Due to their ready availability, it was decided to make use of piping materials available within the Department, that is copper, mild steel, PVC and reinforced PVC. Of the materials available, it was decided that copper piping would be most suitable on the basis that it would have a greater corrosion resistance to gasification products, notably water and pyroligneous acid than mild steel, and would be more durable and hard wearing than the PVC tubing.

The selection of the tube diameter to be used was based on the following criteria: the diameter of pipe available, ie nominal diameters of 6.35, 9.5, 15.0, 22.0 and 28.0 mm; cost, which is directly proportional to the pipe diameter; and the fluid velocity, which is generally taken to be between 15 and 30 m/s [88][92].

The diameter of pipe that gave the most suitable gas velocity for the maximum anticipated gas yields, was 15 mm. This diameter of pipe also permitted a maximum exit temperature (from the primary exchanger) of approximately 300 °C to keep within the gas velocity limits. It was, therefore, decided to fit the gasifier system with 15 mm diameter copper tubing.

However, 15 mm diameter copper tubing could not be used for the entire system. The heat exchanger was fabricated from 25.4 mm diameter stainless steel tube (see Section 3.4.1). In addition, the pump recycle loop was fabricated from 22 mm diameter copper pipe to match the inlet and outlet ports on the pump and thus minimise turbulence at these points, and the final length of piping to the burner which, in order to allow the burner to be readily moved, was plumbed in using 19.0 mm diameter reinforced PVC tubing.

Two types of pipe joint were employed, soldered fittings and compression fittings. The type of joint employed depended on the permanency of the joint and the temperature conditions to which it was subjected. For low temperatures (<100 °C) and permanent joints, soldered fittings were employed, whereas for high temperatures (>100 °C) and/or joints that had to be regularly disassembled for cleaning or modification, compression fittings were employed.

3.8 INSTRUMENTATION

This section describes the instrumentation employed in the gasifier system. A number of parameters were recorded both to allow for the formation of mass and energy balances and to monitor the gasification process itself. It was, therefore, necessary to monitor the inputs and outputs, both in terms of materials and energy flows from the gasifier system, and to monitor the pressure and temperature conditions within the reactor and elsewhere throughout the gasifier system (see P and I diagram in Appendix III). The instruments selected are described in Sections 3.8.1 to 3.8.5.

3.8.1 Gas Analysis

The composition of the product gas from the gasifier is an important parameter that requires both accurate and, in order to identify trends and monitor transient conditions, frequent measurement. The gas composition must be known so that it can be related to variations in reaction parameters; for preparing mass and energy balances; and for calculating the heating value of the gas. The design process for the gas analysis equipment consisted of the identification of the most appropriate type of system for the application; and then the specification of that system.

3.8.1.1 Selection of Type of Analysis System to be Employed

A review of the technical literature available indicated that three types of gas analysis system could be employed. These are described below:

i) Dedicated On-line Gas Analysers - this type of system consists of a single instrument for each gas to be detected and generally requires an automated sampling system. Analysers of this type give continuous gas analysis. However, this type of system is expensive, approximately £2000 - 3500 per analyser with an additional cost for the sample system, although generally the cost of the system is dependent on the number of gases detected. They are generally system specific, an analysis system being designed for a particular application with only limited scope for variation in the detection range.

ii) Manual batch - gas samples are taken by hand using either syringes or special sample bags; these samples are then stored until analysis can be performed off-line. Analysis can then be performed by mass spectroscopy and/or gas chromatography which, with different columns, detectors and the appropriate standards, could allow for a wide variety of gases to be detected. However, the method has the following drawbacks: the storage time between sampling and analysis decreases the analysis accuracy due to gas, notably hydrogen, leakage [84]; taking the gas samples can take a considerable amount of the operators' time; and the analysis of the gas is also time consuming and may further compound any losses of accuracy due to gas leakage.

iii) Process gas chromatography - this consists of an 'on-line' chromatograph and automatic sampling system, and can take and analyse a gas sample approximately every 10 to 12 minutes. This type of system is very application specific and is only designed to detect the gases over set ranges specified in the original design. These systems are also very expensive, in the order of £25000.

The selection of the system to be employed would have to be based on a comparison of the relative merits of each type of system available. It was felt that in order to identify the changes occurring in reaction parameters and their influence on the product gas composition, the most useful system would perform a continual and accurate analysis of all components in the gas. It was also felt that the system should require minimal operator time in order to leave the operator free to both observe and control the gasifier.

However, the ability of the system to fulfil these needs would be constrained by the funds available for its purchase. The anticipated cost of a suitable analysis system meant that it had to be seen to be readily adaptable in order to be used on other projects in the future so that the necessary financial outlay could be justified as cost effective.

The selection of the system to be employed would, therefore, be judged on the following criteria:

a) Sampling rate.
b) Accuracy of analysis.
c) Number of gases detected.

d) 'Stand-alone' ability, ie amount of time dedicated to analyser operation by the gasifier operators.
e) Cost.
f) Adaptability.

The various types of system available were assigned a rating for each of these criteria, the most appropriate system would have the best total rating. The ratings are presented in Table 3.6.

Table 3.6 Gas Analysis System Selection

System Type	Manual batch	Process gas chromatography	Dedicated analysers
Sampling Rate	1	2	3
Accuracy	1	3	3
Number of Gases Detected	3	3	2
'Stand-Alone' Ability	1	3	3
Cost	3	1	2
Adaptability	3	1	2
TOTAL	12	13	15

Key - Rank: 1 - Poor, 2 - Average, 3 - Excellent

From this analysis, it can be seen that the dedicated analyser type of system had the best overall rating and it was, therefore, decided to purchase a system of this type.

3.8.1.2 System Specification

Before any quotations could be obtained and the system purchased, it was necessary to specify the gases to be detected, the required detection ranges and the nature and degree of any gas contaminants. To obtain the necessary data on which to base the selection of the gases to be detected and their required ranges, a survey was performed of the relevant literature for both air-blown open core and throated downdraft gasifiers. This survey is summarised in Table 3.7.

Table 3.7 Summary of Data Available in the Literature for Gas Components and their Composition Ranges of Downdraft Gasifiers

Component	Composition (Volume %)
H_2	6.3 - 18.6
CO	12.4 - 24.9
CO_2	6.0 - 31.8
CH_4	0.0 - 3.8
N_2	42.7 - 66.3
O_2	0 - 2.7
C_{2+}*	0 - 2.6

* - Higher hydrocarbon gases, for example ethane, ethene and propane.
(Based on data in Chapter 6).

The dedicated analysis type of system selected requires an analyser for each gas to be detected. However, insufficient funds were available to purchase a system capable of detecting all the gases listed in Table 3.7, therefore, the most important components had to be identified in order to remain within the limitations of the funds available. Sufficient funds were available for a four analyser system.

Discussions with a number of analyser manufacturers indicated that nitrogen analysers were not readily available, therefore, the purchase of a nitrogen analyser could be excluded. Reference to the literature (see Table 3.7) indicated that oxygen and the C_{2+} hydrocarbon gases were the least significant components in percentage terms and, in many cases, were not analysed for at all. It was, therefore, concluded that the most appropriate analysis system would detect the following gases, hydrogen, carbon monoxide, carbon dioxide and methane, and nitrogen would be estimated by difference.

The analysis ranges also needed to be pre-selected as this was set by the manufacturers, although only the upper limit needed to be specified as the lower range limit would be constrained to 0 %. As with the selection of which gases to detect, the upper ranges were also selected on consideration of the data in the literature (see Table 3.7). The ranges subsequently chosen included a safety margin and a degree of flexibility in order to allow the system to be used for future projects. For example, the system selected is currently being employed to analyse the product gas from a molten salt pyrolyser [93]. On consideration of the above points, the following ranges were selected: hydrogen 0 - 25 %; carbon monoxide 0 - 30 %; carbon dioxide 0 - 35 %; and methane 0 - 10 %.

The complete system would include gas sampling and sample conditioning. Analysers are delicate instruments and require a clean gas passing through them in order to prevent damage. In this particular case, the nature of the gas contaminants (see Section 3.5.2) meant that a sample conditioning unit would be required in order to obtain the required level of gas purity.

3.8.1.3 System Description

A number of manufacturers were approached to provide a suitable system. However, only MSA were able to meet the requirements listed above (see Section 3.8.1.2). The analysis system was purchased as a complete unit and consisted of a gas sampling system and sample conditioning unit (sample clean-up system) as well as the analysers themselves. The sample conditioning consisted of two halves, the primary conditioning being provided externally to the analyser cubicle by a unit known as the 'hotbox' (see below) with the final conditioning being provided within the analyser cubicle.

A four analyser system was purchased covering the specification discussed in Section 3.8.1.2. The hydrogen analyser is a Leybold-Hereaus Hydros unit and has a thermal conductivity detector. The other analysers are all MSA Lira 3000 units and employ infra-red detectors. Each analyser has an analogue display and also produces an electrical output of 0 to 100 mV which is proportional to the gas composition (see Section 3.9). The analyser cubicle is illustrated in Figure 3.12. The gas sampling system, of which a flow diagram is shown in Figures 3.13 and 3.14, consisted of a sample pump and the necessary flow control valving to control and balance the sample flowrate to each analyser. The sampling unit also included a number of filters and a final sample conditioning unit, the FSA1 (see Figure 3.15). This equipment was all contained within the main analyser cubicle.

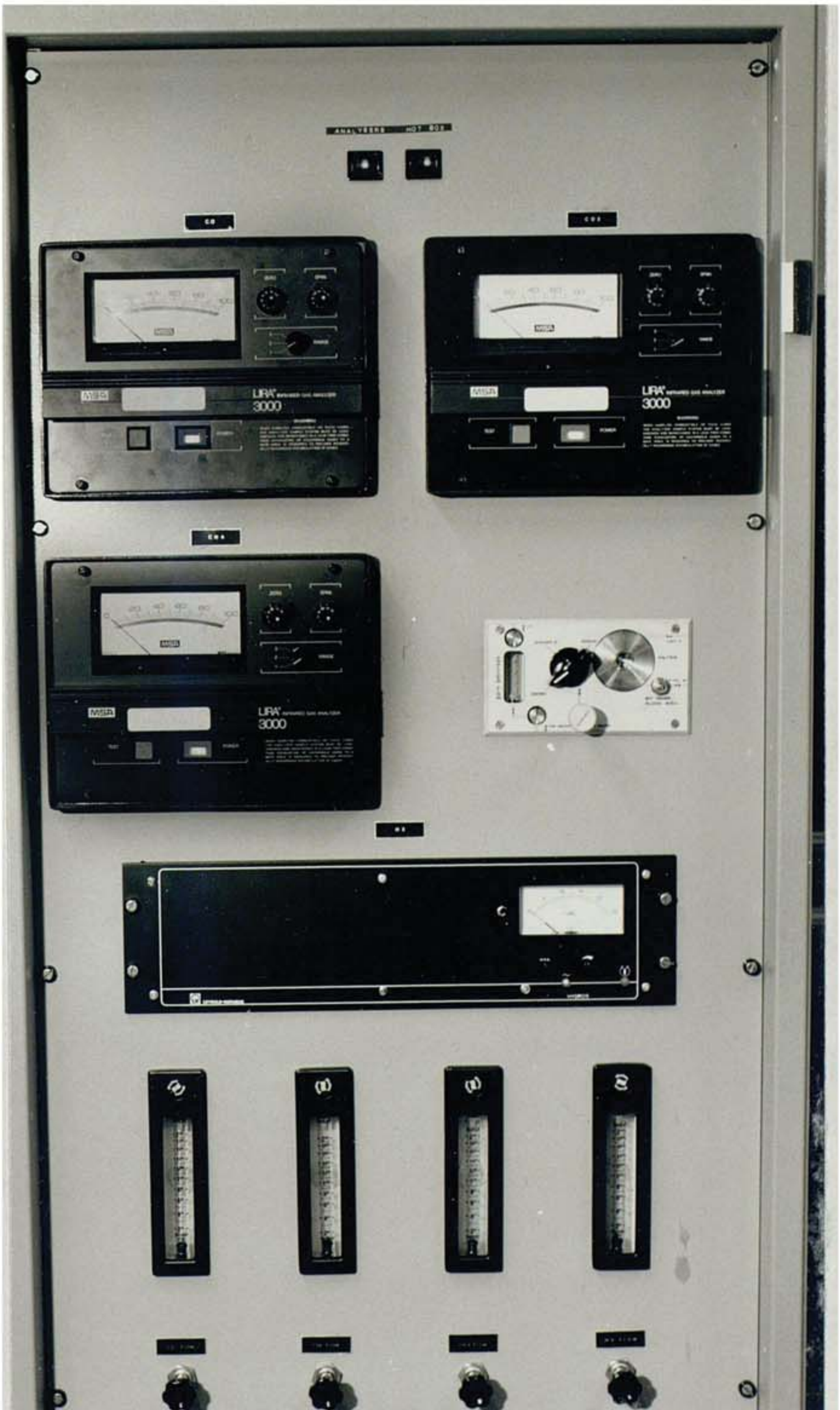
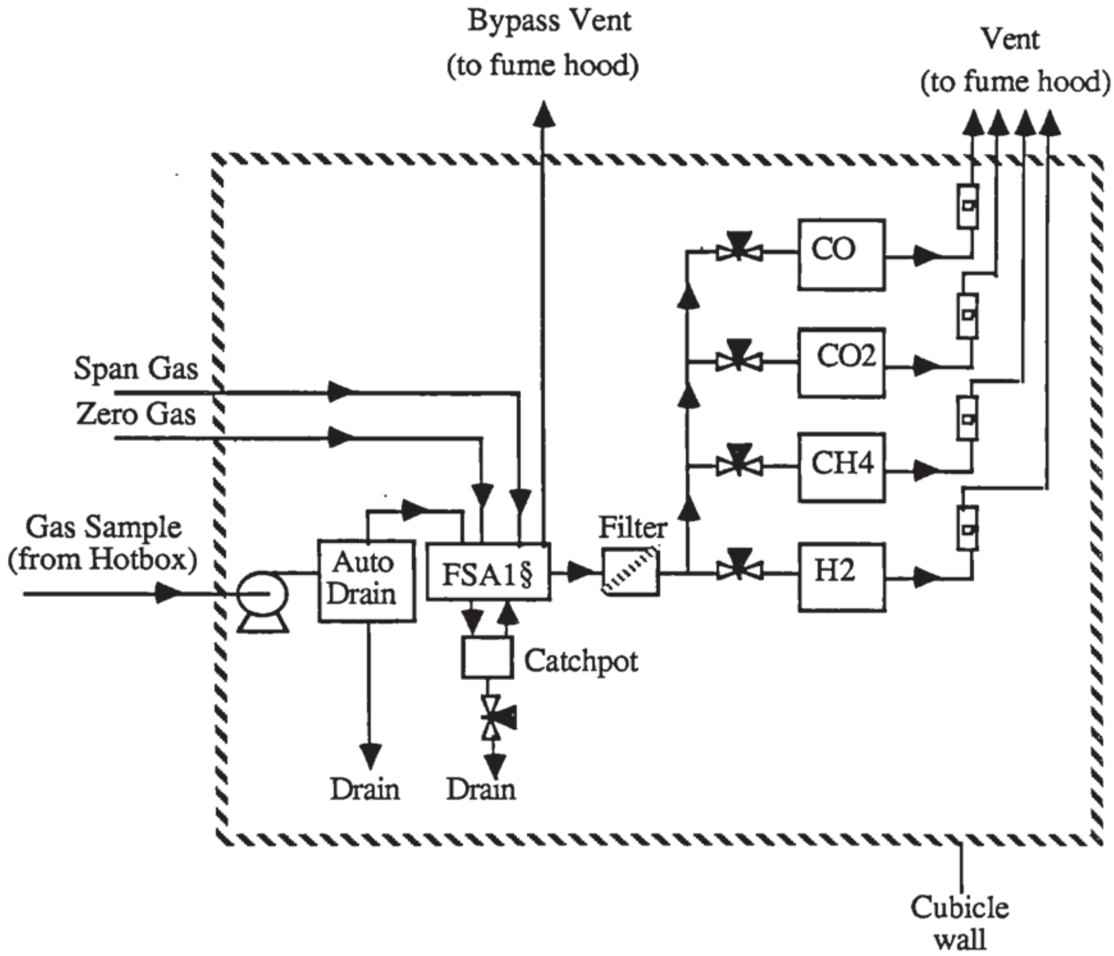
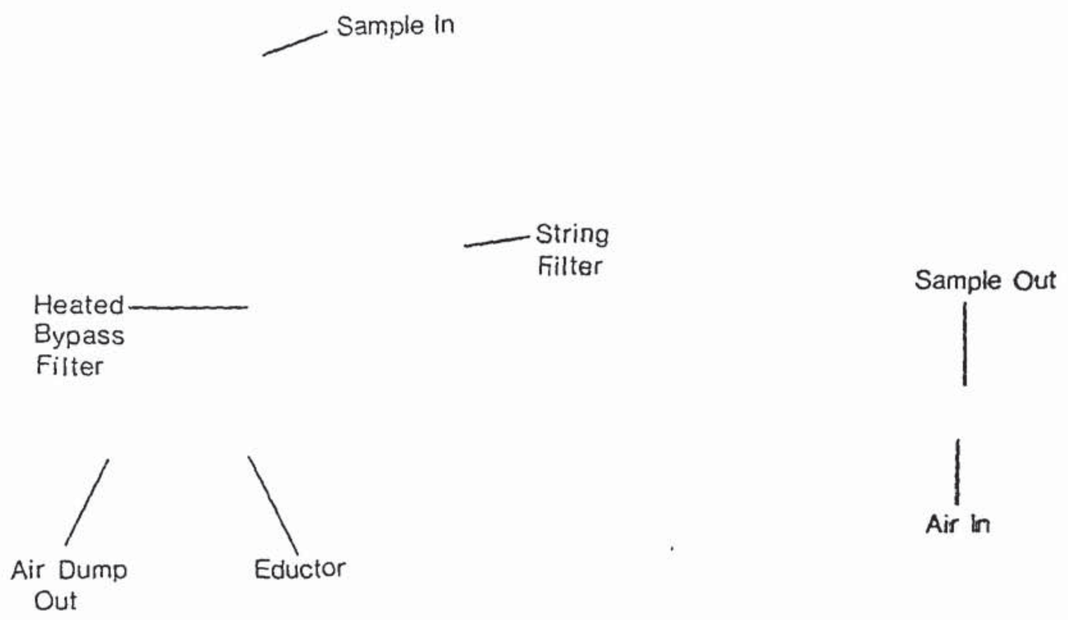


Figure 3.13 Gas Analyser System



§ See Figure 3.15 for diagram of FSA1

Figure 3.14 Flow Diagram of Analyser Cubicle Illustrating Sampling System



Sample In
String Filter
Sample Out
Heated Bypass Filter
Air In
Air Dump Out
Eductor

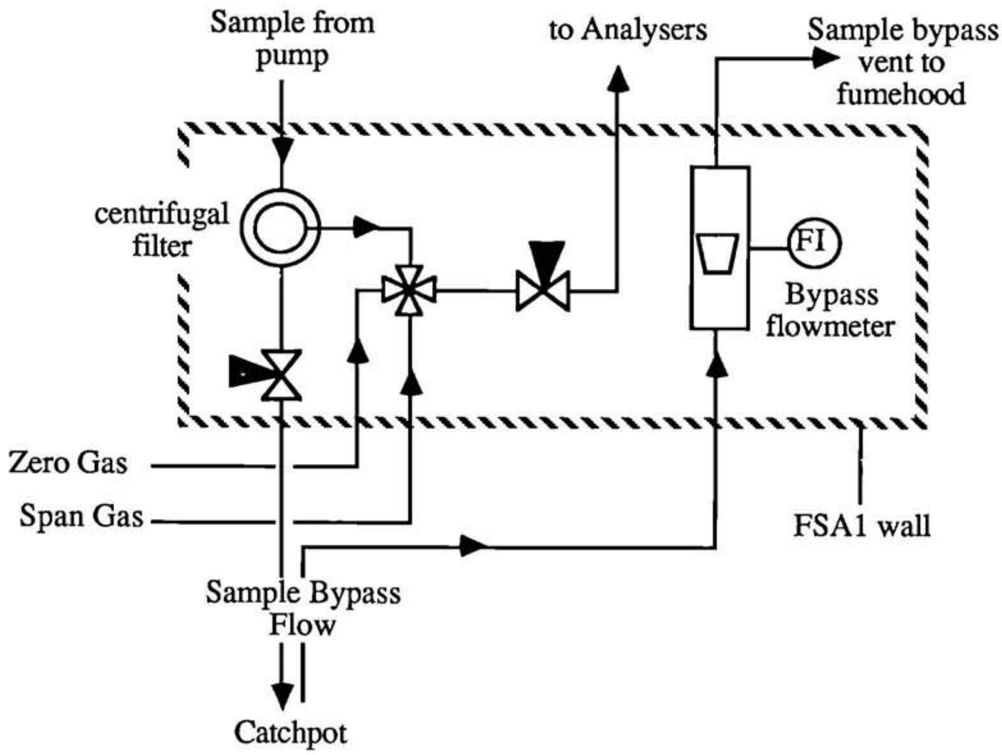


Figure 3.15 Final Sample Conditioning Unit (FSA1)

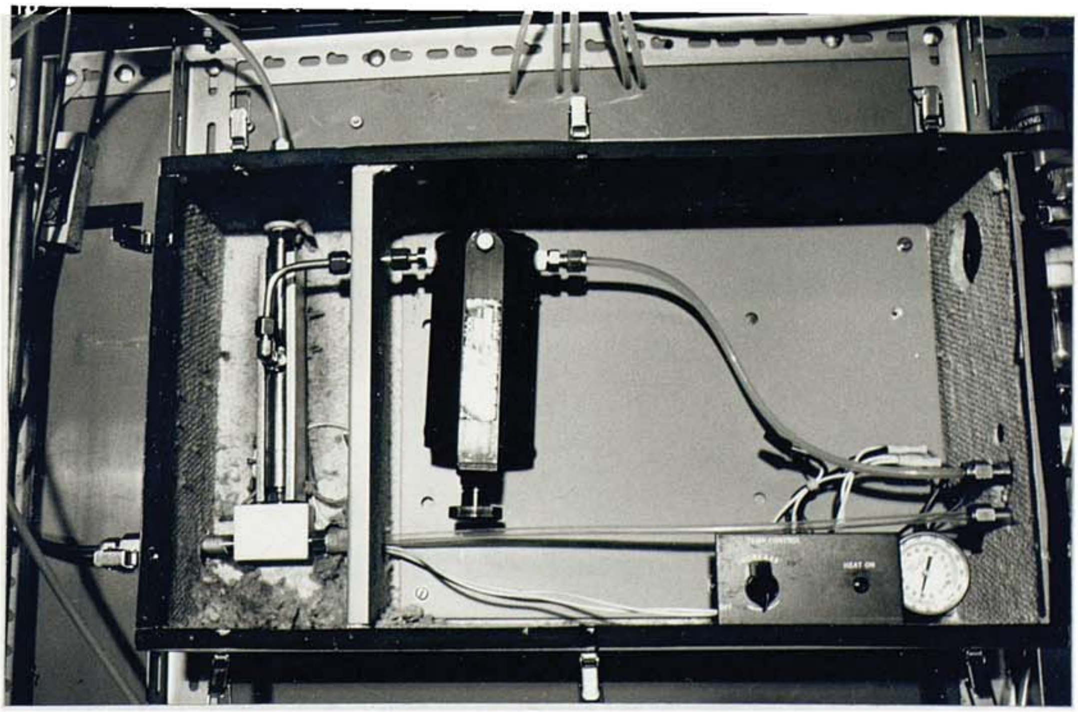


Figure 3.16 Gas Sample Clean-up 'Hotbox'

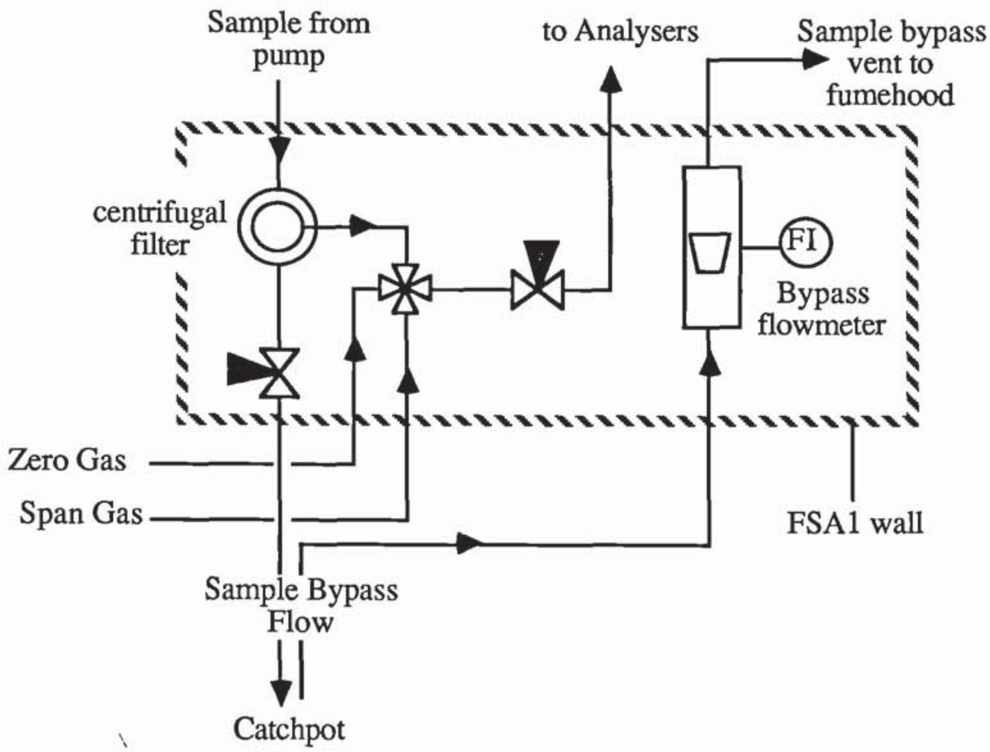


Figure 3.15 Final Sample Conditioning Unit (FSA1)

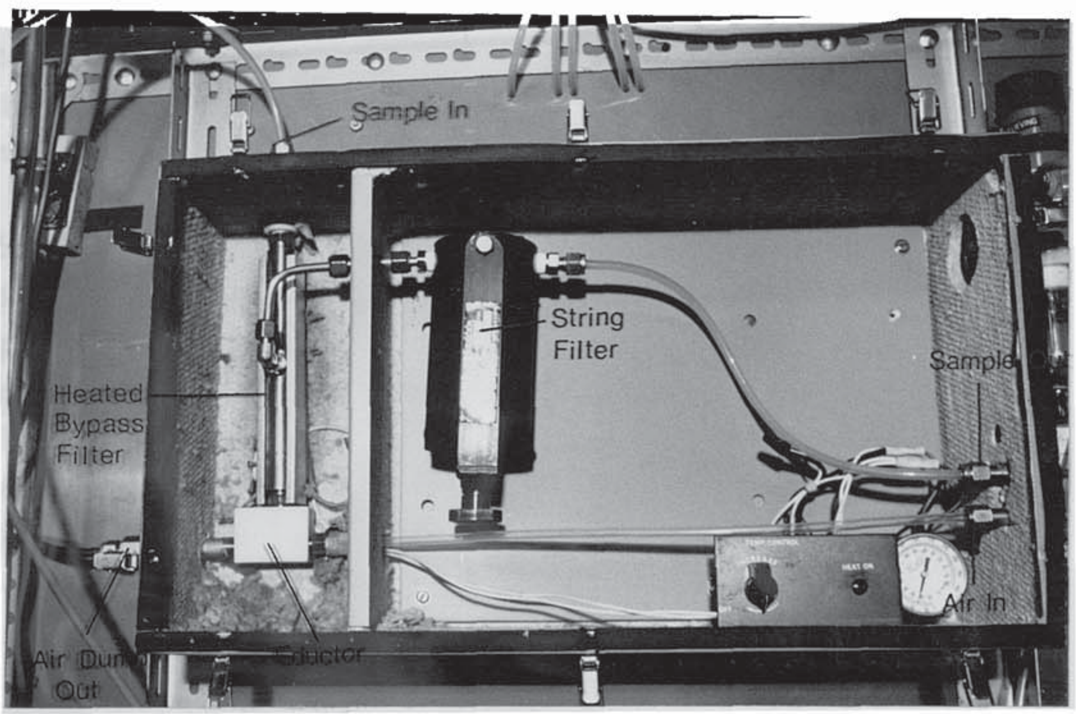


Figure 3.16 Gas Sample Clean-up 'Hotbox'

The primary gas conditioning system was a separate unit, a Perma Pure Model 2112 E filter-dryer, known as the 'hotbox', and is pictured in Figure 3.16. A flow diagram of the 'hotbox' can be seen as part of the general sample system flow diagram, Figure 3.17 (see later). The gas sample entering the hotbox passed through a heated, sintered stainless steel, bypass filter, the sample being drawn into the filter by a compressed air eductor. The heated filter operated at approximately 120 °C and is designed to remove condensible liquids and particulates down to a claimed 1 µm [94]. It was felt that at the operating temperature of the filter, any thermal degradation of the tarry products would be insignificant and would not effect the accuracy of the analysis. The sample bypass was vented with the eductor air to the fumehood. The filtered gas from the bypass filter then passed to a wound string cartridge filter prior to exiting the hotbox. The total gas sample rate taken was about 10 l/min of which about 4 l/min was passed to the analysers, the remainder being lost in the sample bypass. The gas sample presented to the analysers, having passed through the sample clean-up system, should be both dry and clean.

3.8.1.4 Modifications to the Analysis System

A number of modifications were necessary to the gas sampling and sample conditioning systems. These modifications, which are discussed below, concerned the addition of extra cleaning stages, the repositioning of the sample point and the metering of the gas sample flowrate.

Initially, it was decided to place the gas sample point as close to the gasifier as possible. This was to minimise the time lag between a variation occurring in the gas composition and its detection, therefore allowing easier identification of the cause of the variation, and to minimise the back mixing of the gas which could disguise these changes. However, the gas leaving the reactor would be at an anticipated 700 to 1000 °C [65] and would require some cooling before it could be passed to the sample clean-up system which could only accept a sample up to 120 °C. It was, therefore, decided to take a pre-cooled gas sample from after the heat exchanger at a temperature of approximately 100 to 200 °C as this would not require any further additions to the sampling system and would only add to the time lag between sampling and analysis by approximately 0.2 seconds. The nylon tubing specified by MSA for the sampling system had a maximum operating temperature of approximately 80 °C and, therefore, the initial 0.5 m of the sample system was piped in using 6.35 mm copper tube.

A modification made prior to the first run to the sample conditioning system as supplied, was the installation of a silica gel column between the hotbox and the analyser cubicle. The system, as specified, has a water knockout pot in this position of approximately 2 litres capacity. However, this knockout pot was felt to be unsuitable, as it could lead to backmixing in the gas sample and could be ineffective in removing any water from the gas sample.

The positioning of the sample point prior to the main gas flowmeter and the positioning of the gas sample flowmeters after the gas analysers, meant that the total sample flowrate would not be monitored as the bypass from the hotbox would be unrecorded. As this loss would be in the order of 6 l/min, which could amount to between 5 and 16 % of the total anticipated gas production rate, it was decided to place a flowmeter in the sample line prior to the hotbox. However, due to a delay in the receipt of the order, this rotameter was not fitted until after the first run.

Gas analysis was only performed for approximately 45 minutes during the first commissioning run. A considerable amount of tar had passed through the hotbox but was removed from the sample stream by the silica gel column and as a result, no tar appeared to reach the analysers themselves. However, before the silica gel column could become overloaded with tar and allow tar to pass through, the gas sample pump was turned off and the gas analysis terminated. It was, therefore, decided that a number of modifications were required to the gas sampling system so that gas analysis could be performed for longer than 45 minutes. In order to remove a large part of the tar prior to the hotbox, it was decided to install a charcoal column in the sample line before the rotameter. It was felt that a liquid based gas cleaner would effect the accuracy of gas analysis due to the differential solubility of the different gas components. Charcoal was selected to be used as it was felt that due to its surface area and pore structure, it would be a suitable tar absorber and it was readily available as a supply had been purchased for reactor start-up. In order to condense water from the sample stream and possibly the higher boiling tars that might pass through the charcoal filter, a salt/ice-cooled trap was placed directly after the charcoal column. During the first run, it was also observed that the tar production was greater during the reactor start-up period. Therefore, it was decided to make a procedural change in order to increase the time over which gas analysis could be performed by only sampling the product gas after start-up and when the gasification of the fuel was well established.

After one run employing a charcoal column, it was decided to replace this with a column packed with wood chips. This was due to concern over the charcoal column acting as a gas chromatograph column [95] which could, therefore, effect the gas analysis due to the differential absorption of the various gas components. Wood based filters were reported to be effective, having seen widespread use with gasifier-engine systems [19].

However, even with these modifications, the gas analysis could only be performed for a time of about 60 minutes. The complete sampling system, except for the heated bypass filter prior to the analyser cabinet, then required stripping and cleaning due to the deposition of tar throughout the system. Therefore, it was decided to move the gas sampling point from its existing position, directly after the primary heat exchanger, to a position after the scrubber, but upstream of the gas pump. After the repositioning of the gas sample point, it was decided that the wood column was no longer required and this was, therefore, removed. In this arrangement, the sampling system performed adequately and no further modifications were made. A flow diagram of the sample cleaning system in its final arrangement, including the hotbox, is shown in Figure 3.17.

A number of problems were also encountered with the 'clogging' of the filters and the eductor in the hotbox. This was attributed to the high levels of tar carry-over during the early runs with the sample point prior to the scrubber. When this occurred, the relevant part was cleaned and, if necessary, replaced. In order to prevent these parts clogging in the latter runs, the hotbox was stripped after every run and the filters and eductor cleaned with acetone or, if necessary, replaced. In addition to this, the gas sample flowmeter was checked to see if any tar had been deposited in it. If there were visible quantities of tar in it, it was stripped and cleaned with acetone.

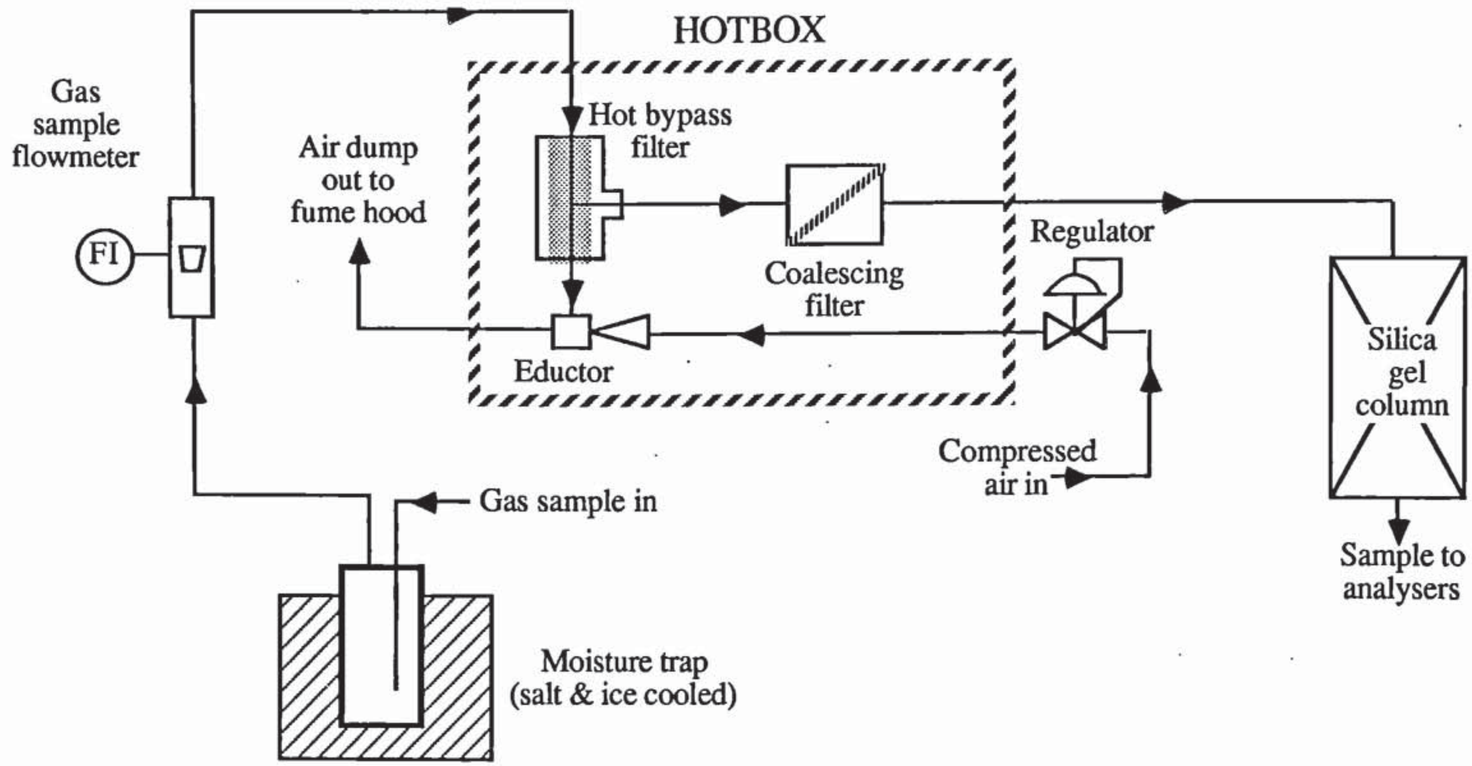


Figure 3.17 **Flow Diagram of Gas Sample Clean-up System**

3.8.1.5 Batch Gas Analysis

The analysis system as described previously, was only able to detect hydrogen, carbon monoxide, carbon dioxide and methane, the other anticipated components, that is nitrogen, oxygen and the C_{2+} hydrocarbons could not be detected by this system. As nitrogen was anticipated to be the major gas component (see Table 3.7), the balance of the gas, excluding that detected by the analysis system, was assumed to be nitrogen for mass balance purposes. Even so, to allow for detection of the other components and to act as a 'back-up' to the analysis system, it was decided to install a batch gas sampling point. These batch samples would be taken using a special gas sample bag and analysed on the Department's gas chromatograph. However, in order to fill these bags, a higher than atmospheric pressure was required and, therefore, this sample point had to be positioned downstream of the pump prior to the lean gas burner.

3.8.2 Product Gas Flowrate

In order to prepare mass and energy balances, it was necessary to monitor the product gas flowrate. For the commissioning runs, except the first run, a standard size 18 rotameter with a koranite float was employed. This covered the flow range of 1.2 to 10.8 m^3/hr of air at ATP (ATP - gas volume at 760 mmHg and 20 °C), which covered the flow range of the pump purchased (see Section 3.5). The flowrate had to be recorded manually which, due to the other operator duties, limited the amount of data that could be collected. However, this flowmeter was only employed temporarily while awaiting delivery of a flowmeter that could be connected to the data-logger.

This new flowmeter (Platon Flowbits CMIE) was also a rotameter in which the position of the float was monitored magnetically. This was translated into both an analogue display of the flowrate and an analogue signal directly proportional to the flowrate. The flowmeter was calibrated over the range 0.8 to 8.0 m^3/hr air at ATP which was felt adequate to cover the anticipated gas flows (see Section 3.3).

To minimise the risk of damage to the flowmeter by gas contaminants such as tar, it was neccessary to position the flowmeter downstream of the gas scrubber and, in order to simplify the system layout, downstream of the gas pump and recycle loop.

However, as discussed in Section 3.8.1.4, this meant that the gas sample flowrate had to be monitored separately, as the gas sample was taken prior to the main gas flowmeter. This was performed using a rotameter calibrated over the range 0 to 25 l/min (0 to 1.5 m^3/hr) of air at ATP.

As discussed above, the flowmeters employed were calibrated for air at ATP, although suitable flowmeters calibrated for specific gases could be purchased. However, the variation in the product gas composition meant that the extra expense incurred by this special calibration was felt to be unnecessary. The gas flow could be calculated from the measured flowrate thus:

Equation 3.2 : $V_{GAS} = V_{AIR} (SG_{AIR} / SG_{GAS})^{1/2}$ [96]

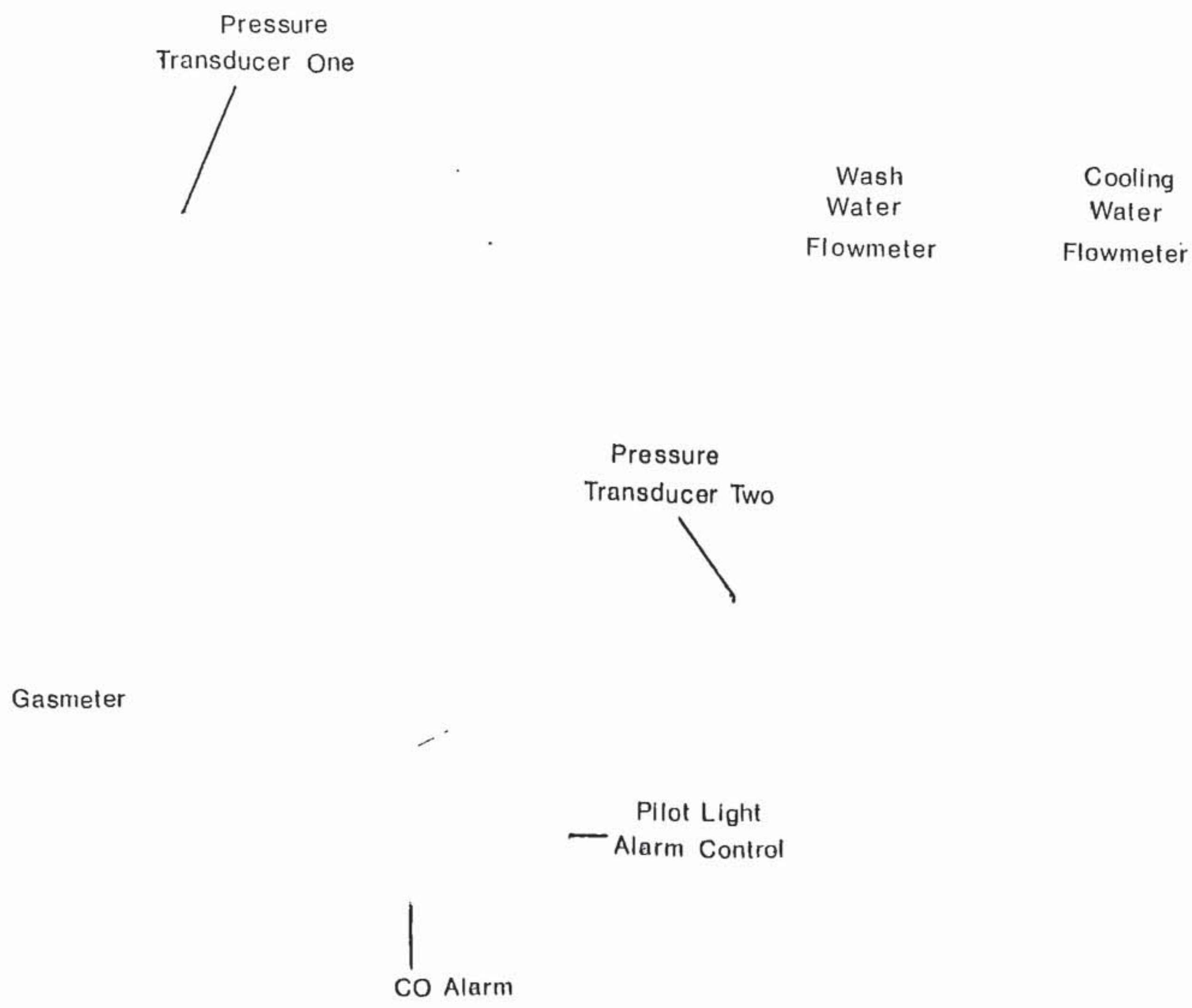
If the gas flowrate was not measured at ATP, it could be converted to the appropriate value (or to whatever standard desired) thus:

Equation 3.3 : $V_{AIR} = V_M (P_M / P_A) (T_A / T_M)$.

In addition to the gas flowmeter which monitored the rate of gas production, the cumulative volume of gas produced was also monitored using a standard gasmeter. For the first run, a gasmeter calibrated to 0.1 cubic feet (2.83 x 10^{-3} m^3) was employed. However, this was damaged by another user and had to be replaced (by them) with an alternative which was calibrated to 10 cubic feet (0.283 m^3) and thus reduced its value due to loss of accuracy in the measurement of the volume of gas produced (see Figure 3.18).

3.8.3 Temperature

Temperatures were monitored at a number of points throughout the gasifier system (see Appendix III) to provide data for the analysis of the gasification process itself and to aid in the preparation of mass and energy balances. Particular importance was placed on the measurement of the temperature distribution in the reactor and the gas exit temperature in order to relate these parameters to variations in gasifier performance (see below). All the temperature measurements were made using type-k (nickel/chrome-nickel/aluminium) thermocouples. For low temperature measurements, below approximately 50 °C, plastic insulated in-house made


Pressure
Transducer One
Wash
Water
Flowmeter
Cooling
Water
Flowmeter
Pressure
Transducer Two
Gasmeter
Pilot Light
Alarm Control
CO Alarm

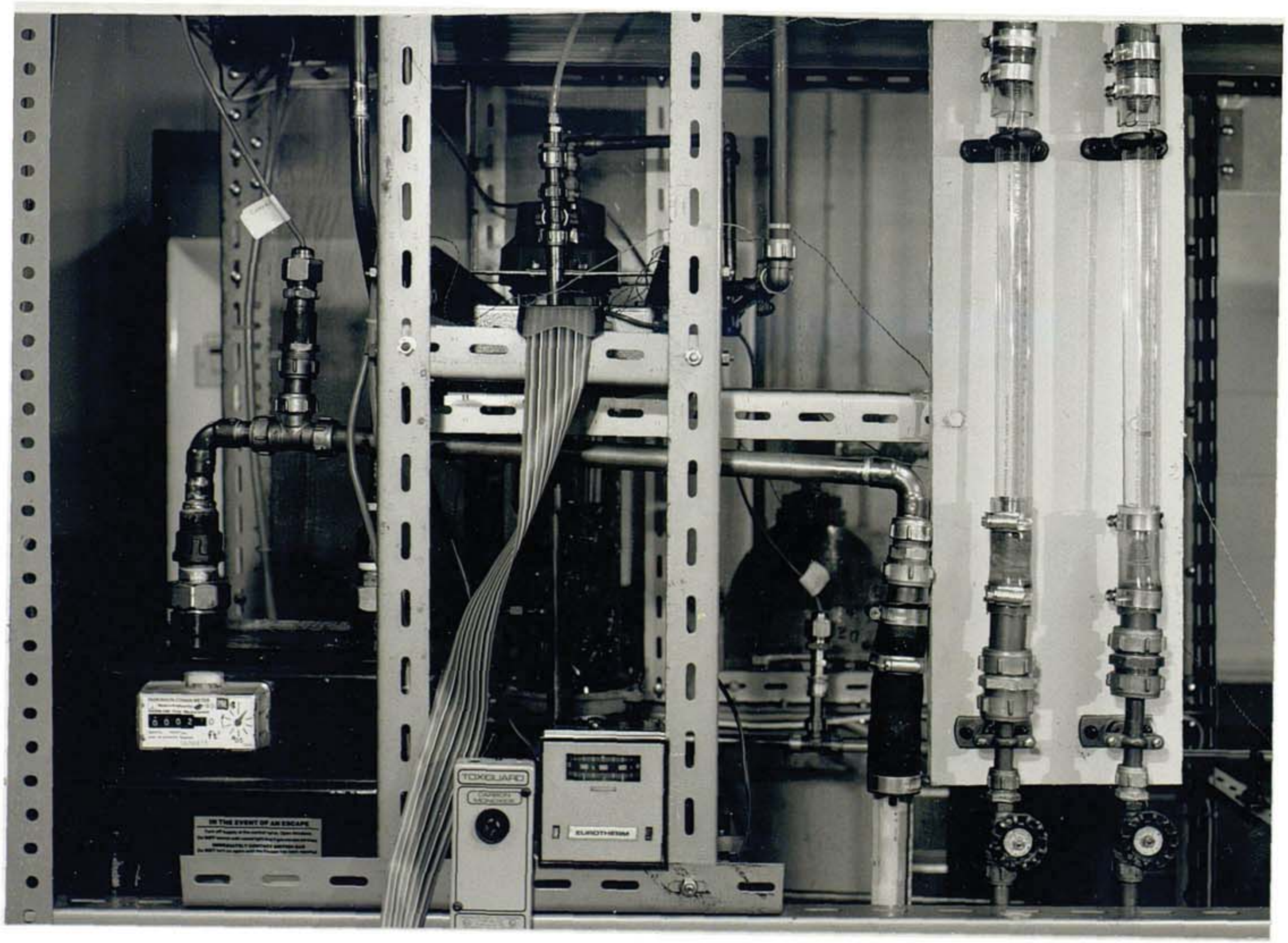


Figure 3.18 Miscellaneous Instrumentation

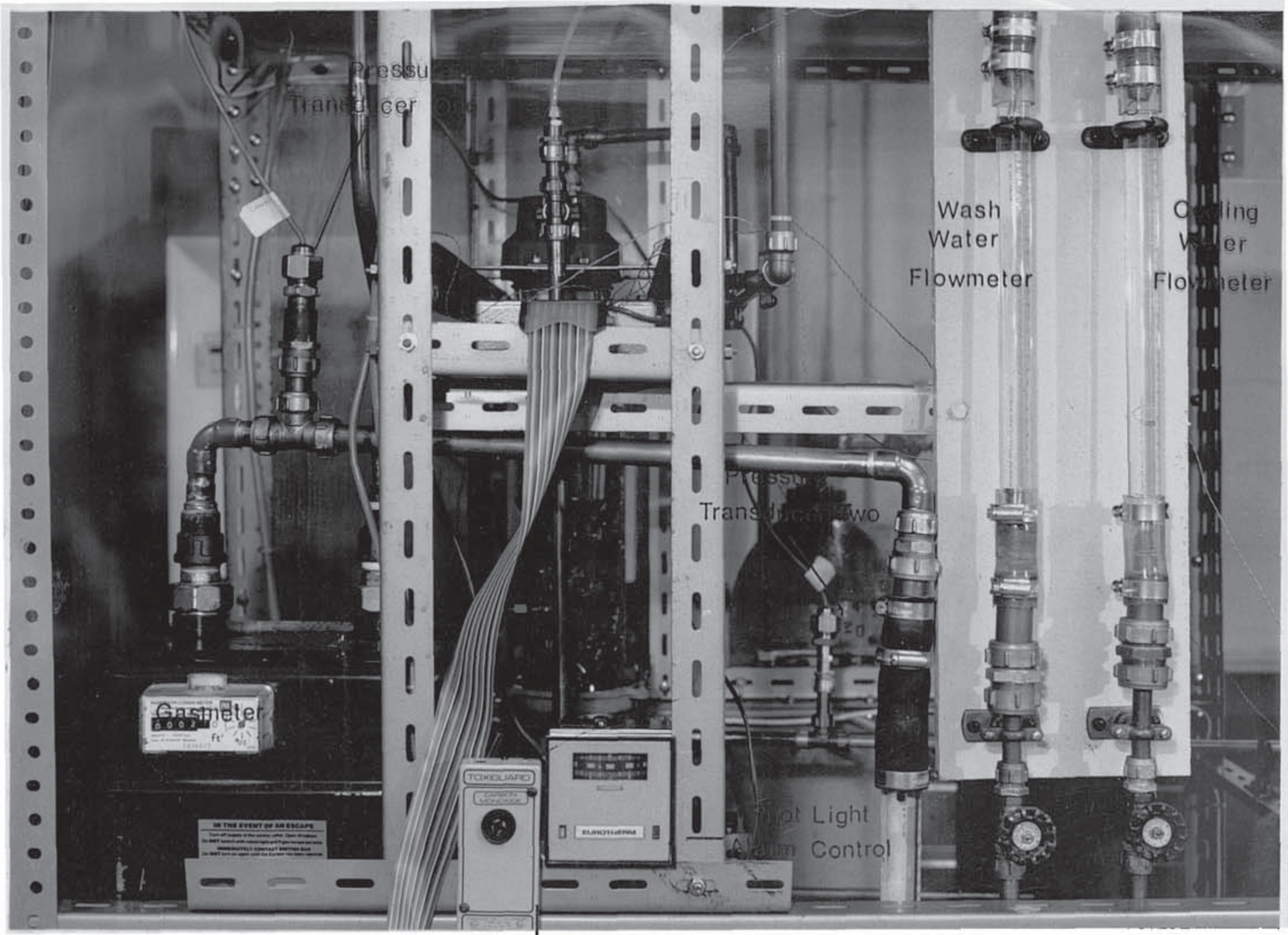


Figure 3.18 Miscellaneous Instrumentation

thermocouples were employed, but for higher temperatures, it was necessary to purchase stainless steel sheathed thermocouples.

In order to collect data to prepare the mass and energy balances, temperatures were measured at the following positions:

- Inlet air temperature.
- Reactor bed temperatures.
- Gas exit temperature directly below the grate.
- Gas temperature after cooling.
- Gas temperature at the point of flow measurement.
- Cooling/cleaning water inlet temperature.
- Cooling water outlet temperature.
- Gas/cleaning water temperature at the scrubber outlet.

In addition to being monitored for mass and energy balances, the gas exit temperature directly below the grate was monitored as one of the main operating variables of the gasifier itself. This temperature was indicative of the degree of gas cooling due to the char reduction reactions and reactor heat loss.

As discussed above, particular importance was placed upon monitoring the temperature profile vertically down the reactor. This would help locate the positions of the various reaction zones within the reactor bed and would indicate the conditions prevailing within the reactor, that is, the temperature and length of the flaming pyrolysis zone and the relative lengths of the char reduction and inert char zones. However, some difficulties were encountered in measuring the reactor temperature distribution.

Initially, an array consisting of three 0.1 cm diameter stainless steel sheathed thermocouples in a stainless steel tube was employed, designed so that the thermocouples could be moved up or down. This had to be replaced as it was both difficult to move the thermocouples when the array was in position in the reactor and difficult to accurately locate the height of the thermocouples. It was, therefore, decided to replace this array with an array consisting of seven stationary thermocouples (0.1 cm diameter stainless steel sheathed) placed at 3 cm intervals from 0 to 18 cm above the grate.

Initially, this array was placed along the central axis of the reactor. This, however, was felt to cause problems with the flow of the biomass fuel through the reactor and was moved to be adjacent to the reactor wall. Damage to two thermocouples during the 'burning-out' of the charcoal bed at the end of the first run meant that the spacing of the thermocouples in the array had to be adjusted to 5 cm. On receipt of replacement thermocouples, this spacing was adjusted to 4 cm which allowed coverage of a greater height in the reactor. In order to prevent a recurrence of the damage to the thermocouples, the array was removed from the reactor prior to the reactor being allowed to 'burn-out' at shut-down.

Although it would also have been desirable to monitor the radial temperature distribution in the gasifier, both to quantify the wall effects and to test Reed's [55] supposition that consistent oxidant and, therefore, temperature distributions exist across the reactor diameter, this was not attempted. The experience with a simple axial thermocouple array (see above) suggested that there was no suitable method of monitoring the radial temperature distribution in the reactor without causing major disturbances to the flow of solids through the reactor which would effect the oxidant, and hence temperature, across the reactor diameter.

3.8.4 Pressure

Pressure was monitored at two points in the gasifier system, these positions being shown in the P and I diagram in Appendix III and can also be seen in Figure 3.18 above:

1) Downstream of the reactor in order to measure the pressure drop across the reactor.

2) At the point of flow measurement in order to correct the gas flow rate for pressure effects (see Section 3.8.2).

The pressure measurements were made using pressure transducers (Data Instruments - Model AB), these were calibrated over the range 0 to 101.3 kN/m^2

giving an analogue signal of 0 to 100 mV inversely proportional to the measured pressure. However, due to limited funds, the pressure transducers had a maximum operating temperature of 93.3 °C and, therefore, the transducer to measure the reactor pressure drop had to be placed after the gas cooler.

3.8.5 Miscellaneous

3.8.5.1 Feed Rate

The feed rate needed to be measured in order to prepare mass and energy balances. As discussed already in Section 3.2, a hand feeding technique was selected and the feed rate could, therefore, be calculated from the rate of addition of the feed batches (see Chapter 5).

3.8.5.2 Height of Char Bed

The height of the char bed is an important parameter in the operation of open-core downdraft gasifiers (see Chapter 2) and it was decided to investigate its influence on the gasifier performance (see Chapter 5). It was, therefore, necessary to be able to measure the height of the char bed. Due to the duties required of the operators while running the gasifier, the method of measurement had to be relatively quick and simple but still be accurate. Two 30 cm stainless steel rulers were placed either side of the reactor so that the scales ran in opposite directions and started at the same level as the grate. The height of the char bed could then be read off by line-of-sight.

3.8.5.3 Condensate Production

In addition to the gaseous products produced from the gasifier, a condensible liquid product consisting of water and pyroligneous tars and acids was also produced. In order to prepare mass and energy balances, the condensible liquid had to be monitored and also the tar levels had to be measured so that methods of product gas upgrading could be evaluated. A number of solvent absorber based sampling systems were developed. However, these systems were not covered under this project and are discussed in greater detail in the thesis by Reyes-Nunez [97].

3.8.5.4 Cooling and Cleaning Water Flow Rates

In order to select the correct water flowrate for the packed bed scrubber, a rotameter was installed in the mains water inlet line. This rotameter was also employed for metering the inlet water to the centrifugal contacting scrubber when used in 'once-through' water mode. However, when this scrubber was converted to recycle operation, the scrubber water rate was not metered, although this rotameter was retained. As an aid to the preparation of energy balances, the flow rate of the cooling water was also metered. These measurements were made using standard size 14 rotameters with stainless steel floats, which cover the flow range 0.5 to 5.0 l/min of water at 20 °C (see Figure 3.18 above), the position of the flowmeters can be seen in the P and I diagram in Appendix III.

In addition to monitoring the wash water flow rate, a sample point was provided for taking samples for analysis. For scrubber device one and scrubber device two used in once-through water mode, this sample point was in the disentrainment vessel drainage line. When scrubber device two was used in the recycle mode, the sample point was moved to after the recycle pump and required a syringe to withdraw the sample.

3.9 DATA-LOGGING

The number of instruments employed to monitor the gasifier system would generate a large amount of data. It was decided that it would be impracticable to record this data manually and, therefore, an automatic data-recording system was required.

Although a number of different data-logging systems were available, it was decided to purchase an interface system manufactured by Biodata. This selection was based on the following criteria:

- such a system had already been used successfully within the Department for measuring the temperature distribution across a distillation column tray [98] and had been proven to be reliable and simple to operate, and experience in the 'setting-up' and maintainance was also available.

- the system could be connected to a BBC B microcomputer. These computers were readily available within the Department and the required software could be written in BBC BASIC.

- the system is readily upgradable to take a variety of different input or output channels for system control.

The data-logger hardware, software and the necessary conversion procedures are described in Sections 3.9.1 and 3.9.2

3.9.1 Data-Logger Hardware

The data-logging system employed consists of three main components:

i) Biodata Microlink Interface

The function of the Microlink interface is to 'condition' and digitise the analogue signals from the thermocouples, flowmeter, pressure transducers and gas analysers. The resultant digital signal is then transmitted to the BBC micro-computer via the IEEE 488 databus.

The Microlink interface consists of two main types of component: the mainframe which is a 'rack' with a power supply and connection to the IEEE 488 interface (see below); and 'function cards', which slot into the 'rack' and are designed to perform specific functions on different signal inputs. The system employed in this project comprises of three cards:

- a 12 bit analogue to digital converter (the A12D) which converts the analogue signal received by the interface to a digital signal for transmission to the BBC. The resolution on the conversion is 1 in 4096 (that is 1 in 2^{12}), so for example over a temperature span of 0 to 100 °C, the temperature could be read to an increment of 100/4096 or 0.0244 °C.

- a specialist thermocouple input card (the TC-16) which supports up to 15 thermocouples and includes a platinum resistance thermometer as the cold junction reference temperature.

- an analogue input card (the AN16/32) which reads the 0 to 100 mV signals from the gas analysers, flowmeter and pressure transducers.

ii) The IEEE 488 databus.

Information is sent from the Microlink interface to the BBC microcomputer via this databus (a physical link for the transmission of information between two or more devices) which was purchased as a separate unit, the Aries-B488. The IEEE 488 databus is specifically for applications such as this and allows up to 15 instruments, that is microcomputers, printers, X-Y plotters or Microlink interfaces, to be interconnected [99]. For this particular application, only two devices were interconnected, that is the BBC microcomputer and the Microlink interface. One instrument acts as the system controller, for this particular application, the BBC microcomputer.

iii) BBC microcomputer (including monitor and disc drive).

This has three roles. Firstly, it controls the Microlink interface, selecting which instrument is to be read, communicating with the interface via the IEEE 488 databus. Secondly, it controls the flow of data over the IEEE 488 databus and thirdly, it converts the digital signal to the appropriate instrument reading, that is °C, mmHg, vol% and m^3/hr, which is both displayed on the computer's VDU and written to a data file on floppy disc. The software required to perform these functions is described in Section 3.9.2.

A schematic diagram of the data-logging system is shown in Figure 3.19 and the interface system is illustrated in Figure 3.20.

3.9.2 Data-Logger Software

As discussed previously in Section 3.9.1, the BBC microcomputer had three roles to fulfil. However, in order to perform these functions, the software had only to be divided into two parts, the IEEE control software (see Section 3.9.2.1) and the 'conversion' software (see Section 3.9.2.2).

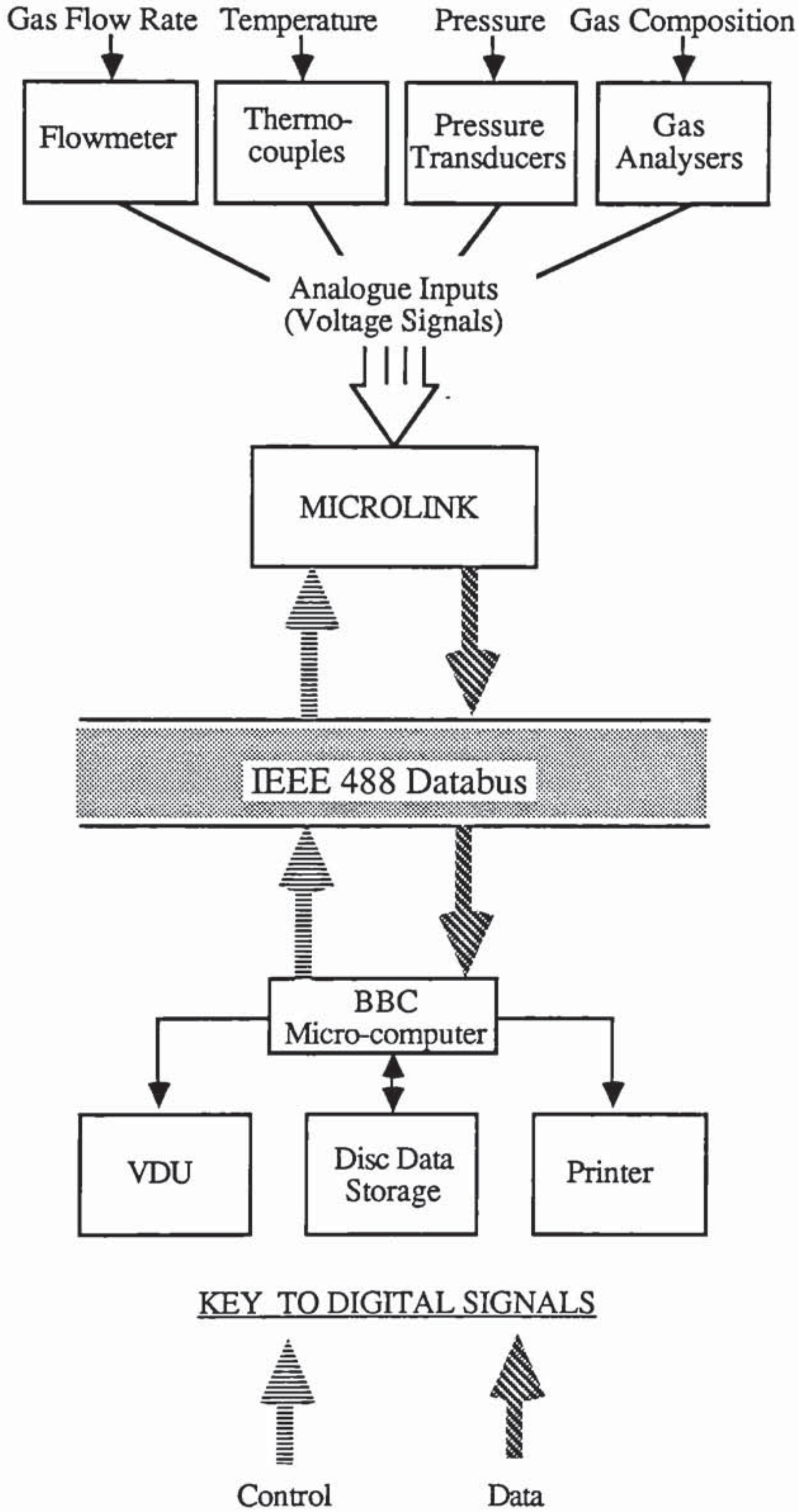


Figure 3.19 Block Diagram of Data-Logging System

Biodata
Interface

A12D
Card

TC16
Card

AN16/32
Card

IEEE
Data Bus

Figure 3.20 Data-Logging System

Figure 3.20 Data-Logging System

3.9.2.1 IEEE Control Routines

These routines had to perform two functions:

- control the flow of data over the databus, that is whether the Microlink should 'listen' to the BBC and receive instructions or if the Microlink should 'talk' to the BBC and send the appropriate data.

- select the device to be read, for example thermocouple number two or the hydrogen analyser.

The software to perform these functions was provided with the Aries B488 IEEE 488 databus. This was, however, written in BBC BASIC and limited the speed at which the data-logger could operate. Therefore, in order to increase the speed of the data-logger, these routines were translated into assembler code by Mr D. Bleby. These routines were able to increase the data-logger speed by up to a factor of ten and are listed in Appendix VI.

3.9.2.2 Conversion Routines

These routines had to perform a number of functions:

- call the IEEE control routines.

- convert the digital reading sent from the Microlink interface to the appropriate value, ie °C, mmHg, vol% and m^3/hr.

- display the converted value on the screen (an example of the display is shown in Figure 3.21) and write this value to floppy disc.

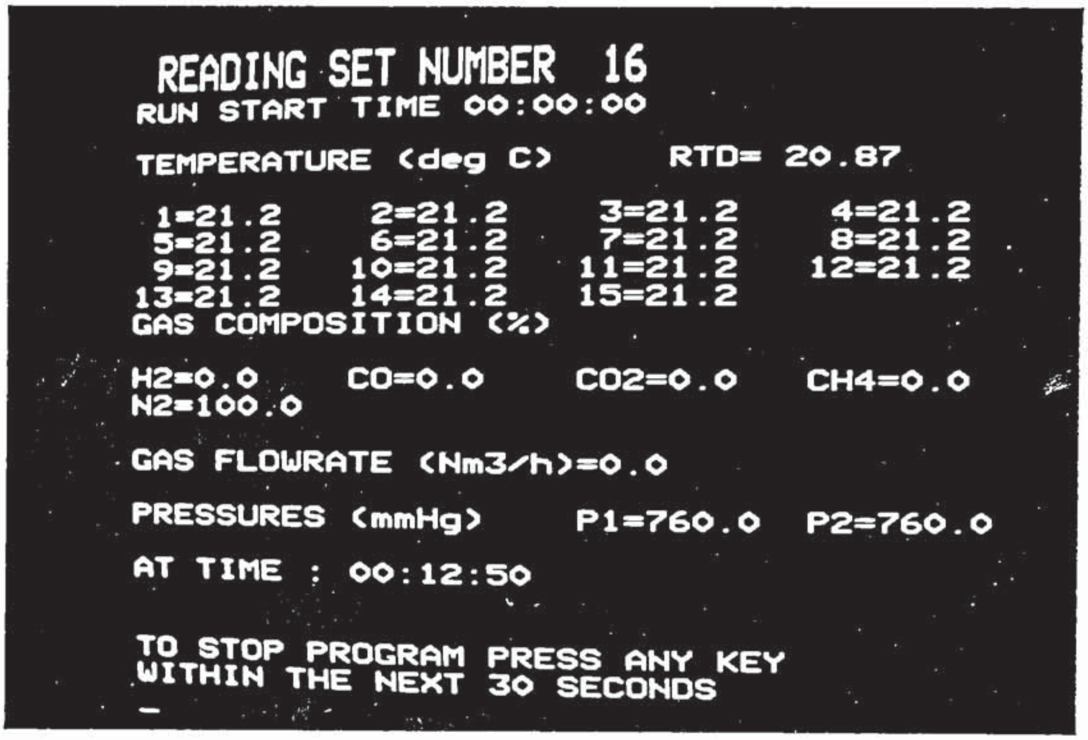


Figure 3.21 Data-Logger Visual Display

The software to perform these functions had to be written in-house by the author of this thesis. Due to a lack of knowledge of assembly code and in order to make the routines more readily adaptable, the routines were written in BBC BASIC. In writing this software, the following points had to be considered:

i) Procedural program structure - the software was written to be made of distinct procedures where possible in order to make modification and upgrading as simple as possible.

ii) Program speed - in order to maximise the software speed, the recommendations in the BBC manual were followed [100].

iii) User friendliness - the data-logger system would have to be used by other people and, therefore, it was necessary to make the program simple to operate.

iv) Signal stability - the thermocouple readings were found to be stable to ± 0.1 %. However, due to signal noise, for example mains 'hum', the signals received by the AN16/32 card, that is for the flowmeter, pressure transducers and gas analysers, were less stable. Therefore, in order to obtain the necessary signal stability, the instruments had to be read a number of times and the values averaged. The number of readings taken to obtain the necessary stability was five, this being a compromise between stability and speed. This average value was then converted to the appropriate display value.

v) Conversion algorithms - these are the procedures necessary to convert the digital signal received from the Microlink interface to the appropriate value, ie °C, mmHg, vol% and m^3/hr. The algorithm for conversion of the digital reading to temperature was provided with the Microlink interface [101]. However, the other conversion routines had to be written within the Department. These algorithms are listed in Appendix VI.

vi) Data-logger calibration - a number of 'conversion coefficients' (see Appendix VI) were required to convert the digital signal received from the interface to the appropriate display value. However, due to instrument 'drift', these coefficients were obtained prior to every run as part of the start-up procedure (see Appendices III and VI). These values were stored in a separate data-file which could be easily edited, while maintaining the write protection on the data-logging software.

The data-logging program is listed in Appendix VI.

3.9.3 Kermit

To help in the analysis and plotting of the data collected by the data-logger, it was transfered to the University's VAX 8650 Cluster system using the Kermit file transfer system [102], the Kermit programs being stored on a ROM chip in the BBC. It was necessary to convert the data file from the BBC format in which it is stored to an ASCII format so that it could be used by the Cluster. Having the data files on the Cluster would allow for a more rapid and comprehensive statistical analysis of the data and would also allow the data to be plotted graphically using the GINO routines available on the Cluster system.

3.10 SAFETY

A number of potential hazards are associated with the operation of a gasifier. The hazards are described below.

3.10.1 Hazards

The hazards associated with the operation of a gasifier can be considerted as either a toxic or an explosion/fire hazard.

3.10.1.1 Toxic Hazards

The products of a gasifier contain a number of toxic compounds in both the gaseous and liquid products. The product gas contains carbon monoxide which is a colourless, odourless, tasteless and highly toxic gas. The long term occupational exposure limit for carbon monoxide is 50 ppm for a weighted average on an eight hour working shift, and in the short term (ten minutes), the exposure limit is 400 ppm, this also being a weighted average [103]. Carbon monoxide is absorbed into the blood to form carboxyhaemoglobin, and the effects of the levels of carboxyhaemoglobin in the blood are detailed in Table 3.8.

Table 3.8 Effects of Carboxyhaemoglobin Levels in the Blood [104]

% carboxyhaemoglobin in blood	Symptoms
< 20	Nil. Slight breathlessness on exertion.
20 - 30	Flashing, tightness across forehead, slight headache. Some breathlessness on exertion.
30 - 40	Severe headache, dizziness, nausea, occasional vomiting, weakness of the knees, irritability and impaired judgement.
40 - 50	As above but more pronounced. Fainting on exertion.
50 - 60	Loss of consciousness.
> 60	Increasing depression of the circulatory and respiratory centres ending in death.

The other gaseous components do not have the serious toxic effects of carbon monoxide. However, they may represent a potential hazard and their toxic effects are listed in Table 3.9.

Table 3.9 Toxic Effects of Other Gas Components [103]

Component	OEL* (ppm)	Toxic Effects
Hydrogen	-	Asphyxiant
Carbon dioxide	5000	-
Nitrogen	-	Asphyxiant
Methane	-	Narcotic at high concentrations in the absence of oxygen
C_2H_4, C_2H_6, C_3H_6 and C_3H_8	-	Asphyxiant and possible anaesthetic at high concentrations

* - Occupational exposure limit.

Another potential toxic hazard is represented by the pyrolysis liquids or tars produced in gasification. A large number of different products have been identified in these products, a number of which are toxic and some of which have been reported to be carcinogenic [105][106][107]. Coal pyrolysis oils and mineral oils, for example, have been known for some time to cause cancer of the scrotum [108][109], and direct analogies with biomass pyrolysis products may be assumed.

3.10.1.2 Explosion and Fire Hazards

Gasification is a process by which a solid fuel is converted to a gaseous fuel. It can, therefore, be seen that both the gasifier feed material and gaseous product present a potential fire, and possibly explosion, hazard. The flammable limits of the main components of the product gas in air are presented in Table 3.10, although these limits would not apply for these components in a mixture. They do, however, give an indication of the likely explosive limits for the product gas. It must be noted that the potential fire and explosion hazard is greater at start-up and shut-down, that is when the system is at unsteady state operation. This is due to

Table 3.10 Flammable Limits of Main Gas Components in Air [110]

Component	Flammable limits (%)		Ignition temperature
	Lower	Upper	(°C)
Hydrogen	4.0	74.2	585
Carbon monoxide	12.5	74.2	609
Methane	5.0	15.0	537

the possibilty of explosive mixtures of product gas and air occurring in the system [48][61].

A further fire hazard associated with the gasifier was due to the storage of the dry wood chips in the laboratory. Another potential hazard associated with the feed material is the possibility of a dust explosion. Figures published by the Joint Fire Research Organization [111] show that the minimum ignition temperature for wood dusts covers the range 360 °C for wood (they do not explain what form of wood or its moisture content) to 470 °C for wood pulp flock. They do not present any figures for the minimum explosive concentration. However, although the potential risk of a dust explosion was identified, it was not considered to be a major hazard. Dust was only generated when the wood chips were being sieved, and due to the general unpleasantness of this task, only a limited amount of wood was sieved at any one time (see Section 4.3.1), thus limiting the quantity of wood dust generated.

The potential for a dust explosion, both wood or char dust, within the gasifier system itself was also recognised. However, it was felt that this risk was minimal compared to the risk of a product gas explosion.

3.10.2 Safety Precautions

The potential hazards involved in the operation of a gasifier have been discussed in Section 3.10.1. In order to minimise the dangers inherent with these hazards, safety measures could be taken in three areas:

i) The design of safety devices into the gasifier system.

ii) Gasifier operational procedures (see Chapter 5 and Appendix IV).

iii) Supporting or laboratory requirements.

3.10.2.1 Gasifier Design

The main safety precaution taken in the design was to include as much of the gasifier system as possible in a fumehood, see Figure 3.1 earlier. The only items outside the fumehood were the burner, the gas analysers and data-logging system. In order to allow ready observation of the gasifier whilst in operation, the fumehood walls were made from wire-reinforced transparent PVC sheeting. The fumehood had to be fitted with a number of removable panels and doors both to allow ready access for feeding and system maintenance. To minimise the risk of injury to the operators in case of explosion, an explosion port opposite the feeding door and an opening in the shielding at the pump end of the fumehood were included in the construction of the fumehood in order to direct any explosion away from the operators.

In order to prevent propagation of flames through the system, a flametrap, consisting of a chamber packed with glass beads and partially filled with water through which the product gas had to pass, was included as an integral part of the burner (see Section 3.6). It was felt that the scrubber would also act as a flametrap.

The system also included two alarms. To dispose of the product gas, a lean gas burner was employed (see Section 3.6). In order to ensure that this burner was flaring the product gas, the burner pilot light was alarmed. This alarm consisted of a thermocouple placed in the pilot flame which actuated a red warning light if the burner was extinguished and caused the thermocouple temperature to fall. Tests were performed to identify both the optimum position and set point temperature (~ 500 °C) of the alarm thermocouple in order to give rapid response time should the pilot flame be extinguished.

The dangers of carbon monoxide have been discussed in Section 3.10.1.1, and, upon consultation with the Departmental safety officer (Dr CJ Mumford), it was decided to install a carbon monoxide alarm (Crowcon Toxiguard). The alarm and tempo as the carbon monoxide level rises above 50 ppm. If the carbon monoxide level reaches 200 ppm, the note changes to a 'siren' and a warning light flashes. This alarm was installed on the outside fumehood wall in the area in which the operators spent the majority of their time whilst the gasifier was in operation (see Figure 3.18 above).

3.10.2.2 Laboratory Requirements

A number of measures independent of the gasifier system were taken to ensure the safe operation of the gasifier. These measures included:

i) Safety equipment - the laboratory breathing apparatus was overhauled.

ii) Fire fighting equipment - in addition to the carbon dioxide extinguishers already available in the laboratory, a water extinguisher was obtained specifically in case of a fire in the feed material. These extinguishers were placed so that they could be readily reached by the operators when running the gasifier. A sand bucket was obtained as a reactor extinguisher as it was felt that both the carbon dioxide and the water extinguishers would be unsuitable for extinguishing the reactor. The position of fire fighting equipment outside the laboratory was identified and was clearly sign-posted within the laboratory.

iii) Access - a clear path around the gasifier system was maintained and also from the gasifier to the laboratory exits to ensure evacuation of the laboratory as quick as possible, if required.

iv) Feed storage - the feed material was stored in lidded plastic dustbins and/or sealed plastic bags on metal trays in order both to contain the material in case of fire and to minimise the spread of wood dust.

v) Emergency procedures - the operators familiarised themselves with the University emergency procedures, that is evacuation points and the emergency telephone number.

3.11 NOMENCLATURE

Symbol	Description	Units (SI)
C_1	Pollutant concentration at scrubber inlet	kg m-3
C_2	Pollutant concentration at scrubber outlet	kg m-3
P_A	Pressure at standard conditions	N m^{-2}
P_M	Pressure at point of variable measurement	N m^{-2}
SG_{AIR}	Specific gravity of air	-
SG_{GAS}	Specific gravity of product gas	-
T_A	Temperature at standard conditions	K
T_M	Temperature at point of variable measurement	K
V_A	Volumetric flowrate at standard conditions	m3 s-1
V_{AIR}	Volumetric flowrate of air	m3 s-1
V_{GAS}	Volumetric flowrate of product gas	m3 s-1
V_M	Volumetric flowrate measured	m3 s-1
η_{ig}	Grade efficiency	-

CHAPTER 4
FEED MATERIALS

4.1 INTRODUCTION

The feed material is an important factor in the design, operation and performance of a gasifier system. There is a wide range of feed characteristics that influence the gasification process of which the most important are generally considered to be particle shape, size, moisture content, ash content and chemical composition [112]. This chapter covers the selection, preparation, properties and the methods of analysis of the properties of the feed materials used in this project.

4.2 FEED CONSTRAINTS

The geometry and physical size of the reactor limited the selection of feed materials that could be used in the gasifier. The constraints placed on the selection of feed materials for this gasifier were notably on the particle size, size range, shape, moisture content and ash content and these are discussed in Sections 4.2.1 to 4.2.4.

4.2.1 Particle Size and Size Range

The absolute upper limit for the particle size was set by the physical dimensions of the reactor itself. As the reactor was a packed bed, it was decided as an initial criterion to set the practical upper limit for particle size on the same considerations as for the sizing of packings employed in packed columns. In packed columns, the maximum packing size allowable is generally taken to be one-eighth of the tower diameter [113][88]. If the packing size is increased above one-eighth of the tower diameter, 'wall' effects, notably mal-distribution of the fluid phases due to the lower packing density near to the column wall, become significant. Therefore, in order to minimise any such 'wall' effects in the gasifier, the maximum particle size was set at one-eighth of the reactor diameter, that is 9.4 mm.

The lower limit for the particle size was constrained by limitations on the equipment employed and the higher pressure drop associated with smaller particle sizes. The design of the grate, that is the size of the holes, may be the limiting design feature, although different grates could be used for different sized feed materials. However, the main constraining factor on the lower particle size limit was the effect on the bed pressure drop and the subsequent effect on the gas pump's capacity, ie as the particle size decreases, bed pressure drop increases and as a result limits the pump capacity. This also causes lower absolute pressures in the equipment increasing the possibility of air ingress into the gasifier, thus increasing the hazards associated with operation of the gasifier and also affecting the performance of the gas analysis sampling system. Feed materials covering a wide range of particle sizes, and in particular those with a large percentage of small particles, are also limited in their use due to pressure drop considerations.

For the consideration of feed particle size as a reactor constraint, it was necessary to quantify the particle size. As most of the feed materials to be employed in the gasifier would be classified by sieving, the particle size was taken to be a sieve size range and was determined by the sieves used in its preparation. The exception to this was feed D (see Section 4.3.4), which was of a regular shape and was cut to a specific size.

4.2.2 Particle Shape

Particle shape was originally defined by observation, that is whether the material appeared to be of a specific shape, for example a sphere or a cube, or by consideration of its geometry, that is its length, depth, breadth ratio (see Section 4.4.1.5). Previous work had suggested that a feed material consisting solely of 'pins' (ie typical length, depth, breadth ratio of 5: 1: 1 or greater) was unsuitable, as it was prone to bridging and did not flow easily [84]. It was, therefore, decided not to employ feed materials consisting solely of 'pins'.

4.2.3 Moisture Content

The moisture content constraints for gasifier fuels is dependant on the reactor geometry. The upper limit acceptable for a downdraft reactor is generally considered to be around 40 % dry basis [15], as the water acts a a 'heat-sink' requiring energy to evaporate it from the feed, and it also takes part in predominantly endothermic reactions such as the water gas reaction (see Chapter 2). There is theoretically no lower limit on the moisture content and it would be feasible and may in fact be desirable to gasify a feed with as low a moisture content as possible to reduce the tar level in the product gas.

4.2.4 Ash Content

While there are constraints on the maximum level and type of ash content of fuels to be gasified, this was not a problem in this experimental programme, as low ash fuels were employed. The problems associated with the gasification of high ash fuels are due to the detrimental effect on solids flow through the reactor due to the agglomeration of the ash into large particles by sintering or fusion; the lack of shrinkage of the fuel in the gasifier; and 'blinding' of the bed due to retained ash. These problems can be reduced or avoided by the use of low ash fuels such as most woods, or in the design of the reactor by the use of reactor-bed stirring, continuous charcoal removal and/or specialised methods of ash removal such as the rotating grate and scraper employed by Manurung and Beenackers [58].

4.3 FEED SELECTION AND PREPARATION

In order to test the effect of size, shape and feed type on the gasification process, four different feed materials were used over the ten runs performed, the type, nominal size and shape of these materials are shown in Table 4.1. The selection and preparation of the feed materials used is described in Sections 4.3.1 to 4.3.4, the feed properties and their measurement are detailed in section 4.4.

Table 4.1 Description of Feed Materials Used in Gasifier

Feed	Type	Bark	Nominal size (mm)	Shape (description)
A	Pine (soft)	Yes	4.75 - 6.35	pins & slabs
B	Pine (soft)	No	4.75 - 6.35	cubes & slabs
C	Pine (soft)	Yes	2.8 - 4.75	pins & slabs
D	Ramin (hard)	No	6.35	cylinders

The above feed materials are illustrated in Figures 4.1 to 4.4.

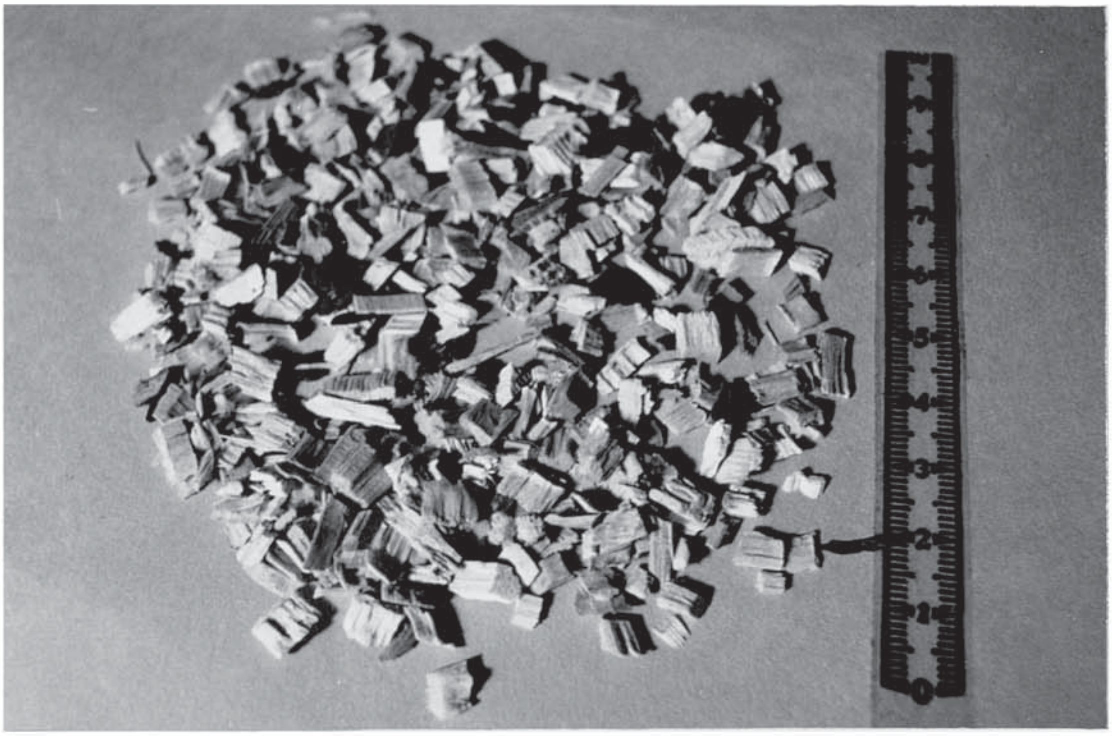


Figure 4.1 Feed A

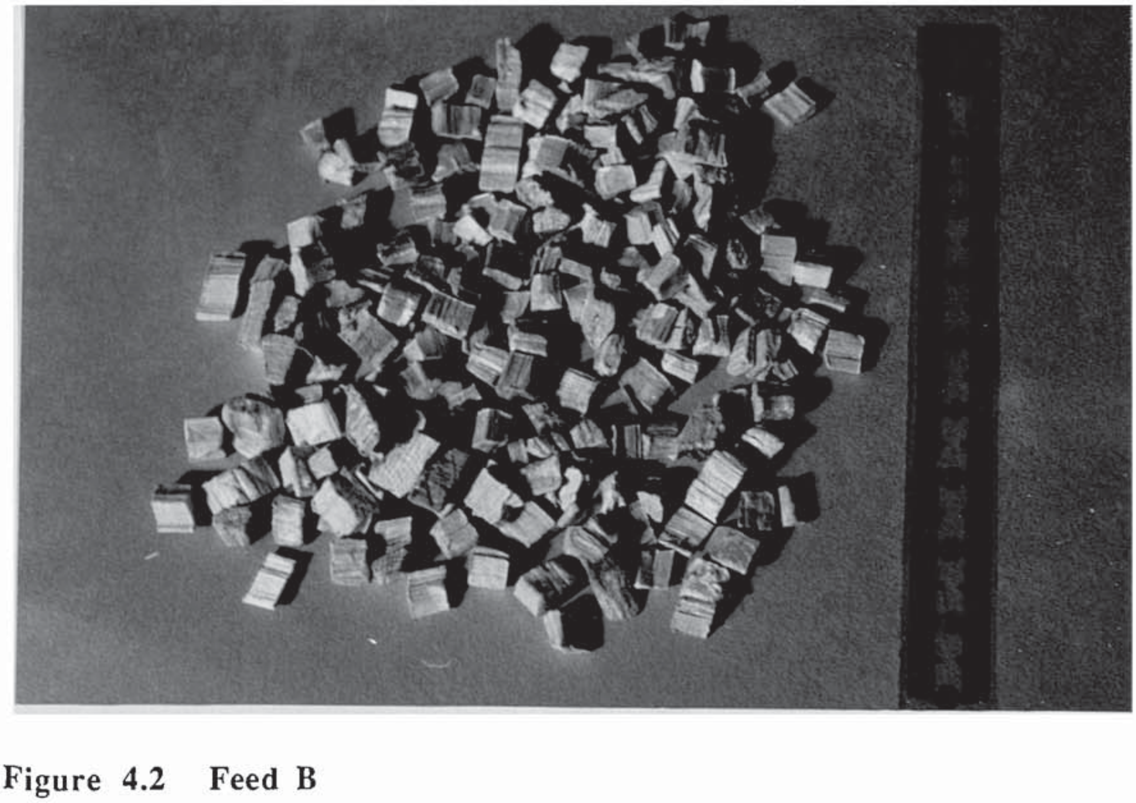


Figure 4.2 Feed B

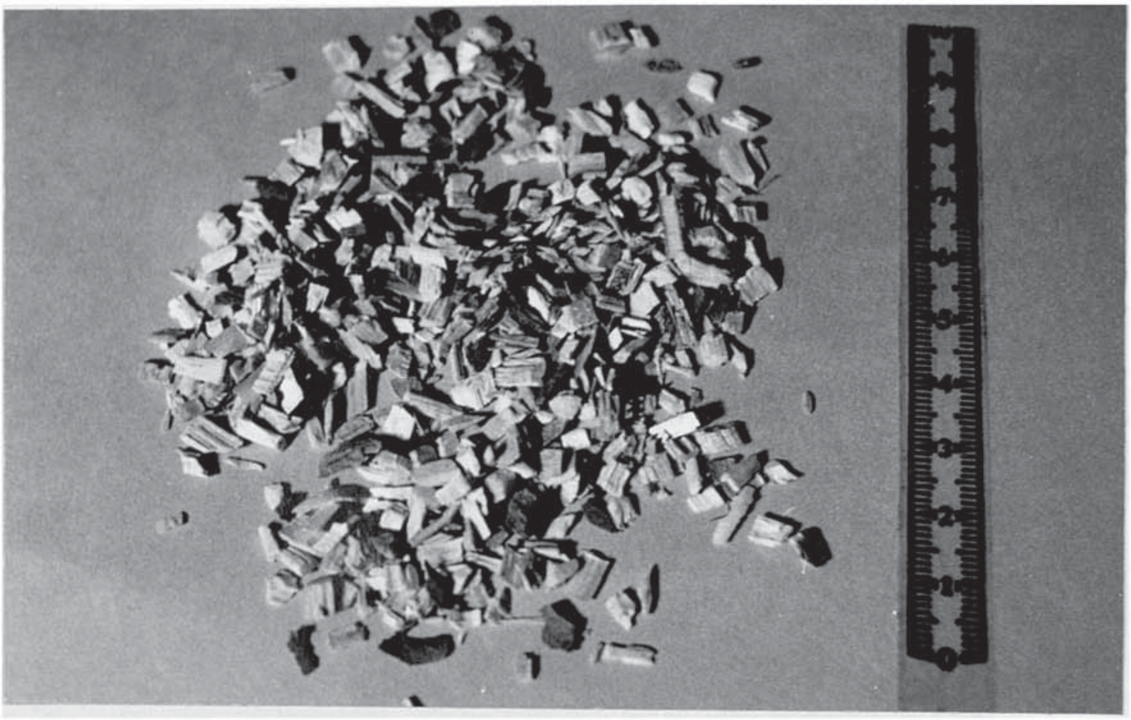


Figure 4.3 Feed C

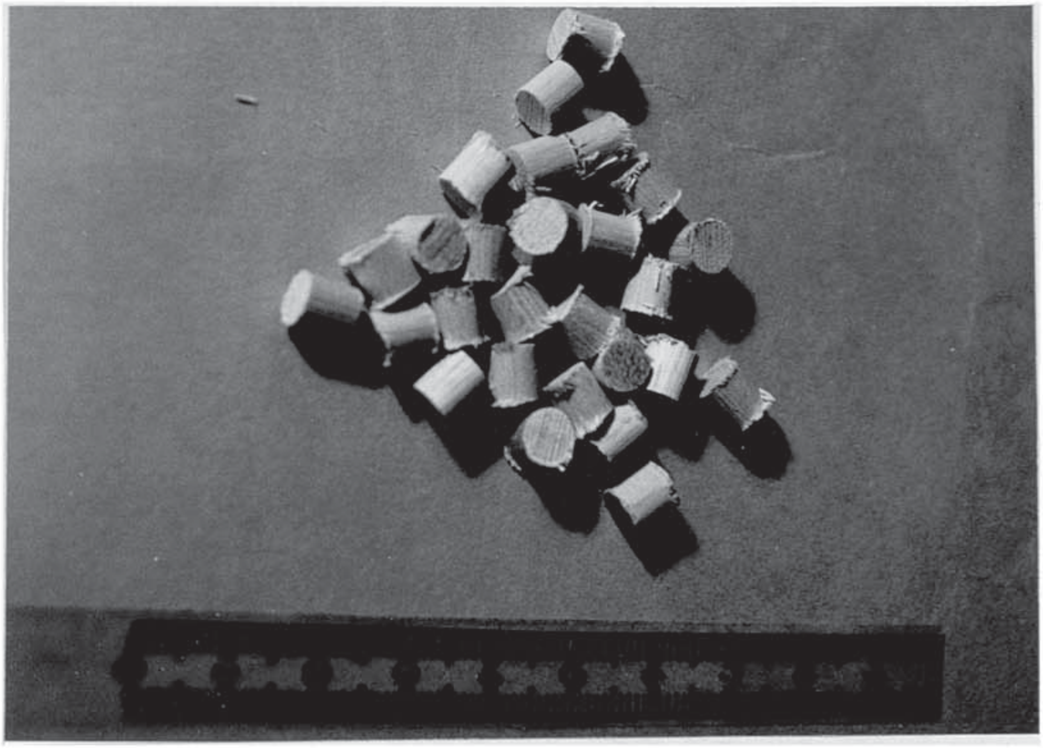


Figure 4.4 Feed D

4.3.1 Feed A

Feed A was selected on the basis that the 'raw' chips were representative of 'real' biomass, having been produced by passing timber yard offcuts through an industrial chipper (see Miles [83]); were readily available; and needed little preparation other than sieving and drying. The size range chosen (4.75 - 6.35 mm) was selected to be in the mid-range of the limitations set by the reactor (see Section 4.2.1) and thus leave scope for future work with different sizes of feed materials. The chips, as received, had a moisture content measured at approximately 50 to 60 % dry basis. A feed at this moisture level would have been unsuitable for use in a downdraft gasifier (see Section 4.2.3) and would have presented storage difficulties. It was, therefore, decided to air dry the wood to its equilibrium moisture content and use the wood at this moisture level as a feed material. The moisture content was measured prior to each run in which the material was used, methods of moisture determination are discussed in Section 4.4.1.3 later with results presented in Chapter 5.

The raw chips were air dried by spreading them out in a 250 mm thick layer on polythene sheeting on the laboratory floor. In order to ensure even drying, the chips were turned at least once a day. The moisture content was measured regularly, initially once a week, but as it approached equilibrium conditions, twice a week, and upon reaching a steady level, that is 11.5 ±1 % dry basis, the chips were assumed to have reached their equilibrium moisture content. This assumption was felt to be valid as the moisture content lay within the anticipated range, 8 to 15 % dry basis, predicted from TRADA data [114] for the laboratory temperature and humidity conditions. The dried chips were either stored in plastic bins or polythene sacks.

Prior to a run, the chips were hand sieved to the desired size range. Generally, only a sufficient quantity of chips to provide about 5 kg of the appropriate size range were classified in one session, as the sieving procedure was time consuming, unpleasant due to the dust generated and physically arduous.

4.3.2 Feed B

Experience with feed material A showed that, although it could be satisfactorily gasified, problems were encountered with its flow through the reactor due to bridging. In order to overcome these problems without modifying the reactor, it was decided to try another feed material which would minimise these solid flow problems and could also give a basis for assessing the effect of particle shape on the gasification process. In previous work at Aston, in-house manufactured blocks had been used as a fuel and had exhibited good flow characteristics [84]. It was, therefore, decided to experiment with a similar feed material for the present reactor. In order to allow for easier comparison between the various feeds, it was decided to use the same nominal size range as feed A. The wood was purchased as commercial timber which had already been dried. It was stored in the laboratory under the same conditions as feed A and was, therefore, used at the equilibrium moisture content for the laboratory conditions, which was measured for each run.

Commercial 50 mm x 50 mm (2 by 2) softwood was purchased in 1250 mm lengths. The timber was sawn across the grain into slabs 6.35 mm thick using a bandsaw. An accuracy of ±0.5 mm was obtained on the slab thickness by cutting against the saw's guide bar. The slabs were fed to a variable pitch hand grinder with sieving to obtain the desired size range and to remove oversize particles for regrinding. The chips were either stored in buckets or polythene sacks, the uncut timber lengths were stored in the open laboratory.

4.3.3 Feed C

As part of the experimental programme, it was decided to investigate the influence of particle size on the gasification process. In order to perform this work, it was necessary to obtain a feed of a different size range to those already used. In view of their ready availability and as they would require less time in preparation, it was decided to produce the new material from the undersize fractions from the production of feeds A and B. However, due to operational difficulties, that is elevated reactor pressure drop (see Chapter 6), only the material produced from feed A was used.

4.3.4 Feed D

Feed D was also selected to assess both its flow characteristics under gasification conditions and to provide a further basis for the assessment of the feed particle shape on the gasification process. A number of alternative feed shapes were considered: that is spheres, cylinders and beads (that is drilled spheres). Dowel cylinders were chosen due to their lower cost and the ready availability of wooden dowel rods. The moisture content was set as supplied and allowed to adjust to its equilibrium moisture content for the laboratory conditions as with feed B (see Section 4.3.2). The smallest diameter of dowel available was 6.35 mm. This was, therefore, selected as it was similar to the upper size of both feeds A and B (see Table 4.1).

The dowel rods were purchased in 2400 mm lengths and were cut into 6.35 mm lengths on a bandsaw, the length being set, to an accuracy of ± 0.5 mm, by the use of the guide bar as with the timber. In order to minimise splintering of the dowel fragments, the rods were cut in bunches. As with the timber, the dowel was received dried and no further drying was performed. The dowel fragments required no further treatment such as sieving and were stored in beakers.

4.4 FEEDSTOCK ANALYSIS AND CHARACTERISATION

4.4.1 Measurement of Properties

In order to prepare mass and energy balances; assess the influence of feed properties on the gasification process; and to allow for valid comparisons between different reactor systems it is necessary to detemine feed properties and characteristics. For fuels such as coal and coke, a series of standard tests have been developed by the British Standards Institute and the American Society for Testing and Materials to ensure accuracy and compatibility of analysis. However, no such comprehensive set of tests exist for the analysis of biomass for fuel purposes. Therefore, a number of workers analysing the properties of biomass fuels have used the existing standards for coal [9][115][116].

The feed characterisation performed in this project has, therefore, where possible, tried to follow these standard tests. However, due to limitations on equipment availability, time and money, this was not always feasible and, therefore, either these existing tests have been adapted or developed to suit the equipment available.

4.4.1.1 Proximate and Ultimate Analyses

The proximate and ultimate analyses of the feed materials were performed at the British Gas PLC, Midland Research Station in Solihull. Each sample was tested four times with a repeatability within ±1 % of the measured value. The mean values for the proximate analyses are presented in Table 4.2. The ultimate analysis data did not add up to 100 % and was, therefore, normalised to 100 % in order that it could be used for equilibrium modelling work. The mean normalised ultimate analyses are also presented in Table 4.2.

Table 4.2 Ultimate and Proximate Analysis of Feed Materials

	Feed Material			
	A	B	C	D
Ultimate Analysis (weight %)				
Carbon	50.74	49.74	50.74	47.44
Hydrogen	5.62	5.85	5.62	5.67
Oxygen	43.05	43.48	43.05	41.62
Nitrogen	<0.2	<0.2	<0.2	<0.2
Sulphur	<0.01	<0.01	<0.01	<0.01
Ash	0.38	0.71	0.38	5.06
H:C Ratio	1.33	1.41	1.33	1.43
O:C Ratio	0.64	0.66	0.64	0.66
Proximate Analysis(weight %)				
Volatile Matter	80.21	83.05	80.21	80.00
Fixed carbon	19.41	16.24	19.41	14.94
Ratio - Volatile Matter:Fixed carbon	4.13	5.11	4.13	5.35
Higher heating value (MJ/daf kg)	19.50	19.41	19.50	18.54

4.4.1.2 Biomass Higher Heating Value

The higher heating value of the feed was calculated from the ultimate analysis of the feed using the IGT equation:

Equation 4.1: $HHV = 0.341C + 1.323\ H + 0.0685 - 0.0153A - 0.12\ (O+N)$ [9]

A survey by Graboski and Bains [9], showed the IGT equation to be the most accurate of the equations available for calculating the heating value of biomass, differing from experimentally determined values for a variety of different materials by an average of ± 1.7 %. Higher heating values for all the feed materials used in the gasifier were calculated using the IGT equation and are presented in Table 4.2. These calculations were based on the average ultimate analyses (see Section 4.4.1.1) and are also presented in Table 4.2 above.

4.4.1.3 Moisture Content

The feed moisture content was determined by an oven drying technique following the TRADA method [114] and ASTM D-3175-85 [117]. Feed samples of approximately 20 g were placed in a fan assisted drying oven, and the oven was maintained in the region of 102 to 104 °C. Samples were dried until a constant weight was obtained, which generally took about 12 hours. However, as this required drying overnight, samples were often dried for up to 24 hours. A typical drying curve is presented in Figure 4.5, although the rate of the drying will vary with the particle size.

The moisture content can be expressed on either a dry basis, the ratio of loss of weight during drying to the final dry weight of the sample; or a wet basis, the ratio of loss of weight during drying to the original weight of the sample. Throughout this thesis, dry basis moisture content has been used. This can be converted to wet basis moisture content as follows:

$$\text{Equation 4.2 : } MC_{wb} = \frac{MC_{db}}{1 + MC_{db}}$$

The feed materials employed were at or near their equilibrium moisture contents. This is known to vary with both humidity and temperature, therefore the moisture content of the materials to be used in a particular gasifier run were measured prior to that run (see Chapter 5). Generally, two different samples of each material were used for each test, the difference between the two samples being generally within ± 5 % of each other.

4.4.1.4 Particle Size Distribution

The size distribution of each feed material used was measured by sieving; the

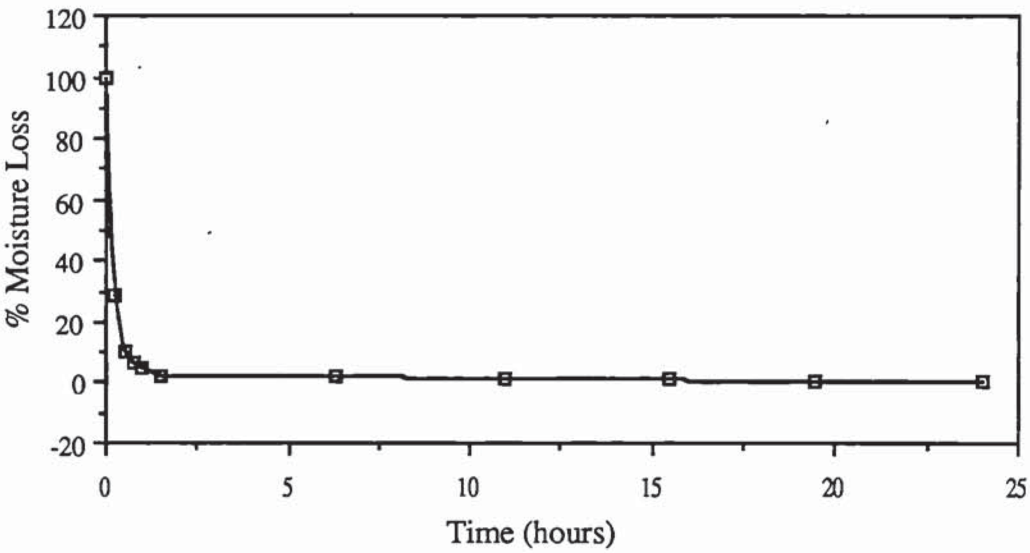


Figure 4.5 Typical Drying Curve for Oven Dried Wood Samples

following sieves being employed: 9.5, 8.0, 6.7, 5.6, 4.75, 3.35, 2.8, 2.0 and 1.0 mm. These sieves were chosen from the range available to give the most representative size distribution for the materials to be tested. Sample weights of 50 or 100 g were used, as larger samples tended to 'overload' individual sieves preventing separation, and smaller samples produced individual size fractions too small to weigh accurately. The sieves were agitated using a mechanical sieve shaker as hand shaking had proved to be inconsistent. Each sample was agitated for five minutes as experimental experience had shown that no improvement in material classification could be obtained if agitated for longer periods. The individual size fractions were removed from the sieves prior to weighing.

Each individual material was sieved twice, a separate sample being used each time. The average size distribution for each material is presented in Table 4.4 and this data, for feed materials A, B and C, is illustrated as a histogram in Figure 4.6.

4.4.1.5 Particle Geometry

Observations were made of the individual particle shapes of the different feed materials employed in the gasifier. This was somewhat subjective and a more

Table 4.3 Feed Size Distributions

Size distribution (mm) Range	Mean	Feed Material A	B	C	D
9.5 >x> 8.0	(8.75)	0.0	0.0	0.0	-
8.0 >x> 6.7	(7.35)	0.0	0.0	0.0	-
6.7 >x> 5.6	(6.15)	0.5	2.0	0.0	100[a]
5.6 >x> 4.75	(5.175)	12.7	23.8	0.1	-
4.75 >x> 3.35	(4.05)	72.2	55.3	31.1	-
3.35 >x> 2.8	(3.075)	5.6	10.3	25.3	-
2.8 >x> 2.0	(2.4)	7.0	6.5	32.1	-
2.0 >x> 1.0	(1.5)	1.7	1.8	10.3	-
1.0 >x> 0.0	(0.5)	0.3	0.3	1.1	-
Total		100	100	100	100

Key

a - Dust was present but in insufficient quantities to measure.

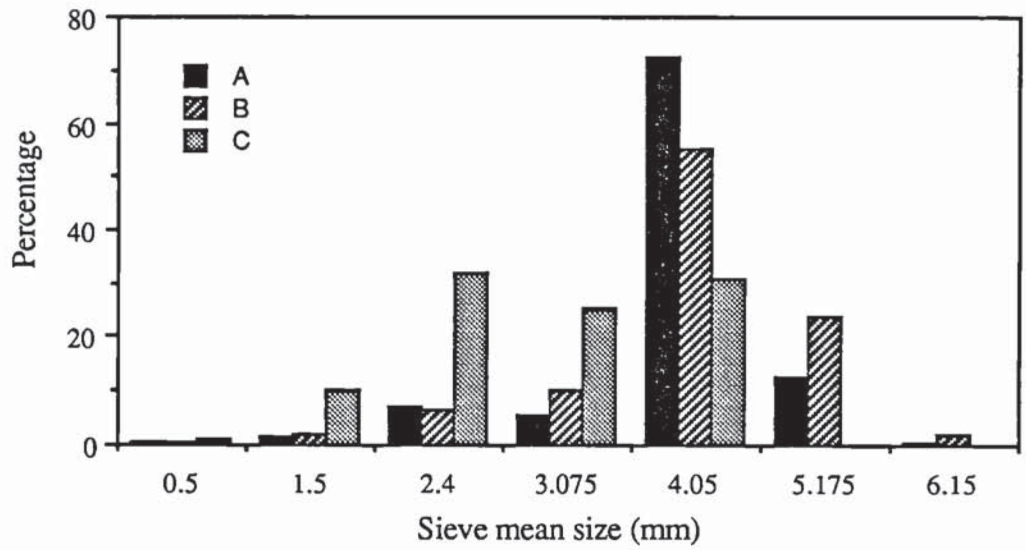


Figure 4.6 Histogram of Size Distributions for feeds A, B and C

objective method of assessing particle shape was sought. However, only a limited time was available in which to perform this analysis and it was decided simply to measure the relative dimensions of the particles, that is their length, depth and breadth. The length was taken to be the longest dimension overall and the depth the smallest dimension overall. However, due to irregularities in the particle shapes, each individual dimension was taken to be the largest measurement in that direction (see Figure 4.7).

In order to perform these measurements, random samples of approximately fifty particles were taken from each of the feed materials and these particles were then hand measured with a rule. The length, breadth and depth for each individual material were then averaged and the ratio of length and breadth were taken relative to the depth. However, due to its uniform particle shape, these measurements were not required for feed D. These data are presented in Table 4.4, feed D is included for comparative purposes.

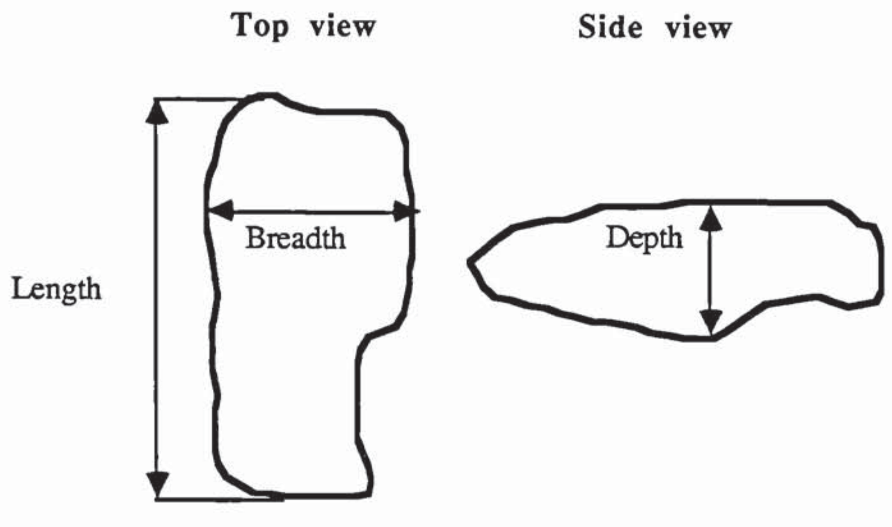


Figure 4.7 Schematic Illustrating Methodology of Particle Geometry Measurement

Table 4.4 Particle Geometries

Feed	Mean L: B: D (mm)	Ratio L: B: D
A	1.4: 3.6: 7.3	1: 2.5: 5.1
B	3.3: 4.6: 6.1	1: 1.4: 1.8
C	1.3: 2.9: 5.6	1: 2.2: 4.2
D	6.35: 6.35: 6.35	1: 1: 1

Key: L - length, B - breadth, D - depth.

4.4.1.6 Bulk Density

A number of different bulk densities exist, these include loose, uncompacted bulk density and compacted bulk density where the sample under test is compacted to different degrees by 'tapping' a set number of times, for example one hundred taps. For this project, it was decided to employ a loose, uncompacted bulk density as this would be less time consuming to measure, would be easier to standardise than a compacted density due to the difficulty in obtaining a consistent tap force and, as the feed fed to the reactor would also be uncompacted, it was felt to be a more representative bulk density.

Feed samples of approximately 50 g were placed in a 250 cm^3 measuring cylinder. The cylinder was then shaken vigorously to minimise any compaction and settling of the sample. The volume was then measured. The bulk density was then calculated by dividing the sample weight by the measured volume.

The measurement for each individual material was repeated three times, with a repeatability within ± 2.5 %. The average bulk density based on these three measurements is presented in Table 4.5 below.

4.4.1.7 Absolute Density

The absolute density was measured by two techniques, the selection of which depended on whether or not the feed material was received pre-chipped.

For unchipped materials, that is the dowel rods and 2 by 2 timber lengths, the density was determined by weighing and calculating the volume. This procedure was repeated ten times for the dowel rods with a repeatability of ± 2 %. Greater care had to be taken in the selection of the 2 by 2 timber to be tested, as a number of lengths were chipped or had knots missing. However, the procedure was repeated five times for the timber with a repeatability within ± 2 %.

For pre-chipped materials, that is feed A and C, the density had, by necessity, to be calculated by a different technique. A small weighed sample of the material (approximately 10 g) was placed in a 50 cm^3 measuring cylinder. The voids in the wood in the packed section of the measuring cylinder were then filled with a fine sand of known bulk density. The absolute density could then be calculated as follows;

$$\text{Equation 4.3 : } \frac{\text{Weight of feed sample}}{\text{Bulk volume of feed sample} - \frac{\text{Weight of sand}}{\text{Bulk density of sand}}}$$

This procedure was repeated twice with a repeatability within ± 5 %. The average densities obtained for all the feed materials are presented in Table 4.5 below.

Knowing both the bulk and absolute density of the feed materials, their fractional voidage could be calculated thus:

$$\text{Equation 4.4 : Fractional voidage} = \frac{\text{Absolute density - Bulk density}}{\text{Absolute density}}$$

The voidages calculated using this equation are presented in Table 4.5

Table 4.5 Feed Densities and Voidage

	Feed Material			
	A	B	C	D
Bulk density (kg/m^3)	155	245	159	315
Absolute density (kg/m^3)	485	410	485	620
Voidage	0.68	0.44	0.67	0.49

4.5 NOMENCLATURE

Symbol	Description	Units (SI)
A	Weight % Ash	-
C	Weight % Carbon	-
H	Weight % Hydrogen	-
O	Weight % Oxygen	-
N	Weight % Nitrogen	-
MC_{db}	% Moisture content dry basis	-
MC_{wb}	% Moisture content wet basis	-

CHAPTER 5
EXPERIMENTAL WORK

5.1 OBJECTIVES

The objectives of this research project were to design, build, commission and operate a laboratory scale gasification system which could be employed to investigate the gasification process and methods of product gas quality improvement. Within the objectives of the project, the experimental work to be performed was divided into stages:

1) Commissioning of the gasifier system and equipment modifications.

2) Investigation of selected parameters influencing the gasification process.

3) Investigation of methods of product gas clean-up

This chapter describes the commissioning; the selection of parameters to be investigated; the operational procedures for the gasifier; and possible methods of product gas upgrading.

5.2 COMMISSIONING

Prior to the commencement of the experimental investigation of the gasification process, the gasifier system, as a new system, had to be commissioned. This was divided into two stages of 'cold' and 'hot' commissioning. The aims of the experimentation performed during the commissioning were:

(i) To test and assess the performance of individual items of equipment

(ii) To test and assess the performance of the complete system.

(iii) To test and, if necessary, amend the operating procedures for the gasifier.

(iv) Utilise resultant data in subsequent analysis if it was of sufficient reliability.

5.2.1 Cold Commissioning

'Cold' commissioning entailed the operation of a number of items of equipment, but without the gasifier operating. The purpose of this was to check that the equipment performed satisfactorily, to obtain operating experience with the equipment, and to calibrate instruments. The majority of the tests were, therefore, performed prior to the initial gasifier start-up. However, the redesign of existing equipment and installation of new equipment meant that some 'cold' tests also had to continue after the commencement of 'hot' commissioning. The 'cold' commissioning tests performed are summarised in Table 5.1, which, where appropriate, are cross-referenced to the relevant discussion in other chapters.The majority of the tests were only performed once. However, a number of the tests have become standard calibration and safety checks and these are indicated in the table.

5.2.2. Hot Commissioning

Although the 'cold' commissioning tests discussed above (Section 5.2.1) were of considerable use, they could not be used to fully test the equipment in the gasifier system. Certain items of equipment and operating procedures could only be adequately tested under 'real' operating conditions, that is with the gasifier in operation. Therefore, in order to perform the tests required, a number of 'hot' commissioning runs were performed.

The results of the 'hot' commissioning runs are listed chronologically in Table 5.2. The original design and any subsequent modifications that were required are also discussed in greater detail in Chapter 3 and, where appropriate, Table 5.2 is cross-referenced to this discussion. Three areas in particular required close attention and a number of modifications: the in-bed temperature measurement, the product gas cleaning and the gas sample clean-up system. The first six runs performed on the gasifier, although yielding some useful data, were used predominantly as conventional commissioning runs.

Table 5.1 Summary of the 'Cold' Commissioning Tests

Item of Equipment	Purpose of Test	Observations/Modifications	Cross-reference to detailed discussion
PRIOR TO RUN C1			
Gas cooler	Leak test	OK. No water leakage	-
Scrubber device 1	Liquid distribution	OK Packing well-irrigated	-
	Column flooding	OK. At full gas pump rate. Column flooded at 2.0 l/min	App. II & 3.4.2.2
	Level control drainage system	OK	-
Gas pump	Test performance	OK. Flow rate determined by recycle loop (see below).	-
Recycle loop	Test flow rate control	OK. Flow range ~0.5 to 10 m^3/hr	3.5
Lean gas burner	Find optimum position of alarm thermocouple & alarm set point	Minor adjustments required	3.10.2.1
	Test pilot light flame stability over full gas pump range	OK	-
Flowmeters and gasmeter	Test calibrations	OK	-
Gas analysers	Test calibration*	OK. Would require regular calibration due to 'drift'	-
	Derive data-logger conversion* coefficients	Due to analyser drift coefficients, would require regular recalibration	App. IV and VI
Data-logger	Test signal stability	TC-16 card OK. Analogue inputs required multiple reading to obtain required signal stability due to 'noise'.	3.9.2.2
	Test calibration of conversion coefficients	OK. Only limited test on gas analysis using zero and span gas.	-
	Test sampling rate	OK. Sample at ~1 set of readings per 15 seconds.	-
System piping and joints	Leak test*	OK. Some joints required tightening	App. IV
Fumehood	Test suction	OK. Smoke from burning paper was drawn off.	-
	Access for feeding	OK. Under cold conditions	Table 5.2

Table 5.1 continued.

Item of Equipment	Purpose of Test	Observations/Modifications	Cross-reference to detailed discussion
PRIOR TO RUN C2			
Scrubber device 2	Determine wash water rate	Pump capacity sensitive to water rate. Optimum ~3 l/min	3.4.2.3
Gas rotameter	Calibrate	OK. Float became soaked in lube oil from pump. Installed oil mist filter	3.4.2.4
Pressure transducers	Calibrate	OK	-
	Derive data-logger conversion* coefficients	Due to drift, coefficients will require regular recalibration.	App. IV and VI
Oil mist filter	Test oil removal	OK	3.4.2.4
	Effect on pump capacity	OK. Low pressure drop, therefore minimal effect.	
PRIOR TO RUN C3			
Scrubber device 2 (once-through water mode)	Test level control with insulated electrodes	OK	3.4.2.3
Pump inlet filter	Effect on pump capacity	OK low pressure drop, therefore minimal effect	
PRIOR TO RUN C4			
Scrubber device 2 (recycle mode)	Determine operational procedure	Valve V4 (see App. III) must not be opened until after recycle pump started	App. IV and 3.8.2.3.
PRIOR TO RUN C5			
No tests required.			
PRIOR TO RUN C6			
No tests required.			
PRIOR TO RUN R7			
CMI-E gas flowmeter	Calibrate	OK	-
	Derive data-logger conversion* coefficients	Due to drift, coefficients will require regular recalibration.	App. IV and VI

Key : * - standard test

Table 5.2 Summary of Modifications Made as a Result of the 'Hot' Commissioning Runs

Item of Equipment	Problem	Remedy/Modifications (prior to next run)	Cross-reference to detailed discussion
<u>RUN C1</u>			
Reactor	Too high for feeding	Reactor lowered - required realignment of heat exchanger and repositioning of hotbox	3.4.1
Gas cleaning	Potential for blockage of primary heat exchanger.	Lowering of reactor required installation of an additional catchpot prior to exchanger directly below reactor	3.4.2.1
Reactor bed temperature measurement	Thermocouple array would not move easily and position could not be accurately gauged	Installation of array with fixed position thermocouples in centre of reactor	3.8.2
Scrubber device 1	Low efficiency causing tar deposits in pump	Replaced with new scrubber	3.4.2.3
Gas pump	Tar and other contaminants in lube oil, pump required service	Scrubber replaced and ordered pump inlet filter (this was not installed until after next run due to order delay)	-
Product gas flowrate	Not monitored due to late arrival of order	Installation of temporary flowmeter (run C1 measurements were taken using gasmeter)	3.8.2
Gas sample clean-up system	Became rapidly overloaded with tar	Installed charcoal column and ice trap prior to hotbox. For next run, decided not to start gas sampling until reactor lit and 'burning' stably	3.8.1.4
Gas sample flowrate	Not monitored due to late arrival of order	Rotameter fitted for run C2	3.8.1.4
CO analyser/ data-logger	CO analyser display value and value recorded by data-logger did not correspond	Believed to be software error which was corrected. This was not the cause however (see run C3).	-
<u>RUN C2</u>			
Reactor bed temperature measurement	Two thermocouples burned through at end of run during char burn out	Operational change. Thermocouple array to be removed prior to char burnout. For next run thermocouple spacing increased to 5 cm	3.8.2

Table 5.2 continued

Item of Equipment	Problem	Remedy/Modifications (prior to next run)	Cross-reference to detailed discussion
Scrubber device 2	Breakdown of level control drainage system due to tar deposition on electrodes. Run aborted	Electrodes enclosed in plastic tube	3.4.2.3
CO analyser/ data-logger	As C1	Believed to be recurrence of same software fault as C1 again this was not the cause (see run C3)	-
Gas sample clean-up system	Became rapidly over loaded with tar Charcoal column could effect analysis accuracy	Increased delay prior to starting gas sampling and replaced charcoal column with wood chip column	3.8.1.4
Pressure transducers/ data-logger	Little variation in pressure reading	Software error, which was corrected	-
RUN 3			
Scrubber device 2	Break down of level control drainage system	Redesign of scrubber to recycle water system	3.4.2.3
CO analyser/ data-logger	As C1. Fault in output amplifier	Output board replaced	-
Gas sample conditioning	Became rapidly overloaded with tar	Moved sample point to after scrubber	3.8.1.4
Back-up (batch) gas analysis	None available	Installed batch sample point after gas pump	3.8.1.5
RUN C4			
Reactor	Voids in reactor due to bridging of feed between thermocouple array and reactor wall	Repositioned array next to reactor wall	3.8.2
Hydrogen analyser	Reading low	Loose connection in analyser which required tightening	
Gas sample clean-up system	After ~1.25 hours problem with sample flowrate reducing	Pipe in eductor blocked with tar. Cleaned and unblocked	-

Table 5.2 continued

Item of Equipment	Problem	Remedy/Modifications (prior to next run)	Cross-reference to detailed discussion
RUN C5			
Gas sample clean-up system	As C4	Filter from hotbox clogged. Cleaned existing filter and ordered replacements	-
RUN C6			
Gas sample clean-up system	As C4	Sintered filter in hotbox clogged ordered new filters and replaced existing filter	-
Product gas flowrate	-	Temporary flowmeter replaced as the flowmeter originally ordered finally arrived	3.8.2
Data-logging	New flowmeter caused wiring difficulties	All input wires taken to a junction box from which a ribbon cable was taken to interface	-
	Analogue signal stability to AN16/32 card	Missing resistor installed. Improved signal stability particularly of pressure transducers, therefore to improve accuracy converted display from PSI to mmHg	-
	Reading speed	Obtained assembler code routines for control of IEEE databus and speed greatly increased	3.9.2.1

5.3 EXPERIMENTATION

This section describes the selection of reaction parameters for investigation and the operating procedures for the gasifier.

5.3.1 Selection of Variables

The gasification process is dependent on a number of process variables related to both the reactor feed and the operation of the gasifier. Table 5.3 lists these variables with particular reference to open-core downdraft gasifiers, together with the permitted variation in the parameters for the existing gasifier system. This table does not include secondary processing stages, these will be discussed in Section 5.4.

Table 5.3 Parameters that Influence the Gasification Process

Parameter	Variation possible
Feed type	wood, bark, straw, RDF
Feed mean particle size	2.0 - 9.4 mm
Feed particle size range	Mean ± 0.0 mm - mean ± 4.7 mm
Feed particle shape	Slabs, pins, cubes, cylinders, spheres
Feed moisture content	0 - 40 % dry basis
Reactor heat loss	With or without insulation (0 - 20 %)
Height of char bed	0 - 25 cm
Air to fuel ratio	0.1 - 0.8 air factor

The limited time available within the project timescale meant that not all these parameters could be investigated. The parameters investigated and the reason for their selection is dicussed in Sections 5.3.1.1 to 5.3.1.4.

5.3.1.1 Height of Char Bed

Work by Reed et al. [65] and preliminary data collected during the commissioning runs when trying to obtain a stable reaction zone suggested that increasing the height of the char bed had the effect of improving the product gas quality. This could be attributed to improved char oxidation due to the increased contact time between the char and gas or tar cracking by the hot char (see Chapter 2). However, further work was required both to verify, and if possible, quantify this effect and it was, therefore, decided to investigate this area as a new contribution.

5.3.1.2 Feed Particle Shape

A number of problems were encountered during the commissioning runs with the flow of the feed through the reactor (see Chapter 4). In order to overcome these problems, it was decided to employ some different feed materials with different particle shapes that might exhibit better flow characteristics. Two different materials (B and D), one with a 'cubic' particle shape and one cylindrical were, therefore, obtained. The selection of these materials is described in Chapter 4.

5.3.1.3 Feed Material Type

The feed materials obtained to allow for the investigation of the feed particle shape also allowed for the investigation of the feed material type. These materials consisted of the initial material (feed A) which was used throughout the commissioning runs and consisted of mixed softwood (pine) and bark; the 'cubic' material (feed B) which consisted of softwood (pine) with no bark; and the cylindrical material (feed C) which consisted of hardwood (ramin) with no bark.

5.3.1.4 Feed Particle Size

The preparation of the feed materials discussed above resulted in the production of both oversized and undersized material. This, therefore, allowed for the preparation of a number of different sized materials. It was decided to investigate the effect of varying the feed particle size, as this would effect the solid flow, the reactor pressure drop, the rate of flaming pyrolysis and the gas-solid contacting and thus the reaction rates.

5.3.2 Experimental Programme

One of the aims of the project was to build a gasifier system that could be used to test a variety of gas upgrading techniques, see Sections 5.1 and 5.4, but the time available within the framework of this project did not permit a detailed investigation of these techniques. However, in order for future workers to assess the performance of these techniques, it will be necessary to have 'base case' data on which judgements on the upgrading techniques performance can be made. The gasifier set-up in its format on the completion of the commissioning runs was considered to be a simple but standard gasifier set-up, that is reactor, gas scrubber and product disposal, and as such was suitable for the collection of this 'base case' performance data. The data thus collected would also be utilised to compare the performance of the Aston system with other open-core and throated systems.

Details of the actual experiments performed including the objectives, the data collected, the feed materials employed, the duration of the experiment and the reason for terminating the run are presented in Table 5.4.

Table 5.4 Actual Experiments Performed

<u>C1</u>	Duration 1 hour.
Objectives -	Commissioning
Feed used -	A (11.9)*
Data collected -	Gas composition. 3 in-bed thermocouples (+ others) Gas volume - manually using gasmeter.
Reason for stopping -	Testing complete.
<u>C2</u>	Duration 1.75 hours.
Objectives -	Commissioning
Feed used -	A (11.4)*
Data collected -	Gas composition. 7 in-bed thermocouples (+ others) Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger.
Reason for stopping -	Level control failure resulted in flooding of disentrainment vessel.
<u>C3</u>	Duration 1 hour.
Objectives -	Commissioning
Feed used -	A (8.8)*
Data collected -	Gas composition. 5 in-bed thermocouples (+ others) Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger.
Reason for stopping -	Level control failure as C2.
<u>C4</u>	Duration 1.25 hours.
Objectives -	Commissioning
Feed used -	A (8.9)*

Table 5.4	continued
Data collected -	Gas composition. 5 in-bed thermocouples (+ others) Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger. Height of char bed.
Reason for stopping -	Gas sample flowrate dropped rapidly to insufficient level for gas analysers.
C5	Duration 0.5 hours.
Objectives -	Commissioning
Feed used -	A (10.1)*
Data collected -	Gas composition. 8 in-bed thermocouples (+ others) Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger. Height of char bed.
Reason for stopping -	Problem with gas sampling system as with run C4 above.
C6	Duration 0.75 hours.
Objectives -	Commissioning
Feed used -	A (9.8)*
Data collected -	Gas composition. 8 in-bed thermocouples (+ others) Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger. Height of char bed.
Reason for stopping -	Problem with gas sampling system as with runs C4 and C5 above.
R7	Duration 1.75 hours.
Objectives -	Investigate height of char bed's influence on performance. Investigate two different feed materials giving different shape and type. Mass balance - tar yield. 'Base case' system performance data.
Feed used -	B (12.2)* D (9.1)*
Data collected -	Gas composition. 8 in-bed thermocouples (+ others) Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger. Height of char bed. Tar sampling.
Reason for stopping -	Experiment complete.

Table 5.4	continued
R8	Duration 1.75 hours
Objectives -	Investigate influence of char bed. Mass balance - tar yield. 'Base case' system performance data.
Feed used -	B (12.5)*.
Data collected -	Gas composition. 8 in-bed thermocouples (+ others). Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger. Height of char bed. Tar sampling. Batch gas samples.
Reason for stopping -	Experiment complete.
R9	Duration 2.25 hours.
Objectives -	Investigate influence of height of char bed. Investigate effect of particle size, shape and type by using three different feed materials. Mass balance - tar yield. 'Base case' system performance data.
Feed used -	B (11.9)* C (11.7)* D (9.1)*.
Data collected -	Gas composition. 8 in-bed thermocouples (+ others). Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger. Height of char bed. Tar sampling. Batch gas samples.
Reason for stopping -	Excessive bed pressure drop - problem with gas pump.
R10	Duration 0.5 hours.
Objectives -	Investigate influence of height of char bed. Investigate effect of particle size, shape and type by using three different feed materials. Mass balance - tar yield. 'Base case' system performance data.
Feed used -	B (12.6)*
Data collected -	Gas composition. 8 in-bed thermocouples (+ others). Pressure - at point of flow measurement and downstream of reactor. Gas volume - manually using gasmeter. Gas flowrate - automatically using data-logger. Height of char bed.
Reason for stopping -	Reactor tube cracked.

* - moisture content dry basis

5.3.3 Gasifier Start-up and Shut-down

The number of individual items of equipment within the system meant that for safe operation and to prevent damage to equipment, well-defined start-up and shut-down procedures had to be drawn-up. The procedures are listed in Appendix IV, with the safety and equipment checks performed prior to each run.

The hazardous nature of the products, being both explosive and toxic (see Chapter 3), meant that emergency shut-down procedures also had to be considered. However, these procedures would be very dependent on the nature of the emergency. These procedures are also listed in Appendix IV.

5.3.4 Operator Duties

Although the initial design of the system was for one-person operation, the gasifier was operated by two people throughout all the runs performed. Therefore, in order to prevent confusion, to allow for efficient operation of the gasifier and for safety, the operators were assigned selected duties to perform. These duties are detailed in Table 5.5.

Table 5.5 Operator Duties

Operator One	Operator Two
Reactor feeding.	Control & monitoring of gas flowrate
Control & monitoring of gas analysis equipment.	Monitoring of data-logging system.
Control & monitoring of gas sampling system in particular recording gas sample rate.	Taking batch gas samples and wash water samples.
	Control & monitoring of gas scrubber.
Monitoring height of char bed.	Control & monitoring of lean gas burner.
Operation & monitoring of tar sampling system.	Monitoring & recording gasmeter readings.

5.3.5 Reactor Lighting

The start-up procedures have already been discussed in Section 5.3.3 and Appendix IV. However, a particular problem in the start-up procedures was the lighting of the reactor.

The initial technique employed was that used by Bright et al [84] which involved charging a small quantity of feed to the reactor (circa 50 g); setting the main gas pump to give a small flow of air into the reactor, sufficient to draw a flame into the wood but not to extinguish it; then dropping lighted household matches onto the wood bed. When the wood was alight and burning evenly, the air flow could then be increased and further wood added.

However, this technique proved to be unsatisfactory for the 75 mm reactor. It often required as many as twenty matches to light the reactor which took a considerable time and often resulted in an uneven lighting of the bed, with combustion occurring on one side of the bed only.

It was concluded that to ignite the bed, matches alone were an insufficient heat source and a more intense source of ignition was required in order to speed up and obtain a more even initial lighting. It was, therefore, decided to employ standard domestic coal fire or barbecue firelighters in the lighting process. The technique was largely similar to the previous lighting technique, except that approximately 1 g of firelighter flakes were added to the top of the wood bed. The matches were then dropped onto these flakes. This resulted in much more rapid and even lighting of the bed.

Subsequently, the lighting technique was further revised to include a layer of wood char or charcoal, of between 5.0 and 7.5 cm thick, beneath the wood bed. The rest of the procedure remained the same. This modification was made in order to assist the even build-up of the char bed and to help reduce the tar production at start-up, as it was observed that the tar production was greater during this period (see Section 3.8.1.4).

5.3.6 Reactor Feeding

As discussed in Chapter 3, a hand feeding technique was selected. The technique employed consisted of adding pre-weighed batches of feed to the reactor when the fuel bed reached a set level in the reactor. The batch size employed was a compromise between maintaining an even bed height and thus minimising bed disturbances by using small batches; and using larger batches and thus minimising the operators' time required in feeding. On consideration of these points, it was decided to employ batches of 50 or 100 g.

As discussed above, the batches were added when the bed level reached a preset mark on the reactor wall. By recording the time at which each successive batch was added to the reactor it was, therefore, possible to calculate the feed rate. However, any voids occurring in the reactor bed could significantly effect the accuracy of these throughput calculations.

5.4 PRODUCT GAS UPGRADING

One of the objectives of this project was to build a system that could be used for investigating a variety of techniques for improving the product gas quality. However, the timescale of this project only allowed for a limited amount of work to be performed in this area, that is the investigation of the height of char bed on the gas quality and the use of a scrubber which was necessitated in order to protect the system instrumentation (see Chapter 3). The techniques that could be employed are outlined in Table 5.6. However, a detailed study of these is outside the scope of this project as they could not be attempted and will not be discussed further.

Table 5.6 Potential Methods of Product Gas Quality Improvement

Physical Methods	gas scrubbing, filtration, cyclone, electrostatic precipitation
Chemical Methods	secondary catalytic reactors inside reactor catalyst addition with feed secondary catalytic reactors outside reactor packed catalyst bed secondary partial oxidation reactors inside reactor, eg air injection into reactor bed at reaction zone as Buck Rogers [76] or into char bed secondary partial oxidation reactors outside reactor, eg steam/oxygen reformer as Creusot-Loire [118] and Foster Wheeler [119]
Thermal Methods	thermal cracking of gas contaminants electrical heating element

CHAPTER 6
RESULTS AND DISCUSSION

6.1 INTRODUCTION

This chapter includes the results and discussion of the work performed. During the experiments, considerable data was collected, both in the form of qualitative observations and quantitative measurements: these measurements were made both manually and automatically using the data-logger (see Chapter 3) with which 22 sets of data were collected approximately every 15 seconds. Raw data from the latter experimental runs (runs C6 to R9) are included in Appendix VII, while this chapter provides summaries and analyses for effective presentation of the major results and their discussion.

The runs performed on the system were in collaboration with Miss LR Reyes. In order to prevent duplication of work, specific areas of investigation were agreed prior to the project with Miss Reyes to formulate mass and energy balances for the system, hence these areas will not be included in this thesis.

6.2 QUALITATIVE OBSERVATIONS

6.2.1 Solids' Flow

In Chapter 2, a number of feed properties were discussed in relation to their effect on gasifier performance. An important feed property was identified to be the particle shape in that a fuel consisting of particles with a high ratio of length to depth and breadth (see Chapter 4) is prone to bridging causing voids, irregular solids' flow and distortion of the reaction zone which can cause bypassing and high tar levels in the product gas.

Observations made on the flow of solids through the reactor support this bridging hypothesis. Four feed materials were used in total over the ten runs performed (including commissioning runs), and are described in Chapter 4. Feeds B and D, regular shaped particles, flowed evenly through the reactor with only a limited degree of bridging occurring and this being generally in the vicinity of the thermocouple array. Feed C also flowed evenly through the reactor, although it did cause an excessive reactor pressure drop which limited its use. However, feed A, the 'real' wood chips containing mixed shapes, that is slabs and pins, exhibited poor flow characteristics and was prone to bridging which caused voids of up to 7.0 cm deep and in some cases covering the complete reactor diameter, that is 7.5 cm. Examples of the voids occurring in the vicinity of the reaction zone can be seen in Figure 6.1.

One effect that is believed to be related to the occurrence of voids was on the reaction zone stability. The bridging and voiding of the material in the bed caused the reaction zone to develop irregularities (dips) which could result in the zone developing a slope of up to 45°. This effect could also be attributed to poor oxidant distribution across the reactor due to poor feed distribution across the bed. This could result in an uneven pressure drop, which would exacerbate the problem by causing small variations to be amplified due to higher pressure drop across the char compared to the feed material. This situation was particularly frequent for feed A, but also occurred with feed B (the most widely used material), when voids occurred in the vicinity of the thermocouple array.

A problem associated with the occurrence of voids in the reaction zone is that they could allow tar to bypass the reaction zone and possibly to pass out of the reactor. Evidence to support this theory with voids occurring in the vicinity of a sloping reaction zone, was a dense 'smoke' observed travelling downward through the reactor. This can be seen in Figure 6.2.

The general conclusion that can be drawn from these observations is that feeds containing particles of mixed shapes or sizes promote bridging and hence cause voids in the reactor which may promote higher tar yields in the product gas. The size of these bridges is a function of particle size and shape and, therefore, at larger reactor diameters, the size of an individual void is likely to be less significant. However, the occurrence of multiple voids within a large gasifier could still allow tar to escape the reactor uncracked.

Figure 6.1 Voiding in Reactor

Figure 6.2 Tar Smoke in Reactor Bed Void

6.2.2 Individual Particle Reaction

One of the reasons for selecting transparent quartz tubing for the reactor was that it enabled the gasification process to be monitored whilst in operation. Observations were made in particular on the particle behaviour, with the gasifier operating at steady state with constant height of char bed. These observations are summarised below and are depicted in Figure 6.3.

A feed particle in the gasifier moves progressively down through the reactor with no visible change until it approaches to within approximately one particle diameter of the reaction zone. The lowest part of the particle, that nearest to the top of the reaction zone, then begins to pyrolyse and due to charring the bottom of the particle blackens. The charring then moves uniformly up through the particle as it descends towards the reaction zone. A visible flame, the burning volatile pyrolysis products, follows this charring across the particle, these flames flowing downwards through the reactor. By the time the particle is completely surrounded by burning volatiles, it is entirely within the reaction zone. The flame dies away as pyrolysis nears completion, due to the cutting off the production of volatiles. The total pyrolysis process occurs within a height of no more than 2 particle diameters.

Due to the shrinkage of the particle being gasified, there is a narrow void, approximately 1 to 2 particle diameters across, between the bottom of the feed section and the char bed. On completion of pyrolysis, a glowing red particle of char remains which drops to the surface of the char bed and rapidly disappears, the gasification process coming to completion within approximately 1 particle diameter. The entire reaction zone from commencement of pyrolysis to the completion of gasification, including the void between the reaction zone and the char bed, is no more than 4 to 5 particle diameters in height. Complete reaction times, including both pyrolysis and gasification are presented in Table 6.5 later.

These observations contradict the work of Reed et al, relating to the time required for char gasification. Reed et al propose that 'complete' char gasification takes in the order of 100 seconds (see Chapter 2). However, observations made indicate that the char gasification is complete very rapidly, the complete reaction including pyrolysis being complete in approximately 36 seconds for feed B and 65 seconds for feed D. This is discussed further in Section 6.4.

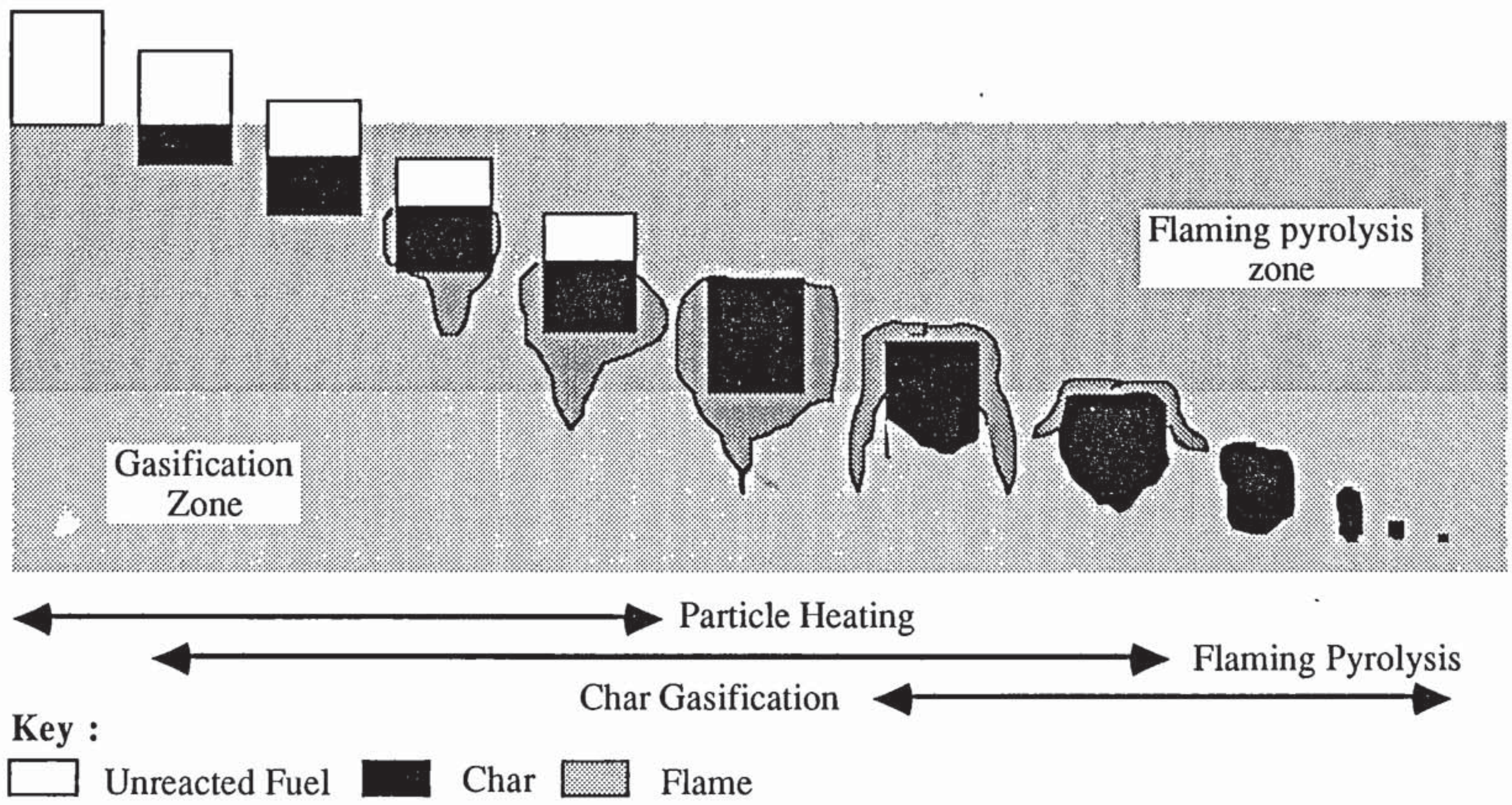


Figure 6.3 Particle Reaction

This would further suggest that at steady state, when the rate of char production by pyrolysis is equal to the rate of the gasification of the char and the position of the reaction zone is constant, the char bed below the reaction zone is not being gasified and so would not appear to be necessary for gasifier operation and, therefore, the reactor could be operated with the reaction zone at the grate. This will be discussed in detail in Section 6.6.

On consideration of these observations, a new 'model' is proposed to represent the zones within the open-core downdraft gasifier. This is represented schematically in Figure 6.4.

6.2.3 Heat Transfer

In Chapter 2, Reed's theory of reaction propagation was discussed, in which it was claimed that the propagation was by the formation of a flame flowing upwards into the unreacted biomass. However, the observations made above show no evidence of flames propagating upwards into the unreacted biomass and, in fact, the opposite was observed, the flames propagated downwards away from the unreacted biomass. This downflow of the flames would be expected due to the rapid downflow of the air and gas in the gasifier. When voids occurred in the reaction zone, large flames of up to 6 cm could be seen flowing downwards through the reactor (see Figure 6.5 and also Figure 6.1 above). This would suggest that the volatiles produced, and hence the flame, are entrained in the bulk forced convection of the gas downwards through the reactor. It also suggests that reaction propagation is by some other heat transfer mechanism.

The possible mechanisms of heat transfer to the particle for pyrolysis to be initiated and maintained include convection, conduction and radiation, all 'backwards' from the reaction zone. Convection can be excluded, due to the flow of heat away from the unreacted biomass in the bulk forced convection flow of the gases down through the reactor. A conduction mechanism can also be excluded, as both wood and wood char are poor heat conductors. For example, pine across the grain has a thermal conductivity of 0.151 W/m K and along the grain 0.346 W/m K [9], and wood char has a typical value of 0.052 W/m K [9] (sheet asbestos has a thermal conductivity of 0.17 W/m K [120]). Further evidence to indicate the lack of a conduction heat transfer mechanism was that the initial charring of the particle took

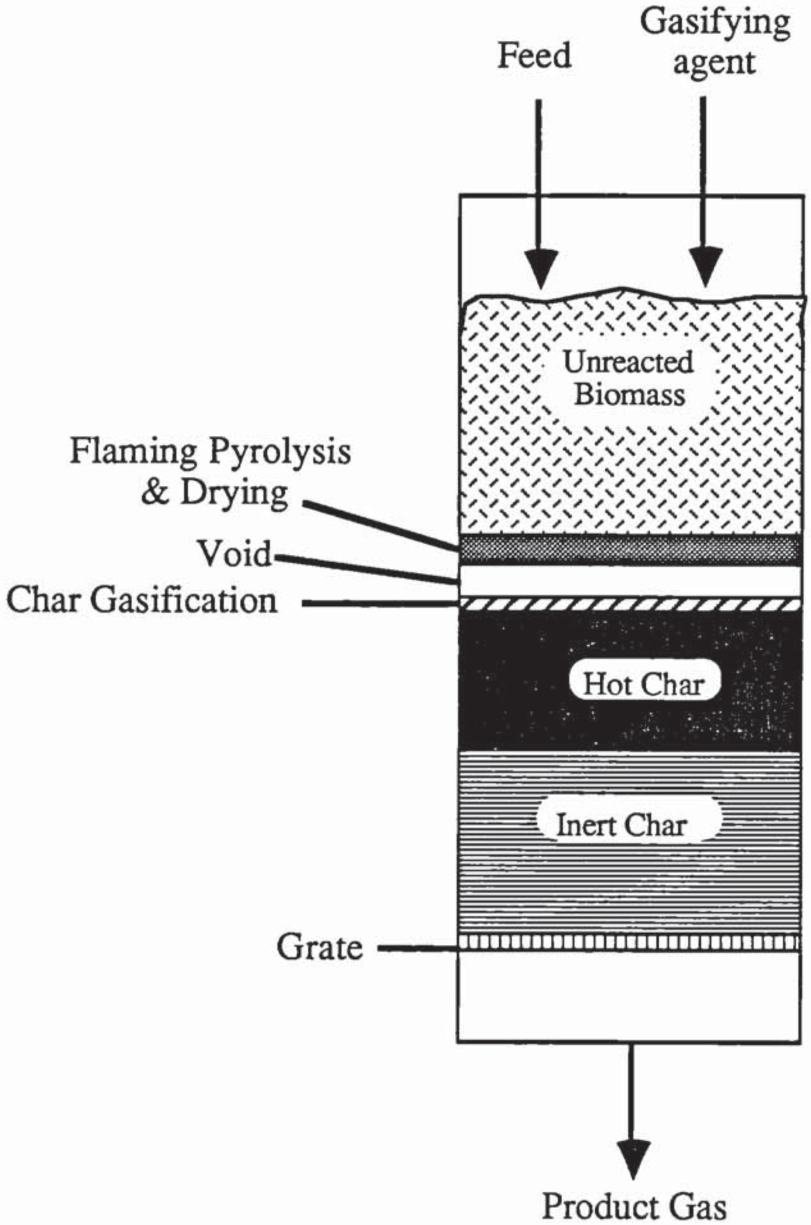


Figure 6.4 Zones in the Open-Core Gasifier

Figure 6.5 Flames in Reactor

place at bottom the particle which was not in contact with any other particles. The mechanism of propagation, therefore, must be radiation from the 'burning' fuel in the reaction zone.

The mechanisms of heat transfer within the reaction zone itself are more complicated. The pyrolysing particle is surrounded by burning gases which can transfer heat to the particle by both radiation and conduction. In addition to this, each particle is surrounded by other pyrolysing particles and there will be radiative heat transfer from the flames surrounding these particles and possibly conduction and convection from the flow of gases through the spaces between particles. A further mechanism of heat transfer may also be by radiation from the hot char below the reaction zone.

6.2.4 Reaction Stability

Further observations were made at unsteady state operation with the char bed growing, that is when the rate of pyrolysis exceeds the rate of char gasification. In this region, it was observed that the char gasification was incomplete leaving small particles of char remaining on top of the existing char bed. This explains the char build-up. This may be attributable to the reactor operating at too low an air factor for complete char gasification. Conversely the reactor could be operated with the char bed being consumed, that is with sufficient excess oxygen available to gasify the existing char bed. These phenomena are discussed further in Section 6.3.3.

6.3 QUANTITATIVE RESULTS

The data used in the quantitative analysis of the results comes mainly from runs R7 to R9. Run R10 could not be utilised as it had to be terminated early due to the reactor cracking (see Chapter 5). Data was also used from the commissioning runs, notably run C6, although these commissioning runs had only manual recording of the gas flowrate and only limited measurement of the height of char bed. They were, however, the only runs performed using feed A.

6.3.1. Feed Materials

One of the aims of the project was to assess the effect of the feed type on the gasifier performance. A qualitative assessment of the feed's flow properties through the reactor has already been presented in Section 6.2.1. However, it was also desired to assess the effect of the materials used on the product gas composition and reactor throughput.

6.3.1.1. Data Selection

To provide a basis for comparison, it was decided to compare data obtained for the materials at steady state conditions. For this case, steady state was taken to be a constant reaction zone position, that is height of char bed, and constant product gas flowrate. The different modes of operation for an open-core reactor will be discussed later in Section 6.3.3. The periods of stable operation identified are shown in Table 6.1 and illustrated in Figures 6.6 to 6.9, the shaded areas

Table 6.1 Periods of Stable Operation Identified.

Run	Feed	Time (secs)
C6	A	1335 - 1610
R7	B	3622 - 4075
R7	D	5456 - 5941
R8	B	2271 - 3384
R9	B	1410 - 2307
R9	D	4022 - 4769

illustrating the stable periods identified. Although other periods of stable operation defined on the above basis were identified, there was insufficient wood throughput data for detailed analysis of the process at these times.

6.3.1.2 Data Treatment

The data collected over each of these periods was then averaged. The averaged gas flowrate data was then converted to Nm^3/hr by using Equations 3.2 and 3.3 (see Chapter 3). The gas heating value was calculated, using the IGU equation [120] (see below) based on the average gas composition. This was modified to include a conversion factor to calculate the heating value at NTP (0 °C and 101.325 kN/m^2,

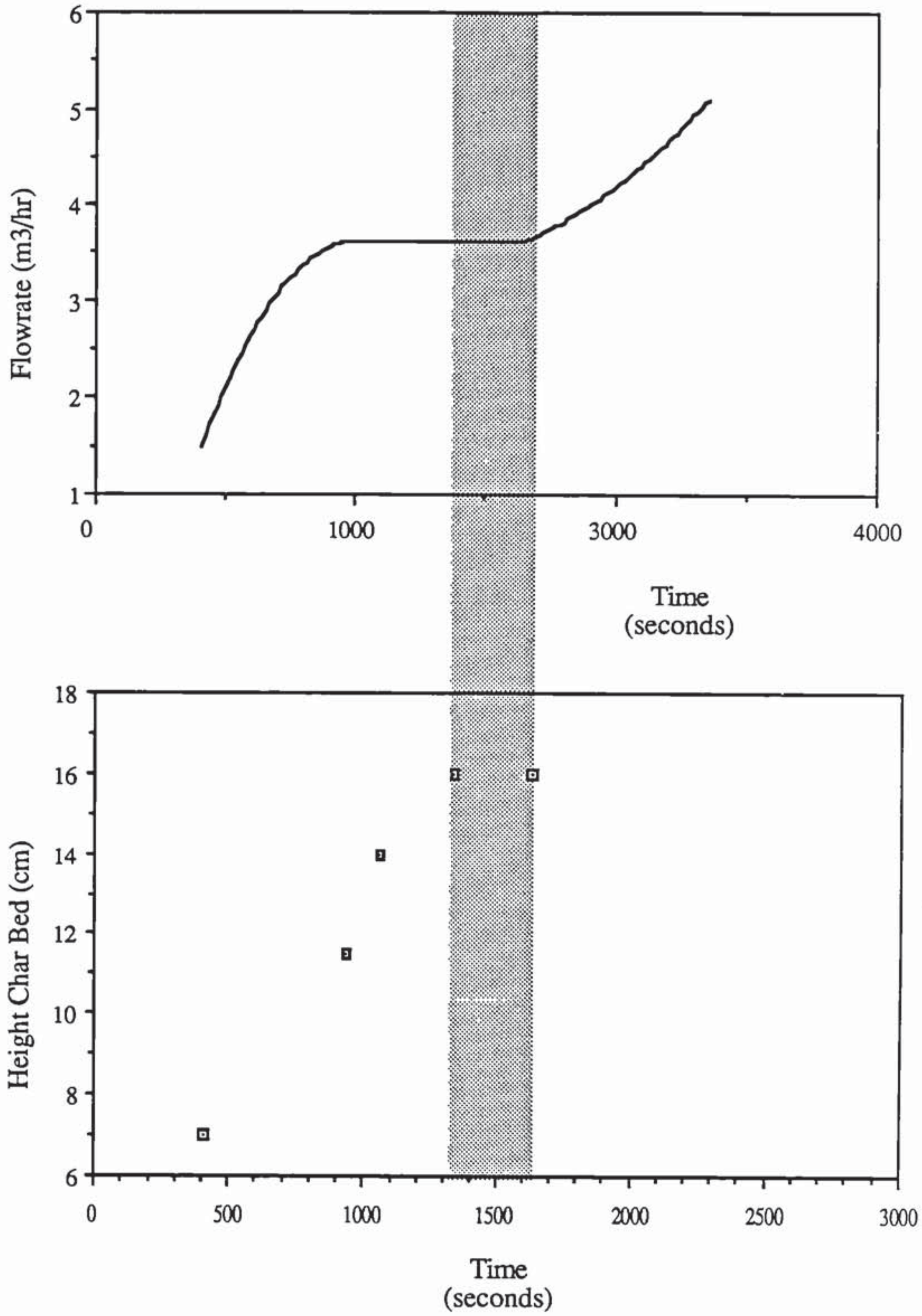


Figure 6.6 Stable Operation Run C6

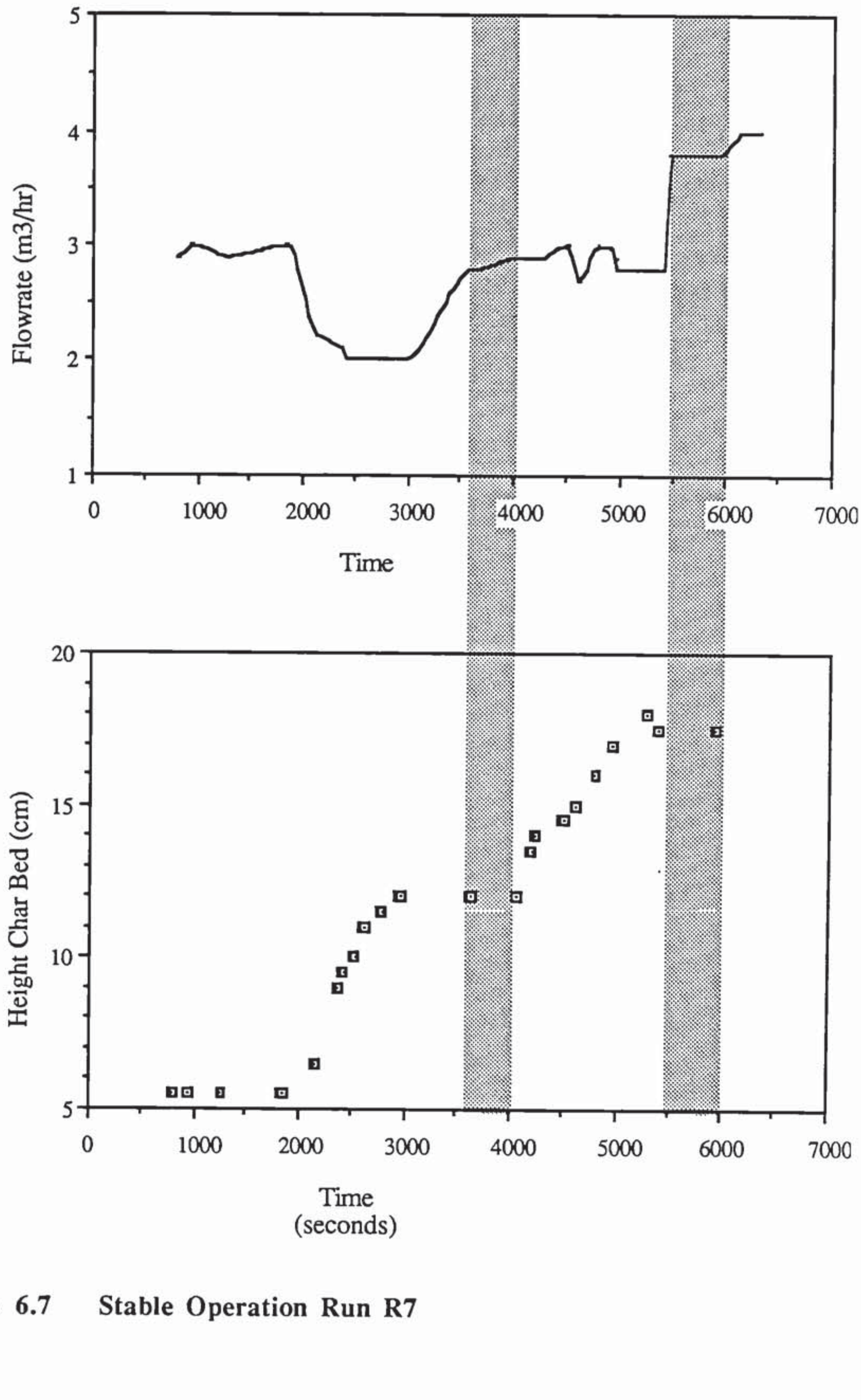


Figure 6.7 Stable Operation Run R7

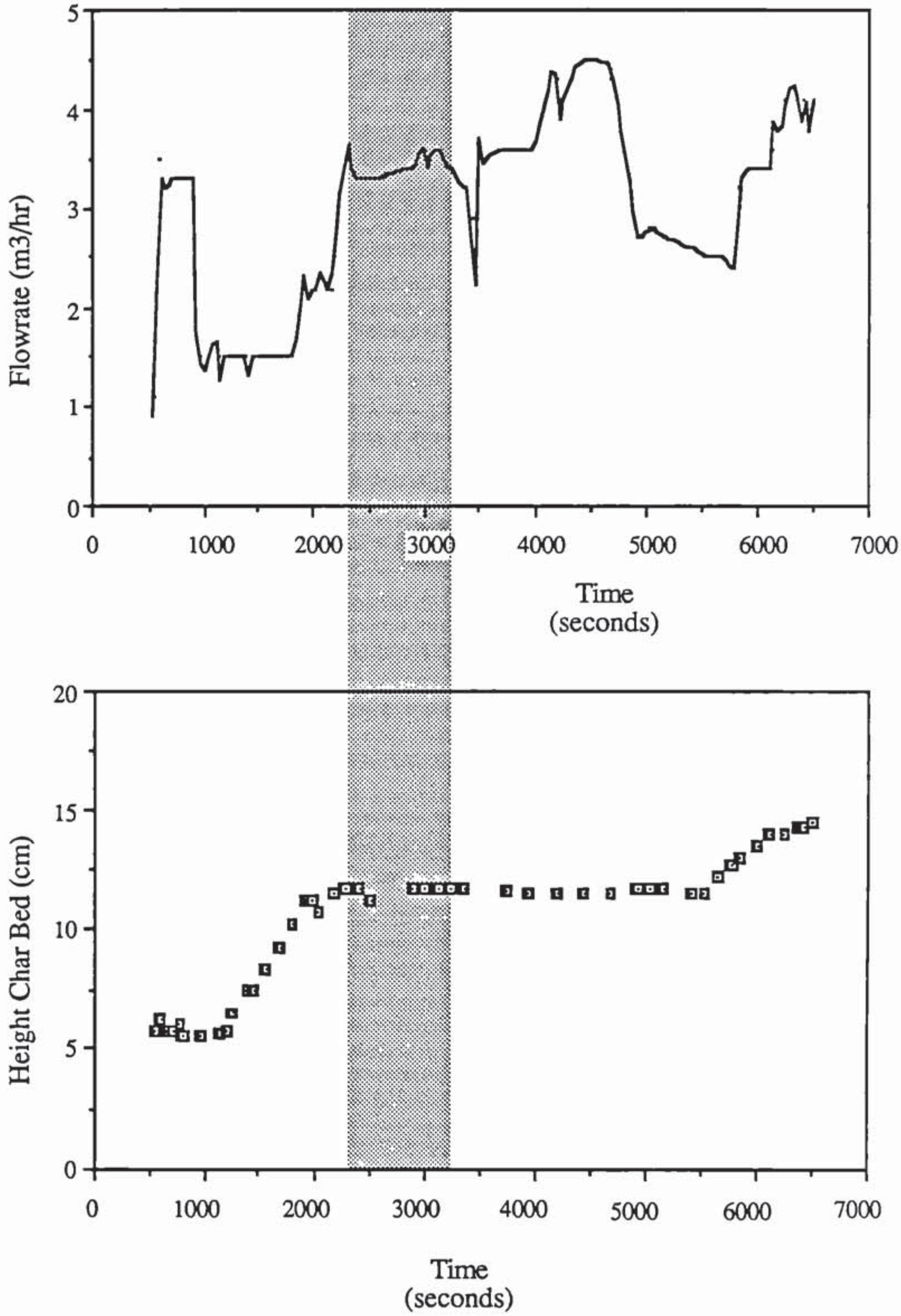


Figure 6.8 Stable Operation Run R8

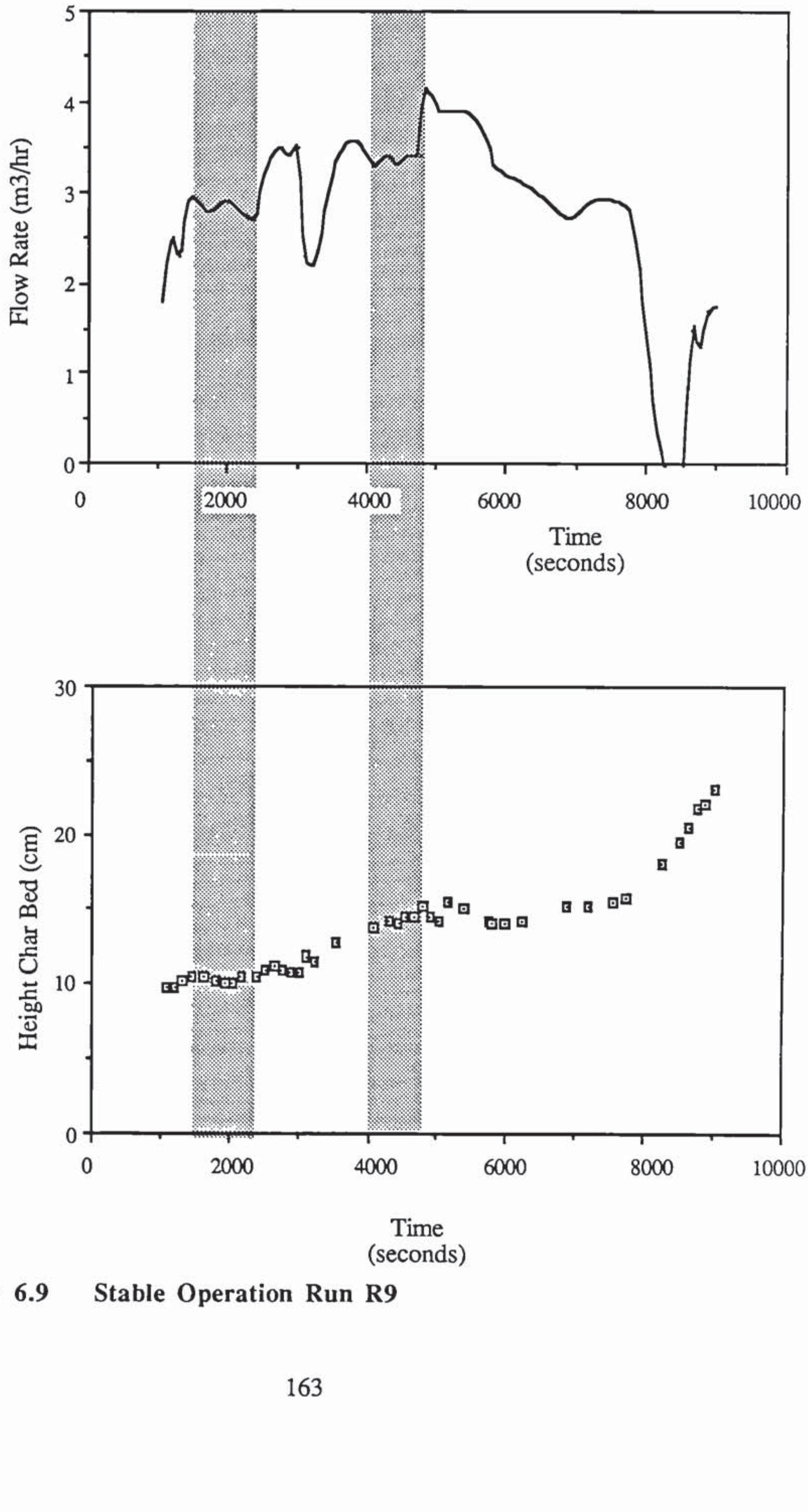


Figure 6.9 Stable Operation Run R9

Equation 6.1 : $HHV = 1.055 * \left[12.1\, M_{H_2} + 11.97\, M_{CO} + 37.69\, M_{CH_4}\right]$
Where M_X is the mole fraction of component X.

The reactor efficiency, to cold clean gas, was calculated thus:

$$\text{Equation 6.2} : \eta = \frac{\text{Dry Gas Flowrate } (Nm^3/hr) * \text{Gas Heating Value } (MJ/Nm^3)}{\text{Feed Rate (daf kg/hr)} * \text{Feed Heating Value (MJ/ daf kg)}}$$

The time of addition of feed had been recorded and the feedrate was calculated from this and averaged for the period under analysis. The feedrate data was felt to be the least accurate of the data collected with as much as a 15 % variation in the measurements which could be attributed to the unavoidable occurrence of voids (see Chapter 5). The feedrate was then converted to a dry, ash free basis using the proximate analyses in Table 4.2 and the feed moisture content as measured prior to each run.

6.3.1.3. Results and Discussion

The results of the study of the various feed materials are presented in Table 6.2. It can be seen from this table that no steady state operation was identified for feed C. When this material was added to the reactor, the bed pressure drop began to rise and approached 13 kN/m^2 (~ 100 mmHg). This reactor pressure drop in conjunction with the scrubber pressure drop greatly reduced the gas sample flowrate and also created difficulties with the gas pump. In order to minimise these difficulties, no more of feed C was added to the reactor and the gas pump was reduced to minimum flow. Therefore, as a result, no suitable data was collected. This increased bed pressure drop could have been attributed to the build-up of ash, from the gasified feed, in the char bed. However, as feed C was 'burned-out', the reactor pressure drop decreased, which would indicate that the elevated pressure drop was due to the small particle size. It can, therefore, be concluded that feed C, nominal size 2.8 to 4.75 mm, is at or below the lower particle size limited for gasifi. · operation.

It can be seen that there is very close agreement for the data collected for feed B from both runs R8 and R9. However, the data collected for the same feed from run

Table 6.2 Performance Data for Various Feeds

Run	C6	R7	R7	R8	R9	R9
Feed Material	A	B	D	B	B	D
Time of stable operation (mins)	4.6	7.6	8.1	18.6	15.0	12.5
Height of char bed (cm)	16.0	12.0	17.5	11.75	10.0	14.0
<u>Inputs</u>						
Wood:						
Feedrate (kg/hr)	1.41	1.21	1.58	1.64	1.38	1.78
Feedrate (daf kg/hr)	1.27	1.07	1.36	1.42	1.22	1.54
Specific capacity (daf kg/m^2hr)	287.5	237.9	307.4	321.6	275.7	348.1
Air:						
Flowrate (Nm^3/hr)	2.97	2.91	3.89	2.56	2.25	2.84
Air/fuel ratio (kg/daf kg)	3.01	3.50	3.68	2.32	2.37	2.37
Air factor (%)	49.4	57.9	60.5	38.4	39.0	39.2
<u>Outputs</u>						
Gas Composition (Vol % dry basis)						
H_2	8.8	7.1	7.6	15.6	15.1	12.3
CO	15.1	10.5	11.1	18.7	18.6	15.7
CO_2	13.0	7.2	6.4	11.4	11.7	10.2
CH_4	1.2	0.9	0.8	1.5	1.5	1.4
N_2	61.9	74.3	74.1	52.9	53.1	60.4
HHV (MJ/Nm^3)	3.51	2.57	2.69	4.94	4.87	4.11
Flowrate (Nm^3/hr)	3.79	3.09	4.15	3.82	3.36	3.71
Yield (Nm^3/daf kg)	2.99	2.94	3.05	2.69	2.76	2.41
Yield (kg/daf kg)	3.69	3.34	3.67	3.08	3.17	2.83
η - efficiency (% to cold clean gas)	53.7	38.4	44.3	68.5	69.2	53.5

R7 is very different, being particularly high in nitrogen. It is believed that this high nitrogen level was due to an air leak into the gas sampling system. It was observed that in run R9, the nitrogen level in the gas analysis increased nearly linearly with the reactor bed pressure drop. To allow for valid comparisons between the various sets of data, those where a possible sample system air leak was identified have been 'normalised' to a nitrogen level of 53 %, to be of a comparable value for feed B in runs R8 and R9, and these data are shown in Table 6.3. A further observation made during run R7 was that the hydrogen analyser was producing a very unstable signal, with consecutive readings varying by as much as ± 40 % of each other. The other analysers' signal stability were as normal.

However, even when normalised, there is still a significant variation between similar feed materials and, therefore, no valid conclusions can be drawn. It was anticipated that no great difference would occur in the product gas compositions, as all the feed materials used were of similar moisture content, one of the major influences on gas composition, consisted of wood and, therefore, had similar chemical compositions,.

The problem of air leakage into the sample system, in conjunction with the problems encountered with the poor gas cleaning capability of the system during the commissioning runs (see Chapters 3 and 5), show that an in-house sample cleaning system must be designed and built to replace the existing system. However, insufficient time was available within the confines of this project to develop such a system. Suggestions are included in the recommendations.

It was anticipated that the effect of varying size, shape and bulk density would be to change the biomass throughput of the gasifier. Altering the shape of the individual particles would change their volume/surface area ratios and would consequently change the individual particles reaction times. The change in reaction times would vary according to the heat penetration time and the area available for the gas-solid reactions, both dependent on the particle geometry (see Section 6.4.1). However, the actual gasifier throughput would also be dependent on the the bulk density of the fuel. As discussed previously, only limited accuracy could be obtained in the measurement of the gasifier throughput. The throughputs calculated for the feed materials (see Table 6.2) when averaged for each feed material, are within the accuracy of the wood rate measurement. It is therefore concluded that in order to

Table 6.3 Normalised Data for Runs C6 and R7

Run	C6	R7	R7
Feed Material	A	B	D
Inputs:			
Air:			
Flowrate(Nm^3/hr)	2.54	2.08	2.78
Air/fuel ratio (kg/daf kg)	2.57	2.50	2.63
Air factor (%)	42.3	41.3	43.3
Outputs			
Gas Composition (Vol % dry basis)			
H_2	10.9	13.0	13.8
CO	18.6	19.2	20.1
CO_2	16.0	13.2	11.6
CH_4	1.5	1.6	1.5
N_2	53.0	53.0	53.0
HHV (MJ/Nm^3)	4.34	4.72	4.90
η - efficiency (% to cold clean gas)	66.4	70.5	80.7

quantify the influence of parameters, a more accurate solids metering system is required and this will be discussed in Chapter 8.

6.3.2. Effect of Height of Char Bed

As discussed previously in Chapter 5, one of the areas to be investigated was the influence of the height of the char bed on gasifier performance.

6.3.2.1. Data Collection and Treatment

The height of the char bed was recorded manually. The frequency of this measurement was, therefore, less frequent than the data collected using the data-logging system, that is the gas analysis, temperature, product gas flowrate and pressure data. The height of the char bed was, therefore, related to the two sets of gas composition readings 'bracketing' the time at which the height of the char bed was measured. Data on the height of the char bed was monitored over the runs R7 to R10 at a frequency of approximately once a minute. The height of char bed was also monitored to a limited extent during the commissioning runs, runs C1 to C6. However, run R10 was very short in duration and, therefore, only limited data was collected. The data collected during runs R7 and R9 was discounted as unsuitable, due to the leakage of air into the analysis system (see Section 6.3.1.3). As can be seen from Figure 6.9 above, run R9 was operated with a char bed of near uniform depth which only grew significantly in the latter stages of the run, when feed C was added.

Therefore, only the data from runs R8 and C6 was utilised, even though this was under conditions of an increasing depth of char bed. The height data collected for run R8 was for both sides of the reactor and therefore to simplify analysis, this was averaged.

6.3.2.2 Results and Discussion

The results of gas composition and heating value against height of char bed for both runs C6 and R7 are presented in Figures 6.10 to 6.13. All these data were collected under conditions where the height of the char bed was increasing, that is when pyrolysis is dominating.

These data indicate that increasing the height of char bed under these conditions, where pyrolysis is dominating, has a minimal effect on the gas quality. Although it can be seen that the levels of H_2 and CO increase, the CO_2 level decreases and the level of CH_4 remains constant. This would suggest that increased char reduction is occurring, with CO being produced by the Boudouard reaction and H_2 by the water gas reaction. However, the measurement was taken during a regime where pyrolysis is dominating and the height of the char bed is increasing, which would in fact suggest that incomplete char gasification is occurring. This would suggest that the levels of CO and H_2 would diminish and so therefore the improving gas quality might be attributable to some other factor.

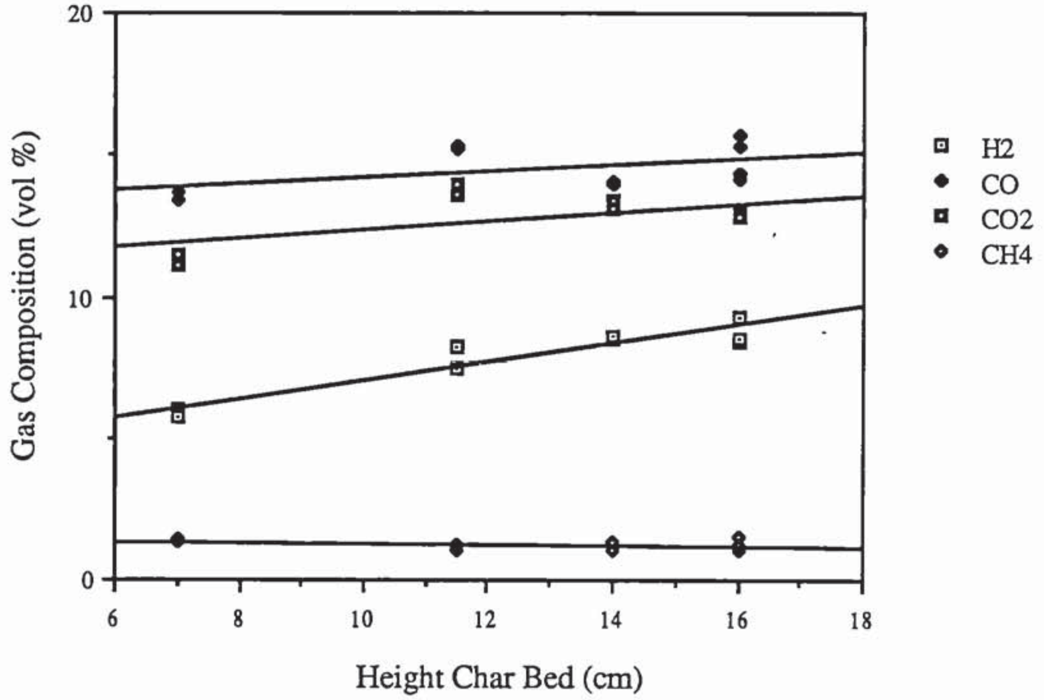


Figure 6.10 Gas Composition v Height of Char Bed for Run C6

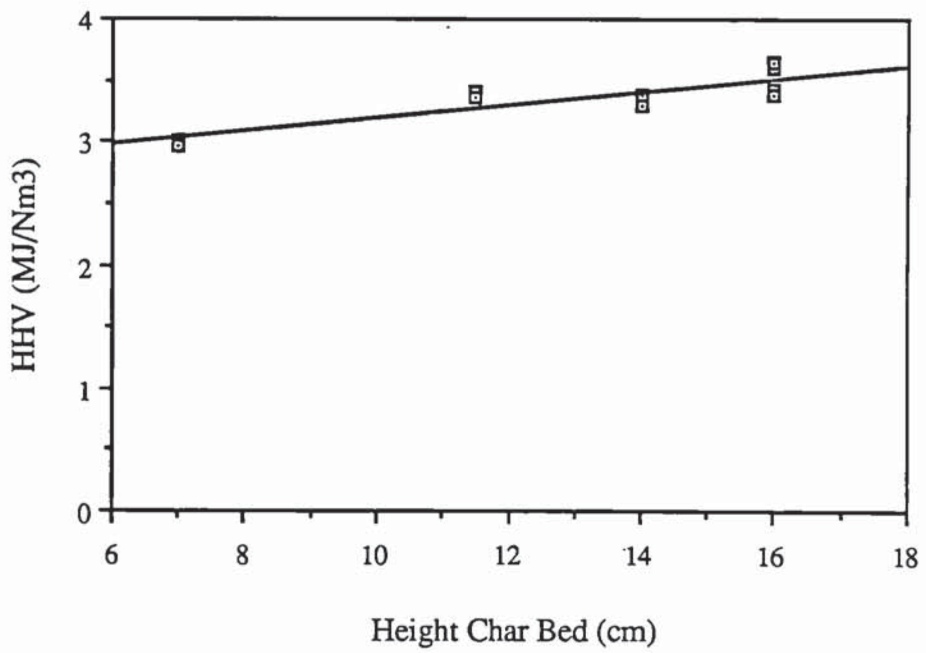


Figure 6.11 Gas HHV v Height of Char Bed for Run C6

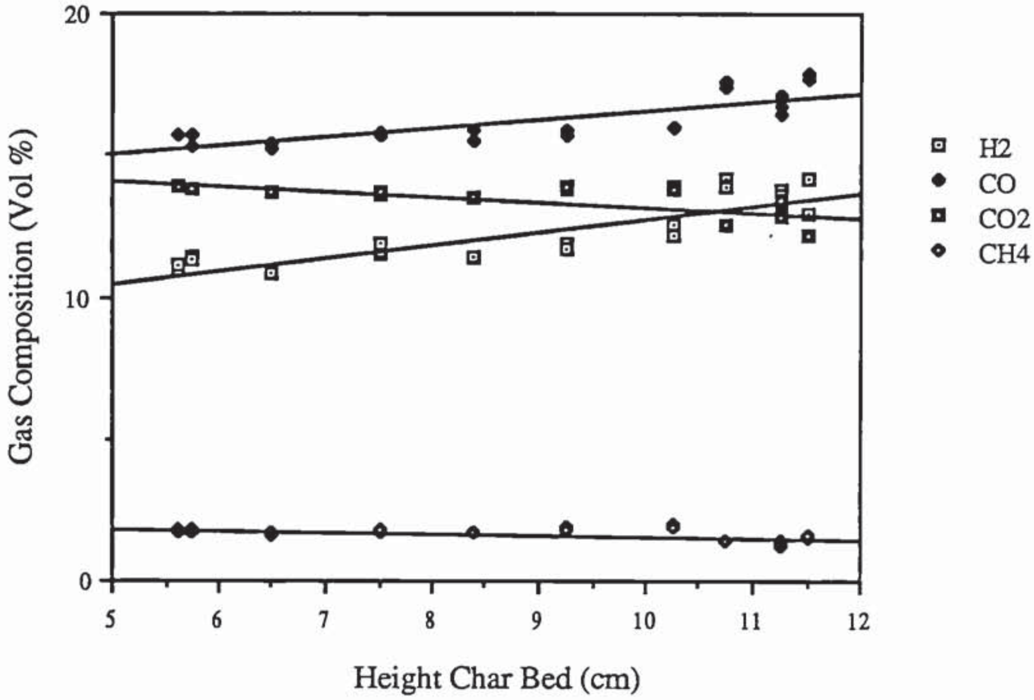


Figure 6.12 Gas Composition v Height of Char Bed for Run R8

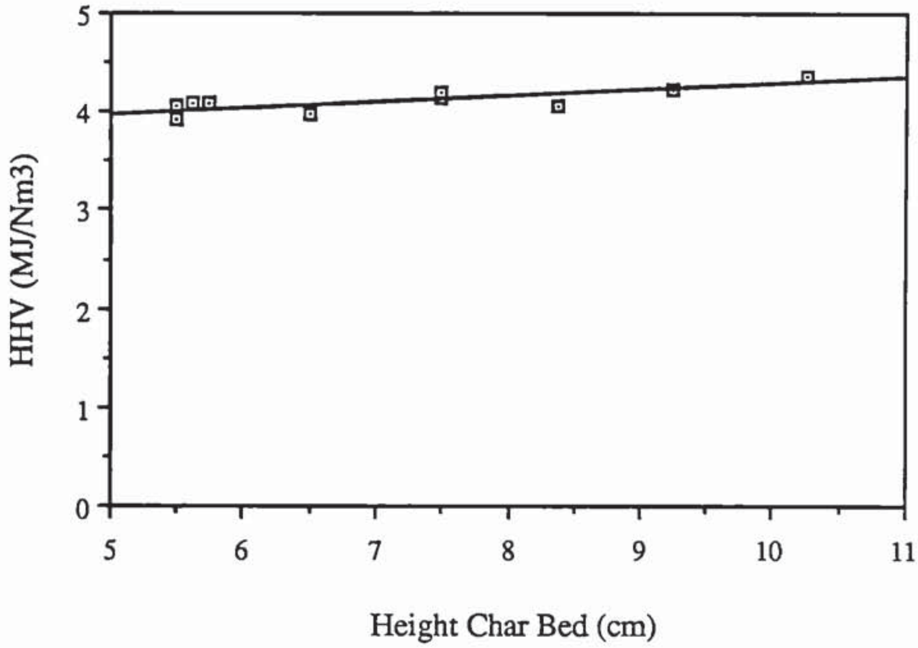


Figure 6.13 Gas HHV v Height of Char Bed for Run R8

A further explanation might be that as the height of the char bed increases, the degree of tar cracking increases. In order for the tar to be cracked, the char must be at a reported 850 °C [21]. Measurements of the char temperature indicate that the char is only at or above this temperature in the near vicinity of the reaction zone. A typical vertical reactor temperature distribution is presented in Figure 6.14, this distribution being measured at the centre of the reactor. However, the tar monitoring performed was on a once only batch system for each run [97] and, therefore, any transient changes in the degree of tar cracking performed could not be monitored. The decrease in the methane levels in the product gas as the depth of char increases may indicate that more cracking of the pyrolysis products is occurring.

The heat loss from the reactor, due to it being uninsulated, is significant, an estimated 10.0 to 15.0 % of heating value of the feed input [97]. This estimation compares with predictions from Double's model (see Section 6.4). The major mechanism of heat loss is by radiation from the reactor wall. Although the major heat loss is from the reaction zone, the overall heat loss will also increase with the height of the char bed, as this increases the 'hot area' of the reactor and the area from which heat can be lost. Figure 6.15 shows the gas exit temperature against the height of char bed at constant gas flowrate. It can be seen from this curve that the gas temperature decreases rapidly with increasing height of char, dropping to below 850 °C within approximately 2 cm of the reaction zone. This may be attributable to either endothermic reaction or reactor heat loss. However, Reed's experience (see Chapter 2), would suggest that no char reduction could occur at temperatures of less than 850 °C and so the gas cooling occurring can be attributed mainly to heat loss and therefore it can be concluded that tar cracking will only occur in a narrow band of char (approximately 2 cm thick) directly below the reaction zone.

The char may also remove tar from the product gas by another mechanism. The char is of a nature similar to activated carbon and therefore tar may be removed from the gas by physical absorption.

All the data collected relating to the effect of the height of the char bed on the gas quality has been for char beds of a depth of 5 cm or more. However, it is possible to operate the gasifier with shallower char beds than this and even with the reaction

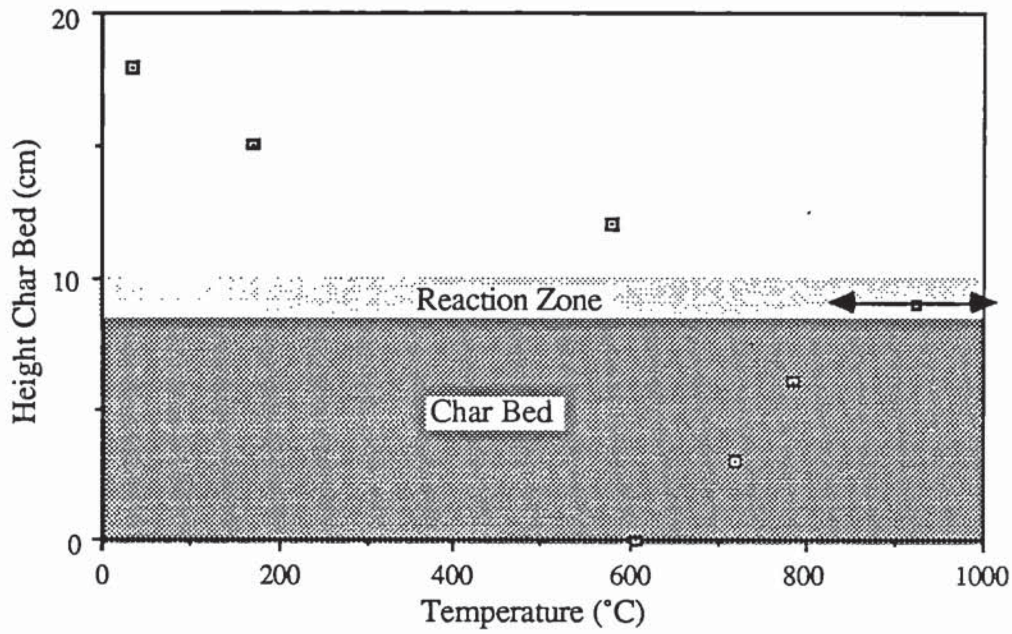


Figure 6.14 Reactor Vertical Temperature Distribution from Run C3

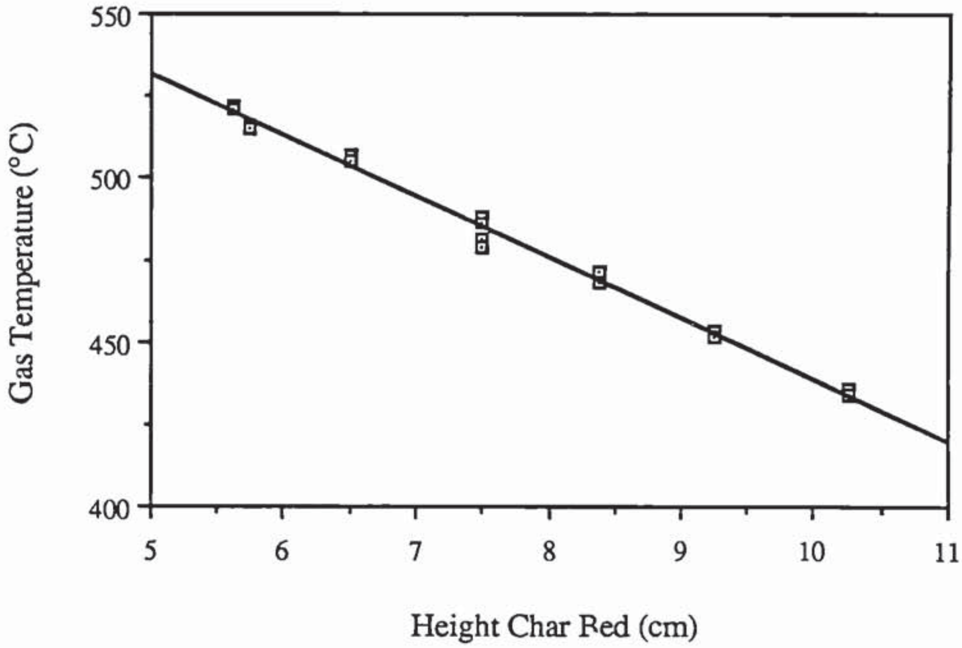


Figure 6.15 Gasifier Gas Exit Temperature v Height of Char Bed

zone on the grate (see Figure 6.16), although this latter mode of operation has only been maintained for very short periods. Operation of the gasifier with the reaction stabilised at the grate will be discussed in more detail in Section 6.6. Therefore, in order to assess the effect of char bed heights of less than 5 cm, simple linear extrapolations of the data presented in Figures 6.10 to 6.13 were performed. These extrapolations are presented in Figures 6.17 to 6.20.

These extrapolations indicate that if the depth of char is decreased to zero and the gasifier is operated in a 'grate stabilised' mode then the gas leaking value will drop to approximately 85 % of the gas produced with a 10.0 cm deep char bed. However, it is believed that these extrapolations are not truly indicative of the real situation. The bed of char improves gas quality by both cracking and absorbing tars and therefore operation without a char bed would have a disproportionately detrimental effect on gas quality, as no tar cracking other than that afforded in the reaction zone would occur.

Evidence of other workers [21] suggests that tar cracking in the char will only occur at char temperatures in excess of 850 °C. Temperatures of this order have been measured to only a limited depth (in the region of 2 cm) before the reaction zone. It is therefore concluded that there would be a noticeable drop in gas quality, particularly in terms of tar loadings, with a char bed of a depth less than 2 cm. These findings must, however, be experimentally verified (see Chapter 8).

The reactor bed temperature distribution presented in Figure 6.14 raises a number of points for discussion. The high temperatures above the reaction zone are likely to be attributable to back conduction through the thermocouple array. The reaction zone temperature is 'arrowed' to indicate the variation that occurred in the temperature measurement in this region. This variation may be attributable to the thermocouples in the reaction zone monitoring either the surface temperature of a pyrolysing particle or the burning volatiles. A further problem associated with the in–bed temperature measurement was its detrimental effect on solids' flow though the reactor and reactor zone stability (see Section 6.2.1).

Figure 6.16 Grate Operation

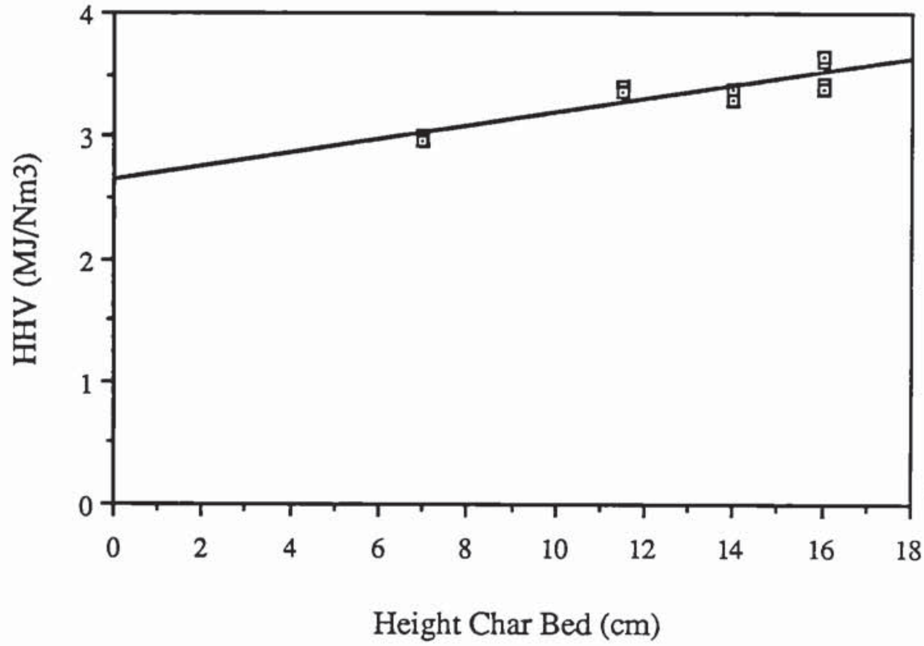


Figure 6.17 Extrapolated Gas HHV v Height of Char Bed (Run C6)

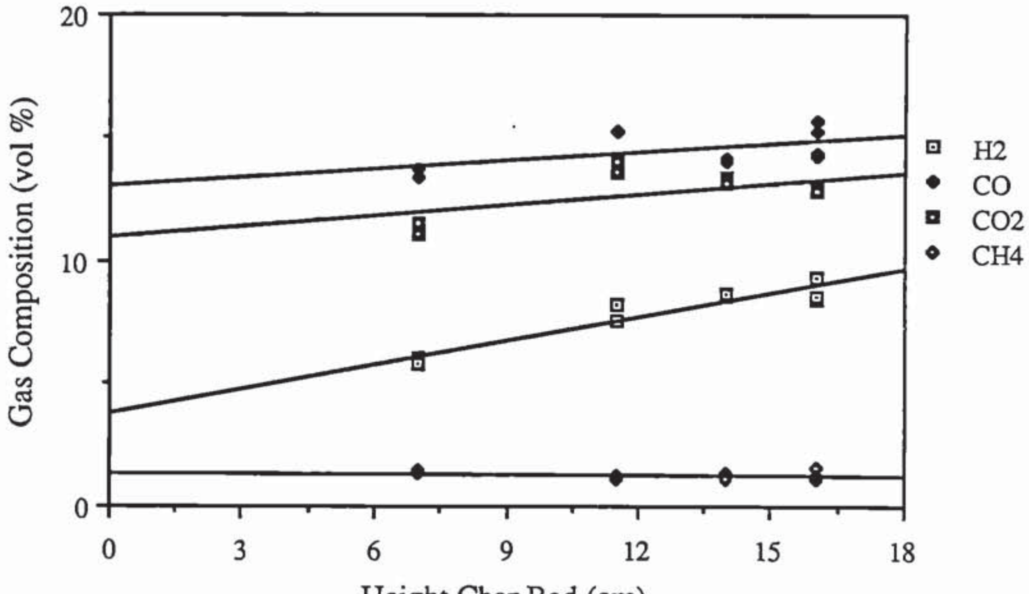


Figure 6.18 Extrapolated Composition v Height of Char Bed (C6)

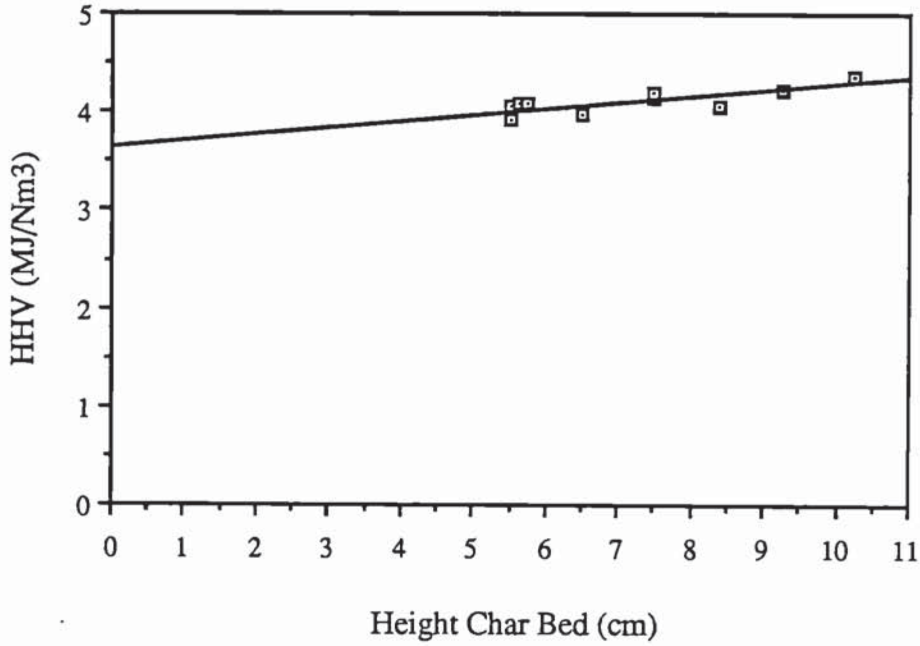


Figure 6.19 Extrapolated Gas HHV v Height of Char Bed (R8)

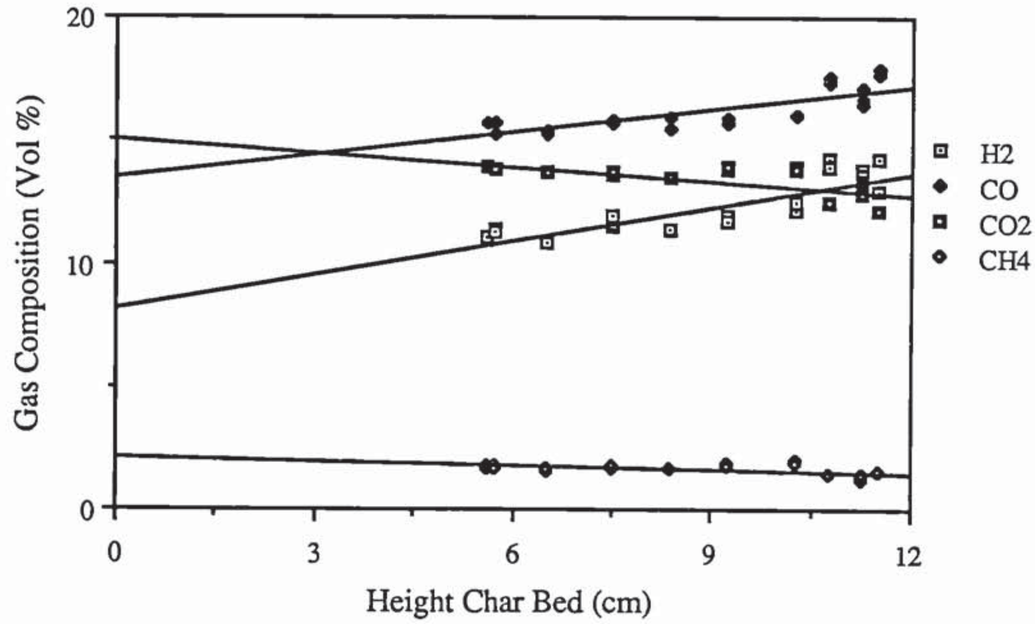


Figure 6.20 Extrapolated Composition v Height of Char Bed (R8)

6.3.3 Reaction Zone Stability

An open-core downdraft gasifier can be operated in three regimes, these are illustrated in Figure 6.21:

- increasing depth of char - the rate of char production by pyrolysis exceeds the rate of char gasification resulting in net char production and an increasing depth of char bed, region A in Figure 6.21.

- constant depth of char - the rate of char production by pyrolysis is equal to the rate of char gasification so there is no production or consumption of char This results in a constant depth of char, region B in Figure 6.21.

- decreasing depth of char - the rate of char consumption by gasification exceeds the rate of char production by pyrolysis. This results in a net char consumption and hence a decreasing depth of char, region C in Figure 6.21.

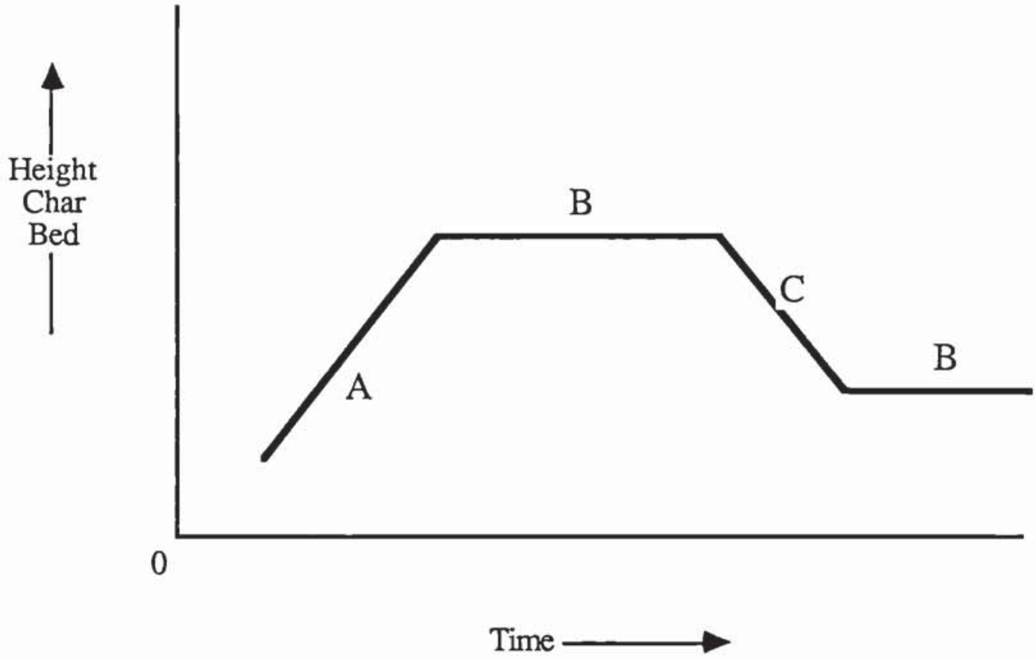


Figure 6.21 Height of Char Bed Against Time for Various Modes of Operation

The Aston system has been operated in all three of these regimes, although most data has been collected for regimes A and B.

6.3.3.1 Data Treatment

In order to compare the performance of the gasifier under conditions of pyrolysis dominating and stable operation, data from run R8 was used as this run had prolonged operation in both modes. The raw data treatment was the same as that for the comparison of the different feed materials (see Section 6.3.1).

The carbon conversion efficiency is calculated thus:

$$\text{Equation 6.3}: \eta = \frac{\text{Weight of Carbon in Product Gas}}{\text{Weight of Carbon in Feed}}$$

6.3.3.2 Results and Discussion

The results of the study are presented in Table 6.4. It can be seen from Table 6.4 that decreasing the inlet air flowrate not only destabilises the reaction zone causing the char bed to increase in depth, but as can be seen from the specific capacity, decreases the reactor throughput. This would suggest that both the rates of pyrolysis and gasification have been reduced as the rate at which the biomass is being converted has decreased. However, as there is a net deposition of char it would also suggest that the rate of char gasification has been reduced to a greater extent.

In order to operate in region A, the gas flowrate, and hence the input air rate to the reactor, was reduced. This would indicate that the air factor (see Equation 6.4) has been reduced and this is supported by theory. The thermochemical processing of biomass covers a spectrum of different processes, the type of process being characterised by the air factor from dry distillation with an air factor of zero, via gasification with an air factor of between 0.2 to 0.5, to combustion with an air factor in excess of one. When the depth of char is increasing, the pyrolysis process is dominating and the rate of char deposition is greater than the rate of char gasification. It would, therefore, be expected that the reactor would operate at a lower air factor.

Table 6.4 Comparison of Performance of the Open-core Gasifier in Stable and Pyrolysis Dominating Modes

	Steady State	Climbing Bed
Time (seconds)	2271 to 3384	1136 to 1805
Gas Composition (vol %)		
H_2	15.6	11.1
CO	18.7	15.8
CO_2	11.4	13.4
CH_4	1.5	1.8
N_2	52.9	57.9
HHV (MJ/Nm^3)	4.94	4.12
Feedrate (daf kg/hr)	1.42	0.73
Gas Yield	2.69	2.67
Air Factor	38.4	41.9
Efficiency - η (cold clean gas %)	68.5	56.7
Carbon conversion η (to gas %)	91.0	84.0
Rate of increase of depth of char (cm/min)	0.0	0.295
Air in (Nm^3/hr)	2.56	1.84
Air fuel ratio (kg/daf kg)	2.32	2.53

$$\text{Equation 6.4 : Air Factor} = \frac{\text{Actual Fuel Oxidant Ratio}}{\text{Stoichiometric Oxidant Fuel Ratio}}$$

However, the data presented in Table 6.4 indicates that in fact the gasifier is operating at a higher air requirement in this region. This may be explained by considering the relative heat losses from the reactor in the two modes of operation detailed. As discussed previously, the reactor heat loss is in the region of for stable operation (ie region B) 10.0 - 15.0 % of the feed input energy and will vary with the height of char bed. However, the major component of the heat loss is by radiation from the 'glowing' reaction zone. There was not an observable difference in the size of this zone between stable operation and a climbing char bed and, therefore, it is fair to assume that the absolute heat loss from this zone is of the same order.

In the region of climbing char, the biomass throughput, and hence energy input to the reactor, has been reduced. At similar absolute heat losses, this entails that the fractional heat loss from the reactor is, therefore, greater in the unstable operation. Futhermore, less of the energy available in the feed is 'released' due to reduced carbon conversion in the unstable operation. Double's model (see Section 6.4) indicates that for the air factors measured, the heat loss from the reactor in stable operation is approximately 10.0 % of the fuel input energy, whereas for the climbing char bed it is 15.0 %.

Further evidence for the higher heat loss may be provided by considering the gas composition. Working at a higher reactor heat loss increases the system air requirement, and subsequently the CO_2 and H_2O, relative to H_2 and CO, and also lowers the reactor efficiency (to cold clean gas). It can be seen from Table 6.4 that at stable operation, the gasifier is operating at higher H_2 and CO levels, a lower CO_2 level and a higher efficiency which, therefore, indicates that it is working at a lower fractional heat loss. It is, therefore, fair to assume that in a period of operation when pyrolysis is dominating, the air factor is reduced relative to that at stable operation, but this change is masked by differences in the reactor heat loss.

6.4 COMPARISON WITH MODELS

As discussed in Chapter 2, Reed et al. at SERI have developed several models of the open-core downdraft gasifier of which one is a 'quantitative' model designed to predict the length of the zones within the reactor. They did not, however, present any comparisons in the performance of this model and it was, therefore, decided to compare its performance against data collected from the Aston system.

An alternative approach has been developed by Double [82] has developed a number of models of gasifier systems including a 'black box' carbon boundary model. This model simulates the performance of an ideal gasifier and was used to measure the performance of the Aston gasifier.

6.4.1 The SERI Model

The predicted length of the flaming pyrolysis and char gasification zones are obtained by first calculating the reaction time for each zone and then calculating the length of the zones from this time and the bulk solid flowrate. The time for flaming pyrolysis is calculated by dividing the energy required for the biomass pyrolysis by the rate at which it is supplied. The time for char gasification is taken to be 100 seconds. The model is described in greater detail in Chapter 2.

Data on individual particle reaction times were taken during run R9. These measurements were made from the instant the initial charring began up to the time when the particle was completely gasified. The total reaction time was taken, as it was difficult to accurately assess at what point pyrolysis finished and gasification began. The times were taken using a stopwatch and data was collected for feeds B and D.

Table 6.5 presents a comparison of the average measured total reaction times and those calculated from the SERI model.

Table 6.5 Comparison of Actual Reaction Times and Those Predicted from the SERI Model

Feed	Measured total reaction time (seconds)	SERI reaction time (seconds)		
		FP	CG	Total
B	36	38.7	100.0	138.7
D	65	79.0	100.0	179.0

Key : FP - Flaming pyrolysis; CG - Char Gasification.

The difference between the predicted total and measured reaction time is to be expected in view of the difference of the theory suggested by Reed et al [81], upon which the model is based, and the observations made on the Aston system (see Section 6.2.2). There does appear to be reasonable agreement between the predicted flaming pyrolysis time and the measured total reaction time, although this may be coincidental. However, this does indicate that the overall particle reaction time is dependent on a number of feed properties as suggested by Reed notably, particle surface area, particle volume, absolute density and moisture content. These controlling parameters would be anticipated from analysis of the process. The actual energy required for the pyrolysis of one particle will depend on the mass of the particle, which in turn will be a function of the density and volume of the particle, and increasing the moisture content of the feed will also add to the overall energy requirement for the process. The rate at which the energy can be supplied will be determined by a number of factors including the method of heat transfer and the area available for heat transfer, which will be determined by the particle shape and orientation to the reaction zone.

The time for char gasification will depend on the particle geometry and in particular the relationship between area and volume. A particle with a large surface area should react at a higher rate as there is a bigger area available for gas-solid contacting and hence reaction. However, the overall time for complete gasification will depend on the mass of char in the particle which will be a function of the particle volume and char density.

6.4.2 The Aston Carbon Boundary Model

This model is described in detail in the thesis of Double [82] and will not be repeated here. However, it can be summarised thus: for a given feed material, the carbon boundary air requirement is calculated, the carbon boundary temperature calculated based on heat and mass balances and the gases brought to equilibrium for that temperature. The model requires the input of the carbon, hydrogen, oxygen, ash and moisture content for the feed and the reactor heat loss. The gasifying agent requirement is calculated by the model, although its inlet temperature has to be specified.

The data selected on which to base the comparison, was that from run R8 at steady state operation (see Table 6.1 and Figure 6.8), which was selected as it was the longest period of steady operation obtained. The reactor heat loss was taken to be between 10.0 and 15.0 % of the fuel input [97]. The results obtained from the model and those from run R8 are presented in Table 6.6.

Table 6.6 Comparison of Aston Carbon Boundary Model Predictions with Actual Gasifier Performance

	Model			Actual Run R8
Reactor heat loss (%)	10.0	12.5	15.0	nm
Gas Compostion (vol % dry basis)				
H_2	18.94	18.02	17.13	15.6
CO	16.84	15.41	13.06	18.7
CO_2	14.35	15.07	15.75	11.4
CH_4	1.06	1.07	1.09	1.5
N_2	48.80	50.43	51.47	52.9
H_2O (dry basis)	7.05	7.33	7.61	nm
Calculated gas HHV (MJ/Nm3)	4.71	4.43	4.17	4.94
Efficiency - η (cold clean gas %)	67.7	65	62.4	68.5
Air requirement (kg/daf kg)	2.30	2.43	2.56	2.32
Gas yield (dry basis) (kg/daf kg)	3.27	3.58	3.50	3.08
Carbon conversion η (to gas %)	100	100	100	91
Equilibrium Temperature °C	629	620	611	515*

* - gas exit temperature
nm - not measured

At steady state, the gasifier should be operating at the carbon boundary so that there is no net production or consumption of char. The model at assumed 10.0 % heatloss appears to most accurately represent the real situation, predicting a near identical air factor. However, there are a number of differences between the ideal and real situations, notably in the gas yield and the balance of the gas composition.

These differences may be attributed to a number of factors. The model works at

100 % carbon conversion to gas with no tar being produced. In the real system, tar is produced, possibly as much as 3 % [97] (on the gas yield), reducing the overall gas yield and reducing the carbon available for conversion to gas. The actual carbon conversion efficiency is 91.0 %, the balance being in the tar. Further evidence to indicate that pyrolysis products are escaping the reactor uncracked is provided by the higher than predicted methane levels.

A further reason for the difference between the actual and predicted gas compositions may be due to the gas in the real system not attaining equilibrium. The gas in the model is brought to equilibrium, this being 629 °C for 10.0 % heat loss. However, the gas leaving the reactor is at an average of 515 °C for the period being recorded, which may not be high enough for the gas to attain equilibrium or may not be the equilibrium temperature for the gasifier, however, equilibrium may be attained at higher temperatures in the vicinity of the reaction zone. In order to assess the approach to equilibrium, it would be necessary to measure the product gas water level. However, this was not monitored.

However, if the tar levels and moisture content of the product gas can be accurately monitored, they may be included into the model to improve its accuracy. There is sufficient agreement between this model and the actual gasifier performance to use this model as a basis for detailed modelling studies of this gasifier system, possibly incorporating data to calculate the thickness of the reaction zone and thus the model may be used as a design tool.

6.5 COMPARATIVE PERFORMANCE

In order to compare the performance of the Aston system to other 'air-blown' open-core systems, performance data was collected from the literature. In addition to the data collected on open-core systems, data was also collected on throated reactors, so that performance comparisons could be made between the two types of reactor. It quickly became evident that no relationships (such as reactor throughput to gas heating value or tar levels) could be drawn between specific parameters and gasifier performance as the data presented in the literature was often insufficient for this aim. The data will, therefore, be utilised on a purely comparative basis. The data is presented in Table 6.7.

TABLE 6.7 Comparison of Results from Various Downdraft Gasifiers

Name	Aston	SERI[55]	Kansas State Univ.[76][77]	Twente Univ.[21]	UCD [89]	Twente Univ.[58]	Forintek [122]	UCD Kaupp [59]
Type	Open-core (Run R8)	Open-core	Open-core & air injection	Throated	Throated	Open-core	Throated	Open-core (batch)
Grate diameter (mm)	75	54	600	65#	89#	450	na	162.1
Specific capacity, grate (dry kg/m^2 h)	322	540	140-260	1000-2500#	3150-3800#	63-157	na	110-210
FEEDSTOCK								
Type	Wood chips	Wood chips	Wood chips	Wood chips	Woodchips	Rice husk	Wood chips	Rice hulls
Moisture content (% dry basis)	12.5	na	10	13	9.9	13-14.3	14.9	11.2-13.6
Size (mm)	4.75-6.35	10x10x3	0-12.7	na	0->25.4	-	12.7-25.4	-
OPERATION								
Pressure (bar)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max. temperature (C)	900-1100	na	1125-1450	~1327	na	700-1000	na	850-1050
OUTPUT (mol % dry and cold)								
H_2	15.6	na	16.1	17.4	15.9	na	17.5	6.3-11.3
CO	18.7	na	19.9	18.5	23.6	na	19.7	15.9-19.0
CO_2	11.4	na	14.4	12.0	11.4	na	12.7	12.7-14.3
CH_4	1.5	na	3.0	1.1	3.4¥	na	3.5	2.2-6.1¥
N_2	52.9¶	na	45.6§	51.0	45.7	na	42.7§*	54.3-57.3
HHV (MJ/Nm3)†	4.94	3.46-5.19	~6.0	5.0	5.73-6.15	4.37-4.77¤	[6.72]	4.5-5.5
Rate (Nm^3/m^2 hr)	860	1440	265-405	3000-6500#	7300-9120	72-252	na	180-480
Gas yield (Nm^3/dry kg)	2.69	2.68	1.55-2.2	2.98	2.0-2.4	1.5-2.0	na	1.78-2.44
Exit temperature (C)	450-750	na	na	na	400-600	na	na	-
Tar loading	~3.5 %	na	1380ppm	~0.25g/Nm^3	Very low	1-13 g/Nm^3	Very low	-

TABLE 6.7 Continued

Name	Reines[67]	Cruz[63]	Duvant[15]	Energy Equipment Engineering[123]				
Type	Open-core	Throated	Throated	Throated	Throated	Throated	Throated	Throated
Grate diameter (mm)	120	1070	na	na	na	na	na	na
Specific capacity, grate (dry kg/m^2 h)	209	278	450Ψ	18.4Ψ	32Ψ	26.7Ψ	24.9Ψ	32Ψ
FEEDSTOCK								
Type	Carrot Fibre	Coconut	Wood blocks	Sawdust+chips	DRDF	Oat chaff	Corn cobs	Wood chips
Moisture content (% dry basis)	0	na	max 25	8.0	10.0	15.0	8.0	10.0
Size (mm)	10x30x30	50-100	13x75x75	3.0	30	2.0	50	18
OPERATION								
Pressure (bar)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Maximum temperature (C)	700-1000	na	na	na	na	na	na	na
OUTPUT (mol % dry and cold)								
H_2	9.1	15.6	17.5	18.2	12.0	11.1	16.9	18.6
CO	12.7	15.9	15.5	17.6	15.9	24.3	16.5	17.1
CO_2	24.6¶	11.9	14.5	16.4	14.8	8.4	14.1	14.4
CH_4	1.8	0.0	2.0	3.1	2.4	1.1	2.0	2.3
N_2	49.1*	56.5*	50.5	44.2§	53.8§	54.9§	51.3§	47.6§
HHV (MJ/Nm3)†	3.33	3.47	4.65	5.02	4.02	4.77	3.99	4.33
Rate (Nm^3/m^2 hr)	316	na	na	na	na	na	na	na
Gas yield (Nm^3/dry kg)	1.51	na	na	na	na	na	na	na
Exit temperature (C)	~300	na	na	na	na	na	na	na
Tar loading	na	na	15 ppm	very low	very low	very low	very low	very low

TABLE 6.7 Continued

Name	Fritz Werner Industrie [15]	Imbert [15]	Pillard[15]	Syngas Inc [15]	Syngas Inc [73]	Vyncke [15] Warmtetech.	Univesity of Florida [124]
Type	Throated	Throated	Throated	Open -core	Open -core	Throated	Throated
Grate diameter (mm)	na	na	na	na	762	na	63.5
Specific capacity, grate (dry kg/m^2 h)	100Ψ	600Ψ	560Ψ	675Ψ	1450	20Ψ	1800-2200
FEEDSTOCK							
Type	Wood chips	na	Wood chips	Wood chips	Wood chips	Wood blocks	Wood chips
Moisture content (% dry basis)	20	25	max 30	max 30	11.1	33	5.3-13.6
Size (mm)	30-100	80	6-200	5-75	na	50	na
OPERATION							
Pressure (bar)	1.0	1.0	1.1	1.0	1.0	1.0	1.0
Maximum temperature (C)	900	na	na	1200	na	na	na
OUTPUT (mol % dry and cold)							
H_2	18.0	16.5	11.0	15.0	17.8	16.3	16.3
CO	23.0	20.5	19.0	20.0	21.2	20.8	20.8
CO_2	10.0	10.0	12.0	15.0	10.9	11.4	10.5
CH_4	2.0	1.5	2.5	3.0	2.9	1.5	1.9
N_2	47.0	50.5§	51.5	45.0	45.8§	49.5	49.0*§
HHV (MJ/Nm3)†	4.7	4.8	4.8	5.63	5.44	5.4	5.46
Rate (Nm^3/m^2 hr)	na	na	na	na	3054	na	na
Gas yield (Nm^3/dry kg)	2.1	na	na	na	2.62	na	na
Exit temperature (C)	na	400	na	750	700	na	na
Tar loading	na	na	na	2500ppm	na	na	na

TABLE 6.7 Continued

Name	Forintek [125]				UCD [126]		
Type	Throated	Throated	Throated	Throated	Throated	Throated	Throated
Grate diameter (mm)	na	na	na	na	177Ψ	177Ψ	177Ψ
Specific capacity, grate (dry kg/m2 h)	60.8Ψ	48.8Ψ	48.4Ψ	56.3Ψ	22.8Ψ	17.5Ψ	16.3Ψ
FEEDSTOCK							
Type	Wood chips	Wood chips	Wood chips	Wood chips	Solid waste cubes	20% sludge cubes	25% sludge cubes
Moisture content (% dry basis)	3.6	26.1	4.2	6.2	5.8	10.3	9.4
Size (mm)	12.7-25.4	12.7-25.4	12.7-25.4	4.8-12.7	na	na	na
OPERATION							
Pressure (bar)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Maximum temperature (C)	na	na	na	na	na	na	na
OUTPUT (mol % dry and cold)							
H2	16.9	9.0	20.0	12.9	12.5	14.5	13.7
CO	23.0	8.3	25.2	21.2	16.5	20.9	21.5
CO2	8.1	7.6	7.8	8.6	8.5	11.9	11.0
CH4	2.8	1.3	2.7	3.4	1.9	2.3	2.5
N2	44.1*§	64.7*§	40.9*§	47.7*§	58.1*§	50.0*§	50.9*§
HHV (MJ/Nm3)†	6.63	3.24	7.23	5.66	4.19¤	5.11¤	5.17¤
Rate (Nm3/m2 hr)	na	na	na	na	na	na	na
Gas yield (Nm3/dry kg)	na	na	na	na	1.75	2.86	2.99
Exit temperature (C)	na	na	na	na	214	198	181
Tar loading	2.0%	1.0%	1.0%	3%	1.6%¢	0.97%¢	1.4%¢

Key
#: Measured at throat
na: Not available.
Ψ: Capacity kg/hr
¶: Calculated by difference
*: Balance O_2
¢: total condensate
†: Calculated from gas composition
¥: total hydrocarbon
§: Balance C_{2+}
¤: LHV

6.5.1 Open-Core Systems

The open-core reactor is a recently developed geometry and is not widely utilised and, therefore, only limited performance data is available in the literature. However, data was collected for a number of different reactors which covered a number of different feed materials and variations in reactor design and operation.

Of the systems so far developed and reported in the literature, the most directly comparable reactor with the Aston system is the SERI quartz reactor. However, only limited data was available on this system, as it has been used mainly as a tool to investigate reaction zone stability (see Chapter 2). It can be seen that the SERI system operates at a higher specific capacity than the Aston system, which may be attributable to the SERI reactor being insulated. Other features such as grate design and reactor stirring may also effect the reactor throughput. However, the gas yield and heating value data are comparable with the Aston system.

The Kansas State University reactor employs secondary in-bed air injection which should result in a stable reaction zone position for a variety of input conditions and, therefore, should allow the system to be readily turned down. The reactor operates at a higher temperature than the Aston system, although this may be attributable to the occurrence of hot spots in the vicinity of the air injectors. The tar loading of the gas is considerably lower than the Aston system, which may be a result of good gas mixing and gas circulation flows within the reactor due to the air injectors. The reactor is operated with ceramic balls on the grate which may also effect some tar cracking. The system operates at a lower specific throughput than the Aston system, which is attributable to the low capacity fan employed [76], but does demonstrate the turn–down ability of the system.

The two rice husk gasifiers, Twente University and UCD, operate at a much lower specific capacity than the Aston reactor. This may be attributable to the poor flow characteristics of the rice husk fuel. However, both gasifiers appear to be operating so that incomplete gasification of the fuel is occurring and char is being produced. In the Twente University gasifier, in order to remove ash from the reactor, some of the char produced is removed by a stirrer/scraper at the grate. In order, therefore, to maintain a constant height of char, the gasifier must be operating in a pyrolysis dominating mode. Experience gained at Aston when operating in this mode suggests that the specific throughput of the reactor drops. The UCD system is a batch reactor and, therefore, reaction zone stability is not required, and in order to minimise the problems of the flow of rice husks through the reactor, it is operated with the reaction zone advancing upwards through a fixed bed of rice husks to leave a residue of unreacted char and ash. The low carbon conversion efficiency is further evidenced by the low gas yield. The Twente system is operating at a relatively high tar loading, although this is still lower than the Aston system and again this difference may be attributed to lower heat loss in the insulated Twente system. Both reactors are operating at a comparable temperature to the Aston reactor.

The Open University reactor is operated in what appears to be a semi-batch mode, and the gas composition data, particularly the high CO_2 level, indicates that there is excess oxygen. The reactor temperature is comparable with the Aston system, but the gas exit temperature is very low. This could be attributed to reactor heat loss, but the reactor is fabricated from refractory. The operation of the gasifier in a semi-batch mode, with unreacted fuel and char being removed from the reactor at the end of each run, would explain the low gas yield.

The Syngas reactor works in the top stabilised mode (see Chapter 2). This particular reactor operates at a considerably higher specific capacity than the Aston system. This may be attributable to the propane pilot light that is used to maintain the reaction zone at the top of the bed. The gas tar loading is lower than the Aston system. The gasifier is operated with a deep bed of char below the reaction zone and, as the reactor is insulated, this may be an effective tar cracker. The reaction zone is hotter than the Aston system, but again this may be attributable to the propane burner.

6.5.2 Throated Systems

The literature survey (Chapter 2) suggested a number of differences in performance between open-core and throated reactors, notably throated reactors produce a gas with a lower tar loading, have tighter control' on the properties of the feed materials and have tighter scale-up limitations than open-core systems. The data collected from the literature was used to assess the validity of these suggestions.

It can be seen that open-core systems have already been operated successfully with difficult fuels, with both Twente University and UCD having developed systems to gasify rice husks, one of the most difficult fuels to gasify due to its ash content and poor flow characteristics. None of the throated systems surveyed has attempted to gasify a fuel of this type, although Energy Equipment Engineering have successfully gasified sawdust. In general, the throated systems have used fuels of a near uniform and large size in order to minimise the problems of air jet penetration. It would, therefore, appear that the findings of this survey support the hypothesis about the limit on fuels that can be accepted by a throated reactor.

It is difficult to draw any conclusions about the relative tar loadings produced from each gasifier. The data for both systems covers a wide variety of gas tar loadings. This may suggest an inconsistency in the measurement of tar levels in the product gas and what individual workers divine as tar, or that the tar loading of the gas is extremely sensitive to variations in feed properties or variations in reactor operation.

The survey indicated that the largest throated system available was of the order of 500 kg/hr, although larger systems have been reported although not in detail [15]. The scale-up potential of the open-core system appears to be demonstrated by the Syngas gasifier which, despite the limited development of the geometry, has been developed up to approximately 900 kg/hr. It must be noted that the throated systems generally work at a higher specific capacity, with specific capacities of up to 3800 kg/m2 hr measured at the throat, this being considerably higher than the open topped open-core systems. The top stabilised Syngas system operates at a higher specific capacity than the conventional open topped system. The high specific capacity at the throat is indicative of the rapid reaction in the throat.

6.6 IMPLEMENTATION

In order for the open-core type of gasifier to be used commercially or for a demonstration project, it must be able to run for prolonged periods with no problems. This study has identified a number of potential difficulties for the implementation of open–core downdraft gasifier systems. These areas will discussed in turn in Sections 6.6.1 to 6.6.3.

6.6.1 Ash Removal

One potential problem identified (see Chapter 2) with the operation of this type of reactor has been a build-up of ash in the reactor bed causing an elevated bed pressure drop which restricts the running time of the reactor. Evidence for the existence of this problem was provided during run R8, as can be seen in Figure 6.22, which illustrates the build up in reactor pressure drop throughout a run. In order to overcome this problem, two alternatives exist: operate the gasifier with a mechanical ash/char removal system; or operate the gasifier with the reaction zone stabilised at the grate.

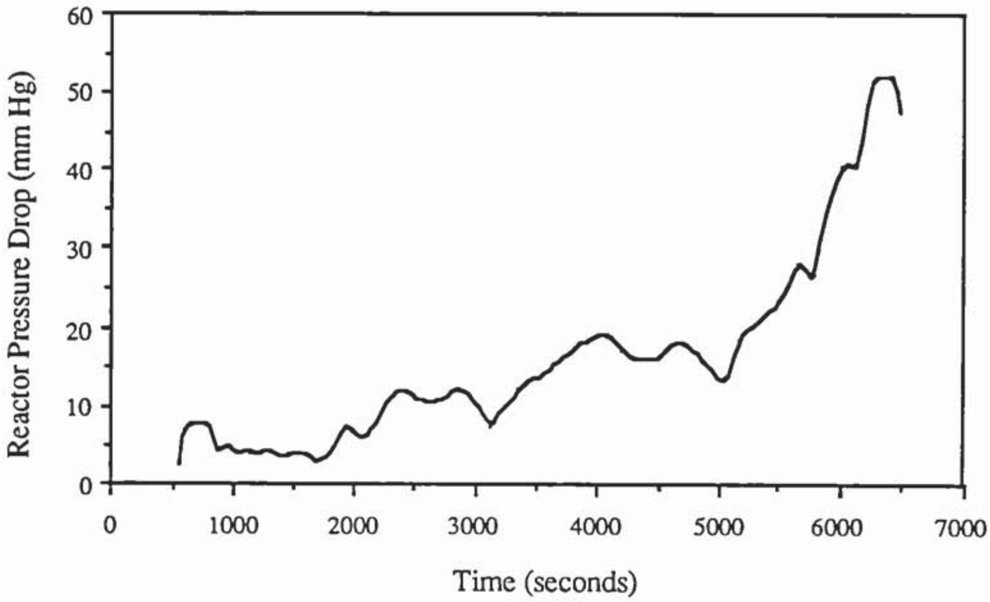


Figure 6.22 Reactor Pressure Drop against Run Time (R8)

Open–core gasifiers employing char/ash removal systems have already been operated successfully. Manurung and Beenackers [58] at Twente University have operated a rice husk (a fuel with a particularly high ash content) gasifier, which employs a revolving scraper on the grate to remove ash and char from the system. However, a potential disadvantage of this type of system is that the overall carbon conversion efficiency is lowered as part of this is removed from the reactor as ungasified char, and the gasifier must be operated in a pyrolysis dominating mode so that char is produced at the same rate at which it is removed. This will both lower the gasifier efficiency (to cold clean gas and carbon conversion) and limit its throughput, as operating in this mode limits the specific capacity of the system.

As discussed in Sections 6.2.2 and 6.3.2.2, the char bed may not be necessary for the operation of the gasifier and, therefore, an alternative mode of operation is to operate the gasifier with the reaction zone at the grate. The Aston gasifier has been operated in this mode for short periods, as can be seen in Figure 6.16 (see above). Operation in this mode will allow the ash to pass through the grate and not become lodged in the char bed.

However, operating the gasifier with the reaction zone on the grate may also have a number of disadvantages. The char bed may effect some tar cracking and evidence from the runs performed (see Section 6.3.2.2) suggest that increasing the depth of the char bed may increase the gas quality. Figures 6.17 to 6.20 are linear extrapolations of the data from Section 6.3.2.2 to indicate the potential gas composition and heating value with the gasifier operating with the reaction zone on the grate. These extrapolations would indicate that operating the gasifier with the reaction zone on the grate has a significant and detrimental effect on gas quality. Indications are that the heating value of the gas at grate operation is approximately 85 % of the heating value for a gas produced with a 10.0 cm char bed. It is anticipated that in reality the detrimental effect of operating the gasifier with the reaction zone may be exacerbated due to less efficient tar cracking.

A further problem associated with the the reaction zone at the grate may be in reactor control. A char bed can operate as a 'buffer' allowing for some variation in process variables, such as air/fuel ratio and feed moisture content, that might destabilise the reaction zone. With the reaction zone stabilised at the grate, a change in a process variable that could cause the reaction zone to move downwards, for example increasing the inlet air rate, could result in the reaction zone being extinguished.

Operation with the reaction zone at the grate may, due to the maximum temperatures in this region being of the order of 1000 °C or higher, result in the need for special materials of construction to be used for the fabrication of the grate.

6.6.2 Bulk Solids Flow

Observations made of the reactor whilst in operation (see Section 6.2.1) have shown that the flow of solids through the reactor has an important influence on the integrity of the reactor bed. It was noted that commercial type pin chips had very poor flow characteristics and tended to bridge in the reactor creating voids, which lead to the formation of a sloping reaction zone which could lead to difficulty in the control of the reactor; and also the possibilty of tar escaping the reactor uncracked.

To prevent or minimise the occurrence of these voids and, therefore, remove or minimise the problems associated with them, a number of steps may be taken. As it was the commercial chips that exhibited the poorest flow characteristics, a simple solution would be to use regular shaped feed materials. However, this is not feasible in a commercial system due to the impracticality and cost of producing of producing such materials. The solution adopted by some workers is to install some form of reactor bed stirring to break up the feed bridges. However, stirrers can create operational difficulties by grinding up the friable char [73] which could cause reactor pressure drop problems, although a number of reactors have been successfully operated with stirrers [58][77].

6.6.3 Reactor Turndown

In many commercial applications, the gasifier system must be able to respond to load changes and therefore have a certain turndown capacity. This study has demonstrated that the open-core gasifier has a specific biomass throughput at which the reactor can be operated with a stable reaction zone, and therefore, turndown. The stability of the reaction zone is highly dependent on feed properties, that is shape, size, moisture content and type; and the air factor. Variations in these parameters will cause the reaction zone to 'drift', either producing char or consuming char (see Section 6.3.3). This 'drift' will allow for short term turndowns of the system but will not allow for long term turndown of the reactor.

Again, a number of alternatives exist to overcome the problems associated with the lack of turndown. A possible situation is to use a bank of reactors that can be bought on and off stream as required. However, this type of system has a slow response time and may create control difficulties. Walawender [76][77] has operated an open-core gasifier with secondary in-bed air injection and has reported that this system can be readily turned down. Eoff [127] has developed an open-core reactor with a choke plate which he too reports can be readily turned down. Possible advantages of the systems of Walawender and Eoff is that gas recirculation may be increased within the reactor and therefore tar cracking may be enhanced. However, both of these systems may be described as throated/open–core hybrids and as such may also inherit some of the disadvantages of throated systems, notably in the fuels that can be accepted.

It may also be possible to facilitate some turndown by the use of a char removal system. The gasifier would be operated in the pyrolysis dominating mode so that there is a net deposition of char, with some of this char being removed, for example by a screw auger, in order to maintain the reaction zone at a constant position. To turndown the reactor, the air rate would be decreased, which would increase the rate of char deposition, and therefore the rate of char removal would have to be increased to maintain the reaction zone stability. This type of system would remove the problems associated with ash build-up (see Section 6.6.1) but would lower the carbon conversion efficiency of the gasifier.

A further, as yet untried, alternative is the use of a tapered reactor, that is the reactor with a diameter and hence cross–sectional area that varies along its length. In order to alter the biomass throughput, the gasifying air rate would be adjusted. This would cause the reaction zone either to climb or fall until the cross-sectional area of the reactor is such that the biomass throughput (specific capacity (kg/m^2 hr) * area (m^2)) is 'matched' to the air rate to give the appropriate air factor for the particular feed material. The overall turndown ability of the reactor would thus be determined by the ratio of the largest diameter to the smallest diameter of the reactor cone. A possible further advantage of a conical reactor (that is a system with the narrow end at the top), is that it will minimise bridging and flow problems in the reactor and hence allow for the formation of a level reaction zone.

6.7 PROJECT REPLICATION

In addition to the results already presented in this Chapter, experience was gained in the design and operation of a gasifier system and its inherent problems. Although the system generally performed adequately, a number of difficulties and areas for improvement were identified and these should be acted upon to enhance the value of the system as a research tool; these are discussed in Sections 6.7.1 to 6.7.4.

6.7.1 Tar

A particular problem was encountered in the measurement of the product gas flowrate, as frequently an unstable signal/reading was obtained from the flowmeter. This was attributed to the relatively high tar content of the product gas. This tar proved to be particularly difficult to remove from the product gas and resulted in problems with the gas pump, notably sticking impeller blades, which would 'mis-fire' causing the flowmeter to hunt, thus limiting the useful data collected and hence analysis possible. The initial design included a packed bed scrubber to remove the tar from the product gas. However, this proved to be totally inadequate and was replaced after the first commissioning run with a centrifugal contacting scrubber. This second scrubber was far more effective, but still allowed tars to pass through and into the gas pump.

A possible solution to this problem, as considered at the initial design stage of the system, is the use of a water ejector pump as a combined gas scrubber, cooler and pump.. This was, however, rejected as it was felt to be too complicated a system and instead it was decided to employ a separate pump and scrubber system. It is now acknowledged that an ejector would have been both a more effective and elegant solution to the gas cleaning and pumping problem.

Another possible solution is to replace the gas scrubber with a different gas cleaning system. Although no quantitative data was obtained relating to the droplet size of the tar mist, it is believed that the droplets are very small; the low efficiency of the packed b.d scrubber (see Section 3 4.2.2) would suggest a drop diameter of less than 5 µm. It is therefore believed that an electrostatic precipitator would be appropriate, as they are suitable for the removal of fine particulates. Such a system could be used with the existing gas pump but would require extra gas cooling as much of the gas cooling in the existing system is provided by the scrubber.

The tar levels in the product gas also created problems with the gas sampling and sample clean-up system. In order to minimise the time lag between a variation occurring in the gas composition and its detection so that the cause of the variation can be identified more easily, it was desirable to place the gas sample point as near downstream as possible to the reactor. However, this proved impractical as the sampling system could only be operated for periods of approximately one hour (due to tar deposition in the system) without the gas sample point being placed after the scrubber. This of course increased the sampling time lag and also resulted in the possibility of carbon dioxide dissolution in the scrubber water. It would be advantageous to design and install a sampling system to deal with the demands required for sampling directly after the reactor and this is discussed in Chapter 8.

The problems associated with the tar loading of the product gas as described above were exacerbated by the heat loss from the reactor and would be minimised if the reactor were insulated.

6.7.2 Reactor Bed Temperature Measurement

Problems were encountered with the flow of the feed through the reactor, feed A in particular being prone to bridging and hence voiding. It was felt that these flow problems were exacerbated by the in–bed thermocouple array. Analysis of the temperature measurements made using this array show that they were of little analytical value, but were merely indicative of the prevailing conditions in the reactor. It would therefore be desirable to remove this array and employ a non–invasive method of temperature measurement.

The type of system to be employed will be dependent on whether the reactor is insulated or not. For an uninsulated reactor, either thermography or optical pyrometry could be employed, and for an insulated reactor, the reactor wall temperature within the insulation could be monitored by thermocouples. All these methods of measurement would be measuring the wall temperature of the reactor which, due to wall effects, may not be indicative of the true conditions within the reactor. However, it is not feasible to measure the temperature along the central axis of the gasifier without causing disturbances to the flow of solids through the reactor and hence effecting the stability of the reaction zone.

6.7.3 Instrumentation

The instrumentation employed proved to be satisfactory. However, it could be improved to allow for a more detailed analysis of the gasification process, and in particular for the preparation of mass and energy balances [97]. Improvements to the instrumentation will be discussed in the Recommendations (Chapter 8). The gas analysis system proved to be a useful tool in that changes within the gas composition could be rapidly recognised. However, the limited number of gases detected meant that in order to calculate mass and energy balances, the balance of the gas was assumed to be nitrogen. Back–up batch gas chromatographic analysis proved to be inadequate.

Particular problems were encountered with the monitoring of the gas tar levels. The tar collection systems developed, see Reyes [97], proved to be inefficient and were only able to measure the tar content of the gas product for one period during a run. It would be desirable to measure the tar levels in the gas at regular intervals throughout a run in order to measure variations in tar levels in particular modes of reactor operation.

A number of tar sampling systems have been reported in the literature [128][129][130] and a suitable system could be developed based on these designs. Another alternative is to pass a sample stream through a cold trap cooled either by liquid nitrogen or acetone/dry ice in order to condense out the tar and other condensibles.

6.7.4 Reactor Feeding

The wood input rate was measured by simply timing the rate of addition of the hand–fed batches, the batches being added when the reactor had reached a preset level. The occurrence of voids in the reactor bed effected the accuracy of these measurements and the feeding process was time consuming. It did, however, considerably simplify the operation and construction of the reactor system. The use of an alternative feeding system will be discussed in Chapter 8.

CHAPTER 7
CONCLUSIONS

The work performed during this project led to the following conclusions being made:

- The unique and direct observations made of the gasification process have shown that the reaction in an open-core gasifier occurs in a very narrow reaction zone within the reactor. The size of this zone is dependent on the feed particle size, reaction being complete within approximately 3 to 5 particle diameters.

- The reaction has been observed to occur in two steps: firstly the biomass pyrolyses and the particle is enveloped by a flame of the burning pyrolysis volatiles, this can be seen as a glowing incandescent band in the reactor; and then the char produced by the pyrolysis is gasified by reaction with the pyrolysis gases. These observations are in agreement with theory suggested by SERI.

- Direct measurements of the total time required for gasification show that it is far quicker, in the order of 25 to 35 %, than that predicted by modelling work performed at SERI. This difference is due to the char gasification being far quicker than predicted, of the order of 10 to 15 seconds rather than the predicted 100 seconds. However, comparisons with the SERI model indicate that the actual reaction time is a function of a number of feed properties, including size, shape, moisture content, type, absolute density and bulk density.

- Based on observations of individual particles approaching the reaction zone, it is concluded that the main method of heat transfer to propagate reaction in the incoming raw biomass, is radiation. It is not, as suggested by Reed and Markson [55], by the propagation of flames upwards through the reactor into the raw biomass, as the only flames observed in the reactor flowed downwards, due to the bulk forced convection of the gas and air down through the reactor. The heat transfer mechanisms within the pyrolysis reaction zone are more complicated, including radiation and conduction from the flame surrounding each particle, radiation and conduction from other pyrolysing particles, convection from the downflowing gas products and by radiation from hot char below this zone.

- The reactor has been operated in three different modes: steady state with a constant depth of char; pyrolysis dominating with an increasing depth of char; and gasification dominating with a decreasing depth of char. The stability of the zone can be controlled relatively simply by adjusting the air input rate. At steady state, the gasifier operates at an air factor of approximately 40 %.

- It has been demonstrated that for a particular feed material, there is only one specific biomass throughput (that is kg/ m^2 hr) and related air rate at which the gasifier can maintain stable operation. At this stable operation point, the gasifier will be operating at its maximum efficiency. It was found that if the air rate was adjusted so that the gasifier was operating in either the pyrolysis or gasification dominating mode, then stable operation could only be obtained again by returning the air rate to its steady state value. The biomass throughput at which stable operation will occur is determined by the time required for the total gasification of the material. As discussed above, the time for gasification is related to feed properties.

- The influence of the depth of char bed on product gas quality was investigated, and it was found that at increased depth of char, the gas quality, in terms of gas heating value, improved. It was concluded that this improvement in gas quality was due to improved tar cracking in the char. However, the char must be in the order of 850 °C to crack tars and these temperatures are only maintained in a narrow band of approximately 2 cm thick directly below the reaction zone. The char may also lower the tar levels in the product gas by physical absorption.

- Qualitative observations support the hypothesis that the shape of the particles to be gasified is an important criterion in the operation of a gasifier and that materials consisting of mix d shapes, notably pins, and sizes are prone to bridging. Observations made during this project have shown that the occurrence of bridges effects the reaction zone stability, causing it to slope, and may allow tars to escape the reactor uncracked.

- Measurements made of the reactor pressure drop have shown it to increase progressively throughout a run. This increase in pressure drop was attributed to the deposition of ash from the gasified material on to the top of the char bed directly below the reaction zone. To enable the reactor to be operated successfully for prolonged periods, this ash residue will have to be removed.

CHAPTER 8
RECOMMENDATIONS

8.1 FUTURE WORK

This study has identified a number of areas for future work and it is recommended that the following receive particular attention:

- Reyes [97] produced mass and energy balances for the gasifier system. However, due to inadequate instrumentation, not all the process streams could be adequately analysed, therefore, upon completion of the modifications discussed in Section 8.2, it is recommended that robust mass and energy balances are obtained.

- It was concluded that many of the effects of the processes occurring in the gasifier were masked by the reactor heat loss. Therefore, experiments must be performed utilising an insulated reactor. This will allow for a more detailed investigation of the effect of the air factor on reaction zone stability and the height of char bed on the degree of tar cracking. This will also minimise the problems associated with the tar content in the product gas.

- A detailed investigation of the effect of variations in the feed properties on the rate of reaction and gasifier throughput must be performed in order to yield scale-up data. This can only be performed if an accurate method of metering feedrate is obtained (see Section 8.2). This should include a detailed study of the reaction times of individual particles so that models may be formulated to aid in the design of open-core gasifier systems.

- The problem of ash build-up in the reactor must be investigated, with particular reference to either the operation of the gasifier with the reaction zone stabilised at the grate or ash/char removal by a scraper or screw auger.

- One of the objectives of the system design was to investigate methods of tar removal, cracking or prevention that could be used to improve product gas quality. This is one area that therefore warrants further investigation.

Particular areas that should be investigated are the use of reactor insulation and, due to problems associated with operation of the pump/scrubber system, the use of a water ejector should also be investigated (see Section 8.2).

Other areas that could be investigated include the following:

- Data on the influence of the height of char bed on gas composition has only be collected for char bed height of 5 cm or more. It is therefore recommended that char bed heights of 0 to 5 cm are investigated in order to identify the thickness of char capable of tar cracking.

- The gasifier has only been operated for short periods in the gasification dominating mode, that is when the reaction zone is falling, and therefore only a limited amount of data has been collected for operation in this mode. Therefore, in order to compare the performance of the gasifier in its various modes of operation, the gasifier should be operated in the gasification dominating mode so that sufficient data for detailed analysis is collected.

- In order to prevent the occurrence of voids and bridges, the use of a reactor stirrer warrants investigation.

- In order to obtain a better understanding of the processes occurring in the gasifier, it is recommended that the gas composition down the reactor length is measured.

8.2 SYSTEM MODIFICATIONS

Generally the system performed adequately, however, a number of areas were identified for improvement or modification. The modifications requiring the highest priority are:

- Problems vere encountered in measuring the gas flowrate and this was attributed to tars effecting the performance of the gas pump which resulted in it running unevenly, causing the flowmeter to hunt. It is believed that this problem could be overcome by using a water ejector as a combined gas pump, cooler and scrubber or the use of an alternative gas cleaning device such as an electrostatic precipitator. It is therefore recommended that one of these areas be investigated.

- Tar sampling was only performed on a single batch basis per run [97]. In order to monitor the change of tar levels during operation, a multiple batch system could be installed. This may be based on a filter system or, as with the existing system, employ a series of solvent bubblers. Another alternative is to cool the sample stream using either liquid nitrogen or acetone/dry ice to condense out the tar and other condensibles.

- Problems were encountered with the performance of the gas sample clean-up system. This did not perform up to standard, requiring the addition of extra clean-up stages and the placing of the gas sample point downstream of the gas scrubber. Furthermore, it is believed that this system allowed air to leak into the gas sample, thus effecting the accuracy of the gas analysis. It is, therefore, recommended that a system be built in-house to replace the existing system. A particular point to be considered in the design and construction of this system, must be to allow a gas sample to be withdrawn from as close to the reactor as possible to minimise sampling delay. A suitable system will have an isokinetic sampling probe in order to obtain a representative gas sample. Particulates could be removed by a cyclone and/or a filter, water and higher boiling tars could be condensed out of the sample stream and tar droplets could be removed by a venturi coalescer.

- The in–bed temperature measurement exacerbated flow difficulties exhibited by the flow of the feed material through the reactor making it difficult to maintain a level reaction zone for prolonged periods. It is therefore recommended that the use of the thermocouple array be discontinued and a non-invasive technique such as thermography or optical pyrometry be employed for an uninsulated reactor or, for an insulated reactor, measurements of the reactor surface temperature beneath the insulation should be taken.

- The feedrate could not be accurately metered. However, the Department has recently acquired a laboratory scale screw feeder. This feeder will cover the feed rates required for the gasifier operation at an accuracy of about ± 5 %

[93] and, therefore, would be suitable for use with the gasifier.

Other modifications that might be made but are of a lower priority include:

- The water content of the product gas was not monitored which decreases the accuracy of the formation of mass and energy balances and makes it difficult to assess the approach of the product gas to equilibrium. It is therefore recommended that a humidity probe or a similar device, preferably one that can be connected to the data-logger, be purchased so that the product gas water content can be monitored.

- The air input rate to the gasifier is determined by nitrogen balance, therefore in order to improve the accuracy of these measurements, the purchase of a nitrogen analyser should be considered. To enhance the accuracy of mass and energy balances, the purchase of an oxygen and/or a total hydrocarbon analyser might also be considered.

- A water flowmeter could be installed in the scrubber recycle line, as this would allow for more precise control of the scrubber.

- The existing pipework could be optimised to lower the system pressure drop.

APPENDIX I
PUBLISHED WORK

i) Earp DM and Bridgwater AV, "Research into a Transparent Open Core Downdraft Gasifier", paper presented at the 4th EC Conference - Energy from Biomass, Orléans, France, May 1987.

APPENDIX II
DESIGN CALCULATIONS

II.1 PRODUCT GAS RATE CALCULATION

II.1.1 Based on Gas Rate Data in Literature

The product gas rate estimates were calculated from the values in the literature using a scaling factor based on the reactor cross sectional area, as shown in the following equation:

Equation (II.1) $F_2 = F_1 \, (d_2/d_1)^2$

The calculations for possible gasifier diameters of 5.0, 7.5,10.0,12.5 and 15.0 cm, based on the data of Bright et al [84] and Reed and Markson [55] is shown in Table II.1.

II.1.2 Based on Wood Rate Data in Literature

The product gas rate was also calculated from the wood throughput. The gas yield (Nm^3/daf kg) was calculated from the data of Shand and Bridgwater [17], which relates the gas yield to the feed material heating value. The feed throughput data of Bright et al and Reed and Markson was used, the calculation of the yield is shown below:

Bright et al [84], HHV feed estimated to be 21 MJ/daf kg based on data of Graboski and Bain [9], which using the data of Shand and Bridgwater [17] gives a gas yield of 2.67 Nm^3/daf kg.

Reed and Markson, feed HHV 18.55 MJ/daf kg, which using the data of Shand and Bridgwater [17] gives a gas yield of 2.29 Nm^3/daf kg.

The respective product gas flowrates are:

0.569 Nm^3/hr for Bright et al and 2.82Nm^3/hr for Reed and Markson.

This flowrate data can then be scaled up for the possible reactor diameters using equation II.1. These values are also presented in Table II.1.

Table II.1 Estimated Product Gas Throughput Based on Gas Throughput Data in Literature

Literature Data: Gas rate (Nm^3/hr)	Literature Data: Reactor diameter (m)	Possible reactor diameter (m)	Scaling factor	Estimated gas rate (Nm^3/hr)
BASED ON GAS THROUGHPUT DATA (Section II.1.1)				
BRIGHT ET AL [84]				
0.93	0.0375	0.05	1.78	1.65
0.93	0.0375	0.075	4.00	3.92
0.93	0.0375	0.1	7.11	6.61
0.93	0.0375	0.125	11.11	10.33
0.93	0.0375	0.15	16.00	14.88
REED & MARKSON [55]				
3.32	0.054	0.05	0.86	2.86
3.32	0.054	0.075	1.93	6.40
3.32	0.054	0.1	3.43	11.39
3.32	0.054	0.125	5.36	17.79
3.32	0.054	0.15	7.72	25.62
BASED ON WOOD THROUGHPUT DATA (Section II.1.2)				
BRIGHT ET AL [84]				
0.569	0.0375	0.05	1.78	1.01
0.569	0.0375	0.075	4.00	2.27
0.569	0.0375	0.1	7.11	4.03
0.569	0.0375	0.125	11.11	6.30
0.569	0.0375	0.15	16.00	9.08
REED & MARKSON [55]				
2.82	0.054	0.05	0.86	2.42
2.82	0.054	0.075	1.93	5.43
2.82	0.054	0.1	3.43	9.64
2.82	0.054	0.125	5.36	15.07
2.82	0.054	0.15	7.72	21.73

II.2 Wash Water Rate Calculation for Packed Bed Scrubber

The liquid rate for the packed bed scrubber was calculated at 80 % flood using the generalised pressure drop correlation in Treybal [113], which is a correlation of:

Equation (II.2) $Y = (C_f\, G'^2\, \mu_L^{0.1}\, J) / (\rho_G(\rho_L - \rho_G)\, g_c)$

against:

Equation (II.3) $X = L'/G'\, (\rho_G/\rho_L)^{0.5}$

Calculations were performed for the following conditions:

A) 6.5 Nm^3/hr product gas at 273 K.

B) 6.5 Nm^3/hr product gas at 546 K.

C) 10.0 Nm^3/hr air at 293 K.

All gases were assumed to be at atmospheric pressure.

ρ_L 1000 kg/m^3

μ_L 1×10^{-4} Ns/m^2

Column area: 8.107×10^{-3} m^2.

Molecular weight product gas assumed to be 26.

Density product gas: 273 K; 1.16 kg/m^3 and 546 K; 0.58 kg/m^3.

Density air 1.2 kg/m^3.

G' product gas = 0.259 kg/m2s

G' air = 0.411 kg/m2s

Calculations:

Conditions A

Substituting appropraite values into equation II.2 gives:

Y = 0.0368

From correlation in Treybal [113]:

X = 1.0

Using equation II.3 gives:

L' = 7.60 kg/m2s

which at 80 % flood gives a liquid rate of:

2.96 l/min.

Conditions B

Substituting appropraite values into equation II.2 gives:

Y = 0.0737

From correlation in Treybal [113]:

X = 0.43

Using equation II.3 gives:

L' = 4.62 kg/m2s

which at 80 % flood gives a liquid rate of:

1.80 l/min.

Conditions C

Substituting appropraite values into equation II.2 gives:

Y = 0.0897

From correlation in Treybal [113]:

X = 0.35

Using equation II.3 gives:

L' = 4.15 kg/m2s

Thus the column will flood at a liquid rate of:

2.01 l/min

II.3 NOMENCLATURE

Symbol	**Description**	**SI Units***
C_f	Packing factor, 1600 for 6.35 mm Raschig ring	-
F_1	Known biomass throughput from the literature	$N\ m^3\ hr^{-1}$
F_2	Estimated biomass throughput	$N\ m^3\ hr^{-1}$
G'	Superficial gas mass velocity	kg m-2 s
J	Conversion factor, 1 for SI units.	
L'	Superficial liquid mass velocity	kg m-2 s
d_1	Diameter of the reactor at known throughput	m
d_2	Diameter of reactor at unknown throughput	m
g_c	Conversion factor, 1 for SI units	-
ρ_G	Gas density	kg m-3
ρ_L	Liquid density	kg m-3
μ_L	Liquid viscosity	N s m-2

* Where applicable

APPENDIX III
P AND I DIAGRAM OF GASIFIER SYSTEM

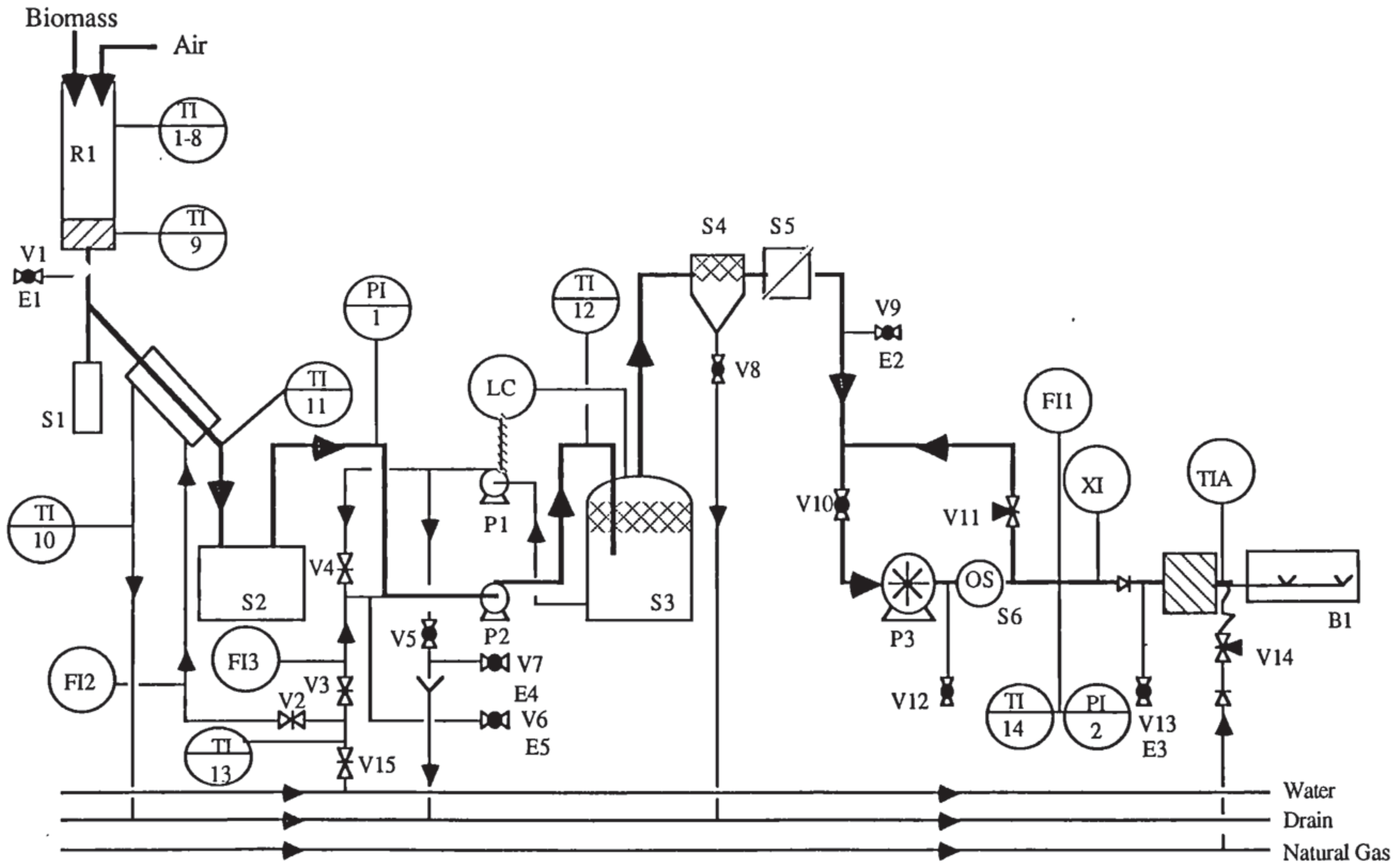


Figure III.1 P and I Diagram of Gasifier System

KEY TO PLANT ITEMS

MISCELLANEOUS

Code	Function
R1	Gasifier
B1	Burner

SAMPLE POINTS

Code	Function
E1	Tar system
E2	On-line gas analysis
E3	Batch gas analysis
E4	Wash water 1
E5	Wash water 2

PUMPS

Code	Function
P1	Scrubber recirculator/drain
P2	Scubber
P3	Gas pump

SEPARATORS

Code	Function
S1	Ash catchpot
S2	Catchpot
S3	Disentrainment vessel (scrubber)
S4	Knock out pot
S5	Vacuum inlet filter
S6	Oil mist filter

KEY TO VALVES

Code	Duty	Type
V1	On/off sample point 1	Ball
V2	Cooling water flow rate control	Gate
V3	Scrubber water flow rate control (once through system)	Gate
V4	Scrubber water recycle rate control	Gate
V5	Water drain on/off	Ball
V6	On/off sample point 5	Ball
V7	On/off sample point 4	Ball`
V8	Knockout pot drain on/off	Ball
V9	On/off sample point 2	Ball
V10	Vacuum pump isolator	Ball
V11	Gas flow rate control	Needle
V12	Oil drain on/off	Ball

V13	On/off sample point 3	Ball
V14	Natural gas flowrate control	Needle
V15	Mains water control	Gate

KEY TO INSTRUMENTS

Code	Function
TI 1-8	In bed temperature measurement
TI 9	Gas temperature below grate
TI 10	Cooling water outlet temperature
TI 11	Gas temperature after cooling
TI 12	Temperature at disentrainment vessel inlet
TI 13	Water inlet temperature
TI 14	Gas temperature at point of flow measurement
PI 1	Pressure downstream of reactor
PI 2	Pressure at point of flow measurement
FI 1	Product gas flowrate
FI 2	Cooling water flowrate
FI 3	Scrubber water (once through system) flowrate
XI	Cumulative gas volume meter
TIA	Pilot light alarm

Symbols used in the drawing are those listed by Austin [131].

APPENDIX IV
START-UP & SHUT DOWN TESTS & PROCEDURES

IV.1 TESTS PRIOR TO START UP

Check all joints for leaks.
Check wiring
Check valve positions.(See Section A4.4)

Test level switch or ensure enough water in disentrainment vessel.

Test CO alarm
Test pilot light alarm

IV.2 START-UP

Check valve positions - agree with checklist (see Section IV.4)

Turn on fume hood.
Turn on computer equipment
Load data logger calibration software.

Calibrate gas analysers.
Calibrate gas analysers for data logger
Calibrate pressure transducers for data logger

Ensure pump inlet valve (V10) is closed.
Ensure oil drain valve (V12) is open.
Ensure gas pump (P3) oil cover is open.
Ensure 'oil-release' vent on gas pump (P3) is open.
Switch gas pump on. (This must be run for 20 to 30 minutes prior to start up of scrubber).

Calibrate flowmeter for data-logger.
Include new calibration values in data-logging software.
Load data-logging software.

Switch on hot-box.
Turn on eductor air (Valve (V16)).

Turn on mains water, valve (V15).
Start cooling system, valve (V2).

Turn on CO alarm.
Turn on pilot flame alarm.
Light pilot flame (Set valve (V14) to maximum open position)

Ensure flow control valve (V11) is set to minimum flow (ie fully open).
Open gas pump inlet valve (V10).
Close oil drain valve (V12).
Close gas pump (P3) oil cover.
Close 'oil-release' vent on gas pump (P3).
Ensure valves (V5 and V7) are closed.
Turn on wash water recycle pump (P1).
Open valve (V4) until desired flowrate is obtained.
Turn on scrubber/pump (P2).

Fill sample bottles on tar sample system.
Add ice (& salt) to ice baths.

Start data-logging software and start stopwatch.

Ensure valve (V9) is open.
Turn on gas sample pump.

Light reactor.

IV.3 SHUT DOWN

Stop feeding wood.
Remove thermocouple array from reactor.
Allow biomass in reactor to burn-out.

Turn off gas analysis sample system.
Stop data-logger.

Set gas flowrate to minimum (open valve V11 to maximum).
Pass air through system for 10-20 minutes.

Turn off pump scrubber/pump (P2).
Close valve (V4).
Turn off wash water recycle (P1).

Turn off pilot light.
Turn off pilot light alarm.
Turn off CO alarm.

Open gas pump (P3) oil cover.
Open 'oil-release' vent on gas pump (P3).
Close pump inlet valve (V10).
Open oil drain valve (V12).
Allow gas pump (P3) to purge for 20-45 minutes.
Turn off gas pump (P3).

Turn off fume hood.

Turn off computer equipment.

IV.4 EMERGENCY SHUT-DOWN PROCEDURES

IN ALL CASES - all people not involved with the operation of the gasifier to evacuate the laboratory.

CO-LEAK

Stop feeding gasifier and allow burning out to commence.
Evacuate laboratory until alarm stops, although one person to remain behind to observe and control system. This person to use air-line breathing apparatus.
Normal shut-down procedure.

SCRUBBER FAILURE

Turn-off wash water recycle pump.
Turn-off scrubber/pump.
Normal shut-down procedure.

BURNER-FAILURE

Turn off natural gas supply.
Normal shut-down procedure.

GAS PUMP FAILURE

Turn off gas pump.
Turn off scrubber pumps.
Put out reactor with sand.
Allow reactor to cool.

REACTOR CRACKING

Normal shut-down procedure.

REACTOR BREAKING

Extinguish any burning feed material.
Allow pump to purge system of product gas.
Normal shut-down procedure.

FIRE (SMALL)

Judged on situation.
Turn gas pump to minimum flow.
Put out reactor with sand.
Tackle fire with appropriate extinguisher - ie to stop further production of flammables.
Once out, complete close-down.

FIRE (MAJOR) AND/OR EXPLOSION

Immediate evacuation of laboratory.
Sound fire alarms.
Inform security (ie dial 222).
Follow building evacuation procedures.

IV.5 VALVE POSITION CHECKLIST

The following are the positions of the valves prior to start-up and after shut-down.

Closed: V1,V2,V3,V4,V5,V6,V7,V8,V10,V13,V14,V15.
Open: V9,V11,V12.

N.B. For key to valve numbers see Appendix III

APPENDIX V
EQUIPMENT COSTS

Description and Quantity	Order Date	Cost or Value £
Reactor		
2 x 0.5m lengths 75mm bore quartz glass tubing	March 85	118.57
2 x 0.5m lengths 75mm bore quartz glass tubing	Feb. 87	139.97
Stainless Steel bar	May 85	37.95
Pumps		
Werner Rietschle VL 10 Vacuum pump	June 85	624.11
No. 10 Stuart Turner	April 85	76.00
No. 12 Stuart Turner	Oct. 86	80.00
Instrumentation		
MSA Gas analysis system	April 85	22293.90
8 x 1 mm Type-k thermocouples	April 85	156.16
5 x 1.5 mm Type-k thermocouples	Jan. 87	95.83
2 Pressure transducers	June 86	423.20
<u>Flowmeters:</u>		
1 CMI-E 0.8-8.0 m3/hr air	June 86	(410.00)
1 0-25 l/min air	June 86	(34.15)
	Order Total	510.77
1 0-25 l/min replacement tube	Dec.86	17.48
1 Gas meter	June 86	142.86
2 x 14P rotameters	April 86	65.32
Data-Logger		
1 BBC-B micro-computer	As new 1982	399.00
1 Cumana CD800S disc drive &	March 85	(298.38)
1 Monochrome VDU	March 85	(76.30)
	Order Total	420.52
1 Epson FX80T Printer	March 85	217.35
1 Computer Lead	March 85	3.45
<u>Biodata:</u>		
1 MF12 mainframe	April 85	(470.00)
1 TC-16 thermocouple card	April 85	(450.00)
1 A12D 12 bit analogue to digital converter	April 85	(220.00)
1 IEEE to IEEE lead	April 85	(35.00)
	Order Total	1404.72
1 AN16/32 analogue input card	March 86	(345.00)

1 blanking panel	March 86	(7.50)
	Order Total	407.68
1 Aries B488 IEEE488 interface	April 85	229.71
15 x 5.25" Floppy discs	-	50.80
1 Box printer paper	April 86	9.37

Piping & Fittings

PVC tube	-	6.70
Copper tube	-	30.60
Nylon tube	-	19.38
Steel tube	-	12.92
Valves	-	-
113.00		
Jubilee clips	-	2.86
<u>Pipe fittings:</u>		
Ermeto stainless steel	June 85	228.52
2 Thermocouple fittings	June 85	15.48
Assorted copper	-	195.09

Gases

1 carbon monoxide regulator	Oct. 85	(214.00)
1 x 5' Cylinder span gas	Oct. 85	(151.74)
	Order Total	427.04
1 x 5' Cylinder span gas	March 87	207.92
1 Test kit for CO alarm	July 86	44.65
1 x 5' Cylinder OFN	Oct.85	4.13
1 x 5' Cylinder OFN	Dec.86	5.00

Miscellaneous

1 Carbon monoxide detector	June 86	258.58
Oil mist separator for VL10 pump	Nov.86	266.84
3 replacement elements oil mist separator	March 87	131.04
2 x Sintered hot box filters	March 87	184.00
5 x Wound string hot box filters	Feb.87	34.50
25 litres pump lubricating oil	June 86	24.44
Cleaning solvents	Dec. 86	74.84
Cleaning solvents	June 87	41.29
Darvic sheeting	July 86	238.76
Handy angle	-	145.86
Electrical components	-	173.28
Misc. withdrawls from Departmental stores	-	510.87
Sundry purchases	-	76.99

Maintainance

Analyser maintaince	July 86	218.50
VL10 pump sevice	Nov.86	210.02

Feed Materials

470 lbs Industrial wood chips	Aug.86	12.08
25 x 1.2 m lengths 5 cm x 5cm timber	June 87	(8.70)
40 x 2.4 m lengths 6mm Ramin dowels	June 87	(18.78)
	Order Total	31.60

TOTAL **31854.02**

Notes: Where appropriate costs include VAT, delivery and any other surcharges, for example handling charges and analysis certificate for span gases. For multiple orders costs in brackets are just the cost of the item excluding VAT, delivery and other surcharges. These however, are included in the order total. If no purchase date is marked then articles indicated are either multiple orders or withdrawals from stores and no specific dates can be given.

APPENDIX VI
LISTINGS OF DATA-LOGGING SOFTWARE AND CONVERSION ALGORITHMS

VI.1 CONVERSION ROUTINES

```
 10 MODE7:CLS
 20 DIMDIGIT%(32),GN%(15),QUAD%(15),REL(4),YCP$(5),GCALIB(4),
    SLOPE(3),CONST(3),MAXVAL%(4),COMPARISON%(32),FINALVALUE%(33)
    ,MINVAL%(4)
 30 ONERRORPROCHELP:GOTO100
 40 *LOAD"MACODE"
 50 setup=&900:getdata=&92D:Data1=&9EF:Data2=&9F0
 60 CALL setup
 70 NCS=7:GA=5:PT=2:FL=1
 80 PROCCONVDATA:PROCINFO
 90 SETNO=1:BT=0:AT=0:X%=7:HALT%=99999
100 PROCDISPLAY(TCS)
110 REPEAT
120 PRINTTAB(0,21)SPC(39):PRINTSPC(39):PRINTSPC(39): AT=TIME-
    TTIME:ZW=0:TCOMP%=0
130 PROCTC16(TCS)
140 PROCAN1632(NCS,TCS)
150 PROCCOLD(DIGIT%(0))
160 FORK=1TOTCS:PROCTEMP(DIGIT%(K)):NEXT
170 FORK=1TO4:PROCMSA(DIGIT%(K+TCS)):NEXT
180 FORK=1TO2:PROCPRESS(DIGIT%(K+TCS+4)):NEXT
190 PROCFLOWMETRE(DIGIT%(TCS+NCS))
200 BT=TIME-TTIME:CT=BT+AT/2:
    FINALVALUE%(TCS+NCS+2)=INT((CT+0.5)/100)
210 PROCREALTIME(CT):PROCSCREEN(TCS,NCS):PROCDATATODISC(TCS,NCS)
    :SETNO=SETNO+1
220 PRINTTAB(0,22)"TO STOP PROGRAM PRESS ANY KEY":PRINT
    "WITHIN THE NEXT ";HOLD/100;" SECONDS"
230 *FX21,0
240 TERM=INKEY(HOLD):UNTILTERM<>-1
250 PRINT#X,HALT%
260 CLS:PRINTTAB(8,9)"PROGRAM NOW TERMINATED"
270 PROCDELAY(250)
280 CLOSE#X
290 PROCRUNINFO(NAME$,SETNO,FINALVALUE%(TCS+NCS+2),TCS,HOLD)
300 CLS:PRINTTAB(2,12);CHR$(141);"FINITO BENITO. THANKS. CALL
    AGAIN!"
310 PRINTTAB(2,13);CHR$(141);"FINITO BENITO. THANKS.
    CALL AGAIN!":PRINTTAB(0,20)
320 END
330 DEFPROCCONVDATA
340 Y=OPENIN("CDATA")
350 FORI=1TO15:INPUT#Y,GN%(I):NEXT
```

```
360 FORI=1TO15:INPUT#Y,QUAD%(I):NEXT
370 FORI=1TO4:INPUT#Y,REL(I):NEXT
380 FORI=1TO4:INPUT#Y,GCALIB(I):NEXT
390 FORI=1TO4:INPUT#Y,MAXVAL%(I):NEXT
400 FORI=1TO4:INPUT#Y,MINVAL%(I):NEXT
410 FORI=1TO3:INPUT#Y,SLOPE(I):NEXT
420 FORI=1TO3:INPUT#Y,CONST(I):NEXT
430 INPUT#Y,QLINE%
440 CLOSE#Y
450 FORI=1TO32:COMPARISON%(I)=-1:NEXT
460 FORI=1TO5:READYCP$(I):NEXT
470 DATAH2=,CO=,CO2=,CH4=,N2=
480 ENDPROC
490 DEFPROCINFO
500 PROCDRIVE
510 CLS:PRINTTAB(0,8)"Please enter the name of the":
    PRINT"data file to be used.":PRINT"Please use the data
    file name":PRINT"as the run number"
520 PRINT"NB. Either use empty disc or":PRINT"overwrite existing
    file."
530 INPUT"Name of data file to be used : "NAM$:CLS
540 NAME$=":"+WDISC$+NAM$
550 X=OPENOUT NAME$
560 PRINTTAB(0,12)"Please enter the  number of":
    INPUT"thermocouples being used    : "TCS
570 PRINTTAB(0,16)"How long a delay in SECONDS":
    PRINT"is required between readings"
580 PRINT"(Minimum delay of 1.0 second)":
    INPUT"Required delay               : "LONG
590 LONG=LONG*100
600 IFLONG<100THENHOLD=100ELSEHOLD=LONG
610 PRINT#X,TCS,GA,PT,FL
620 CLS
630 PRINTTAB(0,2)"PLEASE ENTER THE TIME"
640 PRINTTAB(0,4)"Hours (24 hour clock) : ":INPUTHOUR
650 PRINTTAB(0,6)"Minutes               : ":INPUTMINS
660 PRINTTAB(0,8)"Seconds               : ":INPUTSECS
670 TTIME=HOUR*360000+MINS*6000+SECS*100:TIME=TTIME
680 ENDPROC
690 DEFPROCDRIVE
700 CLS:PRINTTAB(4,8)"In which drive is the data disc":
    PRINTTAB(17,10)"WARNING"
710 PRINTTAB(7,12)"Please do not use DRIVE 0":
    INPUTTAB(5,15)"Number of drive to be used :"WDISC$
720 IFWDISC$="0"THENPROCDR0
730 IFWDISC$=""THENWDISC$="1"
740 WDISC$=WDISC$+".$.":CLS
750 ENDPROC
760 DEFPROCDR0
770 CLS:PRINTTAB(7,0)"Please do not use DRIVE 0":
    PRINTTAB(17,3)"TRY AGAIN"
780 PROCDRIVE
790 ENDPROC
800 DEFPROCDISPLAY(TCS)
```

```
810 LOCALOY,OZ,OX
820 CLS:PRINTTAB(0,0)CHR$(141);"READING SET NUMBER  0":
    PRINTTAB(0,1)CHR$(141);"READING SET NUMBER  0":
    PRINTTAB(0,4)"TEMPERATURE (deg C)     RTD= 0":
    PRINTTAB(0,19)"AT TIME : "
830 @%=10
840 PRINTTAB(0,2)"RUN START TIME 00:00:00"
850 IFHOUR<=9THENPRINTTAB(16,2);HOUR ELSE PRINTTAB(15,2);HOUR
860 IFMINS<=9THENPRINTTAB(19,2);MINS ELSEPRINTTAB(18,2);MINS
870 IFSECS<=9THENPRINTTAB(22,2);SECS ELSEPRINTTAB(21,2);SECS
880 OZ=0
890 FORI=1TOTCS:OY=6+((I-1)DIV4):
    OZ=(OZ+I)DIV5:OX=10*(I-(1+(4*OZ))DIV1)
900 IFI<10THENOX=OX+1
910 PRINTTAB(OX,OY);I;"=0"
920 NEXT
930 PRINTTAB(0,10)"GAS COMPOSITION (%)"
940 FORI=1TO5:XW=(I-1)*10:YW=12+(I DIV5)
950 PRINTTAB(XW,YW);YCP$(I);"0":NEXT
960 PRINTTAB(0,15);"GAS FLOWRATE (Nm3/h)=0"
970 PRINTTAB(0,17);"PRESSURES (mmHg)":PRINTTAB(20,17);"P1=0":
    PRINTTAB(30,17);"P2=0"
980 ENDPROC
990 DEFPROCCOLD(PC%)
1000 VOUT=(PC%-1024)*0.0025/100:RX=100*(0.5+VOUT)/(0.5-VOUT)
1010 TRTD=(RX-
    100)*2.5707:VMOD=TRTD*3.955707E1+(TRTD^2*1.7584397E-2)
1020 ENDPROC
1030 DEFPROCTEMP(PT%)
1040 MVOLT=FNCONV(PT%,GN%(K)):VACT=MVOLT+VMOD
1050 IFQUAD%(K)=0THENTEMP=FNPOLY1(VACT)
1060 IFQUAD%(K)=1THENTEMP=FNPOLY2(VACT)
1070 IFQUAD%(K)=2THENTEMP=FNPOLY3(VACT)
1080 IFTEMP>=30THENFINALVALUE%(K)=(INT(TEMP+0.5)*10)
    ELSEFINALVALUE%(K)=INT((TEMP*10)+0.5)
1090 IFFINALVALUE%(K)<-273THENFINALVALUE%(K)=0
1100 ENDPROC
1110 DEFPROCMSA(MSA%)
    1120IFK=1THENAMV=MSA%-MINVAL%(K) ELSE
    AMV=(MSA%-MINVAL%(K))/(MAXVAL%(K)-MINVAL%(K))
    1130IFK=1THENCOMP=REL(K)*AMV ELSE
    COMP=GCALIB(K)*FNGASCOMP(REL(K),AMV)
1140 IFCOMP>=GCALIB(K)THENCOMP=GCALIB(K)
    1150IFCOMP<0THENCOMP=0
1160 FINALVALUE%(K+TCS)=INT(COMP*10):
    TCOMP%=TCOMP%+FINALVALUE%(K+TCS)
1170 IFTCOMP%>=1000THENFINALVALUE%(TCS+5)=0ELSE
    FINALVALUE%(TCS+5)=1000-TCOMP%
1180 ENDPROC
1190 DEFPROCDELAY(DEL):LOCALFIN:FIN=TIME+DEL:
    REPEAT:UNTILTIME>=FIN:ENDPROC
1200 DEFPROCRUNINFO(NAME$,J,AT%,TCS,HOLD)
1210 PRINTCHR$(2)
1220 PRINTCHR$(21)
```

```
1230 PRINT:PRINT"################################################
     #############"
1240 PRINT"DATA FILE NAME ";NAME$:PRINT
1250 PRINT"NUMBER OF READING SETS ";J-1
1260 PRINT"USING ";TCS;" THERMOCOUPLES"
1270 PRINT"OVER ";AT%;" SECONDS USING A ";HOLD/100;" SECOND
     DELAY"
1280 PRINT:PRINT"################################################
     #############"
1290 PRINTCHR$(6)
1300 PRINTCHR$(3)
1310 ENDPROC
1320 DEFFNCONV(PT%,c2%)
1330 LOCALG,V
1340 G=100
1350 IFc2%=1THENG=200
1360 IFc2%=2THENG=500
1370 IFc2%=3THENG=1000
1380 =((PT%-1024)*0.0025/G)*1E6
1390 DEFFNPOLY1(VACT)
1400 LOCALT
1410 =VACT*2.438328E-2+(9.7830251E-9*VACT^2)+
     (3.627696E-12*VACT^3)+(-2.5756438E-16*VACT^4)
1420 DEFFNPOLY2(VACT)
1430 LOCALT
1440 =VACT*2.5132785E-2+(-6.0883423E-8*VACT^2)+
     (5.5358209E-13*VACT^3)+(9.3720918E-18*VACT^4)
1450 DEFFNPOLY3(VACT)
1460 LOCALT
1470 =6.2300671+(VACT*2.4955374E-2)+(-7.8788333E-8*VACT^2)+
     (1.3269743E-12*VACT^3)+(1.5580541E-18*VACT^4)
1480 DEFFNGASCOMP(RBC,AMV)=AMV/(RBC-(RBC-1)*AMV)
1490 DEFPROCHELP
1500 CLOSE#0
1510 REPEAT
1520 PROCCLOSEENC3K
1530 CLS:PRINTTAB(0,8)"PROGRAM INTERRUPTED":PRINT"Error number :
     ";ERR
1540 PRINT"At line      : ";ERL
1550 PRINTTAB(0,12)"PLEASE PRESS ANY LETTER OR NUMBER KEY":
     PRINT"IN THE NEXT 5 SECONDS TO CONTINUE"
1560 ZT=INKEY(500):UNTILZT<>-1
1570 IFERR<>191STOP
1580 CLS:PRINTTAB(12,8)"DATA DISC IS FULL":
     PRINTTAB(0,10)"Do you wish to continue"
1590 INPUT"Please answer YES or NO  : "ANS$
1600 IFLEFT$(ANS$,1)="N"ORLEFT$(ANS$,1)="n"THENSTOP
1610 PRINT:PRINT"SELECT ANOTHER DRIVE OR CHANGE DISC"
1620 INPUT"ENTER NEW DESTINATION DRIVE (NOT 0): "WDISC$
1630 WDISC$=WDISC$+".$."
1640 PRINT"OLD DATA FILE NAME WILL BE USED":PRINT"PLEASE WAIT"
1650 PROCDELAY(1000)
1660 NAME$=":"+WDISC$+NAM$
1670 FORI=1TO(TCS+NCS+1):COMPARISON%(I)=0:NEXT
```

```
1680 X=OPENOUT NAME$
1690 PRINT#X,TCS,GA,PT,FL
1700 ENDPROC
1710 DEFPROCCLOSEENC3K
1720 SOUND1,-15,97,10
1730 SOUND1,-15,105,10
1740 SOUND1,-15,89,10
1750 SOUND1,-15,41,10
1760 SOUND1,-15,69,10
1770 ENDPROC
1780 DEFPROCSCREEN(TCS,NCS)
1790 PRINTTAB(20,0)CHR$(141);SETNO:PRINTTAB(20,1)CHR$(141);SETNO
1800 @%=&20205
1810 PRINTTAB(29,4);TRTD
1820 @%=10
1830 PRINTTAB(10,19)SPC(10):PRINTTAB(10,19)"00:00:00"
1840 IFHOUR<=9THENPRINTTAB(11,19);HOUR ELSEPRINTTAB(10,19);HOUR
1850 IFMINS<=9THENPRINTTAB(14,19);MINS ELSEPRINTTAB(13,19);MINS
1860 IFSECS<=9THENPRINTTAB(17,19);SECS ELSEPRINTTAB(16,19);SECS
1870 @%=&20107
1880 FORK=1TOTCS:YW=6+((K-1)DIV4):ZW=(ZW+K)DIV5
1890 XW=(K-(1+(4*ZW))DIV1)*10+(2+(K DIV10)):IFK<10THENXW=XW+1
1900 IFFINALVALUE%(K)<>COMPARISON%(K)THEN
     PRINTTAB(XW,YW)SPC(6):PRINTTAB(XW,YW);FINALVALUE%(K)/10
1910 COMPARISON%(K)=FINALVALUE%(K):NEXT
1920 FORI=1TO5:XW=10*(I-1)+LEN(YCP$(I)):YW=12+(I DIV5):
     IFI>=5THENXW=LEN(YCP$(I))
1930 IFFINALVALUE%(I+TCS)<>COMPARISON%(I+TCS)THEN
     PRINTTAB(XW,YW)SPC(6):PRINTTAB(XW,YW);FINALVALUE%(I+TCS)/10
1940 COMPARISON%(I+TCS)=FINALVALUE%(I+TCS):NEXT
1950 FORI=1TO2:XW=13+(I*10)
1960 IFFINALVALUE%(I+TCS+5)<>COMPARISON%(I+TCS+5)THEN
     PRINTTAB(XW,17)SPC(6):PRINTTAB(XW,17);FINALVALUE%(I+TCS+5)/1
     0
1970 COMPARISON%(I+TCS+5)=FINALVALUE%(I+TCS+5):NEXT
1980 IFFINALVALUE%(TCS+NCS+1)<>COMPARISON%(TCS+NCS+1)THEN
     PRINTTAB(21,15);SPC(6):PRINTTAB(21,15);
     FINALVALUE%(TCS+NCS+1)/10
1990 COMPARISON%(TCS+NCS+1)=FINALVALUE%(TCS+NCS+1)
2000 @%=10
2010 ENDPROC
2020 DEFPROCDATATODISC(TCS,NCS)
2030 FORI=1TO(TCS+NCS+2):PRINT#X,FINALVALUE%(I):NEXT
2040 ENDPROC
2050 DEFPROCPRESS(TA%)
2060 PRES1=FNCALC(TA%,SLOPE(K),CONST(K)):
     PRES=.5*(INT((PRES1*2)+0.5)):FINALVALUE%(K+TCS+5)=10*PRES
2070 ENDPROC
2080 DEFFNCALC(TA%,SLOPE(K),CONST(K))=SLOPE(K)*TA%+CONST(K)
2090 DEFPROCREALTIME(CT)
2100 SECS=(CT DIV100)MOD60:MINS=(CT DIV6000)MOD60:
     HOUR=(CT DIV360000)MOD24
2110 ENDPROC
2120 DEFPROCTC16(TCS)
```

```
2130 Y%=17:FORK=0TOTCS:A%=K+16*GN%(K)
2140 CALL getdata
2150 VMULT1=?Data1:VMULT2=?Data2
2160 DIGIT%(K)=VMULT1*256+VMULT2:NEXT
2170 ENDPROC
2180 DEFPROCAN1632(NCS,TCS)
2190 Y%=25:FORK=1TONCS:VTOT=0:FORJ=1TO10:A%=K*4
2200 CALL getdata
2210 VMULT1=?Data1:VMULT2=?Data2
2220 VTOT=VMULT2+(VMULT1*256)+VTOT:NEXT
2230 DIGIT%(TCS+K)=INT((VTOT/10)+0.5):NEXT
2240 ENDPROC
2250 DEFPROCFLOWMETRE(FM%)
2260 IFFM%>=QLINE%THENFLOW=FNRATE(FM%,SLOPE(3),CONST(3))
     ELSEFLOW=0
2270 IFFLOW<=0THENFINALVALUE%(TCS+NCS+1)=0 ELSE
     FINALVALUE%(TCS+NCS+1)=INT((FLOW*10)+0.5)
2280 ENDPROC
2290 DEFFNRATE(FM%,FSL,FCN)=(FM%*FSL)+FCN
```

VI.2 IEEE DATA BUS CONTROL ROUTINE

```
 10  REM machine code routine for Microlink (IEEE)
 20  MODE 0
 30  VDU23,1,0;0;0;0;
 40  REM A% = channel number : X% = primary address :
     Y% = secondary address
 50  :
 60  FOR I%=0 TO 3 STEP3:P%=&900:[OPT I%
 70  .setup
 80  LDA #&80:STA &FC23              \ software reset disable
 90  LDA #&93:STA &FC23              \ dissable all Int.
100  LDA #&83:STA &FC23              \ holdoff on all data
110  LDA #0:STA Flag                 \ RFD holdoff flag
120  STA &FC20:STA &FC21             \ set Int.masks
130  STA &FC23                       \ software reset enable
140  LDA #&8F:STA &FC23              \ send interface clear
150  LDA #&90:STA &FC23              \ send remote enable
160  LDA #&F:STA &FC23               \ reset interface clear
170  RTS
180  :
190  .getdata
200  STA Chan                        \ A% into chan byte
210  STX Prim                        \ X% into Prim byte
220  STY Sec                         \ Y% into Sec byte
230  LDA #12:STA &FC23               \ take control
    asynchronously
240  LDA #&8A:STA &FC23              \ set controler to talk
250  JSR clearlisteners
260  CLC:LDA Prim:ADC #32            \ send listen primary
    address
270  STA Data:JSR byteout
```

```
280  CLC:LDA Sec:ADC #96              \ send listen secondary
    address
290  STA Data:JSR byteout
300  LDA #11:STA &FC23                \ goto stanby
310  LDA Chan:STA Data:JSR byteout    \ send channel number
320  :
330  LDA#12:STA &FC23                 \ take control
    asynchronously
340  JSR cleartalkers
350  CLC:LDA Prim:ADC #64             \ send talk primary address
360  STA Data:JSR byteout
370  CLC:LDA Sec:ADC #96              \ send talk secondary
    address
380  STA Data:JSR byteout
390  LDA #&89:STA &FC23               \ set interface up to
    listen
400  LDA #11:STA &FC23                \ goto stanby
410  :
415  LDY #5:.loop
420  LDX #0:.delay                    \ delay for ADC to settle
430  DEX:BNE delay
435  DEY:BNE loop
440  :
450  JSR bytein:STA Data1             \ get data1
460  JSR bytein:STA Data2             \ get data2
470  RTS
480  :
490  .bytein
500  LDA Flag:STA &FC23               \ release RFD holdoff
510  LDA #2:STA Flag                  \ restore flag
520  .IEG1
530  LDA &FC20:AND#&20:BEQ IEG1       \ test for B1 in Int status
    Reg
540  LDA &FC27:STA Data               \ Data in
550  RTS
560  :
570  .byteout
580  LDA &FC20:AND#&10:BEQ byteout
590  LDA Data:STA &FC27               \ put the byte
600  RTS
610  :
620  .cleartalkers
630  LDA #95:STA Data:JSR byteout
640  LDA #10:STA &FC23:RTS             \ set controller not talk
650  :
660  .clearlisteners
670  LDA #63:STA Data:JSR byteout
680  LDA #9:STA &FC23:RTS              \ set controller not
    listen
690  :
700  .Data:EQUB 00
710  .Chan:EQUB 00
720  .Data1:EQUB 00
730  .Data2:EQUB 00
```

```
740   .Prim:EQUB 00
750   .Sec:EQUB 00
760   .Flag:EQUB 00
770   :
780   ]:NEXT I%
790   CLS:
800   PRINT'"setup = &";~setup
810   PRINT'"getdata = &";~getdata
820   PRINT'"Data1 = &";~Data1
830   PRINT'"Data2 = &";~Data2
```

NB This program was written by Mr. D Bleby.

VI.3 CONVERSION ALGORITHMS

VI.3.1 Temperature

Procedures were set out by Biodata [101] to calculate the temperature at a number of type-k thermocouples using a platinum resistance thermometer (RTD) as the cold junction reference.

i) Read signal sent from RTD.

ii) Calculate voltage across the RTD bridge thus:

Equation VI.1: $V_{OUT} = (X_{adc} - 1024) * 0.0025 / G$

iii) Calculate cold junction temperature thus:

Equation VI.2: $T_{CJ} = (R_X - 100) * 2.5707$

where:

Equation VI.3: $R_X = 100 * (0.5 + V_{OUT}) / (0.5 - V_{OUT})$

For each thermocouple:

iv) Calculate offset voltage thus:

Equation VI.3: $V_{OFFSET} = 39.557007 * T_{CJ} + 1.7584387 * T_{CJ}^2$

v) Select thermocouple and read the digital signal.

vi) Calculate thermocouple voltage:

Equation VI.5: $V_{TC} = (X_{TC} - 1024) * 0.0025 / G$

vii) Convert thermocouple voltage to reference temperature 0 °C:

Equation VI.6 $V_{MOD} = V_{TC} + V_{OFFSET}$

viii) Calculate the thermocouple temperature thus:

Equation VI.7 $T = a_0 + a_1 V_{MOD} + a_2 V_{MOD}^2 + a_3 V_{MOD}^3 + a_4 V_{MOD}^4$

The quartic coefficients are given in Table VI.1

Table VI.1 Quartic Coeffecients for Calculation of Thermocouple Temperature

Temperature Range (°C)	0-400	0-1370	400-1370
Quartic Coefficients			
a_0	0	0	6.2300671
a_1	2.4383248×10^{-2}	2.5132785×10^{-2}	2.4955374×10^{-2}
a_2	9.7830251×10^{-9}	$-6.0883423 \times 10^{-8}$	$-7.8788333 \times 10^{-8}$
a_3	$3.6276965 \times 10^{-12}$	$5.5358209 \times 10^{-13}$	$1.3269743 \times 10^{-12}$
a_4	$-2.5756438 \times 10^{-16}$	$9.3720918 \times 10^{-18}$	$1.5580541 \times 10^{-18}$

VI.3.2 Gas Analysis

VI.3.2.1 Hydrogen Analyser

The gas composition is directly proportional to the analogue signal produced by the analyser which in turn is directly proportional to the digital signal produced by the Microlink interface:

Equation VI.8: $C_{H_2} = m_1 V_{H_2} = m_2 X_{H_2}$

For $C_{H_2} = 0, X_{H_2} = X_0$

The relationship between the gas composition and the Microlink output can be expressed thus:

Equation VI.9: $C_{H_2} = m_2 X_{H_2} - X_0$

in the computer program, this was calculated thus:

Equation VI.10: $C_{H_2} = m_2 X'_{H_2}$

where:

Equation VI.11: $X'_{H_2} = X_{H_2} - X_0$

It is necessary at calibration to obtain values for m_2 and X_0 (the digital signal for the zero gas) and where:

$$\text{Equation VI.12}: \; m_2 = \frac{X_{SPAN} - X_0}{C_{SPAN}}$$

VI.3.2.2 CO, CO2 and CH4 Analysers

The gas composition is related to the analyser display as shown in Figure VI.1 (see following page). As with the hydrogen analyser, the analogue signal and hence the digital signal produced by the Microlink interface is directly proportional to the gas composition. The gas composition and the digital signal can be related thus:

Equation VI.13 $C_X = C_{CALIB} * (X' / (\alpha - (\alpha - 1) X'))$

where:

Equation VI.14 : $X' = \frac{X_X - X_0}{X_{CALIB}}$

The values of C_{CALIB} and α are presented in Table VI.2 (below).

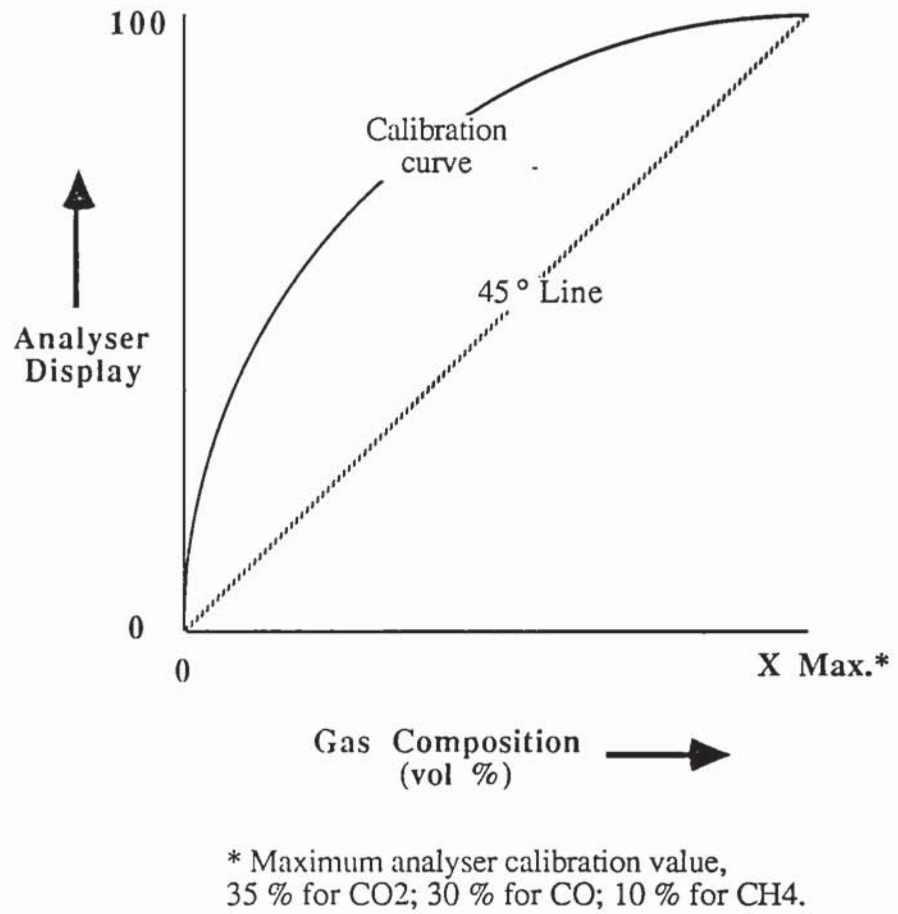


Figure VI.1 Relationship Between Analyser Display and Gas Composition (Calibration Curve)

Table VI.2 Values of C_{CALIB} and α

Gas analyser	α	C_{CALIB} (volume %)
CO	1.3256	30.0
CO_2	1.3256	35.0
CH_4	1.4703	10.0

When the analysers are calibrated:

X_0 and X_{SPAN} are measured, X_{CALIB} is calculated thus:

Equation VI.15: $X_{CALIB} = X_{SPAN} * (100 / C_{SPAN})$

VI.3.3 Flowrate and Pressure

Both flowrate and pressure can be related to the digital signal by a simple straight line relationship:

Equation VI.16: $Y = mX + k$

In calibration, values of the digital signal are recorded for a variety of pressures and flowrates. The values of m and k are then calculated using a least squares fit regression.

VI.4 NOMENCLATURE

Symbol	Description	SI Units*
C_{CALIB}	Calibration range of analyser	volume %
C_{SPAN}	Composition of component X in span gas	volume %
C_X	Composition of gas X	volume %
G	Amplifier gain	-
R_X	Resistance RTD	ohms
T_{CJ}	Cold junction temperature	°C
T_{TC}	Thermocouple temperature	°C
V_{MOD}	Thermocouple voltage referred to 0°C	microvolts
V_{OFFSET}	Cold junction offset voltage	microvolts
V_{OUT}	RTD Bridge voltage	microvolts
V_{TC}	Thermocouple voltage	microvolts
V_X	Voltage signal for gas composition of C_X	volts
X	Digital signal	-
X_{CALIB}	Digital signal at C_{CALIB}	-

X_{TC}	Digital signal from thermocouple	-
X_X	Digital signal for gas composition of C_X	-
X_{adc}	Digital signal from RTD	-
X_0	Digital signal for zero gas	-
k	Constant	-
m_i	Slope	-
α	Constant	-

* Where applicable

APPENDIX VII
RAW DATA FROM RUNS C6 TO R9

RUN C6

WOOD ADDITION DATA:

TIME	SIZE (grammes)
160	163
510	100
1010	100
1290	100
1565	100
1810	200
2295	100
2545	100

HEIGHT OF CHAR BED DATA:

TIME	HEIGHT (cms)
415	7.0
930	11.5
1050	14.0
1335	16.0
1610	16.0

GAS COMPOSITION ,PRESSURE & FLOWRATE DATA:

NO.	TIME	H2	CO	CO2	CH4	PT1	PT2
1	9	0.0	0.7	0.3	0.0	14.6	12.1
2	26	0.0	0.0	0.0	0.0	14.6	14.6
3	43	0.0	0.7	0.1	0.0	14.7	14.1
4	60	0.0	0.0	0.1	0.0	14.9	14.4
5	77	0.0	0.0	0.0	0.0	14.6	14.2
6	94	0.0	0.2	0.0	0.0	14.7	14.1
7	111	0.0	0.4	0.1	0.0	14.6	14.5
8	129	0.3	2.1	0.1	0.1	14.7	14.4
9	146	1.3	6.2	0.1	0.5	14.9	14.8
10	164	4.2	10.8	0.3	1.3	14.6	14.0
11	181	6.3	13.3	0.3	1.9	14.6	14.5
12	198	6.8	14.1	0.9	1.9	14.7	14.2
13	215	7.3	14.2	1.6	1.8	14.7	14.3
14	232	7.6	14.9	2.5	1.7	14.9	14.5
15	250	7.9	16.0	4.0	2.0	14.7	14.6
16	267	7.7	15.2	4.9	1.8	14.7	14.5
17	285	8.0	15.6	6.3	1.9	14.6	14.8
18	302	7.8	15.1	7.7	1.6	14.7	14.9
19	319	6.3	14.6	8.7	1.6	14.9	14.5
20	336	7.0	15.1	8.8	1.8	14.8	14.1
21	353	6.6	14.4	9.6	1.7	14.6	14.6
22	371	6.4	13.9	10.6	1.5	14.6	14.0
23	388	5.3	13.8	10.4	1.7	14.6	14.9
24	406	6.0	13.4	11.5	1.4	14.7	14.3
25	423	5.7	13.7	11.1	1.3	14.7	14.5
26	440	6.0	13.8	11.6	1.1	14.8	14.7
27	457	5.2	12.8	11.6	1.4	14.6	14.6
28	474	5.1	12.6	11.6	1.3	14.7	14.7
29	492	4.6	12.5	11.7	1.3	14.6	14.5
30	509	5.3	12.8	12.6	1.2	14.6	14.5
31	527	5.5	13.5	12.1	1.3	14.6	13.7
32	544	5.7	13.0	12.2	1.3	14.8	15.1
33	561	6.0	13.3	12.5	1.2	14.6	14.4
34	578	6.0	14.0	12.7	1.0	14.7	14.9
35	595	5.8	13.6	12.7	1.2	14.9	14.9
36	613	6.2	13.9	14.0	1.0	14.6	14.9

37	630	6.0	13.9	12.6	1.0	14.7	14.8
38	648	6.4	13.8	12.7	1.5	14.7	14.8
39	664	6.6	13.6	12.5	1.4	14.6	15.2
40	682	7.3	13.8	12.5	1.3	14.9	14.8
41	699	7.5	14.0	12.7	1.5	14.6	15.1
42	716	7.6	14.0	12.6	1.5	14.6	14.5
43	734	7.5	13.9	12.6	1.5	14.7	15.1
44	751	7.5	14.0	12.8	1.7	14.6	14.9
45	768	7.5	14.2	12.9	1.7	14.6	15.0
46	785	6.6	14.8	12.9	1.6	14.7	14.9
47	802	6.0	14.4	12.8	1.4	14.6	14.6
48	820	6.4	13.5	12.7	1.3	14.9	14.3
49	837	6.2	13.9	13.6	1.4	14.8	14.6
50	855	6.3	13.3	13.3	1.3	14.6	14.6
51	872	5.9	13.1	13.3	1.1	14.6	14.3
52	889	7.5	13.8	13.2	1.0	14.8	14.3
53	906	8.7	14.5	13.2	1.1	14.5	15.0
54	923	8.2	15.2	13.6	1.1	14.7	14.3
55	941	7.5	15.3	14.0	1.2	14.6	14.9
56	958	8.5	14.4	13.0	1.1	14.5	14.2
57	976	8.8	14.4	13.2	0.9	14.6	15.2
58	993	8.7	14.4	14.0	1.0	14.7	15.4
59	1010	9.2	14.6	14.1	1.1	14.5	14.7
60	1027	8.2	14.7	13.8	1.1	14.6	15.1
61	1044	8.5	14.1	13.4	1.3	14.6	14.3
62	1062	8.6	14.0	13.1	1.1	14.5	14.5
63	1079	8.7	14.2	13.1	1.1	14.7	14.9
64	1097	7.4	15.6	13.7	1.1	14.7	15.0
65	1114	8.4	15.5	13.1	0.9	14.6	15.1
66	1131	8.3	16.2	12.9	0.8	14.7	14.9
67	1148	8.6	16.2	13.0	0.9	14.6	15.1
68	1165	7.9	17.1	13.1	1.1	14.5	15.1
69	1183	8.5	16.1	12.7	1.3	14.6	14.7
70	1200	9.7	16.3	13.1	1.3	14.5	14.7
71	1218	9.4	16.3	12.6	1.1	14.7	15.2
72	1235	9.5	15.9	14.1	1.1	14.5	14.1
73	1252	8.9	16.3	13.0	1.1	14.8	14.6
74	1269	9.6	17.1	12.9	1.1	14.7	14.7
75	1286	9.0	16.5	14.2	0.9	14.7	15.2
76	1304	9.3	16.3	13.5	1.0	14.8	14.7
77	1321	8.8	16.5	13.0	1.3	14.6	14.4
78	1339	9.5	15.9	12.8	1.5	14.7	15.0
79	1356	8.4	15.3	12.8	1.5	14.6	14.2
80	1373	9.3	15.7	12.8	1.2	14.4	14.1
81	1390	9.1	15.0	13.9	1.1	14.4	14.6
82	1407	9.2	14.9	13.1	1.2	14.4	14.8
83	1425	7.9	14.9	12.7	1.2	14.6	14.9
84	1442	8.0	15.1	12.5	1.4	14.6	15.2
85	1460	9.0	15.1	13.2	1.2	14.8	15.0
86	1477	9.2	16.6	12.6	1.1	14.6	14.7
87	1494	8.9	15.3	14.0	1.1	14.5	15.1
88	1511	9.1	14.9	12.9	1.2	14.4	14.3
89	1528	7.8	15.0	12.9	1.2	14.5	15.0
90	1546	7.9	14.9	12.9	1.1	14.5	14.7
91	1563	9.3	14.5	13.0	1.0	14.7	14.9
92	1581	9.3	15.0	13.1	1.1	14.5	14.6
93	1598	9.3	14.2	13.0	1.1	14.4	14.2
94	1615	8.5	14.4	12.8	1.2	14.5	14.7
95	1632	9.1	14.4	13.0	1.2	14.5	14.4

96	1649	8.8	14.6	13.2	1.2	14.5	14.5
97	1667	9.4	14.8	12.9	1.2	14.6	14.7
98	1684	9.6	14.5	13.2	1.1	14.4	14.9
99	1702	9.3	14.5	12.9	1.3	14.7	14.2
100	1719	9.3	14.2	12.7	1.1	14.5	14.9
101	1736	9.0	14.2	12.7	1.0	14.5	14.0
102	1753	8.8	15.1	12.8	1.0	14.7	14.9
103	1770	9.4	14.9	13.2	0.9	14.5	15.2
104	1788	9.5	15.9	12.7	1.0	14.5	14.9
105	1805	9.8	15.3	12.6	1.3	14.5	14.2
106	1823	9.7	15.3	12.6	1.3	14.5	14.8
107	1840	8.9	15.0	12.8	1.2	14.6	14.1
108	1857	8.1	15.0	12.7	1.2	14.5	14.3
109	1874	8.5	14.6	12.9	1.0	14.4	15.0
110	1891	7.6	14.1	12.6	0.8	14.5	14.6
111	1909	7.3	14.7	12.7	0.9	14.7	15.2
112	1926	8.8	15.2	12.7	1.1	14.5	15.1
113	1944	9.7	14.1	12.5	1.3	14.4	14.6
114	1961	9.6	14.2	12.1	1.3	14.6	14.2
115	1978	9.7	14.4	13.2	1.2	14.6	15.2
116	1995	9.7	14.2	13.0	1.2	14.5	14.4
117	2012	8.7	14.4	12.1	1.0	14.5	14.5
118	2030	9.9	15.1	12.3	0.9	14.5	14.5
119	2047	9.2	14.2	12.2	1.1	14.4	14.6
120	2065	9.8	14.2	12.7	0.9	14.7	15.3
121	2082	10.1	14.5	12.4	1.1	14.4	14.2
122	2099	8.6	14.8	12.0	1.1	14.5	14.6
123	2116	10.1	14.5	13.0	1.2	14.4	14.9
124	2133	10.1	15.6	11.9	1.1	14.6	14.8
125	2151	9.7	15.8	11.7	1.1	14.4	14.2
126	2168	9.0	14.7	11.6	1.3	14.4	14.4
127	2185	9.6	15.5	11.5	1.3	14.4	14.3
128	2202	9.7	14.9	13.3	1.3	14.5	15.1
129	2220	9.3	15.0	11.5	1.3	14.5	14.8
130	2237	8.0	14.6	11.6	1.5	14.4	14.4
131	2255	9.3	14.3	11.8	1.2	14.4	14.9
132	2272	8.7	14.3	11.6	1.2	14.7	14.9
133	2289	9.8	14.3	11.5	1.4	14.4	15.3
134	2306	9.8	14.2	12.1	1.1	14.4	15.1
135	2323	9.7	15.0	11.9	1.1	14.5	14.3
136	2341	9.4	14.3	11.6	1.2	14.6	14.7
137	2358	9.2	14.6	11.5	1.3	14.6	14.2
138	2376	9.0	14.4	11.6	1.2	14.5	14.4
139	2393	8.8	15.1	11.9	1.3	14.2	14.9
140	2410	8.8	14.5	11.9	1.2	14.3	13.9
141	2427	9.0	14.9	11.8	1.3	14.4	15.3
142	2444	7.5	14.6	11.9	0.9	14.2	14.8
143	2462	8.8	14.7	11.8	0.9	14.3	14.1
144	2479	9.1	15.1	13.2	0.9	14.2	13.9
145	2497	9.6	15.4	11.9	0.9	14.3	14.9
146	2514	9.7	15.3	12.8	1.1	14.5	14.2
147	2531	10.2	15.4	11.7	1.3	14.2	15.1
148	2548	10.3	14.8	12.1	1.1	14.3	14.6
149	2565	10.2	15.3	11.7	1.0	14.5	14.4
150	2584	8.9	15.4	11.7	1.1	14.4	14.5
151	2601	10.1	16.0	12.2	0.6	14.5	15.2
152	2619	9.8	17.0	11.7	0.6	14.5	14.6
153	2636	9.5	16.7	12.2	0.7	14.5	14.3
154	2653	0.0	0.0	0.4	0.0	14.3	15.1

155	2670	0.0	0.1	0.3	0.0	14.3	15.1

TEMPERATURE DATA:

THERMOCOUPLE NUMBERS (TEMPERATURES deg C)

NO.	TIME	1	2	3	4	5	6	7	8
1	9	12.8	12.9	17.1	15.4	10.0	16.2	16.2	15.6
2	26	12.8	12.9	17.0	15.3	9.7	16.2	16.2	15.6
3	43	12.9	12.9	17.0	15.9	9.7	16.2	16.2	15.6
4	60	12.9	12.9	17.0	16.5	9.6	16.2	16.2	21.2
5	77	12.9	12.9	17.0	16.8	9.9	17.4	17.4	47.4
6	94	12.9	12.9	17.1	16.2	10.9	41.2	23.7	74.1
7	111	12.9	13.0	17.1	16.5	14.5	69.2	41.2	58.6
8	129	12.9	13.2	17.1	16.2	21.5	91.4	72.3	44.3
9	146	12.9	13.4	17.1	15.7	27.0	157.2	105.0	72.9
10	164	12.9	13.4	17.1	15.6	27.6	225.8	160.8	150.5
11	181	12.9	13.5	17.2	15.4	29.2	278.3	256.0	405.9
12	198	12.9	13.4	17.3	16.6	29.5	325.6	372.1	718.6
13	215	12.9	13.4	17.3	17.0	30.1	357.8	412.5	839.1
14	232	12.9	13.4	17.3	17.1	30.7	380.4	425.5	819.5
15	250	12.8	13.4	17.4	17.5	31.0	399.4	420.1	801.8
16	267	12.8	13.4	17.3	16.8	31.9	413.6	421.3	803.1
17	285	12.9	13.4	17.4	17.3	32.5	427.8	430.2	766.7
18	302	12.9	13.4	17.3	18.3	33.7	436.1	427.3	730.6
19	319	12.9	13.4	17.4	17.2	34.3	439.7	424.9	724.0
20	336	12.9	13.5	17.4	17.0	35.6	444.5	426.7	722.8
21	353	12.9	13.5	17.4	18.3	36.2	449.8	422.5	691.7
22	371	12.9	13.5	17.6	16.7	36.5	451.0	422.5	678.6
23	388	13.0	13.5	17.6	18.4	37.1	451.0	421.3	666.6
24	406	12.9	13.5	17.6	18.5	37.7	453.3	420.8	672.0
25	423	12.9	13.5	17.6	18.1	38.0	459.9	420.2	648.2
26	440	12.9	13.6	17.7	18.5	38.9	467.5	420.8	618.5
27	457	12.9	13.5	17.7	17.2	39.2	477.0	420.2	660.1
28	474	12.9	13.7	17.7	18.9	40.2	485.9	423.1	641.6
29	492	12.9	13.6	17.7	18.4	40.8	488.3	423.7	612.5
30	509	12.9	13.5	17.7	19.9	41.1	487.1	430.8	614.3
31	527	13.0	13.6	17.8	19.2	40.8	491.2	436.8	594.8
32	544	12.9	13.5	17.9	18.8	40.8	500.1	632.7	566.9
33	561	13.0	13.5	17.9	19.3	41.1	511.9	564.6	540.3
34	578	13.0	13.6	18.0	19.4	41.4	517.3	542.1	521.4
35	595	13.0	13.6	18.0	20.0	41.4	529.1	527.9	514.3
36	613	13.0	13.7	18.0	20.0	42.6	523.2	495.4	529.7
37	630	13.0	13.7	18.0	19.5	42.3	514.3	498.3	540.3
38	648	13.0	13.6	18.0	17.1	42.0	503.1	462.2	564.6
39	664	13.0	13.8	18.2	19.0	42.7	495.4	448.7	583.6
40	682	13.0	13.7	18.1	17.3	42.6	491.2	439.7	587.7
41	699	13.0	13.8	18.2	19.4	42.7	486.5	432.7	588.3
42	716	13.0	13.7	18.2	19.0	43.3	481.2	427.3	580.0
43	734	13.0	13.7	18.2	21.4	43.6	473.5	421.4	581.8
44	751	13.0	13.7	18.3	17.9	43.6	466.4	416.1	583.6
45	768	13.0	13.7	18.3	19.4	41.8	458.7	411.9	586.5
46	785	13.0	13.7	18.4	20.2	41.5	452.2	410.2	588.9
47	802	13.0	13.7	18.4	17.8	42.4	452.2	407.8	590.7
48	820	13.1	13.7	18.4	17.8	41.8	455.2	404.8	575.3
49	837	13.0	13.7	18.5	20.6	42.1	445.7	402.5	575.3
50	855	13.1	13.8	18.7	18.9	45.1	459.3	410.2	600.8
51	872	13.1	14.0	18.8	18.3	47.3	478.3	424.4	631.0
52	889	13.1	14.2	19.0	19.7	47.6	497.2	432.1	650.1
53	906	13.1	14.1	19.0	18.6	48.8	515.6	438.6	653.6
54	923	13.1	14.2	19.2	23.8	52.5	531.0	445.2	645.3

55	941	13.1	14.1	19.3	22.6	54.0	523.9	451.7	659.6
56	958	13.1	14.2	19.3	21.8	54.3	536.3	460.0	666.2
57	976	13.1	14.2	19.4	22.6	55.6	537.5	469.5	673.3
58	993	13.1	14.1	19.4	23.5	55.6	535.1	481.3	691.8
59	1010	13.2	14.2	19.3	20.9	57.1	536.9	486.6	644.8
60	1027	13.1	14.2	19.6	21.7	57.5	529.8	478.4	640.0
61	1044	13.1	14.2	19.7	22.1	57.8	526.3	476.0	641.2
62	1062	13.2	14.1	19.8	21.6	58.4	521.6	475.4	654.9
63	1079	13.1	14.1	19.9	22.5	58.4	519.8	472.5	656.7
64	1097	13.1	14.1	19.9	22.3	58.4	523.9	473.1	684.1
65	1114	13.2	14.1	19.9	23.9	58.7	529.9	480.8	699.1
66	1131	13.2	14.1	20.1	21.2	60.0	536.4	484.3	657.3
67	1148	13.2	14.3	20.1	25.3	60.0	530.5	473.1	636.5
68	1165	13.2	14.3	20.2	22.7	60.3	529.3	469.6	633.6
69	1183	13.2	14.3	20.4	24.7	60.6	525.2	469.0	642.5
70	1200	13.2	14.3	20.4	22.6	60.3	523.4	469.0	647.9
71	1218	13.2	14.2	20.4	22.9	60.4	524.6	470.8	669.3
72	1235	13.3	14.3	20.6	25.6	60.7	522.3	471.4	655.0
73	1252	13.2	14.1	20.7	20.6	60.4	518.8	472.6	710.0
74	1269	13.2	14.3	20.7	23.4	61.0	521.1	481.5	714.8
75	1286	13.2	14.5	20.9	24.2	62.9	521.7	480.3	645.0
76	1304	13.2	14.4	20.9	25.5	62.5	511.7	467.3	606.4
77	1321	13.3	14.4	21.0	21.4	61.7	507.0	461.4	610.0
78	1339	13.2	14.3	21.2	20.1	63.2	504.6	459.7	618.9
79	1356	13.2	14.3	21.4	21.7	63.8	504.6	456.1	611.2
80	1373	13.3	14.3	21.3	24.9	64.5	501.1	452.0	607.6
81	1390	13.3	14.4	21.3	25.2	65.7	498.8	451.4	607.7
82	1407	13.3	14.4	21.5	23.4	66.3	495.8	449.7	611.8
83	1425	13.3	14.4	21.6	24.1	66.1	494.1	447.9	613.6
84	1442	13.3	14.3	21.6	24.7	66.1	491.1	446.2	614.3
85	1460	13.3	14.2	21.7	24.2	66.7	489.4	446.2	617.8
86	1477	13.3	14.3	21.7	23.6	66.4	487.1	444.4	618.5
87	1494	13.3	14.3	21.8	24.6	66.4	484.7	443.3	619.1
88	1511	13.2	14.3	21.8	26.1	66.5	482.9	443.3	619.7
89	1528	13.3	14.3	21.9	23.7	66.5	480.6	443.3	620.3
90	1546	13.3	14.3	22.0	23.9	66.5	480.0	441.6	620.3
91	1563	13.3	14.4	22.0	26.4	66.9	480.1	442.8	632.8
92	1581	13.4	14.3	22.2	25.9	66.6	478.9	443.4	623.9
93	1598	13.4	14.4	22.2	21.9	66.9	477.2	441.0	619.2
94	1615	13.3	14.4	22.3	24.8	66.9	476.6	440.5	617.4
95	1632	13.3	14.3	22.3	23.0	66.3	472.4	438.1	610.3
96	1649	13.3	14.3	22.5	26.9	66.3	469.5	435.8	609.8
97	1667	13.3	14.3	22.5	25.6	66.4	467.8	436.4	611.6
98	1684	13.3	14.3	22.5	27.6	66.7	467.2	436.4	612.8
99	1702	13.3	14.4	22.5	24.7	65.5	479.1	444.1	622.3
100	1719	13.3	14.3	22.6	22.8	65.5	489.1	449.5	638.4
101	1736	13.4	14.2	22.6	22.9	65.6	493.9	452.5	649.7
102	1753	13.4	14.4	22.7	23.8	66.5	492.7	450.7	646.7
103	1770	13.3	14.4	22.8	23.6	66.2	489.2	449.0	640.8
104	1788	13.3	14.4	22.9	29.1	66.3	486.3	448.4	665.8
105	1805	13.4	14.3	22.9	26.3	66.3	486.9	456.1	710.1
106	1823	13.3	14.3	22.9	26.8	66.6	489.9	465.0	711.9
107	1840	13.3	14.4	23.0	20.9	68.2	494.1	466.3	641.5
108	1857	13.3	14.4	23.3	21.7	69.4	493.5	459.2	624.9
109	1874	13.4	14.5	23.4	26.0	70.4	497.7	458.6	622.6
110	1891	13.3	14.5	23.5	26.3	70.7	498.9	456.3	617.9
111	1909	13.4	14.6	23.3	24.4	70.7	500.1	455.1	620.3
112	1926	13.3	14.5	23.7	27.1	71.4	497.7	455.7	617.3
113	1944	13.3	14.5	24.0	26.0	72.0	496.0	453.4	612.6

114	1961	13.4	14.5	23.9	26.5	71.8	493.1	451.1	613.2
115	1978	13.4	14.5	23.9	24.5	71.8	490.7	449.9	612.1
116	1995	13.4	14.5	23.9	24.3	71.8	489.6	449.9	612.7
117	2012	13.4	14.6	23.9	25.9	71.8	488.4	449.4	611.5
118	2030	13.3	14.7	24.0	29.1	72.2	487.9	449.4	612.7
119	2047	13.3	14.5	24.1	25.0	72.2	486.7	448.8	606.3
120	2065	13.4	14.5	24.2	24.1	72.2	484.4	446.5	607.5
121	2082	13.3	14.5	24.2	28.4	72.9	483.8	447.7	608.7
122	2099	13.3	14.6	24.5	23.6	72.9	485.0	447.1	605.1
123	2116	13.4	14.6	24.4	28.7	73.3	485.1	445.4	602.2
124	2133	13.3	14.6	24.6	24.6	73.9	486.3	445.4	605.2
125	2151	13.4	14.6	24.7	24.5	74.2	484.5	445.5	613.0
126	2168	13.4	14.5	24.7	23.4	74.3	484.6	445.5	613.0
127	2185	13.4	14.5	24.8	27.6	74.0	485.2	445.5	609.5
128	2202	13.3	14.6	24.8	28.7	74.0	485.2	444.4	606.5
129	2220	13.4	14.5	25.0	30.0	74.1	485.3	444.4	607.2
130	2237	13.3	14.6	25.1	28.8	74.4	484.1	444.4	607.2
131	2255	13.3	14.5	25.2	30.9	74.7	483.5	443.9	605.4
132	2272	13.3	14.5	25.2	25.5	75.1	481.8	442.1	591.8
133	2289	13.4	14.5	25.3	27.1	74.5	476.5	438.0	586.0
134	2306	13.4	14.6	25.4	29.4	75.5	477.7	436.9	591.9
135	2323	13.4	14.5	25.5	29.2	75.5	477.7	435.7	577.1
136	2341	13.3	14.6	25.5	25.4	74.6	473.6	430.4	565.9
137	2358	13.4	14.6	25.7	26.7	76.5	469.0	429.3	567.7
138	2376	13.4	14.6	25.8	29.9	77.1	469.6	432.3	584.9
139	2393	13.4	14.6	25.8	30.8	77.5	476.7	436.4	596.2
140	2410	13.4	14.7	26.0	28.4	77.8	482.7	441.2	605.2
141	2427	13.4	14.8	26.2	27.0	78.8	485.6	444.8	601.6
142	2444	13.4	14.8	26.3	28.0	79.4	486.9	445.4	593.4
143	2462	13.3	14.8	26.2	32.3	79.4	486.3	443.1	587.5
144	2479	13.4	14.7	26.2	26.9	78.9	486.3	440.7	588.1
145	2497	13.4	14.6	26.2	27.1	78.9	485.8	439.0	586.4
146	2514	13.4	14.5	26.1	24.1	79.2	482.8	439.0	592.9
147	2531	13.4	14.5	26.1	29.1	79.3	481.7	440.3	602.4
148	2548	13.4	14.6	26.3	30.1	79.3	485.9	443.3	620.8
149	2565	13.4	14.7	26.5	26.3	80.3	495.4	451.0	638.1
150	2584	13.4	14.7	26.8	27.5	80.6	491.3	451.6	613.2
151	2601	13.4	14.8	26.8	28.5	80.7	486.0	449.9	604.3
152	2619	13.4	14.8	26.9	29.2	81.0	484.2	449.3	602.6
153	2636	13.5	14.8	27.0	30.1	81.0	481.9	448.8	600.8
154	2653	13.4	14.7	27.0	28.6	81.1	480.8	448.2	601.5
155	2670	13.4	14.8	27.1	30.6	82.0	479.6	448.8	603.3

TEMPERATURE DATA:

		THERMOCOUPLE NUMBERS (TEMPERATURES deg C)						
NO.	TIME	9	10	11	12	13	14	15
1	9	15.6	15.6	15.6	16.2	16.2	15.6	17.8
2	26	15.6	15.6	16.2	16.2	16.2	15.6	17.7
3	43	16.2	15.6	15.6	16.2	16.2	15.6	17.7
4	60	19.3	21.2	18.7	19.3	16.2	17.4	17.7
5	77	29.3	30.6	28.1	25.6	16.2	20.6	17.6
6	94	58.6	52.4	39.9	41.8	16.2	29.3	17.6
7	111	57.4	44.3	34.3	33.1	16.2	24.3	17.7
8	129	40.[illegible]	33.7	27.4	27.4	16.2	21.8	17.8
9	146	31.8	27.4	23.1	24.9	16.2	20.6	17.8
10	164	27.4	24.3	20.6	23.7	16.2	20.6	17.8
11	181	24.9	22.4	19.3	23.7	16.2	20.6	17.9
12	198	24.3	21.2	18.7	23.7	16.8	19.9	17.9
13	215	24.9	20.6	18.7	24.3	16.2	19.9	17.9

14	232	31.2	19.3	18.1	24.3	16.8	19.9	18.1
15	250	39.3	19.3	18.0	24.9	16.8	19.9	18.0
16	267	58.6	19.3	18.0	26.2	16.8	20.5	18.1
17	285	78.4	18.7	18.0	26.8	16.8	21.2	18.3
18	302	86.5	19.3	18.7	27.4	16.8	21.8	18.3
19	319	100.1	19.3	18.0	28.7	16.8	23.0	18.3
20	336	105.6	19.9	18.7	29.9	16.8	23.7	18.4
21	353	106.9	19.9	18.7	30.6	16.8	24.3	18.4
22	371	126.6	20.6	18.7	31.8	16.8	24.9	18.4
23	388	141.9	21.2	18.7	31.2	16.8	26.2	18.7
24	406	187.6	21.2	18.7	31.2	16.8	27.4	18.7
25	423	298.7	23.1	19.3	30.6	16.8	29.3	18.7
26	440	495.4	22.4	19.3	30.6	16.8	30.6	18.7
27	457	644.6	22.4	19.3	32.4	16.8	31.8	18.8
28	474	733.0	22.4	19.3	33.7	16.8	32.4	18.8
29	492	826.2	23.1	19.9	34.9	16.8	33.1	18.8
30	509	806.7	23.7	19.9	36.2	16.8	33.7	18.8
31	527	673.2	26.9	20.0	37.5	16.8	36.2	18.9
32	544	660.7	31.8	19.9	38.1	16.8	37.4	18.9
33	561	712.0	35.6	20.6	39.9	16.8	39.3	18.9
34	578	731.8	38.7	20.6	42.5	16.8	41.8	19.2
35	595	695.3	46.2	20.6	44.9	16.8	43.1	19.2
36	613	707.3	46.2	21.2	46.8	16.8	44.3	19.2
37	630	684.5	58.6	21.8	48.1	16.8	44.3	19.2
38	648	676.8	61.1	21.2	47.4	16.8	45.6	19.2
39	664	673.2	72.3	21.3	48.7	16.9	47.5	19.2
40	682	654.2	84.7	21.8	47.4	16.8	48.1	19.2
41	699	661.9	97.7	21.9	49.3	16.9	49.3	19.3
42	716	663.7	110.0	22.5	51.8	16.9	50.6	19.3
43	734	669.1	105.7	23.1	54.3	16.9	52.4	19.3
44	751	676.2	115.5	23.1	57.4	16.9	53.1	19.4
45	768	673.3	135.8	23.2	59.3	16.9	53.1	19.5
46	785	663.1	265.1	24.4	63.0	16.9	55.0	19.6
47	802	641.7	383.4	25.0	74.2	17.5	57.4	19.6
48	820	629.8	347.7	26.3	108.8	17.5	58.7	19.6
49	837	629.3	400.7	27.6	154.2	17.5	60.0	20.1
50	855	661.9	587.7	27.5	122.3	17.5	58.7	20.7
51	872	713.9	734.3	26.9	145.7	17.5	61.8	20.8
52	889	712.1	643.5	26.9	137.7	18.2	66.2	21.2
53	906	712.1	743.3	27.6	115.6	18.2	68.7	21.5
54	923	716.3	811.1	28.8	307.8	18.2	72.4	21.6
55	941	711.0	808.7	30.1	156.1	18.8	79.8	21.8
56	958	695.4	806.9	32.0	128.5	18.8	83.5	22.1
57	976	687.1	822.1	33.9	127.3	18.9	92.2	22.2
58	993	675.1	921.5	33.9	338.3	18.9	102.1	22.5
59	1010	668.6	861.9	35.1	673.3	18.9	106.4	22.7
60	1027	677.5	888.5	37.0	439.9	18.9	126.1	22.9
61	1044	687.1	860.7	39.5	672.2	18.9	151.9	23.0
62	1062	682.9	811.2	46.4	765.7	18.9	188.5	23.1
63	1079	662.1	856.5	47.0	534.0	18.9	143.9	23.3
64	1097	663.3	786.3	57.6	675.2	18.9	123.1	23.4
65	1114	639.5	746.5	53.9	758.5	19.6	112.7	23.5
66	1131	615.7	694.3	58.9	762.7	19.6	136.0	23.7
67	1148	630.6	742.9	53.2	779.1	19.6	9[illegible].7	23.8
68	1165	663.3	754.9	62.6	814.9	19.6	90.5	23.9
69	1183	675.9	742.3	69.5	860.2	19.6	77.5	24.1
70	1200	675.9	723.1	79.4	710.5	19.6	71.9	24.2
71	1218	652.7	731.5	83.7	444.2	19.6	83.1	24.2
72	1235	647.9	745.4	88.1	327.1	20.3	88.1	24.4

73	1252	658.0	740.6	106.0	331.9	20.3	81.3	24.5
74	1269	638.4	718.4	153.2	209.8	20.3	92.4	24.5
75	1286	616.5	732.2	222.6	370.1	19.7	97.4	24.5
76	1304	628.3	740.6	202.0	607.6	20.3	109.7	24.7
77	1321	649.2	756.9	177.1	887.5	20.4	134.3	24.8
78	1339	657.5	759.3	294.9	924.2	20.4	169.8	25.0
79	1356	653.4	770.2	342.7	684.9	20.4	147.8	25.0
80	1373	651.0	769.6	575.7	795.6	20.4	165.6	25.0
81	1390	657.0	732.3	713.7	985.5	20.4	624.3	25.1
82	1407	659.4	711.9	722.1	838.3	21.1	645.7	25.2
83	1425	658.8	743.1	780.5	930.0	21.1	359.5	25.4
84	1442	668.9	742.0	793.9	835.9	21.1	487.6	25.4
85	1460	670.8	732.4	813.4	800.6	21.2	339.3	25.5
86	1477	669.0	734.8	824.4	796.4	21.2	281.8	25.5
87	1494	673.8	745.6	808.5	792.7	21.2	419.6	25.6
88	1511	678.6	753.5	896.4	759.5	21.2	517.8	25.8
89	1528	682.2	768.6	886.5	740.9	21.2	609.6	25.8
90	1546	701.3	761.4	843.4	873.6	21.3	534.4	25.9
91	1563	715.1	751.7	823.3	809.3	21.3	487.8	25.8
92	1581	693.6	765.0	892.2	743.3	21.3	443.4	25.9
93	1598	689.4	772.9	973.0	730.2	22.0	459.4	26.0
94	1615	690.0	769.9	908.3	729.0	22.0	682.9	26.0
95	1632	680.5	782.0	909.0	712.8	21.4	682.3	26.0
96	1649	684.7	779.6	805.7	720.6	21.4	732.0	26.1
97	1667	682.9	760.9	847.3	750.7	22.1	722.4	26.2
98	1684	684.8	745.3	828.3	708.1	22.1	700.9	26.2
99	1702	705.7	779.7	892.3	783.3	22.1	773.7	26.3
100	1719	728.5	785.8	909.1	840.6	22.1	770.1	26.2
101	1736	748.4	765.9	865.8	965.6	22.2	829.6	26.2
102	1753	739.4	732.8	791.9	830.9	22.2	782.2	26.3
103	1770	747.8	711.2	788.9	991.1	22.8	809.5	26.4
104	1788	801.1	682.5	758.7	753.9	22.9	729.8	26.4
105	1805	797.4	649.8	793.2	745.5	22.9	639.1	26.2
106	1823	702.3	641.5	804.2	813.3	22.9	740.7	26.6
107	1840	672.5	726.9	771.5	660.6	23.0	774.5	26.6
108	1857	695.2	758.2	878.3	833.5	23.0	815.2	26.8
109	1874	700.0	776.9	840.2	912.5	23.0	831.7	26.8
110	1891	694.6	778.8	815.8	958.3	23.0	842.7	26.9
111	1909	707.8	775.2	888.9	1040.8	23.1	807.3	27.1
112	1926	693.5	763.1	892.1	1002.9	23.1	831.7	27.1
113	1944	700.7	782.5	899.5	917.0	23.1	836.1	27.1
114	1961	704.3	785.0	897.7	946.5	23.8	725.3	27.2
115	1978	703.8	777.7	842.9	1078.1	23.8	700.8	27.2
116	1995	706.8	773.5	822.7	988.3	23.9	679.9	27.4
117	2012	701.4	759.1	818.5	1016.5	23.9	650.1	27.4
118	2030	699.1	751.9	824.0	1068.4	23.9	652.5	27.4
119	2047	693.7	757.9	856.5	978.9	23.9	663.3	27.4
120	2065	699.1	765.2	808.8	977.0	24.0	686.6	27.5
121	2082	693.2	746.5	773.1	875.0	23.4	662.2	27.6
122	2099	684.8	730.9	763.4	1047.0	24.0	644.9	27.6
123	2116	682.5	723.2	767.1	1005.8	24.1	615.9	27.7
124	2133	687.3	739.4	763.5	900.5	24.1	576.8	27.9
125	2151	695.1	731.6	773.8	773.8	24.1	562.0	27.8
126	2168	690.9	731.7	767.8	861.0	24.2	549.6	27.9
127	2185	681.4	727.5	781.7	807.2	24.2	560.9	27.9
128	2202	683.2	737.1	784.8	759.4	23.6	556.8	27.8
129	2220	681.5	742.0	781.2	760.0	24.3	564.5	28.0
130	2237	683.9	736.6	718.6	752.2	24.3	559.8	28.0
131	2255	670.2	707.8	736.6	813.4	24.3	546.8	28.1

132	2272	654.2	706.1	748.7	753.5	24.4	606.6	28.1
133	2289	660.8	731.9	749.3	700.1	24.4	678.0	28.2
134	2306	661.4	709.7	724.7	752.4	24.4	597.8	28.2
135	2323	641.2	700.2	742.2	696.6	24.5	573.0	28.2
136	2341	635.3	708.6	766.9	665.0	24.5	554.7	28.1
137	2358	643.6	736.2	825.2	645.4	23.9	554.1	28.7
138	2376	671.0	763.4	800.3	682.4	24.6	583.2	28.7
139	2393	681.8	776.1	805.8	706.3	24.0	574.9	28.7
140	2410	687.2	765.3	787.6	759.2	24.7	571.4	28.8
141	2427	677.7	749.0	768.9	794.9	24.1	571.4	28.8
142	2444	658.7	726.2	796.2	781.0	24.7	558.4	28.9
143	2462	666.4	749.7	792.0	726.2	24.1	554.3	29.1
144	2479	662.9	739.5	813.3	661.7	24.2	551.4	29.0
145	2497	670.1	764.2	856.7	634.4	24.2	564.4	28.9
146	2514	683.2	788.4	858.0	632.0	24.2	582.2	29.2
147	2531	702.4	815.2	817.6	840.8	24.3	578.1	29.2
148	2548	739.0	893.3	797.6	866.1	24.9	549.2	29.3
149	2565	722.2	820.1	803.1	962.8	24.3	522.6	29.2
150	2584	704.9	775.2	807.4	984.4	24.4	515.5	29.2
151	2601	691.8	774.1	801.4	918.3	24.4	504.9	29.3
152	2619	688.8	763.8	810.5	937.7	24.5	498.4	29.3
153	2636	689.5	777.2	802.0	1021.6	24.5	493.7	29.3
154	2653	692.5	774.2	797.8	1088.7	25.2	487.3	29.5
155	2670	693.7	773.6	796.0	893.5	25.2	490.3	29.4

RUN R7

WOOD ADDITION DATA:

TIME	SIZE (grammes)
794	100
1028	100
1260	100
1700	200
2505	100
2918	100
3120	200
3528	100
3810	100
4125	100
4455	100
4755	100
4990	100
5215	100
5445	100
5835	100

HEIGHT OF CHAR BED DATA:

TIME	HEIGHT (cms)
210	4.0
794	5.5
954	5.5
1060	5.5
1845	6.5
2150	9.0
2372	9.5
2420	10.0
2530	11.0
2608	11.5
2773	12.0
2956	13.0
3002	13.5
3120	13.5
3635	12.0
4065	12.0
4200	13.5
4240	14.0
4560	14.5
4610	15.0
4808	16.0
4963	17.0
5291	18.0
5400	17.5
5929	17.5

GAS COMPOSITION ,PRESSURE & FLOWRATE DATA:

NO.	TIME	H2	CO	CO2	CH4	N2	PT1	PT2	FLOW
1	2	0.3	0.0	0.0	0.0	99.7	14.7	14.8	1.1
2	16	0.0	0.0	0.0	0.0	100.0	14.7	14.8	1.0
3	29	0.[illegible]	0.0	0.1	0.0	99.1	14.7	14.8	1.0
4	43	0.4	0.0	0.0	0.0	99.6	14.7	14.8	1.0
5	57	0.7	0.0	0.0	0.0	99.3	14.7	14.8	1.0
6	70	0.0	0.0	0.0	0.0	100.0	14.7	14.8	1.0
7	83	0.2	0.1	0.1	0.0	99.6	14.7	14.8	1.0
8	98	0.5	0.3	0.1	0.0	99.1	14.7	14.8	1.0

9	111	0.2	0.6	0.0	0.0	99.2	14.7	14.8	1.0
10	125	0.6	1.0	0.1	0.0	98.3	14.7	14.8	1.0
11	139	1.1	1.8	0.1	0.1	96.9	14.7	14.8	1.0
12	153	0.5	2.7	0.3	0.3	96.2	14.7	14.8	0.9
13	166	0.8	3.5	0.5	0.4	94.8	14.7	14.8	1.0
14	181	1.4	4.9	0.9	0.7	92.1	14.7	14.8	1.0
15	194	1.8	6.5	1.3	1.0	89.4	14.7	14.8	1.0
16	208	2.8	8.3	1.8	1.3	85.8	14.7	14.8	1.0
17	222	3.6	9.7	2.3	1.7	82.7	14.7	14.8	1.0
18	235	6.2	10.9	3.2	1.9	77.8	14.7	14.8	1.0
19	249	6.0	11.7	4.0	2.1	76.2	14.7	14.8	1.0
20	263	4.8	12.1	4.8	2.2	76.1	14.7	14.8	1.0
21	276	5.9	12.4	5.6	2.2	73.9	14.7	14.8	1.0
22	290	7.8	12.5	6.3	2.2	71.2	14.7	14.8	1.0
23	301	6.0	12.3	6.8	2.2	72.7	14.7	14.8	1.0
24	315	6.6	12.4	7.4	2.1	71.5	14.7	14.8	1.0
25	329	6.6	12.4	7.9	2.1	71.0	14.7	14.8	1.0
26	342	9.0	12.4	8.3	2.0	68.3	14.7	14.8	1.0
27	356	8.9	12.3	8.7	1.9	68.2	14.7	14.8	1.0
28	370	5.5	12.2	9.0	1.9	71.4	14.7	14.8	1.0
29	384	6.1	12.1	9.3	1.8	70.7	14.7	14.8	1.0
30	397	4.3	12.1	9.6	1.8	72.2	14.7	14.8	1.0
31	409	6.8	12.2	9.7	1.8	69.5	14.7	14.8	1.0
32	422	7.3	12.1	10.0	1.8	68.8	14.7	14.9	1.5
33	436	5.6	12.1	10.2	1.7	70.4	14.7	14.8	1.4
34	449	8.4	12.7	10.3	1.6	67.0	14.7	14.8	1.4
35	463	8.2	13.0	10.4	1.5	66.9	14.7	14.8	1.3
36	477	7.9	13.0	10.4	1.4	67.3	14.6	14.8	1.3
37	491	8.7	12.9	10.4	1.3	66.7	14.7	14.8	1.3
38	504	7.7	13.1	10.5	1.3	67.4	14.7	14.8	1.4
39	518	7.3	13.2	10.4	1.3	67.8	14.6	14.8	1.5
40	532	7.0	13.2	10.4	1.3	68.1	14.7	14.8	1.4
41	545	6.8	13.0	10.5	1.2	68.5	14.6	14.8	1.4
42	559	6.7	13.0	10.5	1.2	68.6	14.7	14.8	1.5
43	573	7.6	13.2	10.5	1.2	67.5	14.7	14.8	1.4
44	587	7.7	13.4	10.6	1.3	67.0	14.7	14.9	1.5
45	600	8.4	13.4	10.6	1.3	66.3	14.7	14.8	1.4
46	614	7.5	13.5	10.6	1.2	67.2	14.7	14.8	1.4
47	628	9.1	13.6	10.7	1.2	65.4	14.7	14.8	1.3
48	642	7.6	13.5	10.7	1.2	67.0	14.7	14.8	1.2
49	655	7.5	13.5	10.7	1.2	67.1	14.7	14.8	1.5
50	669	7.7	13.6	10.7	1.2	66.8	14.7	14.9	1.5
51	683	8.5	13.6	10.6	1.2	66.1	14.7	14.8	1.4
52	696	7.3	13.6	10.7	1.2	67.2	14.7	14.8	1.4
53	707	8.8	13.6	10.7	1.2	65.7	14.7	14.8	1.4
54	721	7.5	13.5	10.6	1.2	67.2	14.7	14.9	2.0
55	735	9.0	13.3	10.7	1.2	65.8	14.6	15.0	2.8
56	748	7.8	13.2	10.9	1.2	66.9	14.6	15.0	2.8
57	762	8.0	13.8	10.8	1.0	66.4	14.6	15.0	2.7
58	776	6.9	14.0	10.7	0.8	67.6	14.6	15.0	2.8
59	790	7.2	14.1	10.5	0.7	67.5	14.6	15.0	2.9
60	803	5.4	14.3	10.4	0.7	69.2	14.6	15.0	2.9
61	818	8.5	14.4	10.1	0.7	66.3	14.6	15.0	2.9
62	831	9.9	14.8	10.0	0.9	64.4	14.6	15.0	3.0
63	846	9.6	15.3	9.9	1.0	64.2	14.6	15.0	2.8
64	859	9.9	15.8	9.8	1.0	63.5	14.6	15.0	2.9
65	873	9.9	15.9	9.6	0.9	63.7	14.6	15.0	2.9
66	887	8.6	16.1	9.6	0.8	64.9	14.6	15.0	2.9
67	900	9.9	16.2	9.4	0.8	63.7	14.6	15.0	2.9

68	914	9.0	16.0	9.2	0.8	65.0	14.6	15.0	2.9
69	928	10.0	16.1	9.1	0.8	64.0	14.6	15.0	2.8
70	941	8.9	15.9	9.1	0.8	65.3	14.6	14.9	2.7
71	955	9.0	15.7	8.9	0.9	65.5	14.6	15.0	3.0
72	969	9.8	15.6	8.9	1.0	64.7	14.6	15.0	2.9
73	983	10.0	15.5	9.0	1.0	64.5	14.6	15.0	2.9
74	997	11.1	15.5	9.1	1.0	63.3	14.6	15.0	2.9
75	1007	9.0	15.6	9.1	1.0	65.3	14.6	15.0	2.8
76	1021	9.1	15.5	9.2	1.0	65.2	14.6	15.0	2.8
77	1035	8.8	15.4	9.2	1.0	65.6	14.6	15.0	2.9
78	1049	9.2	15.2	9.2	1.0	65.4	14.6	15.0	2.8
79	1063	8.9	15.2	9.2	0.9	65.8	14.6	15.0	2.9
80	1077	9.5	15.3	9.2	0.9	65.1	14.6	15.0	3.0
81	1090	10.5	15.0	9.2	1.0	64.3	14.6	15.0	3.1
82	1104	7.2	14.2	9.2	1.0	68.4	14.6	15.0	3.0
83	1118	9.0	14.1	9.2	1.0	66.7	14.6	15.0	2.9
84	1129	7.5	13.8	9.2	1.0	68.5	14.5	15.0	3.0
85	1142	7.3	13.6	9.2	0.9	69.0	14.5	15.0	3.0
86	1156	5.4	13.3	9.2	1.0	71.1	14.5	15.0	3.0
87	1170	6.5	13.3	9.2	1.0	70.0	14.6	15.0	3.0
88	1183	7.6	13.4	9.3	1.0	68.7	14.5	15.0	3.1
89	1197	6.4	13.3	9.3	0.9	70.1	14.5	15.0	3.1
90	1211	6.7	12.8	9.3	0.9	70.3	14.6	15.0	3.2
91	1225	6.2	12.3	9.3	1.0	71.2	14.6	15.0	3.1
92	1239	4.1	11.8	9.2	1.0	73.9	14.6	15.0	3.1
93	1253	3.1	11.3	9.2	1.0	75.4	14.6	15.0	3.2
94	1266	3.1	11.6	9.2	1.0	75.1	14.6	15.0	3.1
95	1280	7.1	12.3	9.2	1.0	70.4	14.5	15.0	3.2
96	1294	5.8	12.1	9.1	1.0	72.0	14.5	15.0	3.0
97	1308	5.7	12.3	9.1	1.0	71.9	14.6	15.0	2.9
98	1321	5.8	12.4	9.1	1.0	71.7	14.6	15.0	3.0
99	1335	4.2	12.2	9.1	1.0	73.5	14.5	15.0	3.0
100	1349	6.4	11.9	8.9	1.1	71.7	14.5	15.0	3.0
101	1363	5.9	11.9	9.0	1.0	72.2	14.5	15.0	3.0
102	1376	6.6	12.4	8.9	1.0	71.1	14.5	15.0	3.2
103	1390	7.1	12.2	8.9	0.9	70.9	14.5	15.0	3.0
104	1401	5.2	11.9	8.9	0.9	73.1	14.6	15.0	3.0
105	1415	5.0	11.9	8.8	0.9	73.4	14.5	15.0	3.0
106	1429	5.8	11.7	8.8	0.9	72.8	14.6	15.0	3.1
107	1442	5.5	11.3	8.7	0.9	73.6	14.6	15.0	3.2
108	1456	7.2	11.2	8.7	1.0	71.9	14.6	15.0	3.1
109	1470	6.5	11.4	8.7	1.0	72.4	14.5	15.0	3.1
110	1484	6.0	11.6	8.7	1.0	72.7	14.5	15.0	3.1
111	1497	6.3	11.8	8.7	0.9	72.3	14.5	15.0	2.9
112	1511	7.3	12.1	8.7	0.9	71.0	14.5	15.0	3.0
113	1524	6.3	12.7	8.7	1.0	71.3	14.5	15.0	3.0
114	1536	7.5	12.9	8.6	0.9	70.1	14.6	15.0	3.0
115	1549	5.7	13.0	8.6	0.9	71.8	14.5	15.0	2.9
116	1563	6.5	12.9	8.5	1.0	71.1	14.5	15.0	2.9
117	1577	8.2	12.8	8.5	1.0	69.5	14.5	15.0	3.1
118	1590	9.3	12.8	8.4	0.9	68.6	14.6	14.9	2.4
119	1604	8.5	13.0	8.4	0.9	69.2	14.6	14.9	2.0
120	1618	9.0	13.3	8.3	1.0	68.4	14.6	14.9	2.1
121	1632	8.1	13.1	8.3	1.1	69.4	14.6	14.9	2.1
122	1645	7.9	12.7	8.3	1.2	69.9	14.6	14.9	2.1
123	1659	6.3	12.3	8.3	1.2	71.9	14.6	14.9	2.2
124	1673	9.1	12.0	8.4	1.1	69.4	14.6	14.9	2.1
125	1687	6.5	12.0	8.5	1.1	71.9	14.6	14.9	2.1
126	1700	8.7	12.3	8.6	1.1	69.3	14.6	14.9	2.1

127	1714	8.7	12.5	8.7	1.1	69.0	14.6	14.9	2.1
128	1728	7.6	12.3	8.8	1.0	70.3	14.6	14.9	2.0
129	1742	8.4	12.3	8.8	1.0	69.5	14.7	14.9	2.1
130	1755	7.5	12.3	8.8	1.1	70.3	14.7	14.9	2.1
131	1769	7.8	12.3	8.8	1.2	69.9	14.6	14.9	2.1
132	1782	6.3	12.5	8.9	1.3	71.0	14.5	14.9	2.0
133	1796	7.5	12.5	8.9	1.2	69.9	14.6	14.9	2.2
134	1810	7.2	12.4	8.9	1.2	70.3	14.5	14.9	2.1
135	1823	7.8	12.2	8.9	1.3	69.8	14.6	14.9	2.0
136	1838	8.0	12.3	8.9	1.4	69.4	14.6	14.9	2.0
137	1851	5.5	12.1	8.9	1.4	72.1	14.6	14.9	2.1
138	1866	7.1	12.0	9.0	1.3	70.6	14.6	14.9	2.0
139	1880	7.6	11.9	9.1	1.1	70.3	14.6	14.9	2.0
140	1894	8.6	11.9	9.0	1.0	69.5	14.6	14.8	1.5
141	1907	6.5	11.9	9.1	1.0	71.5	14.6	14.9	2.1
142	1921	8.3	11.9	9.0	1.0	69.8	14.6	14.9	2.1
143	1935	7.7	11.7	9.1	1.0	70.5	14.6	14.9	2.0
144	1949	7.6	11.8	9.1	1.1	70.4	14.5	14.9	2.0
145	1962	7.9	11.9	9.1	1.1	70.0	14.7	14.9	2.0
146	1976	8.3	11.8	9.0	1.1	69.8	14.6	14.9	2.0
147	1990	8.5	11.5	9.0	1.1	69.9	14.6	14.9	1.9
148	2004	8.9	11.4	9.0	1.1	69.6	14.6	14.9	2.1
149	2017	7.6	11.5	9.0	1.1	70.8	14.6	14.9	2.2
150	2031	8.2	11.5	9.0	1.0	70.3	14.6	14.9	1.8
151	2045	6.8	11.5	9.0	1.0	71.7	14.6	14.9	2.1
152	2058	7.4	11.4	8.9	1.0	71.3	14.6	14.9	1.7
153	2072	7.2	11.4	8.9	0.9	71.6	14.6	14.9	2.0
154	2086	6.5	11.3	8.9	0.9	72.4	14.5	14.9	1.9
155	2100	6.8	11.3	8.9	0.8	72.2	14.6	14.9	2.0
156	2113	6.9	11.4	8.9	0.8	72.0	14.6	14.9	1.9
157	2127	8.1	11.5	8.8	0.8	70.8	14.6	14.9	1.8
158	2141	7.7	11.7	8.8	0.9	70.9	14.6	14.9	2.1
159	2155	7.3	11.8	8.7	1.0	71.2	14.6	14.9	1.9
160	2168	8.4	11.8	8.7	1.0	70.1	14.6	14.9	1.9
161	2182	8.3	11.7	8.8	0.9	70.3	14.6	14.9	2.0
162	2196	7.5	11.6	8.7	0.9	71.3	14.6	14.9	2.1
163	2210	7.6	11.6	8.7	0.9	71.2	14.6	14.9	1.8
164	2223	6.5	11.7	8.7	0.9	72.2	14.5	14.9	2.0
165	2237	6.7	11.9	8.7	0.9	71.8	14.5	14.9	1.9
166	2251	7.6	11.8	8.6	0.9	71.1	14.5	14.9	1.7
167	2264	8.1	11.9	8.6	0.9	70.5	14.5	14.9	2.0
168	2278	8.2	12.0	8.6	0.9	70.3	14.5	14.9	2.0
169	2292	9.2	11.8	8.6	0.9	69.5	14.5	14.9	1.8
170	2306	8.6	11.7	8.6	0.9	70.2	14.5	14.9	2.0
171	2319	6.5	11.5	8.6	1.0	72.4	14.5	14.9	2.0
172	2333	7.8	11.5	8.6	1.0	71.1	14.5	14.9	1.8
173	2347	7.7	11.6	8.6	0.9	71.2	14.5	14.9	1.9
174	2361	7.7	11.6	8.6	0.9	71.2	14.6	14.9	1.9
175	2374	7.9	11.6	8.6	1.0	70.9	14.6	14.9	1.9
176	2388	7.3	11.6	8.7	1.0	71.4	14.5	14.9	1.8
177	2402	7.1	11.7	8.7	1.0	71.5	14.5	14.9	1.9
178	2416	9.5	11.7	8.7	1.1	69.0	14.6	14.9	1.9
179	2429	7.7	11.8	8.6	1.1	70.8	14.5	14.9	1.9
180	2443	6.8	11.6	8.6	1.0	72.0	14.5	14.9	1.9
181	2456	8.8	11.6	8.5	1.0	70.1	14.5	14.9	1.8
182	2470	7.4	11.7	8.6	0.9	71.4	14.6	14.9	2.0
183	2484	9.5	11.7	8.6	1.0	69.2	14.6	14.9	1.8
184	2497	8.1	11.6	8.5	1.0	70.8	14.5	14.9	1.9
185	2511	8.7	11.5	8.5	1.0	70.3	14.5	14.9	1.9

186	2525	8.6	11.3	8.5	0.9	70.7	14.5	14.9	1.8
187	2539	9.5	11.6	8.5	1.0	69.4	14.5	14.9	1.9
188	2552	8.3	11.7	8.5	1.0	70.5	14.6	14.9	1.8
189	2566	7.5	11.7	8.5	0.9	71.4	14.5	14.9	2.0
190	2580	6.8	11.7	8.5	0.9	72.1	14.5	14.9	1.9
191	2594	8.3	11.8	8.5	0.9	70.5	14.5	14.9	1.9
192	2607	7.8	11.6	8.5	0.9	71.2	14.5	14.9	1.9
193	2621	5.3	11.4	8.5	0.9	73.9	14.5	14.9	1.9
194	2635	8.5	11.3	8.5	0.9	70.8	14.5	14.9	1.8
195	2649	5.6	11.3	8.5	0.9	73.7	14.5	14.9	1.9
196	2662	7.7	11.6	8.5	1.0	71.2	14.5	14.9	1.8
197	2676	8.3	11.7	8.5	1.1	70.4	14.5	14.9	2.0
198	2689	7.4	11.6	8.5	1.1	71.4	14.6	14.9	1.6
199	2703	9.6	11.6	8.6	1.0	69.2	14.6	14.9	1.9
200	2717	6.7	11.5	8.6	1.0	72.2	14.5	14.9	1.9
201	2730	7.6	11.4	8.6	1.0	71.4	14.5	14.9	1.8
202	2744	7.6	11.3	8.6	1.0	71.5	14.5	14.9	1.9
203	2758	7.1	11.1	8.6	1.0	72.2	14.6	14.9	2.1
204	2772	7.9	11.0	8.7	0.9	71.5	14.5	14.9	1.9
205	2785	7.0	10.9	8.6	0.9	72.6	14.6	14.9	1.9
206	2800	7.3	11.1	8.6	0.8	72.2	14.5	14.9	1.9
207	2813	7.5	11.2	8.6	0.8	71.9	14.5	14.9	1.9
208	2827	8.0	11.3	8.6	0.9	71.2	14.5	14.9	1.9
209	2841	8.5	11.3	8.5	1.1	70.6	14.5	14.9	1.8
210	2855	9.0	11.1	8.6	1.1	70.2	14.5	14.9	1.8
211	2868	7.8	11.1	8.6	1.2	71.3	14.5	14.9	1.7
212	2882	7.3	11.1	8.6	1.1	71.9	14.5	14.9	2.0
213	2895	7.3	11.1	8.7	1.0	71.9	14.6	14.9	1.8
214	2909	6.6	11.0	8.7	1.1	72.6	14.5	14.9	1.9
215	2923	6.9	11.1	8.6	1.0	72.4	14.5	15.0	2.6
216	2937	8.0	11.2	8.7	1.0	71.1	14.3	15.1	3.7
217	2951	6.8	10.5	8.8	0.9	73.0	14.3	15.1	3.7
218	2964	4.9	10.9	8.8	0.7	74.7	14.4	15.1	3.8
219	2978	7.8	11.7	8.6	0.5	71.4	14.4	15.1	3.9
220	2992	6.8	12.4	8.3	0.5	72.0	14.4	15.1	3.7
221	3006	8.2	12.7	8.0	0.5	70.6	14.3	15.1	3.9
222	3020	7.7	12.7	7.8	0.5	71.3	14.3	15.1	3.9
223	3034	5.8	12.7	7.6	0.5	73.4	14.3	15.1	3.8
224	3047	7.0	12.9	7.4	0.5	72.2	14.4	15.2	4.0
225	3062	7.8	13.1	7.2	0.6	71.3	14.3	15.2	3.9
226	3075	8.4	13.1	7.1	0.6	70.8	14.3	15.2	3.7
227	3089	8.7	12.7	7.0	0.6	71.0	14.3	15.1	3.9
228	3103	7.1	12.8	6.8	0.6	72.7	14.3	15.1	3.9
229	3117	8.2	13.1	6.8	0.6	71.3	14.3	15.1	3.7
230	3130	9.0	13.1	6.7	0.7	70.5	14.3	15.1	3.8
231	3144	7.0	13.4	6.6	0.7	72.3	14.3	15.1	3.8
232	3158	7.6	13.5	6.6	0.7	71.6	14.3	15.2	3.8
233	3171	8.5	13.2	6.6	0.7	71.0	14.3	15.2	3.9
234	3185	7.9	13.0	6.5	0.8	71.8	14.3	15.2	4.0
235	3199	10.2	13.1	6.5	0.8	69.4	14.3	15.2	3.8
236	3213	8.1	13.0	6.6	0.9	71.4	14.3	15.2	3.9
237	3226	8.4	13.1	6.6	0.8	71.1	14.3	15.2	3.9
238	3240	7.8	13.3	6.7	0.8	71.4	14.3	15.2	3.7
239	3251	8.8	13.2	6.7	0.8	70.5	14.3	15.2	3.9
240	3265	8.3	12.9	6.6	0.9	71.3	14.3	15.2	4.0
241	3279	8.4	12.8	6.6	1.0	71.2	14.3	15.2	3.8
242	3293	7.6	12.7	6.6	1.1	72.0	14.3	15.2	4.0
243	3306	8.7	12.5	6.7	1.0	71.1	14.3	15.2	3.9
244	3320	8.2	12.6	6.7	0.9	71.6	14.3	15.2	3.8

245	3334	8.0	12.5	6.7	1.0	71.8	14.3	15.2	3.9
246	3347	8.7	12.0	6.8	1.0	71.5	14.3	15.2	3.8
247	3361	7.3	11.9	6.8	0.9	73.1	14.3	15.1	3.3
248	3375	6.2	11.9	6.8	0.9	74.2	14.3	15.2	4.0
249	3389	7.4	12.0	6.9	0.9	72.8	14.2	15.2	3.8
250	3402	8.2	12.0	6.9	0.9	72.0	14.3	15.2	3.7
251	3416	7.2	12.6	6.9	0.9	72.4	14.3	15.2	4.0
252	3430	7.1	12.7	6.9	0.9	72.4	14.4	15.2	3.9
253	3443	8.8	12.5	6.8	1.0	70.9	14.3	15.2	3.8
254	3457	7.3	12.1	6.8	1.0	72.8	14.3	15.2	4.0
255	3471	7.0	11.6	6.9	1.0	73.5	14.3	15.2	3.9
256	3485	6.7	11.3	6.9	1.0	74.1	14.3	15.2	3.8
257	3499	8.4	11.3	6.9	1.0	72.4	14.3	15.2	3.7
258	3512	8.1	11.7	7.0	0.9	72.3	14.3	15.2	3.8
259	3526	6.7	12.0	7.0	0.7	73.6	14.3	15.2	4.0
260	3540	6.3	12.0	7.0	0.7	74.0	14.5	15.0	2.8
261	3553	7.8	12.5	6.8	0.7	72.2	14.5	15.0	2.6
262	3567	8.1	12.4	6.7	0.8	72.0	14.5	15.0	2.8
263	3581	8.7	12.4	6.8	1.0	71.1	14.5	15.0	2.7
264	3595	10.2	12.3	6.8	1.0	69.7	14.4	15.0	2.7
265	3608	10.7	11.9	7.0	1.0	69.4	14.4	15.0	2.8
266	3622	7.6	11.7	7.1	1.1	72.5	14.5	15.0	2.7
267	3636	10.2	11.8	7.3	1.1	69.6	14.4	15.0	2.8
268	3649	8.8	11.8	7.5	1.1	70.8	14.4	15.0	2.6
269	3663	8.1	11.8	7.6	0.9	71.6	14.5	15.0	2.8
270	3677	9.3	12.0	7.7	0.9	70.1	14.5	15.0	2.9
271	3690	8.3	12.0	7.6	0.9	71.2	14.5	15.0	2.8
272	3704	7.2	11.1	7.6	0.9	73.2	14.5	15.0	2.9
273	3718	8.1	10.6	7.5	1.0	72.8	14.5	15.0	2.9
274	3732	9.4	10.2	7.4	1.0	72.0	14.5	15.0	2.9
275	3745	7.3	10.0	7.4	1.0	74.3	14.5	15.0	2.9
276	3759	5.8	10.0	7.3	0.9	76.0	14.5	15.0	2.8
277	3773	5.9	10.2	7.3	0.8	75.8	14.5	15.0	2.9
278	3786	6.6	10.4	7.2	0.9	74.9	14.5	15.0	2.9
279	3800	7.2	10.5	7.2	0.9	74.2	14.5	15.0	2.7
280	3814	6.4	10.4	7.2	0.9	75.1	14.5	15.0	2.9
281	3828	8.0	10.1	7.1	0.9	73.9	14.5	15.0	2.9
282	3841	7.5	10.0	7.2	0.8	74.5	14.5	15.0	2.9
283	3855	5.7	10.0	7.2	0.8	76.3	14.5	15.0	2.9
284	3869	7.6	10.1	7.1	0.7	74.5	14.5	15.0	2.6
285	3883	6.6	10.2	7.1	0.7	75.4	14.5	15.0	2.8
286	3896	6.1	10.1	7.1	0.7	76.0	14.5	15.0	2.8
287	3910	6.7	10.1	7.1	0.8	75.3	14.5	15.0	2.8
288	3924	6.1	10.0	7.1	0.8	76.0	14.4	15.0	2.8
289	3938	6.7	10.1	7.1	0.8	75.3	14.4	15.0	2.7
290	3951	7.8	10.1	7.1	0.8	74.2	14.4	15.0	2.9
291	3965	6.5	10.0	7.1	0.8	75.6	14.5	15.0	2.8
292	3979	6.7	10.1	7.1	0.8	75.3	14.5	15.0	2.7
293	3993	7.4	10.0	7.1	0.8	74.7	14.5	15.0	2.9
294	4006	6.3	9.9	7.0	0.7	76.1	14.5	15.0	2.7
295	4020	6.1	10.1	7.1	0.7	76.0	14.5	15.0	2.8
296	4034	5.1	10.2	7.1	0.7	76.9	14.5	15.0	2.8
297	4047	6.5	10.3	7.0	0.7	75.5	14.5	15.0	2.7
298	4061	6.0	10.2	7.0	0.8	76.0	14.4	15.0	2.8
299	4075	7.2	10.1	7.0	0.9	74.8	14.5	15.0	2.8
300	4089	6.6	9.8	7.0	0.9	75.7	14.4	15.0	2.8
301	4102	8.0	9.6	7.0	0.9	74.5	14.4	15.0	2.9
302	4116	7.4	9.6	7.1	0.9	75.0	14.4	15.0	2.8
303	4129	6.2	9.6	7.1	0.9	76.2	14.4	15.0	2.8

304	4143	5.6	9.6	7.1	0.8	76.9	14.5	15.0	2.7
305	4157	7.9	9.6	7.1	0.8	74.6	14.4	15.0	2.7
306	4171	7.0	9.6	7.1	0.8	75.5	14.4	15.0	2.8
307	4184	7.9	9.8	7.1	0.7	74.5	14.4	15.0	2.8
308	4196	6.9	9.9	7.0	0.7	75.5	14.4	15.0	2.8
309	4209	7.7	9.9	7.0	0.7	74.7	14.4	15.0	2.9
310	4223	6.9	10.0	7.0	0.7	75.4	14.5	15.0	2.7
311	4237	7.0	9.9	7.0	0.8	75.3	14.5	15.0	2.9
312	4250	7.1	9.9	7.0	0.7	75.3	14.4	15.0	2.7
313	4264	6.8	9.8	7.0	0.7	75.7	14.4	15.0	2.6
314	4278	5.8	9.8	7.0	0.8	76.6	14.4	15.0	2.7
315	4292	5.8	9.9	7.0	0.8	76.5	14.4	15.0	2.8
316	4305	5.7	9.9	7.0	0.8	76.6	14.5	15.0	2.3
317	4319	7.8	9.8	7.0	0.9	74.5	14.4	15.0	2.8
318	4333	5.9	9.7	7.0	0.8	76.6	14.4	15.0	2.7
319	4347	6.0	9.5	7.0	0.8	76.7	14.4	15.0	2.9
320	4360	6.3	9.5	7.1	0.7	76.4	14.4	15.0	2.7
321	4374	6.1	9.5	7.0	0.7	76.7	14.4	15.0	2.8
322	4388	6.3	9.6	7.0	0.7	76.4	14.4	15.0	2.7
323	4402	6.0	9.9	7.0	0.7	76.4	14.4	15.0	2.8
324	4415	6.8	9.8	6.9	0.6	75.9	14.4	15.0	2.7
325	4429	7.5	9.8	6.9	0.6	75.2	14.4	15.0	2.9
326	4442	5.9	9.8	6.9	0.6	76.8	14.3	15.0	2.7
327	4456	6.8	9.8	6.9	0.7	75.8	14.3	15.0	2.8
328	4470	4.5	9.8	6.9	0.7	78.1	14.3	15.0	2.8
329	4483	6.0	9.9	6.8	0.8	76.5	14.4	15.0	2.9
330	4497	5.2	9.8	6.8	0.7	77.5	14.3	15.0	2.8
331	4511	5.1	9.9	6.8	0.8	77.4	14.4	15.0	3.0
332	4525	6.9	10.0	6.9	0.8	75.4	14.4	15.0	2.8
333	4538	5.8	10.1	6.9	0.8	76.4	14.4	15.0	2.9
334	4552	7.3	10.3	6.9	0.7	74.8	14.3	15.0	2.3
335	4566	6.2	10.2	6.8	0.8	76.0	14.3	15.0	2.9
336	4580	6.6	10.0	6.8	0.8	75.8	14.4	15.0	2.8
337	4593	7.6	9.9	6.9	0.9	74.7	14.3	15.0	2.8
338	4607	8.0	10.1	6.9	0.8	74.2	14.3	15.0	2.6
339	4621	7.2	10.9	6.9	0.8	74.2	14.3	15.0	2.7
340	4635	6.2	11.1	6.8	0.8	75.1	14.3	15.0	2.6
341	4646	6.9	11.1	7.0	0.8	74.2	14.3	15.0	2.7
342	4659	7.7	11.1	7.0	0.7	73.5	14.4	15.0	2.7
343	4673	7.8	11.1	7.1	0.7	73.3	14.3	15.0	2.6
344	4687	8.8	11.2	7.1	0.7	72.2	14.3	15.0	2.7
345	4701	8.1	11.2	7.2	0.8	72.7	14.3	15.0	2.7
346	4714	8.3	11.3	7.2	0.8	72.4	14.3	15.0	2.8
347	4728	5.8	11.0	7.2	0.9	75.1	14.3	15.0	2.7
348	4742	7.7	10.9	7.2	0.9	73.3	14.3	15.0	2.7
349	4755	7.1	11.0	7.3	0.9	73.7	14.3	15.0	2.6
350	4769	7.8	11.1	7.3	0.9	72.9	14.3	15.0	2.7
351	4783	7.4	11.2	7.3	0.9	73.2	14.3	15.0	2.5
352	4796	8.0	11.3	7.3	0.9	72.5	14.2	15.0	3.0
353	4810	6.9	11.3	7.3	0.8	73.7	14.2	15.0	2.9
354	4824	6.5	11.0	7.3	0.7	74.5	14.3	15.0	2.9
355	4838	7.0	10.9	7.3	0.7	74.1	14.2	15.0	2.8
356	4851	7.2	11.0	7.2	0.7	73.9	14.2	15.0	2.9
357	4865	6.8	11.1	7.2	0.7	74.2	14.2	15.0	2.8
358	4879	7.3	11.3	7.2	0.7	73.5	14.3	15.0	2.8
359	4892	6.7	11.1	7.1	0.7	74.4	14.2	15.0	2.8
360	4906	7.6	11.2	7.1	0.8	73.3	14.2	15.0	2.8
361	4920	6.5	11.1	7.1	0.7	74.6	14.3	15.0	2.9
362	4934	6.6	11.4	7.1	0.7	74.2	14.2	15.0	2.9

363	4947	9.6	11.5	7.1	0.7	71.1	14.2	15.0	2.9
364	4961	8.1	11.4	7.1	0.7	72.7	14.2	15.0	2.8
365	4975	7.8	11.3	7.0	0.7	73.2	14.2	15.0	2.8
366	4989	8.9	11.3	7.0	0.7	72.1	14.2	15.0	2.7
367	5002	7.5	11.2	7.0	0.8	73.5	14.2	15.0	2.9
368	5016	8.2	11.3	7.0	0.9	72.6	14.2	15.0	2.7
369	5030	7.0	11.3	7.1	0.8	73.8	14.2	15.0	2.9
370	5044	6.8	11.2	7.1	0.8	74.1	14.3	15.0	2.8
371	5057	7.5	11.0	7.1	0.8	73.6	14.2	15.0	2.9
372	5071	7.9	10.8	7.1	0.8	73.4	14.2	15.1	2.8
373	5085	7.3	11.0	7.1	0.8	73.8	14.3	15.0	2.8
374	5098	8.0	11.1	7.1	0.7	73.1	14.2	15.0	2.8
375	5112	7.7	11.4	7.1	0.7	73.1	14.2	15.0	2.7
376	5126	5.9	11.3	7.1	0.8	74.9	14.2	15.0	2.8
377	5140	6.4	11.2	7.0	0.8	74.6	14.2	15.0	2.7
378	5153	9.5	11.3	7.1	0.9	71.2	14.2	15.0	2.8
379	5167	7.4	11.0	7.1	0.9	73.6	14.2	15.0	2.9
380	5181	8.5	11.3	7.1	0.9	72.2	14.3	15.0	2.9
381	5194	7.7	11.2	7.1	0.9	73.1	14.2	15.0	2.8
382	5208	8.9	11.2	7.2	0.9	71.8	14.2	15.0	2.8
383	5222	8.6	11.4	7.2	1.0	71.8	14.2	15.0	2.8
384	5235	7.3	11.4	7.2	1.0	73.1	14.1	15.0	2.7
385	5249	7.6	11.4	7.2	1.0	72.8	14.1	15.0	2.8
386	5263	8.0	11.1	7.3	1.1	72.5	14.2	15.1	2.7
387	5277	6.9	11.0	7.3	1.3	73.5	14.1	15.0	2.9
388	5291	6.1	11.1	7.4	1.3	74.1	14.1	15.0	2.7
389	5305	8.1	11.2	7.4	1.2	72.1	14.2	15.2	2.8
390	5318	7.9	11.4	7.4	1.0	72.3	14.2	15.0	2.8
391	5332	8.1	11.4	7.4	1.0	72.1	14.2	15.0	2.7
392	5346	7.1	11.5	7.3	0.9	73.2	14.2	15.0	2.8
393	5360	7.7	11.4	7.3	0.9	72.7	14.2	15.0	2.6
394	5373	7.0	11.5	7.2	1.0	73.3	14.2	15.0	2.8
395	5387	7.3	11.7	7.2	0.9	72.9	14.2	15.1	2.8
396	5401	7.5	11.7	7.2	0.9	72.7	14.2	15.0	2.7
397	5414	6.4	11.8	7.2	0.9	73.7	14.1	15.0	2.8
398	5428	7.0	12.0	7.1	0.9	73.0	14.2	15.0	2.7
399	5442	8.7	12.1	7.1	0.9	71.2	14.1	15.1	2.8
400	5456	8.6	11.9	7.1	0.9	71.5	14.0	15.2	3.7
401	5469	8.4	11.3	7.1	0.9	72.3	14.0	15.2	3.8
402	5481	7.9	11.6	7.1	0.9	72.5	14.0	15.2	3.6
403	5494	9.2	11.8	7.1	0.8	71.1	14.1	15.2	3.7
404	5508	5.7	11.5	7.0	0.8	75.0	14.0	15.2	3.6
405	5522	6.7	11.5	6.8	0.8	74.2	14.0	15.2	3.9
406	5535	8.5	11.6	6.7	0.8	72.4	14.0	15.2	3.7
407	5550	6.2	11.4	6.6	0.8	75.0	13.9	15.2	3.9
408	5563	7.0	11.2	6.4	0.8	74.6	13.9	15.2	3.8
409	5577	7.8	10.9	6.5	0.9	73.9	13.9	15.2	3.9
410	5590	8.1	10.7	6.4	1.0	73.8	14.0	15.2	3.8
411	5604	8.7	10.7	6.5	1.0	73.1	14.0	15.2	3.9
412	5618	6.9	10.7	6.5	1.0	74.9	13.9	15.2	3.8
413	5632	7.1	10.8	6.5	0.9	74.7	14.0	15.2	3.9
414	5645	6.8	11.0	6.5	0.8	74.9	13.9	15.2	3.8
415	5660	7.2	11.1	6.5	0.8	74.4	13.9	15.2	3.8
416	5671	6.5	11.0	6.4	0.8	75.3	13.9	15.2	3.8
417	5685	7.7	10.9	6.3	0.8	74.3	14.0	15.2	3.8
418	5695	8.4	10.9	6.4	0.8	73.5	13.9	15.2	3.9
419	5710	8.0	10.9	6.3	0.8	74.0	13.9	15.2	3.6
420	5723	6.9	11.0	6.3	0.8	75.0	13.9	15.2	3.9
421	5737	7.0	10.8	6.3	0.9	75.0	13.9	15.2	3.8

422	5751	7.4	10.8	6.3	0.8	74.7	13.9	15.2	3.9
423	5764	7.8	10.8	6.3	0.7	74.4	13.9	15.2	3.7
424	5778	8.2	10.7	6.3	0.7	74.1	13.9	15.2	3.9
425	5792	5.5	10.8	6.2	0.7	76.8	13.9	15.2	3.7
426	5806	7.9	11.0	6.2	0.6	74.3	13.9	15.2	3.9
427	5819	8.2	10.9	6.2	0.6	74.1	14.0	15.2	3.7
428	5833	8.1	10.8	6.1	0.7	74.3	14.1	15.2	3.6
429	5847	9.0	10.6	6.1	0.7	73.6	13.9	15.2	3.7
430	5861	8.8	10.9	6.1	0.6	73.6	14.0	15.2	3.8
431	5874	6.1	11.5	6.2	0.6	75.6	13.9	15.2	4.0
432	5888	7.5	11.6	6.1	0.6	74.2	13.9	15.2	3.8
433	5899	6.8	11.8	6.0	0.7	74.7	13.9	15.2	3.8
434	5913	8.4	11.9	6.0	0.7	73.0	13.9	15.2	3.7
435	5927	8.6	11.7	6.0	0.8	72.9	13.9	15.2	3.9
436	5941	7.5	11.5	5.9	0.8	74.3	13.9	15.2	3.7
437	5954	8.9	11.4	5.9	0.9	72.9	13.9	15.2	3.9
438	5968	7.5	11.6	5.9	0.9	74.1	13.9	15.2	3.7
439	5982	8.7	11.5	5.9	0.8	73.1	13.9	15.2	3.9
440	5996	9.4	11.3	6.0	0.8	72.5	13.9	15.2	3.8
441	6010	8.5	11.5	5.9	0.9	73.2	13.9	15.2	3.8
442	6023	6.9	11.5	6.0	0.9	74.7	13.8	15.2	3.9
443	6037	6.6	11.6	5.8	0.9	75.1	13.9	15.2	3.8
444	6050	8.2	11.7	6.0	0.8	73.3	13.8	15.2	3.9
445	6064	7.7	11.5	6.0	0.8	74.0	13.9	15.2	3.8
446	6078	7.7	11.5	5.9	0.8	74.1	13.9	15.2	3.8
447	6092	7.7	11.6	5.9	0.8	74.0	13.8	15.2	3.7
448	6103	9.2	11.5	5.9	0.8	72.6	13.8	15.2	3.9
449	6117	6.2	11.3	5.9	0.9	75.7	13.9	15.2	3.6
450	6130	9.3	11.2	6.0	0.8	72.7	13.8	15.2	4.0
451	6144	7.7	11.2	6.0	0.8	74.3	13.8	15.3	3.8
452	6158	8.1	11.5	6.0	0.9	73.5	13.8	15.2	3.7
453	6172	8.8	11.4	6.0	0.9	72.9	13.8	15.2	3.8
454	6185	6.9	11.3	6.0	0.8	75.0	13.9	15.2	3.7
455	6199	7.4	11.6	6.0	0.8	74.2	14.0	15.3	3.8
456	6213	8.5	11.8	6.0	0.7	73.0	14.0	15.3	3.8
457	6226	7.1	11.6	5.9	0.8	74.6	13.9	15.3	3.7
458	6240	7.4	11.5	5.9	0.8	74.4	14.0	15.2	3.8
459	6254	7.7	11.6	5.9	0.8	74.0	13.9	15.2	3.7
460	6268	8.0	11.8	5.9	0.7	73.6	13.9	15.3	3.7
461	6281	5.8	11.8	5.8	0.7	75.9	13.9	15.3	3.9
462	6295	6.2	1.7	1.4	0.2	90.5	13.9	15.3	3.8
463	6309	0.0	0.0	0.0	0.0	100.0	13.9	15.3	4.0

TEMPERATURE DATA:

		THERMOCOUPLE NUMBERS (TEMPERATURES deg C)							
NO.	TIME	1	2	3	4	5	6	7	8
1	2	23.2	23.1	23.5	24.3	15.2	23.1	29.8	29.8
2	16	23.2	23.1	23.4	23.7	15.2	23.1	29.8	29.8
3	29	23.5	23.1	23.5	24.9	15.2	23.1	29.8	29.8
4	43	23.2	23.2	23.5	24.8	15.2	23.1	30.0	34.0
5	57	23.2	23.1	23.5	24.8	15.2	24.4	36.0	66.0
6	70	23.2	23.1	23.5	25.3	15.8	34.0	70.0	145.0
7	83	23.2	23.1	23.6	25.3	15.8	54.0	88.0	194.0
8	98	23.3	23.1	23.6	25.1	16.1	70.0	113.0	218.0
9	111	23.2	23.1	23.6	24.8	17.3	80.0	142.0	238.0
10	125	23.2	23.2	23.7	24.7	18.3	83.0	185.0	164.0
11	139	23.3	23.2	23.7	25.2	19.8	91.0	234.0	139.0
12	153	23.1	23.3	23.7	25.3	22.2	104.0	268.0	133.0
13	166	23.2	23.4	23.8	25.2	24.1	119.0	304.0	138.0

14	181	23.2	23.5	23.8	24.7	25.6	144.0	356.0	144.0
15	194	23.2	23.5	23.8	24.9	27.1	179.0	407.0	151.0
16	208	23.5	23.5	23.8	25.4	27.4	199.0	421.0	158.0
17	222	23.4	23.5	23.9	25.8	27.5	211.0	435.0	162.0
18	235	23.2	23.4	23.9	25.1	27.2	227.0	446.0	169.0
19	249	23.5	23.4	23.9	25.8	27.2	240.0	448.0	187.0
20	263	23.2	23.4	24.0	25.4	26.5	251.0	459.0	209.0
21	276	23.2	23.3	24.0	25.0	26.8	262.0	458.0	225.0
22	290	23.2	23.3	24.0	25.5	26.9	273.0	464.0	239.0
23	301	23.2	23.3	24.0	25.3	26.9	284.0	477.0	230.0
24	315	23.2	23.3	24.0	25.2	26.6	298.0.	502.0	219.0
25	329	23.3	23.3	24.1	25.6	26.6	311.0	514.0	217.0
26	342	23.2	23.4	24.2	25.7	26.6	323.0	533.0	221.0
27	356	23.2	23.3	24.2	25.1	26.6	335.0	553.0	228.0
28	370	23.2	23.3	24.2	25.3	26.9	344.0	569.0	256.0
29	384	23.2	23.3	24.2	25.4	26.9	353.0	582.0	261.0
30	397	23.2	23.3	24.3	25.7	27.2	362.0	578.0	285.0
31	409	23.3	23.3	24.3	25.6	28.5	371.0	618.0	304.0
32	422	23.2	23.5	24.3	25.0	32.0	394.0	625.0	412.0
33	436	23.2	23.5	24.4	25.5	33.0	422.0	745.0	417.0
34	449	23.2	23.5	24.4	25.6	35.0	442.0	705.0	463.0
35	463	23.2	23.6	24.5	25.7	36.0	459.0	796.0	362.0
36	477	23.2	23.8	24.5	25.5	37.0	473.0	779.0	397.0
37	491	23.4	23.6	24.5	25.8	39.0	484.0	746.0	493.0
38	504	23.2	23.7	24.5	25.6	40.0	493.0	739.0	468.0
39	518	23.2	23.6	24.5	25.8	40.0	500.0	762.0	633.0
40	532	23.2	23.7	24.6	25.6	41.0	503.0	726.0	602.0
41	545	23.2	23.7	24.7	25.6	42.0	506.0	766.0	551.0
42	559	23.2	23.7	24.8	25.8	43.0	508.0	712.0	602.0
43	573	23.2	23.7	24.8	25.4	44.0	511.0	694.0	704.0
44	587	23.2	23.6	24.8	25.0	44.0	514.0	652.0	700.0
45	600	23.1	23.7	24.8	25.1	44.0	515.0	634.0	733.0
46	614	23.2	23.7	24.9	25.6	45.0	517.0	642.0	716.0
47	628	23.2	23.6	24.9	25.6	46.0	519.0	697.0	755.0
48	642	23.2	23.7	25.1	25.7	47.0	520.0	700.0	701.0
49	655	23.2	23.7	25.1	25.4	47.0	519.0	667.0	757.0
50	669	23.2	23.7	25.2	25.5	48.0	519.0	641.0	770.0
51	683	23.3	23.7	25.2	25.4	48.0	519.0	610.0	744.0
52	696	23.3	23.7	25.3	25.4	48.0	518.0	594.0	783.0
53	707	23.2	23.7	25.3	25.4	49.0	518.0	584.0	748.0
54	721	23.2	23.6	25.4	25.4	49.0	521.0	573.0	727.0
55	735	23.2	23.8	25.7	25.9	52.0	544.0	591.0	846.0
56	748	23.2	23.9	25.8	25.0	53.0	579.0	602.0	851.0
57	762	23.2	23.9	25.9	25.8	54.0	599.0	597.0	805.0
58	776	23.2	24.0	26.1	25.9	56.0	617.0	598.0	888.0
59	790	23.3	24.1	26.1	25.8	57.0	624.0	598.0	759.0
60	803	23.2	24.1	26.3	26.1	58.0	627.0	594.0	747.0
61	818	23.2	24.1	26.4	26.0	59.0	623.0	595.0	759.0
62	831	23.2	24.0	26.5	25.9	59.0	617.0	595.0	743.0
63	846	23.3	24.0	26.6	25.8	60.0	616.0	596.0	724.0
64	859	23.2	24.0	26.6	25.7	61.0	617.0	598.0	744.0
65	873	23.3	24.1	26.7	25.5	62.0	619.0	598.0	733.0
66	887	23.2	24.1	26.8	25.2	63.0	616.0	596.0	709.0
67	900	23.2	24.0	26.8	25.6	63.0	614.0	597.0	700.0
68	914	23.2	24.0	26.9	26.3	65.0	618.0	596.0	653.0
69	928	23.2	24.1	27.1	26.8	66.0	621.0	593.0	677.0
70	941	23.3	24.3	27.2	26.3	67.0	621.0	594.0	662.0
71	955	23.3	24.1	27.3	27.1	68.0	627.0	590.0	658.0
72	969	23.3	24.2	27.5	27.1	69.0	629.0	588.0	671.0

73	983	23.2	24.1	27.6	26.6	70.0	625.0	592.0	702.0
74	997	23.3	24.2	27.7	26.6	70.0	623.0	598.0	681.0
75	1007	23.3	24.2	27.7	27.5	71.0	622.0	601.0	678.0
76	1021	23.3	24.1	27.8	27.0	72.0	623.0	609.0	699.0
77	1035	23.4	24.1	27.9	26.5	73.0	621.0	607.0	698.0
78	1049	23.3	24.2	28.1	26.3	73.0	618.0	608.0	687.0
79	1063	23.3	24.2	28.3	26.7	75.0	619.0	600.0	646.0
80	1077	23.2	24.3	28.4	27.2	77.0	617.0	592.0	668.0
81	1090	23.2	24.4	28.5	27.3	77.0	623.0	596.0	705.0
82	1104	23.4	24.3	28.6	27.7	79.0	626.0	597.0	749.0
83	1118	23.3	24.4	28.8	27.5	79.0	626.0	597.0	710.0
84	1129	23.2	24.4	28.9	27.5	80.0	622.0	596.0	683.0
85	1142	23.4	24.4	29.1	27.2	81.0	619.0	596.0	670.0
86	1156	23.2	24.3	29.2	27.5	80.0	617.0	598.0	703.0
87	1170	23.4	24.3	29.3	27.4	80.0	623.0	608.0	691.0
88	1183	23.3	24.6	29.4	27.4	81.0	628.0	619.0	683.0
89	1197	23.2	24.4	29.6	27.4	83.0	621.0	623.0	682.0
90	1211	23.2	24.6	29.8	28.1	83.0	613.0	622.0	706.0
91	1225	23.2	24.5	29.8	27.2	83.0	611.0	615.0	725.0
92	1239	23.3	24.5	30.0	27.2	84.0	607.0	614.0	702.0
93	1253	23.2	24.6	30.0	27.4	83.0	601.0	609.0	751.0
94	1266	23.3	24.5	30.0	26.7	84.0	597.0	602.0	736.0
95	1280	23.2	24.5	31.0	28.4	84.0	595.0	601.0	757.0
96	1294	23.2	24.5	30.0	27.7	84.0	593.0	604.0	735.0
97	1308	23.3	24.7	31.0	27.5	85.0	592.0	603.0	708.0
98	1321	23.4	24.7	31.0	27.9	85.0	593.0	595.0	733.0
99	1335	23.4	24.6	31.0	27.5	84.0	587.0	617.0	768.0
100	1349	23.3	24.4	31.0	27.5	84.0	591.0	628.0	815.0
101	1363	23.3	24.4	31.0	27.5	84.0	595.0	618.0	813.0
102	1376	23.3	24.5	31.0	27.8	85.0	599.0	621.0	818.0
103	1390	23.2	24.6	31.0	28.2	85.0	597.0	620.0	800.0
104	1401	23.2	24.6	31.0	27.7	85.0	593.0	611.0	757.0
105	1415	23.2	24.5	31.0	27.7	85.0	590.0	605.0	754.0
106	1429	23.3	24.6	32.0	27.5	85.0	593.0	605.0	742.0
107	1442	23.2	24.7	32.0	27.4	85.0	588.0	599.0	698.0
108	1456	23.2	24.6	32.0	27.4	85.0	585.0	596.0	707.0
109	1470	23.2	24.6	32.0	27.8	84.0	587.0	593.0	713.0
110	1484	23.3	24.5	32.0	26.8	85.0	597.0	593.0	695.0
111	1497	23.3	24.6	32.0	27.4	84.0	598.0	594.0	702.0
112	1511	23.4	24.5	32.0	27.6	84.0	596.0	597.0	695.0
113	1524	23.2	24.4	32.0	27.5	83.0	594.0	602.0	704.0
114	1536	23.4	24.7	32.0	27.6	84.0	597.0	611.0	717.0
115	1549	23.2	24.6	32.0	28.1	84.0	595.0	610.0	717.0
116	1563	23.3	24.5	32.0	27.9	83.0	595.0	609.0	700.0
117	1577	23.2	24.5	32.0	27.7	83.0	596.0	606.0	674.0
118	1590	23.2	24.4	32.0	27.9	83.0	598.0	605.0	665.0
119	1604	23.3	24.4	32.0	27.8	80.0	590.0	590.0	643.0
120	1618	23.3	24.4	32.0	27.1	80.0	585.0	580.0	641.0
121	1632	23.4	24.3	32.0	27.5	79.0	580.0	573.0	643.0
122	1645	23.3	24.2	32.0	27.5	79.0	577.0	573.0	659.0
123	1659	23.3	24.3	32.0	27.9	78.0	583.0	570.0	644.0
124	1673	23.2	24.3	32.0	27.3	78.0	582.0	565.0	634.0
125	1687	23.2	24.2	32.0	27.9	77.0	574.0	560.0	630.0
126	1700	23.3	24.2	32.0	27.6	77.0	570.0	556.0	629.0
127	1714	23.2	24.3	32.0	27.6	77.0	564.0	555.0	612.0
128	1728	23.3	24.2	32.0	27.8	76.0	555.0	551.0	613.0
129	1742	23.2	24.2	33.0	28.0	76.0	551.0	551.0	610.0
130	1755	23.3	24.3	33.0	28.5	76.0	547.0	548.0	623.0
131	1769	23.4	24.3	33.0	27.7	75.0	543.0	548.0	640.0

132	1782	23.3	24.3	33.0	28.1	75.0	541.0	548.0	630.0
133	1796	23.2	24.1	33.0	28.7	75.0	545.0	546.0	597.0
134	1810	23.3	24.2	33.0	28.3	75.0	545.0	542.0	590.0
135	1823	23.3	24.3	33.0	28.4	74.0	544.0	541.0	584.0
136	1838	23.2	24.2	33.0	27.5	74.0	545.0	540.0	577.0
137	1851	23.3	24.2	33.0	28.0	73.0	541.0	539.0	574.0
138	1866	23.2	24.2	33.0	28.1	73.0	535.0	539.0	574.0
139	1880	23.3	24.2	33.0	28.3	72.0	532.0	539.0	572.0
140	1894	23.3	24.1	33.0	28.5	72.0	530.0	539.0	590.0
141	1907	23.2	24.1	33.0	27.9	71.0	526.0	537.0	605.0
142	1921	23.3	24.1	33.0	28.3	71.0	524.0	538.0	586.0
143	1935	23.3	24.1	33.0	28.0	71.0	523.0	539.0	576.0
144	1949	23.4	24.1	33.0	28.5	70.0	520.0	537.0	574.0
145	1962	23.3	24.2	33.0	28.9	70.0	517.0	536.0	570.0
146	1976	23.2	24.1	33.0	28.2	70.0	515.0	536.0	569.0
147	1990	23.3	24.1	33.0	28.6	70.0	514.0	536.0	567.0
148	2004	23.3	24.1	33.0	28.5	69.0	514.0	535.0	570.0
149	2017	23.4	24.1	33.0	28.6	69.0	511.0	534.0	582.0
150	2031	23.3	24.1	33.0	29.0	69.0	507.0	537.0	600.0
151	2045	23.3	24.1	33.0	29.0	69.0	504.0	536.0	601.0
152	2058	23.3	24.1	34.0	29.2	68.0	504.0	532.0	569.0
153	2072	23.3	24.1	34.0	28.7	68.0	503.0	530.0	551.0
154	2086	23.2	24.0	34.0	28.6	68.0	500.0	528.0	542.0
155	2100	23.3	24.0	34.0	28.9	68.0	496.0	526.0	541.0
156	2113	23.4	24.0	34.0	29.0	67.0	494.0	524.0	540.0
157	2127	23.3	24.0	34.0	29.2	67.0	492.0	523.0	542.0
158	2141	23.3	24.0	34.0	28.3	67.0	489.0	523.0	557.0
159	2155	23.2	24.0	34.0	28.0	67.0	487.0	524.0	570.0
160	2168	23.4	24.0	34.0	28.6	66.0	484.0	524.0	569.0
161	2182	23.3	24.0	34.0	30.0	66.0	482.0	521.0	551.0
162	2196	23.2	24.0	34.0	29.2	66.0	479.0	518.0	550.0
163	2210	23.3	24.1	34.0	28.8	66.0	477.0	518.0	562.0
164	2223	23.2	24.1	34.0	28.6	65.0	476.0	518.0	550.0
165	2237	23.4	24.0	34.0	28.6	65.0	473.0	517.0	540.0
166	2251	23.3	24.0	34.0	28.6	65.0	470.0	514.0	532.0
167	2264	23.3	24.0	34.0	28.5	64.0	469.0	514.0	536.0
168	2278	23.3	24.0	34.0	28.3	64.0	466.0	512.0	537.0
169	2292	23.3	24.0	34.0	28.6	64.0	466.0	509.0	526.0
170	2306	23.3	24.0	34.0	29.0	64.0	463.0	508.0	520.0
171	2319	23.3	24.1	34.0	28.0	63.0	461.0	507.0	517.0
172	2333	23.3	24.1	34.0	29.5	63.0	459.0	505.0	513.0
173	2347	23.2	24.0	34.0	28.6	63.0	458.0	503.0	509.0
174	2361	23.3	24.0	34.0	29.4	63.0	456.0	500.0	505.0
175	2374	23.2	23.9	34.0	30.0	63.0	454.0	498.0	502.0
176	2388	23.3	24.1	34.0	28.8	63.0	453.0	496.0	499.0
177	2402	23.4	24.0	34.0	27.5	63.0	452.0	495.0	497.0
178	2416	23.2	24.0	34.0	27.2	62.0	449.0	492.0	499.0
179	2429	23.3	24.0	34.0	28.1	62.0	448.0	492.0	495.0
180	2443	23.3	24.0	34.0	28.7	62.0	446.0	493.0	492.0
181	2456	23.3	24.0	34.0	28.9	62.0	443.0	493.0	492.0
182	2470	23.3	24.1	35.0	29.3	62.0	441.0	491.0	489.0
183	2484	23.3	24.0	34.0	27.5	62.0	440.0	490.0	489.0
184	2497	23.3	24.1	35.0	27.2	61.0	440.0	489.0	487.0
185	2511	23.3	24.0	35.0	27.4	61.0	439.0	491.0	490.0
186	2525	23.3	24.0	35.0	28.0	61.0	438.0	490.0	491.0
187	2539	23.3	23.9	35.0	28.5	61.0	436.0	490.0	494.0
188	2552	23.2	23.9	35.0	27.5	61.0	432.0	491.0	496.0
189	2566	23.3	24.0	35.0	27.1	61.0	429.0	493.0	504.0

190	2580	23.4	24.0	35.0	28.6	61.0	428.0	492.0	498.0
191	2594	23.2	24.3	35.0	29.0	60.0	429.0	490.0	493.0
192	2607	23.3	23.9	35.0	29.0	60.0	428.0	488.0	494.0
193	2621	23.3	24.4	35.0	29.6	60.0	427.0	486.0	490.0
194	2635	23.3	24.1	35.0	28.2	60.0	427.0	485.0	490.0
195	2649	23.3	24.1	35.0	29.0	60.0	426.0	483.0	489.0
196	2662	23.2	24.0	35.0	29.5	60.0	426.0	482.0	484.0
197	2676	23.3	24.0	35.0	29.6	60.0	424.0	481.0	481.0
198	2689	23.3	24.1	35.0	29.3	60.0	424.0	481.0	480.0
199	2703	23.3	24.0	35.0	28.9	60.0	423.0	480.0	479.0
200	2717	23.3	24.0	35.0	28.8	60.0	423.0	479.0	479.0
201	2730	23.2	24.0	35.0	29.9	60.0	423.0	479.0	480.0
202	2744	23.2	23.9	35.0	28.7	60.0	424.0	479.0	479.0
203	2758	23.3	23.9	35.0	27.9	59.0	425.0	478.0	478.0
204	2772	23.2	24.0	35.0	28.4	59.0	423.0	479.0	485.0
205	2785	23.3	23.9	35.0	29.3	59.0	421.0	481.0	494.0
206	2800	23.3	23.9	35.0	29.8	59.0	420.0	484.0	499.0
207	2813	23.3	24.0	35.0	29.6	59.0	420.0	485.0	495.0
208	2827	23.3	24.1	35.0	29.4	59.0	420.0	484.0	491.0
209	2841	23.3	24.0	35.0	29.8	59.0	420.0	483.0	487.0
210	2855	23.3	24.1	35.0	28.7	59.0	421.0	480.0	480.0
211	2868	23.3	23.9	35.0	28.7	59.0	420.0	477.0	476.0
212	2882	23.2	24.0	36.0	29.5	59.0	419.0	477.0	474.0
213	2895	23.3	24.0	35.0	30.0	59.0	419.0	474.0	471.0
214	2909	23.3	23.9	35.0	29.5	58.0	419.0	472.0	469.0
215	2923	23.3	24.0	35.0	27.9	58.0	419.0	472.0	467.0
216	2937	23.3	24.0	36.0	27.6	60.0	425.0	478.0	477.0
217	2951	23.3	24.1	36.0	28.1	61.0	437.0	489.0	496.0
218	2964	23.2	24.2	36.0	29.4	62.0	447.0	502.0	507.0
219	2978	23.3	24.3	36.0	28.8	63.0	450.0	518.0	531.0
220	2992	23.3	24.2	36.0	28.2	63.0	453.0	526.0	544.0
221	3006	23.2	24.2	36.0	29.5	64.0	457.0	533.0	556.0
222	3020	23.3	24.2	36.0	29.4	64.0	463.0	540.0	560.0
223	3034	23.4	24.3	36.0	28.9	65.0	468.0	553.0	558.0
224	3047	23.2	24.3	36.0	28.7	65.0	472.0	558.0	556.0
225	3062	23.3	24.3	36.0	30.0	66.0	477.0	560.0	552.0
226	3075	23.3	24.3	36.0	29.3	66.0	482.0	563.0	555.0
227	3089	23.3	24.4	36.0	29.2	67.0	486.0	566.0	556.0
228	3103	23.3	24.4	36.0	30.0	67.0	489.0	568.0	556.0
229	3117	23.3	24.4	36.0	29.9	67.0	490.0	569.0	551.0
230	3130	23.3	24.4	36.0	27.7	67.0	490.0	569.0	548.0
231	3144	23.3	24.4	36.0	28.5	68.0	492.0	571.0	548.0
232	3158	23.3	24.4	37.0	28.9	69.0	496.0	570.0	546.0
233	3171	23.3	24.4	37.0	28.9	69.0	500.0	571.0	543.0
234	3185	23.3	24.6	37.0	29.0	70.0	505.0	569.0	542.0
235	3199	23.3	24.5	37.0	31.0	70.0	508.0	569.0	542.0
236	3213	23.3	24.7	37.0	29.5	70.0	513.0	571.0	540.0
237	3226	23.3	24.6	37.0	29.5	71.0	519.0	571.0	538.0
238	3240	23.3	24.5	37.0	28.9	71.0	524.0	571.0	537.0
239	3251	23.3	24.6	37.0	29.7	72.0	527.0	570.0	533.0
240	3265	23.3	24.6	37.0	28.8	72.0	534.0	570.0	528.0
241	3279	23.3	24.5	37.0	29.2	72.0	537.0	570.0	524.0
242	3293	23.3	24.7	37.0	27.4	73.0	539.0	571.0	524.0
243	3306	23.3	24.6	37.0	27.3	74.0	540.0	572.0	522.0
244	3320	23.2	24.6	37.0	27.4	74.0	540.0	570.0	518.0
245	3334	23.3	24.5	37.0	27.7	75.0	540.0	570.0	518.0
246	3347	23.3	24.6	38.0	28.0	75.0	541.0	571.0	514.0
247	3361	23.3	24.5	38.0	27.9	75.0	540.0	570.0	511.0
248	3375	23.3	24.7	38.0	30.0	75.0	540.0	571.0	507.0

249	3389	23.3	24.6	38.0	29.1	75.0	543.0	583.0	507.0
250	3402	23.2	24.7	38.0	29.4	76.0	547.0	587.0	510.0
251	3416	23.3	24.6	38.0	27.7	77.0	551.0	582.0	507.0
252	3430	23.3	24.7	38.0	29.8	77.0	559.0	581.0	502.0
253	3443	23.3	24.7	38.0	29.7	78.0	565.0	574.0	496.0
254	3457	23.3	24.7	38.0	29.8	79.0	566.0	571.0	495.0
255	3471	23.3	24.6	38.0	28.7	79.0	556.0	566.0	497.0
256	3485	23.2	24.8	38.0	29.2	79.0	553.0	564.0	498.0
257	3499	23.3	24.7	38.0	30.0	79.0	553.0	566.0	499.0
258	3512	23.3	24.8	38.0	28.7	80.0	552.0	566.0	501.0
259	3526	23.3	24.6	38.0	29.7	80.0	555.0	566.0	502.0
260	3540	23.2	25.1	38.0	28.0	79.0	552.0	561.0	495.0
261	3553	23.3	24.5	38.0	27.7	78.0	543.0	554.0	488.0
262	3567	23.3	24.4	38.0	29.3	77.0	542.0	549.0	481.0
263	3581	23.3	24.5	38.0	31.0	77.0	544.0	546.0	477.0
264	3595	23.3	24.5	38.0	30.0	77.0	541.0	550.0	474.0
265	3608	23.3	24.5	38.0	29.7	77.0	538.0	549.0	473.0
266	3622	23.3	24.3	38.0	27.9	76.0	533.0	548.0	472.0
267	3636	23.3	24.4	38.0	27.5	76.0	528.0	547.0	472.0
268	3649	23.3	24.3	38.0	27.8	76.0	534.0	547.0	472.0
269	3663	23.3	24.3	38.0	28.0	75.0	533.0	547.0	471.0
270	3677	23.3	24.4	38.0	28.0	75.0	526.0	542.0	467.0
271	3690	23.4	24.4	38.0	27.7	75.0	517.0	537.0	464.0
272	3704	23.2	24.2	38.0	27.5	75.0	512.0	533.0	460.0
273	3718	23.3	24.2	39.0	27.8	75.0	509.0	531.0	458.0
274	3732	23.3	24.2	38.0	27.9	75.0	505.0	530.0	462.0
275	3745	23.3	24.3	38.0	27.7	75.0	502.0	530.0	466.0
276	3759	23.3	24.1	39.0	28.0	74.0	500.0	530.0	466.0
277	3773	23.3	24.3	39.0	27.6	74.0	498.0	528.0	467.0
278	3786	23.3	24.3	38.0	27.6	74.0	496.0	527.0	467.0
279	3800	23.3	24.3	39.0	27.6	74.0	494.0	528.0	465.0
280	3814	23.2	24.3	39.0	27.3	73.0	491.0	527.0	464.0
281	3828	23.2	24.3	39.0	27.5	73.0	488.0	526.0	466.0
282	3841	23.2	24.4	39.0	27.7	73.0	489.0	528.0	466.0
283	3855	23.2	24.2	39.0	27.6	73.0	488.0	530.0	468.0
284	3869	23.3	24.2	39.0	27.5	73.0	488.0	530.0	467.0
285	3883	23.2	24.3	39.0	27.6	73.0	488.0	529.0	465.0
286	3896	23.2	24.3	39.0	27.8	73.0	489.0	527.0	465.0
287	3910	23.3	24.3	39.0	28.3	73.0	489.0	526.0	465.0
288	3924	23.3	24.2	39.0	31.0	72.0	488.0	525.0	464.0
289	3938	23.3	24.2	39.0	29.0	72.0	488.0	525.0	466.0
290	3951	23.3	24.2	39.0	29.3	72.0	484.0	523.0	466.0
291	3965	23.3	24.2	39.0	29.7	72.0	481.0	524.0	466.0
292	3979	23.2	24.2	39.0	29.6	72.0	480.0	522.0	467.0
293	3993	23.3	24.1	39.0	33.0	72.0	478.0	522.0	468.0
294	4006	23.2	24.1	39.0	29.2	72.0	478.0	522.0	468.0
295	4020	23.3	24.4	39.0	29.4	72.0	480.0	522.0	468.0
296	4034	23.2	24.3	39.0	28.9	72.0	480.0	522.0	468.0
297	4047	23.5	24.3	39.0	27.9	72.0	480.0	522.0	466.0
298	4061	23.4	24.3	39.0	31.0	72.0	481.0	521.0	465.0
299	4075	23.3	24.2	39.0	30.0	72.0	480.0	519.0	465.0
300	4089	23.5	24.2	39.0	29.2	72.0	480.0	520.0	468.0
301	4102	23.3	24.3	39.0	29.7	72.0	480.0	519.0	467.0
302	4116	23.3	24.2	39.0	29.8	72.0	479.0	519.0	468.0
303	4129	23.4	24.2	39.0	28.6	71.0	479.0	518.0	469.0
304	4143	23.3	24.2	39.0	29.7	71.0	479.0	517.0	470.0
305	4157	23.3	24.1	39.0	29.1	71.0	477.0	517.0	470.0
306	4171	23.3	24.1	39.0	31.0	71.0	474.0	517.0	471.0
307	4184	23.3	24.3	39.0	30.0	71.0	470.0	516.0	470.0

308	4196	23.4	24.1	39.0	31.0	71.0	469.0	515.0	469.0
309	4209	23.3	24.2	39.0	29.8	71.0	469.0	515.0	469.0
310	4223	23.2	24.2	39.0	29.0	70.0	467.0	508.0	469.0
311	4237	23.2	24.2	39.0	29.6	70.0	464.0	504.0	468.0
312	4250	23.3	24.2	39.0	29.5	70.0	464.0	506.0	467.0
313	4264	23.3	24.2	39.0	30.0	70.0	462.0	505.0	466.0
314	4278	23.2	24.2	39.0	31.0	70.0	459.0	504.0	465.0
315	4292	23.2	24.2	39.0	29.9	70.0	458.0	502.0	463.0
316	4305	24.4	24.1	39.0	29.6	70.0	456.0	501.0	462.0
317	4319	23.3	24.1	39.0	30.0	70.0	453.0	497.0	463.0
318	4333	23.2	24.3	39.0	30.0	70.0	453.0	498.0	463.0
319	4347	23.4	24.2	39.0	30.0	69.0	452.0	497.0	465.0
320	4360	23.3	24.1	39.0	30.0	69.0	452.0	496.0	466.0
321	4374	23.3	24.0	39.0	31.0	69.0	450.0	496.0	468.0
322	4388	23.3	24.1	39.0	31.0	69.0	449.0	496.0	468.0
323	4402	23.2	24.1	39.0	32.0	69.0	448.0	495.0	468.0
324	4415	23.4	24.1	39.0	30.0	69.0	447.0	494.0	465.0
325	4429	23.3	24.1	39.0	29.9	69.0	446.0	492.0	463.0
326	4442	23.3	24.1	39.0	27.7	69.0	445.0	503.0	463.0
327	4456	23.3	24.1	39.0	28.0	69.0	445.0	503.0	464.0
328	4470	23.3	24.2	39.0	28.7	69.0	444.0	502.0	462.0
329	4483	23.3	24.2	39.0	29.6	68.0	444.0	501.0	461.0
330	4497	23.3	24.3	40.0	29.1	69.0	443.0	502.0	461.0
331	4511	23.3	24.1	40.0	28.8	68.0	442.0	501.0	460.0
332	4525	23.2	24.2	40.0	29.6	68.0	440.0	501.0	461.0
333	4538	23.3	24.2	40.0	29.2	69.0	440.0	501.0	462.0
334	4552	23.3	24.1	40.0	36.0	68.0	439.0	501.0	462.0
335	4566	23.2	24.1	40.0	27.7	68.0	438.0	498.0	459.0
336	4580	23.3	24.1	40.0	27.9	68.0	436.0	496.0	458.0
337	4593	23.3	24.1	40.0	27.4	68.0	436.0	497.0	460.0
338	4607	23.3	24.2	40.0	27.8	68.0	437.0	498.0	462.0
339	4621	23.3	24.1	40.0	27.6	68.0	436.0	499.0	461.0
340	4635	23.4	24.1	40.0	27.8	68.0	436.0	498.0	460.0
341	4646	23.3	24.1	40.0	27.9	68.0	435.0	498.0	458.0
342	4659	23.4	24.0	40.0	27.7	68.0	435.0	498.0	460.0
343	4673	23.4	24.2	40.0	28.4	68.0	434.0	499.0	460.0
344	4687	23.3	24.2	40.0	28.2	68.0	433.0	499.0	458.0
345	4701	23.3	24.2	40.0	27.8	68.0	434.0	499.0	457.0
346	4714	23.3	24.2	40.0	27.8	68.0	434.0	498.0	456.0
347	4728	23.6	24.2	40.0	27.6	67.0	434.0	497.0	456.0
348	4742	23.3	24.2	40.0	27.6	68.0	434.0	496.0	455.0
349	4755	23.3	24.2	40.0	27.5	67.0	432.0	494.0	453.0
350	4769	23.3	24.1	40.0	27.7	67.0	432.0	492.0	452.0
351	4783	23.3	24.1	40.0	27.7	67.0	430.0	490.0	450.0
352	4796	23.3	24.1	40.0	27.7	67.0	429.0	490.0	452.0
353	4810	23.3	24.3	40.0	28.4	67.0	429.0	491.0	454.0
354	4824	23.3	24.2	40.0	29.4	67.0	429.0	491.0	455.0
355	4838	23.3	24.2	40.0	30.0	67.0	429.0	491.0	455.0
356	4851	23.3	24.2	40.0	33.0	67.0	429.0	492.0	454.0
357	4865	23.3	24.2	40.0	29.9	67.0	429.0	493.0	454.0
358	4879	23.3	24.1	40.0	29.6	67.0	428.0	493.0	453.0
359	4892	23.3	24.2	40.0	29.2	67.0	428.0	492.0	451.0
360	4906	23.5	24.2	40.0	29.0	67.0	427.0	491.0	452.0
361	4920	23.3	24.2	40.0	35.0	67.0	427.0	491.0	451.0
362	4934	23.6	24.1	40.0	31.0	67.0	427.0	491.0	452.0
363	4947	23.4	24.1	40.0	28.1	67.0	426.0	492.0	453.0
364	4961	23.4	24.2	40.0	28.7	67.0	425.0	493.0	455.0
365	4975	23.3	24.2	40.0	31.0	67.0	426.0	493.0	456.0
366	4989	23.3	24.2	40.0	31.0	67.0	425.0	492.0	455.0

367	5002	23.3	24.1	40.0	28.2	67.0	425.0	490.0	453.0
368	5016	23.3	24.1	40.0	28.0	67.0	425.0	489.0	452.0
369	5030	23.3	24.1	40.0	27.4	67.0	424.0	490.0	451.0
370	5044	23.3	24.1	40.0	28.2	67.0	424.0	482.0	451.0
371	5057	23.4	24.2	40.0	30.0	67.0	424.0	468.0	449.0
372	5071	23.3	24.1	40.0	29.7	66.0	423.0	466.0	449.0
373	5085	23.3	24.2	40.0	30.0	66.0	422.0	466.0	450.0
374	5098	23.3	24.1	40.0	29.0	67.0	423.0	467.0	451.0
375	5112	23.3	24.1	40.0	28.0	66.0	423.0	467.0	451.0
376	5126	23.3	24.2	40.0	28.3	66.0	423.0	467.0	449.0
377	5140	23.4	24.2	40.0	28.1	66.0	423.0	465.0	449.0
378	5153	23.3	24.3	40.0	27.9	66.0	421.0	464.0	448.0
379	5167	23.4	24.1	41.0	27.6	66.0	420.0	462.0	447.0
380	5181	23.3	24.1	40.0	27.6	66.0	420.0	464.0	447.0
381	5194	23.3	24.3	40.0	27.6	66.0	421.0	465.0	447.0
382	5208	23.3	24.2	40.0	27.9	66.0	421.0	465.0	447.0
383	5222	23.3	24.2	40.0	27.6	66.0	421.0	464.0	447.0
384	5235	23.3	24.3	41.0	27.6	66.0	423.0	465.0	445.0
385	5249	23.3	24.3	41.0	27.6	67.0	424.0	475.0	444.0
386	5263	23.3	24.3	41.0	28.3	67.0	423.0	470.0	438.0
387	5277	23.3	24.3	41.0	27.4	66.0	421.0	462.0	435.0
388	5291	23.4	24.1	41.0	27.7	66.0	420.0	464.0	436.0
389	5305	23.3	24.2	41.0	28.2	66.0	419.0	467.0	439.0
390	5318	23.4	24.2	41.0	28.2	66.0	418.0	468.0	441.0
391	5332	23.4	24.1	41.0	28.6	66.0	417.0	468.0	443.0
392	5346	23.5	24.2	41.0	28.3	66.0	417.0	468.0	444.0
393	5360	23.4	24.2	41.0	28.2	65.0	417.0	467.0	444.0
394	5373	23.3	24.2	41.0	27.8	65.0	416.0	465.0	442.0
395	5387	23.4	24.2	41.0	28.7	65.0	414.0	466.0	441.0
396	5401	23.3	24.2	41.0	28.2	65.0	414.0	465.0	441.0
397	5414	23.3	24.2	41.0	29.0	65.0	413.0	465.0	441.0
398	5428	23.3	24.2	41.0	29.6	65.0	413.0	464.0	441.0
399	5442	23.3	24.2	41.0	28.5	65.0	413.0	462.0	440.0
400	5456	23.3	24.2	41.0	27.2	66.0	414.0	459.0	437.0
401	5469	23.3	24.3	41.0	27.4	67.0	416.0	461.0	440.0
402	5481	23.3	24.2	41.0	27.7	67.0	418.0	464.0	444.0
403	5494	23.4	24.4	41.0	27.4	67.0	420.0	467.0	450.0
404	5508	23.4	24.2	41.0	31.0	68.0	423.0	471.0	455.0
405	5522	23.4	24.3	41.0	29.0	68.0	426.0	474.0	459.0
406	5535	23.4	24.3	41.0	29.2	69.0	429.0	476.0	461.0
407	5550	23.3	24.5	41.0	27.7	69.0	432.0	478.0	461.0
408	5563	23.3	24.4	41.0	28.1	69.0	433.0	490.0	464.0
409	5577	23.3	24.4	41.0	28.1	70.0	436.0	493.0	465.0
410	5590	23.3	24.4	41.0	28.6	70.0	438.0	496.0	466.0
411	5604	23.4	24.5	41.0	29.8	70.0	438.0	496.0	467.0
412	5618	23.4	24.4	41.0	29.5	70.0	439.0	498.0	466.0
413	5632	23.5	24.3	41.0	28.5	70.0	441.0	499.0	467.0
414	5645	23.3	24.4	41.0	28.6	71.0	442.0	500.0	469.0
415	5660	23.3	24.5	41.0	28.1	71.0	443.0	502.0	469.0
416	5671	23.3	24.4	41.0	28.4	71.0	444.0	502.0	467.0
417	5685	23.3	24.4	41.0	29.4	72.0	445.0	500.0	466.0
418	5695	23.3	24.4	41.0	30.0	71.0	445.0	499.0	466.0
419	5710	23.3	24.5	41.0	29.9	72.0	446.0	501.0	467.0
420	5723	23.3	24.4	41.0	30.0	72.0	446.0	501.0	469.0
421	5737	23.3	24.4	41.0	29.6	72.0	447.0	501.0	471.0
422	5751	23.5	24.6	41.0	30.0	72.0	447.0	502.0	472.0
423	5764	23.4	24.4	41.0	30.0	72.0	446.0	501.0	473.0
424	5778	23.3	24.4	41.0	28.0	72.0	445.0	501.0	474.0
425	5792	23.3	24.5	41.0	28.3	72.0	445.0	503.0	476.0

426	5806	23.3	24.4	41.0	30.0	72.0	445.0	503.0	478.0
427	5819	23.3	24.4	41.0	32.0	72.0	445.0	503.0	479.0
428	5833	23.3	24.4	41.0	32.0	71.0	445.0	502.0	478.0
429	5847	23.3	24.4	41.0	28.8	72.0	444.0	501.0	478.0
430	5861	23.3	24.4	41.0	28.7	71.0	444.0	502.0	480.0
431	5874	23.4	24.3	41.0	30.0	71.0	444.0	503.0	480.0
432	5888	23.3	24.3	41.0	32.0	71.0	444.0	503.0	480.0
433	5899	23.4	24.5	41.0	31.0	71.0	445.0	503.0	480.0
434	5913	23.3	24.4	41.0	31.0	72.0	445.0	503.0	481.0
435	5927	23.3	24.4	41.0	31.0	72.0	446.0	502.0	480.0
436	5941	23.3	24.4	41.0	35.0	72.0	446.0	501.0	480.0
437	5954	23.3	24.4	41.0	29.3	72.0	445.0	502.0	480.0
438	5968	23.3	24.4	41.0	28.9	72.0	445.0	503.0	480.0
439	5982	23.4	24.6	41.0	31.0	72.0	445.0	501.0	480.0
440	5996	23.3	24.6	41.0	32.0	72.0	445.0	501.0	481.0
441	6010	23.4	24.3	41.0	32.0	72.0	444.0	501.0	482.0
442	6023	23.5	24.4	41.0	28.8	72.0	444.0	501.0	483.0
443	6037	23.4	24.4	41.0	28.5	72.0	444.0	501.0	484.0
444	6050	23.3	24.4	41.0	28.2	72.0	444.0	500.0	484.0
445	6064	23.3	24.4	41.0	28.4	73.0	444.0	500.0	485.0
446	6078	23.3	24.4	41.0	28.1	73.0	445.0	501.0	485.0
447	6092	23.4	24.4	41.0	27.9	73.0	445.0	500.0	485.0
448	6103	23.3	24.3	41.0	28.1	73.0	445.0	500.0	484.0
449	6117	23.3	24.3	41.0	28.4	73.0	445.0	500.0	484.0
450	6130	23.3	24.4	41.0	28.4	73.0	445.0	500.0	485.0
451	6144	23.3	24.4	41.0	28.2	72.0	444.0	499.0	485.0
452	6158	23.3	24.4	41.0	28.3	73.0	444.0	499.0	485.0
453	6172	24.0	24.4	41.0	28.3	73.0	444.0	495.0	489.0
454	6185	23.3	24.5	41.0	28.8	72.0	443.0	516.0	514.0
455	6199	23.3	24.4	41.0	28.2	72.0	442.0	361.0	405.0
456	6213	23.4	24.4	41.0	27.7	73.0	442.0	175.0	219.0
457	6226	23.3	24.4	41.0	27.8	72.0	442.0	123.0	155.0
458	6240	23.3	24.3	41.0	29.6	72.0	440.0	94.0	117.0
459	6254	23.3	24.4	41.0	32.0	73.0	440.0	81.0	94.0
460	6268	23.3	24.2	41.0	32.0	73.0	442.0	72.0	79.0
461	6281	23.4	24.5	41.0	33.0	73.0	442.0	67.0	70.0
462	6295	23.3	24.5	41.0	33.0	73.0	443.0	65.0	64.0
463	6309	23.3	24.5	41.0	29.8	73.0	444.0	65.0	61.0

TEMPERATURE DATA

		THERMOCOUPLE NUMBERS (TEMPERATURES deg C)						
NO.	TIME	9	10	11	12	13	14	15
1	2	29.8	23.7	23.7	23.7	25.0	23.7	24.6
2	16	29.8	23.7	23.7	23.7	25.0	23.7	24.6
3	29	29.8	23.7	23.7	23.7	25.0	23.7	24.6
4	43	39.0	35.0	31.0	30.0	25.0	26.9	24.3
5	57	53.0	42.0	37.0	41.0	25.0	31.0	24.4
6	70	63.0	44.0	37.0	42.0	25.0	31.0	24.6
7	83	69.0	45.0	39.0	42.0	25.0	32.0	24.4
8	98	82.0	55.0	45.0	47.0	25.0	35.0	24.6
9	111	93.0	58.0	45.0	51.0	25.0	36.0	24.6
10	125	77.0	44.0	38.0	42.0	25.0	33.0	24.5
11	139	63.0	36.0	33.0	35.0	25.0	31.0	24.6
12	153	55.0	33.0	31.0	32.0	25.0	28.8	24.6
13	166	51.0	32.0	29.4	31.0	25.1	28.2	24.6
14	181	48.0	31.0	28.8	30.0	25.1	26.9	24.6
15	194	47.0	30.0	28.2	30.0	25.7	26.3	24.6
16	208	45.0	30.0	28.2	29.4	25.7	25.7	24.6
17	222	45.0	30.0	27.6	30.0	25.7	25.7	24.7

18	235	45.0	30.0	27.6	30.0	25.7	25.1	24.7
19	249	45.0	30.0	27.0	30.0	25.7	25.1	24.5
20	263	46.0	31.0	27.0	30.0	25.7	25.1	24.5
21	276	46.0	31.0	27.6	30.0	25.7	25.1	24.7
22	290	46.0	31.0	27.6	30.0	26.4	24.5	24.7
23	301	46.0	31.0	27.6	30.0	25.7	25.1	24.7
24	315	46.0	31.0	27.6	30.0	26.4	24.5	24.7
25	329	47.0	31.0	27.6	30.0	26.4	24.5	24.6
26	342	48.0	31.0	27.6	30.0	26.4	24.5	24.7
27	356	49.0	32.0	28.3	30.0	26.4	24.5	24.7
28	370	49.0	32.0	28.3	30.0	26.4	25.1	24.6
29	384	50.0	32.0	28.3	31.0	26.4	25.1	24.7
30	397	50.0	32.0	28.3	31.0	26.4	25.2	24.7
31	409	52.0	33.0	28.3	32.0	26.4	25.2	24.7
32	422	53.0	33.0	28.3	32.0	26.4	25.2	24.6
33	436	53.0	33.0	28.3	33.0	26.4	25.2	24.6
34	449	54.0	33.0	28.3	33.0	27.1	25.2	24.8
35	463	53.0	33.0	28.3	32.0	27.1	25.2	24.8
36	477	55.0	35.0	27.7	33.0	27.1	25.2	24.8
37	491	56.0	35.0	28.4	33.0	27.1	25.2	24.8
38	504	57.0	36.0	28.4	34.0	27.1	25.2	24.8
39	518	57.0	36.0	28.4	35.0	27.1	25.2	24.8
40	532	60.0	35.0	29.0	36.0	27.7	25.2	24.8
41	545	63.0	36.0	29.0	36.0	27.7	25.2	24.8
42	559	65.0	38.0	29.6	36.0	27.8	25.3	24.8
43	573	68.0	38.0	29.6	36.0	27.8	25.9	24.8
44	587	68.0	40.0	29.7	37.0	27.8	25.9	25.0
45	600	73.0	40.0	29.6	39.0	28.4	25.9	24.8
46	614	76.0	40.0	29.0	40.0	28.4	25.9	24.8
47	628	78.0	41.0	29.0	42.0	28.4	25.9	25.0
48	642	82.0	42.0	29.1	43.0	28.4	25.9	25.0
49	655	91.0	42.0	29.7	43.0	28.4	25.9	25.0
50	669	101.0	42.0	30.0	43.0	28.4	25.9	25.0
51	683	105.0	42.0	30.0	43.0	28.5	26.0	25.0
52	696	113.0	42.0	30.0	43.0	28.5	26.6	25.0
53	707	114.0	43.0	30.0	43.0	28.5	26.6	25.0
54	721	120.0	43.0	30.0	45.0	28.5	27.2	25.1
55	735	116.0	40.0	30.0	43.0	28.5	27.2	25.1
56	748	107.0	41.0	30.0	43.0	28.5	27.3	25.2
57	762	106.0	41.0	30.0	42.0	29.1	27.3	25.2
58	776	116.0	42.0	30.0	43.0	29.1	27.3	25.1
59	790	113.0	41.0	30.0	44.0	29.2	26.7	25.2
60	803	114.0	39.0	30.0	44.0	29.2	26.7	25.2
61	818	119.0	40.0	30.0	42.0	29.2	27.3	25.3
62	831	122.0	40.0	31.0	41.0	29.2	27.3	25.3
63	846	121.0	39.0	31.0	42.0	29.2	27.4	25.3
64	859	122.0	40.0	31.0	43.0	29.2	27.4	25.4
65	873	126.0	40.0	30.0	44.0	29.2	28.0	25.4
66	887	128.0	39.0	31.0	43.0	29.2	28.0	25.4
67	900	124.0	38.0	31.0	43.0	29.3	27.4	25.4
68	914	114.0	40.0	32.0	41.0	29.3	27.4	25.4
69	928	115.0	43.0	31.0	42.0	29.3	28.0	25.6
70	941	116.0	42.0	31.0	44.0	29.3	28.0	25.5
71	955	118.0	43.0	32.0	43.0	29.3	28.1	25.6
72	969	116.0	44.0	32.0	43.0	29.3	28.7	25.6
73	983	111.0	42.0	32.0	44.0	29.3	28.7	25.6
74	997	105.0	42.0	32.0	44.0	29.3	28.7	25.8
75	1007	101.0	42.0	32.0	44.0	29.3	29.3	25.8
76	1021	96.0	42.0	32.0	45.0	29.3	29.3	25.8

77	1035	95.0	41.0	33.0	46.0	29.4	29.4	25.8
78	1049	92.0	42.0	33.0	46.0	29.4	29.4	25.9
79	1063	96.0	43.0	34.0	46.0	29.4	29.4	25.9
80	1077	95.0	44.0	33.0	46.0	29.4	30.0	26.1
81	1090	96.0	44.0	33.0	47.0	30.0	30.0	26.1
82	1104	93.0	44.0	34.0	46.0	29.5	29.5	26.1
83	1118	90.0	44.0	34.0	46.0	29.5	29.5	26.1
84	1129	84.0	43.0	34.0	46.0	29.5	30.0	26.1
85	1142	84.0	43.0	34.0	44.0	29.5	30.0	26.1
86	1156	88.0	41.0	35.0	43.0	30.0	30.0	26.3
87	1170	91.0	41.0	35.0	43.0	30.0	30.0	26.3
88	1183	88.0	42.0	34.0	42.0	30.0	30.0	26.3
89	1197	85.0	42.0	35.0	43.0	30.0	29.5	26.4
90	1211	82.0	42.0	34.0	44.0	30.0	30.0	26.5
91	1225	78.0	43.0	33.0	45.0	30.0	29.6	26.5
92	1239	76.0	43.0	33.0	43.0	30.0	29.6	26.6
93	1253	78.0	43.0	34.0	45.0	30.0	29.6	26.7
94	1266	83.0	43.0	35.0	44.0	30.0	30.0	26.7
95	1280	84.0	42.0	34.0	43.0	29.7	30.0	26.7
96	1294	87.0	42.0	34.0	43.0	30.0	31.0	26.7
97	1308	87.0	42.0	34.0	42.0	30.0	31.0	26.8
98	1321	86.0	42.0	33.0	42.0	30.0	31.0	26.8
99	1335	89.0	40.0	33.0	41.0	30.0	31.0	26.9
100	1349	92.0	40.0	33.0	42.0	30.0	32.0	26.9
101	1363	95.0	42.0	34.0	44.0	30.0	32.0	27.0
102	1376	93.0	42.0	34.0	43.0	30.0	31.0	27.0
103	1390	91.0	40.0	34.0	43.0	30.0	31.0	27.1
104	1401	91.0	40.0	34.0	43.0	30.0	31.0	27.1
105	1415	97.0	39.0	34.0	44.0	30.0	31.0	27.1
106	1429	101.0	40.0	34.0	47.0	30.0	31.0	27.1
107	1442	98.0	42.0	34.0	47.0	30.0	31.0	27.1
108	1456	101.0	44.0	35.0	45.0	30.0	31.0	27.2
109	1470	108.0	44.0	35.0	45.0	31.0	31.0	27.3
110	1484	122.0	44.0	35.0	44.0	31.0	31.0	27.3
111	1497	130.0	43.0	36.0	44.0	31.0	31.0	27.4
112	1511	131.0	44.0	36.0	45.0	31.0	31.0	27.3
113	1524	122.0	42.0	36.0	47.0	31.0	31.0	27.5
114	1536	113.0	42.0	36.0	48.0	31.0	31.0	27.6
115	1549	109.0	43.0	35.0	49.0	31.0	31.0	27.5
116	1563	107.0	44.0	36.0	49.0	31.0	32.0	27.7
117	1577	109.0	44.0	36.0	48.0	31.0	32.0	27.7
118	1590	116.0	44.0	36.0	49.0	31.0	33.0	27.6
119	1604	128.0	46.0	36.0	51.0	31.0	33.0	27.7
120	1618	127.0	47.0	35.0	51.0	31.0	33.0	27.7
121	1632	132.0	48.0	36.0	53.0	31.0	33.0	27.8
122	1645	146.0	49.0	35.0	52.0	31.0	33.0	27.8
123	1659	159.0	49.0	35.0	52.0	31.0	33.0	27.9
124	1673	170.0	48.0	36.0	53.0	31.0	33.0	27.8
125	1687	175.0	48.0	36.0	53.0	31.0	34.0	27.9
126	1700	178.0	49.0	36.0	51.0	31.0	33.0	28.0
127	1714	183.0	48.0	37.0	52.0	31.0	33.0	28.0
128	1728	191.0	49.0	38.0	53.0	31.0	33.0	28.0
129	1742	209.0	50.0	38.0	53.0	31.0	33.0	28.0
130	1755	217.0	51.0	38.0	54.0	31.0	33.0	28.1
131	1769	220.0	52.0	39.0	55.0	31.0	33.0	28.1
132	1782	226.0	52.0	38.0	55.0	31.0	33.0	28.1
133	1796	296.0	52.0	38.0	53.0	31.0	33.0	28.1
134	1810	374.0	53.0	39.0	50.0	31.0	34.0	28.1
135	1823	626.0	52.0	39.0	50.0	31.0	33.0	28.2

136	1838	644.0	53.0	38.0	52.0	31.0	33.0	28.2
137	1851	692.0	54.0	38.0	55.0	31.0	33.0	28.2
138	1866	699.0	54.0	39.0	57.0	31.0	34.0	28.3
139	1880	606.0	54.0	39.0	58.0	31.0	34.0	28.4
140	1894	626.0	56.0	39.0	58.0	31.0	33.0	28.3
141	1907	720.0	59.0	39.0	58.0	31.0	33.0	28.3
142	1921	789.0	61.0	39.0	58.0	31.0	33.0	28.3
143	1935	747.0	62.0	39.0	57.0	31.0	33.0	28.3
144	1949	709.0	61.0	39.0	57.0	32.0	33.0	28.5
145	1962	714.0	64.0	41.0	57.0	32.0	33.0	28.4
146	1976	716.0	67.0	40.0	58.0	31.0	33.0	28.5
147	1990	722.0	69.0	40.0	60.0	32.0	33.0	28.6
148	2004	697.0	71.0	41.0	62.0	32.0	33.0	28.6
149	2017	698.0	70.0	43.0	63.0	32.0	34.0	28.5
150	2031	676.0	69.0	43.0	63.0	32.0	34.0	28.6
151	2045	668.0	68.0	43.0	63.0	32.0	35.0	28.7
152	2058	692.0	69.0	43.0	64.0	32.0	35.0	28.6
153	2072	697.0	73.0	45.0	64.0	32.0	35.0	28.7
154	2086	678.0	77.0	45.0	65.0	32.0	35.0	28.7
155	2100	688.0	81.0	45.0	64.0	32.0	35.0	28.7
156	2113	689.0	85.0	45.0	63.0	32.0	35.0	28.8
157	2127	703.0	87.0	44.0	64.0	32.0	35.0	28.7
158	2141	735.0	87.0	43.0	64.0	32.0	36.0	28.8
159	2155	700.0	84.0	42.0	65.0	32.0	37.0	28.9
160	2168	705.0	86.0	41.0	64.0	32.0	37.0	28.9
161	2182	715.0	88.0	44.0	63.0	32.0	37.0	28.9
162	2196	709.0	97.0	45.0	62.0	32.0	37.0	28.9
163	2210	683.0	98.0	46.0	63.0	32.0	37.0	28.9
164	2223	681.0	99.0	46.0	66.0	32.0	37.0	28.9
165	2237	686.0	104.0	48.0	68.0	33.0	38.0	29.0
166	2251	700.0	107.0	48.0	68.0	33.0	38.0	29.0
167	2264	733.0	114.0	47.0	67.0	33.0	38.0	29.0
168	2278	693.0	120.0	48.0	64.0	33.0	38.0	29.1
169	2292	673.0	128.0	48.0	62.0	33.0	39.0	29.1
170	2306	667.0	136.0	49.0	64.0	33.0	39.0	29.1
171	2319	671.0	144.0	49.0	67.0	33.0	39.0	29.0
172	2333	641.0	166.0	50.0	74.0	33.0	40.0	29.1
173	2347	637.0	182.0	50.0	76.0	33.0	40.0	29.2
174	2361	624.0	188.0	51.0	76.0	33.0	41.0	29.1
175	2374	627.0	194.0	51.0	76.0	33.0	41.0	29.2
176	2388	619.0	250.0	51.0	78.0	33.0	41.0	29.2
177	2402	622.0	337.0	51.0	79.0	33.0	41.0	29.1
178	2416	636.0	385.0	52.0	81.0	33.0	41.0	29.2
179	2429	614.0	425.0	53.0	82.0	33.0	41.0	29.3
180	2443	605.0	553.0	52.0	88.0	33.0	41.0	29.2
181	2456	597.0	516.0	53.0	92.0	33.0	41.0	29.2
182	2470	594.0	425.0	53.0	91.0	33.0	42.0	29.3
183	2484	590.0	605.0	53.0	91.0	33.0	42.0	29.3
184	2497	584.0	542.0	53.0	89.0	33.0	42.0	29.3
185	2511	587.0	464.0	56.0	91.0	33.0	41.0	29.3
186	2525	590.0	474.0	58.0	94.0	33.0	41.0	29.4
187	2539	589.0	422.0	61.0	99.0	33.0	42.0	29.4
188	2552	588.0	389.0	62.0	104.0	34.0	42.0	29.3
189	2566	613.0	444.0	62.0	113.0	34.0	42.0	29.3
190	2580	595.0	664.0	62.0	114.0	34.0	42.0	29.3
191	2594	585.0	636.0	63.0	112.0	34.0	42.0	29.5
192	2607	593.0	560.0	62.0	107.0	34.0	42.0	29.4
193	2621	582.0	633.0	61.0	107.0	34.0	42.0	29.4
194	2635	572.0	614.0	64.0	109.0	34.0	42.0	29.4

195	2649	566.0	594.0	64.0	113.0	34.0	42.0	29.5
196	2662	559.0	645.0	63.0	113.0	34.0	42.0	29.5
197	2676	557.0	716.0	65.0	112.0	34.0	42.0	29.6
198	2689	557.0	702.0	67.0	116.0	34.0	43.0	29.5
199	2703	555.0	699.0	69.0	127.0	34.0	43.0	29.5
200	2717	556.0	651.0	72.0	146.0	34.0	42.0	29.6
201	2730	556.0	629.0	74.0	188.0	34.0	43.0	29.6
202	2744	553.0	643.0	75.0	172.0	35.0	43.0	29.6
203	2758	553.0	660.0	76.0	197.0	34.0	43.0	29.6
204	2772	560.0	679.0	76.0	187.0	34.0	43.0	29.7
205	2785	554.0	693.0	76.0	357.0	35.0	43.0	29.6
206	2800	548.0	708.0	77.0	489.0	35.0	43.0	29.6
207	2813	558.0	745.0	78.0	638.0	35.0	42.0	29.7
208	2827	567.0	819.0	79.0	659.0	35.0	42.0	29.6
209	2841	559.0	882.0	84.0	641.0	35.0	42.0	29.6
210	2855	560.0	925.0	85.0	483.0	35.0	42.0	29.8
211	2868	563.0	896.0	86.0	693.0	35.0	42.0	29.7
212	2882	561.0	814.0	87.0	835.0	35.0	41.0	29.7
213	2895	555.0	753.0	89.0	867.0	35.0	42.0	29.7
214	2909	552.0	711.0	94.0	865.0	35.0	43.0	29.7
215	2923	551.0	732.0	96.0	801.0	35.0	43.0	29.8
216	2937	572.0	810.0	95.0	751.0	35.0	42.0	29.8
217	2951	600.0	862.0	88.0	723.0	35.0	42.0	29.7
218	2964	610.0	1066.0	86.0	513.0	36.0	43.0	29.8
219	2978	670.0	899.0	87.0	610.0	36.0	43.0	29.9
220	2992	732.0	892.0	85.0	557.0	36.0	43.0	29.9
221	3006	731.0	849.0	83.0	282.0	36.0	44.0	29.9
222	3020	716.0	848.0	78.0	275.0	36.0	43.0	29.9
223	3034	682.0	874.0	77.0	196.0	36.0	42.0	30.0
224	3047	663.0	897.0	75.0	177.0	37.0	41.0	30.0
225	3062	665.0	820.0	75.0	151.0	37.0	41.0	30.0
226	3075	672.0	844.0	77.0	147.0	37.0	41.0	30.0
227	3089	661.0	861.0	79.0	122.0	37.0	39.0	30.0
228	3103	650.0	770.0	77.0	123.0	37.0	41.0	30.0
229	3117	631.0	876.0	80.0	126.0	37.0	43.0	30.0
230	3130	628.0	886.0	80.0	124.0	36.0	42.0	30.0
231	3144	626.0	836.0	81.0	139.0	36.0	41.0	30.0
232	3158	617.0	802.0	79.0	121.0	36.0	43.0	30.0
233	3171	611.0	753.0	82.0	105.0	36.0	43.0	30.0
234	3185	617.0	757.0	79.0	105.0	36.0	41.0	30.0
235	3199	620.0	791.0	76.0	107.0	37.0	42.0	30.0
236	3213	615.0	730.0	76.0	102.0	36.0	42.0	30.0
237	3226	616.0	686.0	73.0	89.0	36.0	41.0	31.0
238	3240	609.0	665.0	71.0	86.0	36.0	41.0	31.0
239	3251	597.0	679.0	73.0	87.0	36.0	42.0	31.0
240	3265	584.0	712.0	75.0	88.0	35.0	42.0	31.0
241	3279	580.0	699.0	72.0	89.0	35.0	41.0	31.0
242	3293	578.0	692.0	73.0	85.0	35.0	41.0	31.0
243	3306	570.0	662.0	73.0	84.0	35.0	41.0	31.0
244	3320	565.0	634.0	70.0	86.0	35.0	41.0	31.0
245	3334	563.0	648.0	71.0	91.0	34.0	40.0	31.0
246	3347	553.0	761.0	70.0	83.0	34.0	40.0	31.0
247	3361	548.0	767.0	70.0	69.0	34.0	39.0	31.0
248	3375	547.0	787.0	71.0	68.0	34.0	39.0	31.0
249	3389	553.0	807.0	70.0	70.0	34.0	39.0	31.0
250	3402	551.0	799.0	65.0	71.0	34.0	39.0	31.0
251	3416	540.0	721.0	64.0	72.0	34.0	39.0	31.0
252	3430	537.0	703.0	63.0	75.0	34.0	40.0	31.0
253	3443	540.0	743.0	64.0	72.0	34.0	39.0	31.0

254	3457	544.0	786.0	64.0	68.0	34.0	39.0	31.0
255	3471	545.0	790.0	67.0	71.0	34.0	40.0	31.0
256	3485	551.0	755.0	67.0	72.0	34.0	40.0	31.0
257	3499	552.0	772.0	66.0	67.0	34.0	40.0	31.0
258	3512	553.0	777.0	66.0	69.0	34.0	39.0	31.0
259	3526	551.0	794.0	66.0	66.0	33.0	40.0	31.0
260	3540	542.0	774.0	67.0	66.0	33.0	40.0	31.0
261	3553	533.0	733.0	68.0	69.0	33.0	41.0	31.0
262	3567	526.0	743.0	68.0	67.0	33.0	40.0	31.0
263	3581	526.0	660.0	70.0	68.0	33.0	40.0	32.0
264	3595	525.0	699.0	69.0	68.0	33.0	41.0	32.0
265	3608	526.0	766.0	69.0	71.0	33.0	41.0	32.0
266	3622	531.0	715.0	68.0	68.0	33.0	40.0	32.0
267	3636	533.0	793.0	67.0	68.0	33.0	40.0	31.0
268	3649	533.0	720.0	66.0	66.0	33.0	40.0	31.0
269	3663	531.0	753.0	66.0	68.0	33.0	40.0	32.0
270	3677	527.0	770.0	66.0	72.0	33.0	39.0	32.0
271	3690	524.0	715.0	66.0	78.0	32.0	38.0	32.0
272	3704	522.0	718.0	66.0	73.0	32.0	38.0	32.0
273	3718	525.0	756.0	67.0	74.0	32.0	37.0	32.0
274	3732	530.0	704.0	67.0	74.0	32.0	35.0	32.0
275	3745	530.0	666.0	67.0	74.0	32.0	35.0	32.0
276	3759	526.0	614.0	67.0	70.0	32.0	36.0	32.0
277	3773	525.0	628.0	67.0	71.0	32.0	36.0	32.0
278	3786	519.0	611.0	63.0	71.0	32.0	35.0	32.0
279	3800	516.0	619.0	62.0	70.0	32.0	35.0	32.0
280	3814	520.0	601.0	64.0	73.0	32.0	34.0	32.0
281	3828	521.0	642.0	68.0	77.0	32.0	34.0	32.0
282	3841	522.0	637.0	67.0	79.0	31.0	34.0	32.0
283	3855	523.0	615.0	67.0	79.0	32.0	35.0	32.0
284	3869	523.0	604.0	67.0	70.0	31.0	35.0	32.0
285	3883	521.0	659.0	70.0	72.0	31.0	34.0	32.0
286	3896	522.0	655.0	71.0	70.0	31.0	35.0	32.0
287	3910	523.0	671.0	74.0	74.0	31.0	36.0	32.0
288	3924	527.0	652.0	71.0	79.0	31.0	36.0	32.0
289	3938	531.0	643.0	69.0	78.0	32.0	36.0	32.0
290	3951	531.0	627.0	68.0	81.0	32.0	36.0	32.0
291	3965	531.0	649.0	67.0	76.0	32.0	36.0	32.0
292	3979	534.0	654.0	68.0	79.0	32.0	36.0	32.0
293	3993	533.0	672.0	78.0	80.0	32.0	36.0	32.0
294	4006	530.0	678.0	85.0	80.0	32.0	36.0	32.0
295	4020	528.0	713.0	92.0	84.0	32.0	37.0	32.0
296	4034	526.0	853.0	102.0	79.0	33.0	37.0	32.0
297	4047	526.0	823.0	103.0	91.0	33.0	38.0	32.0
298	4061	531.0	816.0	102.0	90.0	33.0	37.0	32.0
299	4075	538.0	842.0	100.0	87.0	33.0	37.0	32.0
300	4089	542.0	725.0	97.0	87.0	33.0	38.0	32.0
301	4102	539.0	739.0	99.0	94.0	33.0	38.0	32.0
302	4116	541.0	692.0	100.0	101.0	33.0	38.0	32.0
303	4129	539.0	732.0	107.0	89.0	33.0	39.0	32.0
304	4143	538.0	703.0	109.0	101.0	33.0	40.0	32.0
305	4157	537.0	691.0	111.0	136.0	33.0	41.0	32.0
306	4171	536.0	675.0	113.0	212.0	33.0	40.0	32.0
307	4184	534.0	663.0	117.0	244.0	34.0	40.0	32.0
308	4196	532.0	649.0	126.0	184.0	34.0	40.0	32.0
309	4209	528.0	653.0	141.0	156.0	34.0	40.0	32.0
310	4223	527.0	640.0	153.0	182.0	34.0	40.0	32.0
311	4237	524.0	622.0	167.0	272.0	34.0	40.0	32.0
312	4250	523.0	630.0	176.0	288.0	34.0	41.0	32.0

313	4264	522.0	621.0	195.0	443.0	34.0	42.0	32.0
314	4278	520.0	632.0	204.0	209.0	34.0	42.0	32.0
315	4292	524.0	668.0	198.0	152.0	34.0	43.0	32.0
316	4305	526.0	671.0	213.0	129.0	34.0	44.0	32.0
317	4319	527.0	692.0	209.0	136.0	35.0	44.0	32.0
318	4333	534.0	717.0	201.0	154.0	35.0	44.0	32.0
319	4347	539.0	720.0	225.0	207.0	35.0	44.0	32.0
320	4360	547.0	732.0	209.0	243.0	35.0	44.0	32.0
321	4374	553.0	755.0	207.0	255.0	35.0	44.0	32.0
322	4388	547.0	738.0	217.0	198.0	36.0	44.0	32.0
323	4402	537.0	720.0	248.0	227.0	36.0	46.0	32.0
324	4415	532.0	710.0	282.0	215.0	36.0	46.0	32.0
325	4429	533.0	699.0	312.0	272.0	36.0	46.0	32.0
326	4442	534.0	686.0	337.0	232.0	36.0	45.0	32.0
327	4456	532.0	677.0	321.0	321.0	36.0	44.0	32.0
328	4470	525.0	675.0	339.0	336.0	35.0	44.0	32.0
329	4483	522.0	670.0	342.0	269.0	35.0	46.0	32.0
330	4497	524.0	673.0	369.0	260.0	35.0	45.0	32.0
331	4511	527.0	674.0	469.0	323.0	35.0	47.0	32.0
332	4525	528.0	670.0	661.0	487.0	36.0	48.0	32.0
333	4538	532.0	670.0	671.0	496.0	36.0	48.0	32.0
334	4552	533.0	670.0	701.0	619.0	36.0	49.0	32.0
335	4566	530.0	675.0	737.0	586.0	36.0	49.0	32.0
336	4580	530.0	670.0	790.0	836.0	35.0	50.0	32.0
337	4593	533.0	676.0	761.0	787.0	35.0	49.0	32.0
338	4607	533.0	673.0	828.0	905.0	35.0	51.0	32.0
339	4621	528.0	664.0	803.0	950.0	35.0	51.0	32.0
340	4635	523.0	659.0	870.0	938.0	35.0	51.0	32.0
341	4646	521.0	655.0	913.0	1000.0	35.0	52.0	32.0
342	4659	519.0	650.0	748.0	990.0	35.0	53.0	32.0
343	4673	519.0	638.0	828.0	740.0	35.0	55.0	32.0
344	4687	516.0	625.0	905.0	928.0	35.0	56.0	32.0
345	4701	514.0	626.0	850.0	890.0	35.0	58.0	32.0
346	4714	512.0	625.0	829.0	965.0	35.0	57.0	32.0
347	4728	512.0	625.0	763.0	1016.0	35.0	57.0	32.0
348	4742	509.0	621.0	766.0	819.0	35.0	56.0	32.0
349	4755	507.0	618.0	727.0	922.0	35.0	58.0	32.0
350	4769	504.0	618.0	727.0	976.0	35.0	61.0	32.0
351	4783	504.0	622.0	762.0	963.0	35.0	62.0	32.0
352	4796	507.0	627.0	770.0	962.0	35.0	65.0	32.0
353	4810	510.0	625.0	703.0	1020.0	35.0	69.0	32.0
354	4824	509.0	622.0	720.0	985.0	35.0	69.0	32.0
355	4838	510.0	616.0	685.0	860.0	35.0	79.0	32.0
356	4851	507.0	615.0	681.0	1003.0	35.0	98.0	32.0
357	4865	507.0	613.0	691.0	989.0	35.0	110.0	32.0
358	4879	505.0	610.0	770.0	1026.0	36.0	120.0	32.0
359	4892	503.0	617.0	793.0	960.0	36.0	121.0	32.0
360	4906	504.0	621.0	779.0	941.0	36.0	111.0	32.0
361	4920	505.0	623.0	784.0	926.0	36.0	110.0	32.0
362	4934	508.0	631.0	784.0	874.0	37.0	110.0	32.0
363	4947	511.0	633.0	762.0	873.0	37.0	106.0	32.0
364	4961	513.0	628.0	721.0	899.0	37.0	104.0	32.0
365	4975	510.0	615.0	707.0	881.0	37.0	111.0	32.0
366	4989	507.0	602.0	712.0	906.0	37.0	117.0	32.0
367	5002	504.0	589.0	699.0	944.0	37.0	122.0	32.0
368	5016	503.0	583.0	703.0	925.0	36.0	139.0	32.0
369	5030	503.0	583.0	717.0	926.0	36.0	165.0	32.0
370	5044	502.0	581.0	710.0	926.0	36.0	187.0	32.0

371	5057	502.0	577.0	713.0	880.0	36.0	188.0	32.0
372	5071	502.0	578.0	723.0	894.0	36.0	190.0	32.0
373	5085	504.0	579.0	711.0	879.0	37.0	209.0	32.0
374	5098	504.0	575.0	710.0	983.0	37.0	199.0	32.0
375	5112	501.0	572.0	705.0	898.0	37.0	203.0	32.0
376	5126	499.0	573.0	698.0	976.0	37.0	197.0	32.0
377	5140	500.0	572.0	674.0	921.0	37.0	202.0	32.0
378	5153	500.0	565.0	671.0	840.0	37.0	214.0	32.0
379	5167	496.0	556.0	669.0	810.0	36.0	221.0	32.0
380	5181	495.0	555.0	664.0	848.0	36.0	340.0	32.0
381	5194	496.0	552.0	655.0	960.0	36.0	348.0	32.0
382	5208	494.0	545.0	640.0	982.0	36.0	329.0	32.0
383	5222	493.0	540.0	612.0	921.0	36.0	361.0	32.0
384	5235	490.0	531.0	605.0	895.0	36.0	341.0	32.0
385	5249	483.0	528.0	688.0	759.0	35.0	246.0	32.0
386	5263	478.0	545.0	705.0	774.0	35.0	216.0	32.0
387	5277	481.0	562.0	707.0	991.0	35.0	201.0	32.0
388	5291	488.0	574.0	728.0	892.0	35.0	208.0	32.0
389	5305	493.0	587.0	728.0	872.0	35.0	257.0	32.0
390	5318	496.0	587.0	703.0	901.0	35.0	274.0	32.0
391	5332	498.0	579.0	759.0	895.0	35.0	248.0	32.0
392	5346	499.0	598.0	756.0	863.0	35.0	239.0	32.0
393	5360	498.0	585.0	766.0	871.0	35.0	240.0	32.0
394	5373	495.0	585.0	859.0	844.0	35.0	249.0	32.0
395	5387	494.0	575.0	739.0	826.0	35.0	265.0	32.0
396	5401	490.0	566.0	695.0	807.0	35.0	278.0	32.0
397	5414	488.0	562.0	678.0	797.0	35.0	263.0	32.0
398	5428	488.0	558.0	682.0	786.0	35.0	299.0	32.0
399	5442	489.0	564.0	716.0	811.0	35.0	328.0	32.0
400	5456	495.0	582.0	780.0	854.0	35.0	283.0	32.0
401	5469	503.0	596.0	829.0	807.0	35.0	287.0	32.0
402	5481	510.0	606.0	783.0	846.0	35.0	335.0	32.0
403	5494	521.0	617.0	766.0	1073.0	35.0	314.0	32.0
404	5508	528.0	622.0	770.0	991.0	35.0	385.0	32.0
405	5522	532.0	613.0	737.0	979.0	35.0	420.0	32.0
406	5535	528.0	598.0	708.0	771.0	35.0	426.0	32.0
407	5550	526.0	597.0	684.0	888.0	35.0	346.0	32.0
408	5563	527.0	595.0	686.0	794.0	35.0	311.0	32.0
409	5577	528.0	595.0	707.0	874.0	35.0	331.0	32.0
410	5590	526.0	583.0	717.0	974.0	35.0	287.0	32.0
411	5604	521.0	574.0	699.0	913.0	36.0	276.0	32.0
412	5618	519.0	577.0	771.0	990.0	36.0	350.0	32.0
413	5632	528.0	597.0	786.0	1089.0	36.0	346.0	32.0
414	5645	528.0	593.0	737.0	1048.0	37.0	360.0	32.0
415	5660	524.0	586.0	719.0	810.0	37.0	313.0	32.0
416	5671	520.0	577.0	723.0	869.0	37.0	299.0	32.0
417	5685	518.0	574.0	713.0	847.0	37.0	309.0	32.0
418	5695	519.0	579.0	747.0	1001.0	37.0	311.0	32.0
419	5710	524.0	593.0	732.0	944.0	37.0	307.0	32.0
420	5723	527.0	596.0	702.0	948.0	37.0	315.0	32.0
421	5737	530.0	600.0	721.0	1055.0	37.0	299.0	33.0
422	5751	532.0	606.0	739.0	992.0	38.0	425.0	33.0
423	5764	534.0	611.0	748.0	1044.0	38.0	425.0	33.0
424	5778	538.0	625.0	816.0	1043.0	38.0	466.0	33.0
425	5792	540.0	637.0	776.0	969.0	38.0	399.0	33.0
426	5806	543.0	639.0	744.0	1105.0	38.0	289.0	33.0
427	5819	542.0	619.0	721.0	1059.0	38.0	262.0	33.0
428	5833	539.0	609.0	727.0	1019.0	38.0	235.0	33.0
429	5847	541.0	610.0	728.0	1014.0	38.0	211.0	33.0

430	5861	542.0	604.0	727.0	929.0	38.0	191.0	33.0
431	5874	542.0	599.0	717.0	857.0	38.0	180.0	33.0
432	5888	541.0	598.0	709.0	815.0	38.0	173.0	33.0
433	5899	542.0	598.0	716.0	805.0	39.0	175.0	33.0
434	5913	542.0	599.0	693.0	809.0	39.0	177.0	33.0
435	5927	542.0	592.0	674.0	700.0	38.0	176.0	33.0
436	5941	543.0	589.0	671.0	807.0	38.0	175.0	33.0
437	5954	545.0	585.0	680.0	789.0	39.0	186.0	33.0
438	5968	544.0	583.0	686.0	832.0	38.0	214.0	33.0
439	5982	544.0	583.0	684.0	805.0	38.0	208.0	33.0
440	5996	546.0	584.0	688.0	870.0	38.0	207.0	33.0
441	6010	549.0	582.0	687.0	532.0	38.0	325.0	33.0
442	6023	551.0	583.0	679.0	299.0	38.0	309.0	33.0
443	6037	552.0	583.0	670.0	489.0	38.0	347.0	33.0
444	6050	551.0	577.0	647.0	709.0	38.0	277.0	33.0
445	6064	551.0	574.0	667.0	799.0	37.0	251.0	33.0
446	6078	550.0	572.0	723.0	871.0	37.0	346.0	33.0
447	6092	549.0	575.0	698.0	790.0	37.0	354.0	33.0
448	6103	550.0	578.0	685.0	991.0	37.0	274.0	33.0
449	6117	550.0	575.0	665.0	793.0	37.0	246.0	33.0
450	6130	553.0	570.0	664.0	708.0	37.0	211.0	33.0
451	6144	550.0	569.0	653.0	758.0	37.0	187.0	33.0
452	6158	551.0	566.0	648.0	951.0	37.0	183.0	33.0
453	6172	556.0	565.0	659.0	367.0	37.0	168.0	33.0
454	6185	540.0	607.0	614.0	180.0	36.0	149.0	33.0
455	6199	433.0	497.0	404.0	120.0	36.0	126.0	33.0
456	6213	260.0	305.0	282.0	90.0	36.0	121.0	33.0
457	6226	183.0	224.0	225.0	75.0	36.0	120.0	33.0
458	6240	141.0	178.0	183.0	66.0	36.0	112.0	33.0
459	6254	115.0	147.0	154.0	62.0	36.0	105.0	33.0
460	6268	93.0	125.0	135.0	61.0	37.0	98.0	33.0
461	6281	81.0	108.0	119.0	60.0	37.0	95.0	33.0
462	6295	72.0	96.0	108.0	59.0	38.0	90.0	33.0
463	6309	67.0	88.0	97.0	59.0	38.0	85.0	33.0

RUN R8

WOOD ADDITION DATA:

TIME	SIZE (grammes)
380	200
600	50
685	50
806	100
1240	100
1665	100
2010	100
2325	100
2550	100
2780	50
2880	200
3390	200
3790	100
4005	100
4155	100
4350	200
4770	200
5050	200
5840	200

HEIGHT OF CHAR BED DATA:

TIME	HEIGHT (cms)	
	L	R
240	6.0	5.5
300	5.0	5.5
360	3.5	5.5
540	5.0	6.5
600	5.5	7.0
660	4.5	7.0
720	5.0	6.5
780	5.5	6.5
870	4.5	6.5
960	4.5	6.5
1020	4.5	6.5
1140	4.5	6.75
1200	4.5	7.0
1260	6.0	7.0
1380	7.0	8.0
1440	6.5	8.5
1560	8.0	8.75
1680	9.0	9.5
1800	10.0	10.5
1920	11.0	11.5
1980	11.0	11.5
2040	10.0	11.5
2160	11.0	12.0
2280	11.5	12.0
2400	11.5	12.0
2520	10.5	12.0
2640	10.5	12.0
2880	11.5	12.0
3000	11.5	12.0
3120	11.5	12.0
3240	11.5	12.0
3360	11.5	12.0

3720		11.25	12.0
4080		11.0	12.0
4200		11.0	12.0
4440		11.0	12.0
4680		11.0	12.0
4920		11.5	12.0
5040		11.5	12.0
5160		11.5	12.0
5400		11.0	12.0
5520		11.0	12.0
5640		12.0	12.5
5760		12.5	13.0
5880		13.0	13.0
6000		13.5	13.5
6120		14.0	14.0
6240		14.5	13.5
6360		15.0	13.5
6420		15.0	13.5
6480		15.0	14.0

GAS COMPOSITION ,PRESSURE & FLOWRATE DATA :

NO.	TIME	H2	CO	CO2	CH4	N2	PT1	PT2	FLOW
1	2	0.4	0.4	0.0	0.0	99.2	767.5	761.0	0.9
2	16	0.4	0.5	0.0	0.0	99.1	768.0	760.5	0.9
3	31	0.5	0.5	0.0	0.0	99.0	768.0	761.0	1.0
4	45	0.5	0.5	0.0	0.0	99.0	768.5	760.5	1.1
5	59	0.5	0.5	0.0	0.0	99.0	768.0	760.0	0.0
6	73	0.4	0.5	0.0	0.0	99.1	768.5	760.0	0.0
7	87	0.5	0.5	0.0	0.0	99.0	768.5	761.5	0.9
8	101	0.4	0.5	0.0	0.0	99.1	768.0	761.5	1.1
9	115	0.5	0.5	0.0	0.0	99.0	769.0	761.5	1.2
10	130	0.4	0.5	0.0	0.0	99.1	769.0	761.5	1.2
11	144	0.5	0.6	0.0	0.0	98.9	768.0	763.0	1.4
12	158	0.4	0.6	0.0	0.0	99.0	768.5	763.0	1.4
13	172	0.4	0.6	0.0	0.0	99.0	768.0	762.5	1.5
14	187	0.5	0.5	0.0	0.0	99.0	768.0	762.5	1.4
15	201	0.4	0.5.	0.0	0.0	99.1	767.5	762.5	1.4
16	215	0.5	0.6	0.0	0.0	98.9	767.5	762.5	1.4
17	229	0.5	0.6	0.0	0.0	98.9	767.5	762.0	1.3
18	244	0.4	0.6	0.0	0.0	99.0	767.0	763.5	1.4
19	258	0.4	0.6	0.0	0.0	99.0	767.0	762.0	1.3
20	272	0.5	0.6	0.0	0.0	98.9	768.0	762.5	1.4
21	286	0.5	0.6	0.0	0.0	98.9	768.0	762.5	1.4
22	300	0.5	0.6	0.0	0.0	98.9	768.0	763.0	1.3
23	314	0.4	0.6	0.0	0.0	99.0	768.5	762.0	1.3
24	328	0.4	0.6	0.0	0.0	99.0	768.0	762.0	1.3
25	343	0.5	0.5	0.0	0.0	99.0	767.5	762.0	1.3
26	357	0.4	0.5	0.0	0.0	99.1	768.0	762.5	1.3
27	371	0.5	0.5	0.0	0.0	99.0	768.0	762.0	1.4
28	385	0.4	0.5	0.0	0.0	99.1	767.5	762.5	1.3
29	400	0.5	0.5	0.0	0.0	99.0	767.0	762.0	1.3
30	411	0.4	0.6	0.0	0.0	99.0	768.0	762.0	1.4
31	426	0.4	0.5	0.1	0.0	99.0	768.5	762.5	1.3
32	440	0.5	0.5	0.0	0.0	99.0	768.0	762.5	1.4
33	454	0.5	0.5	0.0	0.0	99.0	767.5	762.5	1.3
34	468	0.4	0.6	0.0	0.0	99.0	766.5	762.0	1.2
35	482	13.5	10.2	5.9	2.1	68.3	766.0	762.5	1.1
36	496	14.1	16.4	0.3	2.0	67.2	767.0	761.5	1.1
37	511	14.4	17.9	0.4	2.3	65.0	767.5	761.0	1.0

38	525	14.4	17.9	1.2	2.3	64.2	767.0	760.5	1.0
39	539	13.7	17.6	2.7	2.2	63.8	767.5	760.5	0.9
40	554	13.1	17.1	4.5	2.1	63.2	767.0	761.5	1.1
41	568	12.6	16.8	6.1	2.1	62.4	767.0	761.0	1.1
42	582	12.4	16.7	7.5	2.1	61.3	764.5	767.5	2.4
43	596	12.3	16.7	8.8	2.1	60.1	763.5	774.0	3.5
44	611	11.9	17.2	9.9	1.9	59.1	762.0	772.5	3.3
45	625	13.6	19.4	10.6	1.4	55.0	763.5	772.5	3.2
46	640	14.3	20.3	11.2	1.1	53.1	761.0	772.0	3.2
47	654	14.1	20.5	11.4	1.0	53.0	763.5	772.0	3.2
48	668	14.2	20.7	11.3	1.0	52.8	761.0	772.5	3.2
49	682	13.9	20.4	11.3	1.0	53.4	762.5	772.5	3.2
50	697	14.2	20.9	11.2	1.1	52.6	762.0	772.5	3.3
51	711	14.2	21.0	11.1	1.1	52.6	762.5	773.0	3.3
52	725	14.1	21.0	11.0	1.0	52.9	762.0	772.5	3.3
53	739	14.3	20.8	11.0	1.1	52.8	761.0	772.5	3.3
54	753	14.3	20.8	10.9	1.2	52.8	762.5	773.0	3.3
55	768	13.9	20.6	10.9	1.2	53.4	763.0	772.5	3.3
56	782	13.2	20.1	10.9	1.2	54.6	761.5	773.5	3.3
57	797	12.5	19.9	10.8	1.1	55.7	761.5	772.5	3.3
58	811	11.9	19.5	10.9	1.1	56.6	761.0	773.5	3.3
59	826	11.5	19.0	10.9	1.1	57.5	761.5	773.0	3.4
60	840	11.5	18.5	11.0	1.2	57.8	760.0	773.5	3.4
61	854	10.7	17.6	11.0	1.2	59.5	762.5	773.0	3.5
62	868	10.0	17.2	10.9	1.2	60.7	765.5	762.5	1.5
63	883	9.7	16.8	10.7	1.3	61.5	766.0	762.5	1.4
64	897	9.7	16.3	10.9	1.4	61.7	767.5	763.0	1.5
65	912	10.0	16.2	11.1	1.7	61.0	765.5	762.5	1.4
66	926	9.5	15.4	11.3	1.8	62.0	766.5	762.5	1.5
67	941	9.3	15.7	11.5	1.9	61.6	766.5	763.0	1.5
68	952	9.4	15.8	11.8	1.9	61.1	764.5	763.0	1.6
69	966	9.3	15.5	12.1	1.9	61.2	765.5	762.5	1.5
70	981	8.9	15.5	12.4	1.9	61.3	766.0	763.0	1.5
71	995	9.1	15.5	12.6	1.9	60.9	766.0	763.5	1.5
72	1009	9.7	15.8	12.9	1.9	59.7	766.5	762.5	1.5
73	1023	10.3	16.4	13.1	1.9	58.3	765.0	762.5	1.4
74	1038	10.4	16.1	13.3	1.9	58.3	766.0	764.0	1.4
75	1052	10.6	16.2	13.5	1.9	57.8	767.5	762.5	1.5
76	1067	10.7	16.2	13.6	1.9	57.6	766.0	762.5	1.5
77	1081	10.4	15.8	13.7	1.9	58.2	766.0	763.0	1.5
78	1093	10.1	15.5	13.8	1.8	58.8	766.5	762.5	1.6
79	1107	10.1	15.5	13.8	1.8	58.8	766.5	763.0	1.6
80	1122	10.5	15.6	13.9	1.8	58.2	766.0	762.5	1.5
81	1136	10.9	15.7	13.9	1.7	57.8	766.5	762.5	1.5
82	1150	11.1	15.7	13.9	1.8	57.5	767.0	762.0	1.3
83	1164	11.1	15.8	13.9	1.8	57.4	766.5	762.5	1.4
84	1179	11.2	15.8	13.8	1.9	57.3	768.0	762.5	1.4
85	1193	11.4	15.7	13.8	1.8	57.3	766.0	762.5	1.5
86	1207	11.3	15.3	13.8	1.7	57.9	766.5	762.5	1.5
87	1221	11.1	15.0	13.7	1.6	58.6	766.5	763.0	1.6
88	1235	10.9	14.9	13.7	1.5	59.0	767.0	762.5	1.5
89	1250	10.8	15.2	13.7	1.6	58.7	765.5	763.0	1.5
90	1264	10.8	15.4	13.7	1.7	58.4	766.0	762.5	1.5
91	1279	11.1	15.7	13.6	1.8	57.8	767.0	763.5	1.4
92	1293	11.5	16.0	13.7	1.9	56.9	767.0	763.5	1.5
93	1308	11.8	15.9	13.6	1.7	57.0	766.0	763.0	1.5
94	1322	11.8	15.8	13.7	1.7	57.0	766.0	763.5	1.5
95	1336	11.6	15.5	13.6	1.7	57.6	767.5	764.0	1.5
96	1350	11.2	15.4	13.6	1.7	58.1	766.0	762.5	1.6

97	1365	11.4	15.6	13.6	1.7	57.7	766.5	762.5	1.5
98	1379	11.5	15.7	13.6	1.7	57.5	767.0	762.5	1.5
99	1393	11.5	15.7	13.6	1.8	57.4	766.0	762.5	1.4
100	1407	11.6	15.6	13.6	1.8	57.4	765.5	763.0	1.5
101	1422	11.4	15.7	13.6	1.8	57.5	766.5	763.0	1.5
102	1436	11.6	15.8	13.6	1.8	57.2	766.0	762.5	1.5
103	1450	11.9	15.8	13.7	1.8	56.8	766.5	764.0	1.5
104	1464	11.9	15.8	13.7	1.7	56.9	767.0	762.5	1.5
105	1479	11.9	15.9	13.6	1.7	56.9	765.5	762.5	1.5
106	1493	11.7	15.8	13.6	1.6	57.3	767.0	762.5	1.4
107	1507	11.5	16.0	13.6	1.5	57.4	766.0	762.5	1.4
108	1522	11.5	16.0	13.5	1.5	57.5	765.5	762.5	1.4
109	1536	11.6	15.8	13.6	1.4	57.6	765.0	763.0	1.6
110	1551	11.4	15.5	13.5	1.4	58.2	766.0	762.5	1.5
111	1565	11.4	15.9	13.5	1.7	57.5	766.0	762.5	1.5
112	1579	11.4	16.3	13.5	2.0	56.8	767.0	762.5	1.5
113	1593	11.6	16.3	13.5	2.1	56.5	765.5	762.5	1.5
114	1608	11.8	16.1	13.5	1.9	56.7	765.5	762.5	1.4
115	1622	11.7	15.9	13.6	1.8	57.0	767.0	762.5	1.4
116	1636	11.8	15.9	13.7	1.9	56.7	765.0	762.5	1.5
117	1650	11.9	16.0	13.8	1.9	56.4	765.0	762.5	1.5
118	1662	12.0	16.1	13.7	1.9	56.3	766.0	762.5	1.5
119	1676	11.9	15.9	13.8	1.9	56.5	766.0	762.5	1.5
120	1690	11.7	15.7	13.9	1.8	56.9	769.0	762.5	1.5
121	1705	11.5	15.7	13.9	1.8	57.1	765.0	762.5	1.4
122	1719	11.6	15.7	13.9	1.8	57.0	766.0	762.5	1.4
123	1733	11.8	15.7	13.9	1.9	56.7	764.5	762.0	1.3
124	1747	11.7	15.7	13.9	1.8	56.9	765.0	763.0	1.5
125	1762	11.5	15.7	13.9	1.8	57.1	766.0	762.5	1.5
126	1776	11.9	15.8	13.9	1.8	56.6	765.5	762.5	1.5
127	1791	12.2	16.0	13.9	2.0	55.9	766.5	762.5	1.5
128	1805	12.5	16.0	13.8	1.9	55.8	765.5	763.5	1.5
129	1819	12.6	15.9	13.8	1.9	55.8	762.5	766.5	1.9
130	1833	12.5	15.9	13.8	1.8	56.0	766.5	762.5	1.7
131	1848	12.5	16.1	13.7	1.8	55.9	764.0	766.0	2.2
132	1862	12.6	16.3	13.7	1.6	55.8	763.0	765.5	2.2
133	1874	12.7	16.3	13.6	1.5	55.9	763.5	765.5	2.2
134	1888	12.6	16.3	13.6	1.4	56.1	762.5	765.5	2.3
135	1902	12.6	16.5	13.4	1.2	56.3	763.0	765.5	2.3
136	1916	12.9	16.5	13.4	1.2	56.0	763.5	765.5	2.3
137	1930	13.1	16.7	13.1	1.3	55.8	762.0	766.0	2.2
138	1944	13.2	16.9	13.2	1.4	55.3	763.5	766.0	2.3
139	1958	13.8	17.1	13.1	1.5	54.5	762.5	766.0	2.3
140	1972	13.8	17.1	12.9	1.4	54.8	763.0	765.0	2.2
141	1986	13.6	17.1	12.8	1.4	55.1	763.0	766.0	2.2
142	2001	13.9	17.2	12.6	1.4	54.9	764.0	773.0	2.2
143	2015	14.0	17.4	12.7	1.4	54.5	764.0	765.5	2.2
144	2027	14.2	17.9	12.6	1.4	53.9	761.5	766.0	2.3
145	2041	14.2	17.6	12.5	1.4	54.3	763.5	765.5	2.3
146	2056	13.9	17.4	12.5	1.4	54.8	764.0	765.5	2.3
147	2070	14.1	17.4	12.4	1.4	54.7	762.5	766.0	2.3
148	2085	14.0	17.6	12.4	1.4	54.6	762.0	765.0	2.3
149	2099	13.9	17.8	12.3	1.5	54.5	763.5	765.0	2.3
150	2113	14.1	18.0	12.3	1.6	54.0	762.5	7[illegible]6.0	2.3
151	2127	13.8	18.0	12.3	1.5	54.4	763.0	765.5	2.2
152	2141	13.1	18.0	12.3	1.5	55.1	764.5	765.5	2.2
153	2156	12.9	17.9	12.2	1.5	55.5	764.5	765.5	2.2
154	2170	14.2	17.7	12.2	1.6	54.3	761.0	770.5	2.5
155	2185	14.4	17.7	12.2	1.7	54.0	757.5	775.5	3.2

156	2199	14.2	17.8	12.2	1.7	54.1	758.0	773.5	3.4
157	2214	13.9	17.8	12.3	1.7	54.3	759.0	773.0	3.2
158	2228	14.0	17.9	12.3	1.6	54.2	758.5	773.0	3.3
159	2242	14.1	18.0	12.3	1.4	54.2	759.0	773.0	3.4
160	2257	14.2	18.0	12.3	1.3	54.2	758.0	773.0	3.4
161	2271	14.3	18.3	12.3	1.3	53.8	758.0	775.0	3.4
162	2285	14.6	18.2	12.2	1.3	53.7	760.0	773.0	3.5
163	2297	14.8	18.3	12.1	1.4	53.4	758.0	773.0	3.5
164	2311	14.8	18.4	12.1	1.3	53.4	759.5	773.0	3.5
165	2326	14.9	18.5	11.9	1.2	53.5	759.5	772.5	3.5
166	2340	14.9	18.5	11.8	1.2	53.6	761.0	776.5	3.4
167	2354	14.9	18.7	11.8	1.3	53.3	757.5	773.0	3.4
168	2368	14.8	18.9	11.7	1.3	53.3	759.5	773.0	3.3
169	2382	15.3	19.0	11.6	1.3	52.8	759.0	773.5	3.3
170	2394	15.5	18.7	11.6	1.4	52.8	758.0	772.5	3.3
171	2408	15.5	18.8	11.5	1.4	52.8	757.0	773.0	3.3
172	2423	15.6	18.8	11.6	1.4	52.6	758.0	773.5	3.3
173	2435	15.7	18.7	11.5	1.5	52.6	759.0	773.0	3.3
174	2449	15.9	18.6	11.5	1.5	52.5	757.0	773.0	3.3
175	2463	15.7	18.8	11.4	1.5	52.6	757.5	773.0	3.3
176	2478	15.6	19.2	11.4	1.4	52.4	757.0	773.0	3.4
177	2492	15.6	19.3	11.4	1.3	52.4	757.0	773.0	3.3
178	2507	16.0	19.3	11.3	1.3	52.1	757.0	773.5	3.3
179	2521	16.1	19.4	11.3	1.3	51.9	760.0	772.5	3.3
180	2535	15.6	19.5	11.3	1.3	52.3	758.5	773.0	3.3
181	2549	15.9	19.5	11.2	1.3	52.1	757.0	773.0	3.3
182	2563	15.9	19.6	11.2	1.3	52.0	757.0	773.0	3.4
183	2578	15.8	19.3	11.1	1.4	52.4	760.0	773.0	3.4
184	2592	16.0	19.0	11.1	1.5	52.4	758.0	773.0	3.4
185	2606	15.9	19.3	11.0	1.5	52.3	757.0	773.0	3.4
186	2620	15.7	19.5	11.0	1.4	52.4	759.5	773.0	3.4
187	2635	15.3	19.7	11.0	1.3	52.7	758.0	772.5	3.3
188	2649	15.5	19.6	11.1	1.4	52.4	760.5	773.0	3.4
189	2664	15.9	19.4	11.0	1.5	52.2	758.0	772.5	3.4
190	2678	16.0	19.1	11.0	1.6	52.3	760.0	772.0	3.4
191	2693	16.0	19.2	11.0	1.5	52.3	760.0	772.0	3.5
192	2707	16.1	19.1	11.1	1.5	52.2	758.5	772.5	3.5
193	2721	16.1	19.3	11.0	1.5	52.1	759.5	770.0	3.5
194	2732	15.6	19.5	11.1	1.4	52.4	756.5	773.0	3.6
195	2747	15.4	19.6	11.0	1.4	52.6	755.5	772.0	3.4
196	2761	15.6	19.3	11.1	1.4	52.6	759.0	772.0	3.4
197	2775	16.1	19.3	11.1	1.6	51.9	760.0	772.5	3.4
198	2789	16.1	18.9	11.1	1.7	52.2	757.5	773.0	3.3
199	2804	15.9	19.0	11.1	1.7	52.3	758.5	773.0	3.3
200	2818	15.8	19.0	11.1	1.6	52.5	759.0	772.5	3.4
201	2832	16.0	19.0	11.2	1.7	52.1	759.5	773.0	3.4
202	2847	16.0	19.0	11.2	1.6	52.2	758.5	772.0	3.4
203	2861	16.2	19.0	11.2	1.6	52.0	761.0	773.0	3.4
204	2875	16.0	19.1	11.2	1.6	52.1	756.5	773.0	3.4
205	2889	15.7	19.1	11.2	1.5	52.5	759.0	773.5	3.4
206	2904	15.7	19.1	11.2	1.5	52.5	759.0	772.5	3.5
207	2918	16.2	18.8	11.3	1.6	52.1	757.5	773.0	3.5
208	2932	16.3	18.5	11.3	1.7	52.2	758.5	773.0	3.5
209	2946	15.6	18.4	11.2	1.6	53.2	759.0	773.0	3.5
210	2958	15.6	18.4	11.3	1.5	53.2	759.0	773.0	3.5
211	2972	15.5	18.7	11.3	1.4	53.1	757.5	773.0	3.6
212	2987	15.4	19.0	11.2	1.4	53.0	757.0	773.0	3.5
213	2998	15.6	19.2	11.3	1.4	52.5	760.5	772.5	3.6
214	3013	15.9	19.6	11.3	1.4	51.8	759.0	773.0	3.5

215	3027	16.3	19.5	11.2	1.5	51.5	759.5	773.0	3.7
216	3041	16.2	19.2	11.3	1.7	51.6	759.0	773.0	3.6
217	3056	15.6	18.4	11.2	1.8	53.0	763.5	769.5	3.7
218	3070	15.2	18.2	11.0	1.9	53.7	760.0	769.0	3.7
219	3084	15.0	18.2	11.1	1.8	53.9	761.5	768.5	3.6
220	3098	15.1	18.3	11.1	1.7	53.8	760.0	769.0	3.7
221	3113	15.2	18.0	11.2	1.6	54.0	761.5	769.5	3.6
222	3127	15.0	17.9	11.3	1.6	54.2	763.5	768.5	3.6
223	3142	14.9	18.0	11.4	1.6	54.1	759.0	769.0	3.4
224	3156	15.0	18.0	11.4	1.6	54.0	759.0	768.5	3.5
225	3171	15.4	17.7	11.4	1.6	53.9	762.5	768.5	3.4
226	3185	15.4	17.7	11.4	1.5	54.0	760.5	768.5	3.4
227	3199	15.2	17.9	11.5	1.6	53.8	761.0	768.5	3.4
228	3213	15.1	17.8	11.6	1.6	53.9	762.0	768.5	3.4
229	3228	15.2	17.9	11.6	1.6	53.7	760.5	768.5	3.4
230	3242	15.7	17.9	11.7	1.6	53.1	759.0	768.5	3.4
231	3256	15.8	17.7	11.6	1.7	53.2	759.0	768.0	3.4
232	3270	15.4	17.8	11.7	1.6	53.5	761.5	768.5	3.3
233	3284	15.3	17.9	11.7	1.5	53.6	759.0	768.5	3.4
234	3299	15.4	18.0	11.8	1.5	53.3	757.0	768.5	3.3
235	3313	15.5	17.9	11.8	1.6	53.2	758.5	768.5	3.2
236	3327	15.5	17.7	11.8	1.7	53.3	758.0	768.5	3.2
237	3341	15.5	17.7	11.8	1.7	53.3	761.0	768.5	3.2
238	3356	15.2	17.5	11.7	1.7	53.9	756.5	768.5	3.2
239	3370	15.3	17.6	11.8	1.6	53.7	759.0	768.5	3.2
240	3384	15.4	18.2	11.8	1.6	53.0	757.5	768.5	3.2
241	3396	15.6	18.6	11.8	1.7	52.3	761.5	768.5	3.2
242	3411	15.0	18.7	11.9	1.6	52.8	758.0	772.0	2.9
243	3425	15.4	18.8	11.8	1.6	52.4	758.0	768.0	2.7
244	3439	15.9	18.7	11.8	1.7	51.9	757.5	770.0	2.9
245	3453	16.2	18.6	11.9	1.8	51.5	756.0	773.0	3.1
246	3467	15.9	18.4	11.9	1.7	52.1	756.0	774.0	3.3
247	3482	15.5	18.6	11.9	1.7	52.3	753.0	774.5	3.5
248	3496	15.7	18.8	11.9	1.6	52.0	753.0	774.0	3.5
249	3510	15.9	19.0	11.9	1.6	51.6	756.5	774.5	3.5
250	3522	15.8	19.0	11.9	1.6	51.7	755.0	774.5	3.5
251	3536	15.8	18.9	11.9	1.6	51.8	752.5	774.0	3.5
252	3550	15.6	19.1	11.8	1.6	51.9	755.0	774.5	3.6
253	3565	16.0	19.0	11.8	1.8	51.4	756.0	774.0	3.6
254	3579	15.9	19.0	11.6	1.8	51.7	753.5	775.0	3.6
255	3593	15.8	18.4	11.7	1.7	52.4	756.0	775.0	3.5
256	3607	15.4	18.1	11.7	1.6	53.2	754.5	775.0	3.6
257	3622	15.4	17.8	11.7	1.6	53.5	754.0	774.5	3.6
258	3636	14.8	18.1	11.7	1.5	53.9	755.5	774.5	3.7
259	3651	15.1	18.5	11.6	1.4	53.4	755.5	774.0	3.6
260	3665	15.1	18.8	11.6	1.3	53.2	754.5	774.5	3.5
261	3679	15.6	18.9	11.5	1.4	52.6	755.5	774.5	3.5
262	3693	15.7	19.0	11.5	1.5	52.3	752.0	774.5	3.6
263	3707	15.9	18.7	11.5	1.6	52.3	752.5	775.5	3.5
264	3722	16.3	18.6	11.5	1.7	51.9	753.5	774.5	3.6
265	3736	16.4	18.7	11.4	1.7	51.8	754.0	775.5	3.6
266	3750	16.1	19.0	11.3	1.7	51.9	754.5	774.5	3.6
267	3764	15.6	19.0	11.3	1.4	52.7	753.5	774.5	3.5
268	377[illegible]	15.4	19.2	11.2	1.4	52.8	753.5	774.5	3.4
269	3793	16.0	18.9	11.4	1.5	52.2	753.5	774.5	3.5
270	3808	16.2	18.6	11.4	1.7	52.1	752.5	774.0	3.5
271	3819	16.0	18.4	11.4	1.6	52.6	751.0	774.5	3.5
272	3834	15.5	18.5	11.3	1.4	53.3	753.5	775.0	3.5
273	3848	15.5	18.4	11.3	1.4	53.4	756.5	775.0	3.6

274	3862	15.6	18.5	11.3	1.5	53.1	759.0	774.0	3.6
275	3874	15.5	18.9	11.3	1.4	52.9	755.0	774.0	3.5
276	3889	15.6	19.0	11.3	1.3	52.8	752.0	773.5	3.5
277	3903	15.9	19.1	11.3	1.5	52.2	757.0	774.0	3.6
278	3917	16.1	19.0	11.3	1.6	52.0	753.0	774.0	3.5
279	3931	15.8	18.3	11.3	1.7	52.9	750.5	774.5	3.6
280	3945	15.3	18.0	11.3	1.8	53.6	752.5	774.0	3.6
281	3960	14.9	17.7	11.3	1.9	54.2	754.0	774.5	3.6
282	3974	14.6	17.8	11.3	1.8	54.5	757.0	775.5	3.6
283	3989	14.5	18.3	11.4	1.5	54.3	753.5	775.0	3.6
284	4003	14.9	18.2	11.4	1.5	54.0	752.5	775.5	3.5
285	4017	15.3	18.4	11.5	1.6	53.2	754.0	775.5	3.6
286	4032	15.4	18.2	11.5	1.7	53.2	752.5	777.0	3.7
287	4046	15.3	18.2	11.5	1.7	53.3	754.0	779.0	3.9
288	4060	15.3	18.4	11.6	1.6	53.1	752.0	778.0	3.9
289	4075	14.7	18.7	11.6	1.6	53.4	750.0	778.0	4.0
290	4089	15.0	18.9	11.6	1.6	52.9	751.5	778.0	4.0
291	4104	15.1	18.7	11.6	1.6	53.0	754.0	779.0	4.0
292	4118	14.7	17.9	11.6	1.8	54.0	750.0	778.5	4.0
293	4133	13.6	17.7	11.5	1.8	55.4	750.0	779.5	4.1
294	4147	13.7	17.8	11.5	1.7	55.3	752.5	779.0	4.1
295	4161	13.5	17.6	11.4	1.7	55.8	751.0	779.0	4.1
296	4175	13.9	18.4	11.4	1.6	54.7	752.0	777.5	4.1
297	4189	14.0	18.5	11.4	1.6	54.5	752.0	779.5	4.3
298	4204	14.3	18.7	11.4	1.7	53.9	754.5	779.0	4.1
299	4218	13.9	18.1	11.3	1.7	55.0	752.0	779.5	4.2
300	4233	13.2	17.8	11.3	1.7	56.0	752.5	780.0	4.1
301	4247	12.6	17.3	11.2	1.7	57.2	754.0	779.5	4.3
302	4262	12.5	17.4	11.1	1.8	57.2	752.0	779.0	4.3
303	4276	13.0	17.6	11.1	1.7	56.6	753.0	780.0	4.2
304	4290	13.4	17.8	11.2	1.7	55.9	753.0	779.5	4.2
305	4304	13.1	18.2	11.3	1.7	55.7	752.5	778.5	4.2
306	4319	13.5	19.0	11.3	1.5	54.7	752.5	780.0	4.2
307	4333	13.9	19.1	11.4	1.5	54.1	753.5	779.5	4.2
308	4348	13.9	18.2	11.4	1.6	54.9	750.5	779.5	4.2
309	4362	13.0	18.0	11.3	1.7	56.0	751.0	779.0	4.2
310	4376	13.3	18.3	11.2	1.6	55.6	754.5	780.0	4.3
311	4391	13.2	17.7	11.2	1.6	56.3	754.5	780.0	4.3
312	4402	12.4	17.4	11.2	1.8	57.2	754.0	781.0	4.4
313	4417	11.8	17.5	11.1	1.8	57.8	754.5	781.5	4.5
314	4431	11.9	17.1	11.2	1.6	58.2	755.5	779.5	4.5
315	4445	10.9	15.9	11.2	1.6	60.4	753.5	781.0	4.5
316	4459	9.9	15.8	11.2	1.6	61.5	757.5	780.5	4.4
317	4474	10.2	15.6	11.2	1.7	61.3	756.5	780.0	4.4
318	4488	10.0	15.7	11.2	1.7	61.4	752.0	780.0	4.4
319	4502	10.8	16.2	11.2	1.6	60.2	752.5	779.5	4.3
320	4517	11.1	16.9	11.3	1.7	59.0	754.5	780.0	4.3
321	4531	11.9	17.5	11.2	1.7	57.7	751.0	779.0	4.3
322	4545	12.5	18.1	11.3	1.5	56.6	752.5	780.5	4.4
323	4558	12.8	18.6	11.3	1.5	55.8	753.0	780.0	4.3
324	4572	12.9	18.0	11.4	1.6	56.1	753.5	780.5	4.3
325	4586	12.3	17.6	11.4	1.6	57.1	754.5	780.5	4.4
326	4600	12.2	17.8	11.3	1.7	57.0	751.0	780.5	4.4
327	4614	12.8	18.4	11.4	1.6	55.8	752.0	781.5	4.4
328	4629	12.6	18.0	11.4	1.5	56.5	753.0	781.0	4.4
329	4643	11.9	17.3	11.4	1.5	57.9	753.0	780.5	4.4
330	4657	11.4	17.0	11.4	1.5	58.7	750.5	781.0	4.4
331	4671	11.3	16.8	11.4	1.5	59.0	752.0	780.5	4.4
332	4686	11.1	16.5	11.4	1.7	59.3	752.0	780.5	4.3

333	4700	10.6	16.4	11.4	1.8	59.8	752.0	780.0	4.3
334	4714	11.0	16.7	11.4	1.7	59.2	751.0	780.5	4.2
335	4729	11.9	16.9	11.4	1.6	58.2	752.5	780.0	4.2
336	4743	12.3	17.1	11.4	1.6	57.6	752.5	780.0	4.3
337	4757	12.5	17.6	11.5	1.5	56.9	750.5	780.0	4.1
338	4772	12.7	17.7	11.5	1.5	56.6	751.0	780.0	4.2
339	4786	12.6	17.5	11.5	1.5	56.9	750.0	780.0	4.2
340	4800	12.1	17.0	11.5	1.6	57.8	752.5	779.5	4.0
341	4814	11.8	17.0	11.5	1.6	58.1	750.5	779.0	3.6
342	4828	12.1	17.3	11.5	1.5	57.6	751.0	778.0	3.9
343	4843	12.5	17.7	11.5	1.4	56.9	748.5	778.0	4.0
344	4857	12.7	17.5	11.5	1.5	56.8	750.0	778.0	3.9
345	4872	12.8	17.3	11.5	1.4	57.0	755.5	770.5	3.1
346	4886	13.1	17.6	11.0	1.4	56.9	756.5	769.5	2.9
347	4900	13.3	18.0	11.2	1.4	56.1	755.5	769.5	2.8
348	4914	13.4	17.6	11.2	1.5	56.3	756.0	769.5	2.7
349	4929	13.4	17.3	11.1	1.6	56.6	754.0	769.5	2.7
350	4943	13.4	17.2	11.1	1.6	56.7	755.5	769.5	2.8
351	4957	13.1	17.6	11.2	1.7	56.4	755.0	770.0	2.8
352	4972	12.9	17.4	11.3	1.8	56.6	755.5	770.5	2.8
353	4986	12.3	17.3	11.3	1.8	57.3	755.5	770.5	2.8
354	5000	12.1	17.5	11.4	1.9	57.1	754.5	770.0	2.8
355	5015	12.2	17.5	11.5	1.9	56.9	753.5	770.0	2.8
356	5029	12.6	17.4	11.6	1.8	56.6	758.0	770.0	2.8
357	5044	12.5	17.3	11.7	1.8	56.7	755.0	770.0	2.8
358	5058	12.4	17.1	11.7	1.8	57.0	754.0	769.5	2.8
359	5072	11.9	16.8	11.8	1.9	57.6	752.0	770.0	2.8
360	5084	11.5	16.7	11.8	1.9	58.1	753.0	770.0	2.8
361	5098	11.7	16.8	11.8	1.8	57.9	753.5	770.5	2.8
362	5112	11.9	16.8	11.9	1.8	57.6	753.0	769.5	2.8
363	5126	11.8	16.7	11.9	1.8	57.8	752.5	769.5	2.8
364	5141	12.0	17.1	12.0	1.8	57.1	752.0	769.5	2.8
365	5155	12.8	17.4	12.0	1.6	56.2	751.0	769.5	2.7
366	5169	13.1	17.6	12.0	1.5	55.8	751.5	769.5	2.7
367	5183	13.4	17.5	11.8	1.5	55.8	751.0	769.0	2.7
368	5198	13.3	17.6	11.9	1.5	55.7	753.5	769.0	2.7
369	5212	13.4	17.7	12.0	1.6	55.3	751.0	769.0	2.7
370	5227	13.7	17.7	11.8	1.5	55.3	749.5	768.5	2.7
371	5241	13.5	17.9	11.8	1.5	55.3	748.5	768.5	2.6
372	5255	13.9	17.8	11.9	1.6	54.8	752.5	768.5	2.6
373	5269	14.0	17.3	11.8	1.7	55.2	748.0	768.5	2.6
374	5283	13.8	17.2	11.8	1.7	55.5	747.0	769.0	2.6
375	5298	13.7	17.2	11.7	1.7	55.7	747.5	769.0	2.6
376	5312	13.7	17.2	11.8	1.6	55.7	748.0	769.5	2.7
377	5326	13.8	17.2	11.8	1.6	55.6	749.0	769.0	2.6
378	5337	14.0	17.3	11.8	1.6	55.3	751.0	769.0	2.6
379	5352	13.8	17.1	11.8	1.6	55.7	746.5	769.0	2.6
380	5366	13.5	17.0	11.9	1.7	55.9	749.0	768.5	2.6
381	5380	13.5	16.9	11.9	1.6	56.1	747.0	769.5	2.6
382	5394	13.3	16.6	11.9	1.5	56.7	751.0	768.0	2.6
383	5409	13.1	16.6	11.9	1.5	56.9	745.0	768.5	2.6
384	5420	13.2	16.6	11.9	1.5	56.8	747.0	768.5	2.5
385	5432	13.4	16.8	11.9	1.6	56.3	744.0	768.0	2.5
386	5446	13.7	17.2	11.9	1.7	55.5	753.5	761.0	1.0
387	5461	13.7	17.2	11.9	1.7	55.5	745.5	767.5	2.5
388	5475	13.9	17.0	11.9	1.7	55.5	745.5	767.5	2.5
389	5490	13.8	16.9	12.0	1.6	55.7	746.0	767.5	2.5
390	5504	13.7	16.8	12.0	1.6	55.9	745.5	767.5	2.5
391	5518	13.7	17.0	12.0	1.6	55.7	746.0	767.0	2.5

392	5532	14.0	17.1	12.0	1.6	55.3	745.5	767.0	2.5
393	5546	14.2	17.3	12.0	1.6	54.9	743.5	767.5	2.5
394	5561	14.3	17.3	12.0	1.5	54.9	748.0	767.5	2.4
395	5575	14.2	17.2	12.0	1.4	55.2	746.5	767.5	2.5
396	5589	14.3	17.1	11.9	1.4	55.3	746.0	767.5	2.5
397	5603	14.0	17.1	11.9	1.5	55.5	742.5	767.0	2.5
398	5618	14.1	17.2	11.8	1.7	55.2	741.5	767.0	2.4
399	5632	14.3	17.1	11.9	1.8	54.9	742.5	767.5	2.5
400	5646	14.3	16.8	11.9	1.7	55.3	741.5	767.5	2.5
401	5660	14.1	16.6	11.9	1.7	55.7	742.5	767.0	2.4
402	5672	14.1	16.5	12.0	1.6	55.8	742.5	767.0	2.5
403	5686	14.0	16.6	12.0	1.7	55.7	744.5	767.0	2.4
404	5701	14.0	16.8	11.9	1.6	55.7	741.0	767.0	2.4
405	5715	14.2	16.8	11.9	1.5	55.6	744.5	765.0	2.4
406	5729	14.2	16.7	12.0	1.5	55.6	740.5	767.0	2.4
407	5744	14.2	16.7	12.0	1.6	55.5	743.0	767.0	2.4
408	5758	13.9	16.6	12.0	1.6	55.9	743.5	767.0	2.4
409	5772	13.7	16.4	11.9	1.6	56.4	743.5	767.5	2.4
410	5783	13.7	16.4	12.0	1.5	56.4	735.0	772.0	3.0
411	5798	13.5	16.5	12.0	1.5	56.5	733.0	774.0	3.2
412	5812	13.5	16.7	12.2	1.5	56.1	733.0	774.0	3.2
413	5826	13.4	16.7	12.2	1.5	56.2	735.5	774.5	3.2
414	5841	13.5	16.8	12.2	1.6	55.9	740.0	774.5	3.3
415	5855	13.9	17.3	12.2	1.5	55.1	734.0	773.0	3.2
416	5869	14.0	17.5	12.2	1.5	54.8	734.0	773.0	3.2
417	5884	14.3	17.0	12.2	1.6	54.9	735.0	773.0	3.2
418	5898	14.1	17.0	12.0	1.4	55.5	731.5	774.0	3.1
419	5912	13.8	17.2	12.0	1.3	55.7	741.5	773.5	3.2
420	5924	14.0	17.3	11.9	1.3	55.5	731.0	773.5	3.2
421	5939	14.0	17.2	11.9	1.3	55.6	732.0	773.0	3.2
422	5953	13.8	17.4	11.8	1.3	55.7	733.0	774.5	3.2
423	5967	14.1	17.7	11.8	1.3	55.1	730.5	775.5	3.4
424	5981	14.4	17.6	11.7	1.3	55.0	729.5	775.0	3.4
425	5995	14.1	17.6	11.7	1.3	55.3	728.5	775.5	3.4
426	6010	14.4	17.6	11.7	1.3	55.0	730.0	775.0	3.4
427	6024	14.6	17.7	11.6	1.5	54.6	725.5	775.0	3.4
428	6039	14.8	17.9	11.6	1.6	54.1	728.5	774.5	3.4
429	6053	15.0	17.9	11.6	1.6	53.9	727.0	774.5	3.4
430	6067	14.9	17.5	11.5	1.6	54.5	726.5	774.5	3.3
431	6081	14.6	17.9	11.5	1.6	54.4	725.0	774.5	3.3
432	6096	14.3	17.9	11.5	1.6	54.7	725.5	776.5	3.4
433	6110	14.3	17.5	11.5	1.7	55.0	725.0	773.5	3.4
434	6124	14.4	17.5	11.4	1.8	54.9	722.5	776.0	3.6
435	6138	14.4	17.3	11.5	1.7	55.1	719.0	779.0	3.8
436	6153	13.8	17.1	11.6	1.5	56.0	720.0	779.0	4.0
437	6167	13.4	17.5	11.7	1.5	55.9	720.5	778.5	4.0
438	6181	13.4	17.9	11.7	1.4	55.6	719.0	778.0	4.1
439	6196	14.1	17.8	11.7	1.4	55.0	719.5	778.0	4.1
440	6210	14.5	17.8	11.6	1.4	54.7	720.5	778.5	4.1
441	6224	14.5	17.6	11.6	1.4	54.9	719.5	778.0	4.1
442	6238	14.2	17.8	11.5	1.4	55.1	718.5	778.0	4.0
443	6253	14.3	17.7	11.4	1.5	55.1	719.0	778.0	4.1
444	6267	14.7	17.6	11.4	1.6	54.7	718.0	779.0	4.1
445	6281	14.7	17.4	11.3	1.5	55.1	718.0	778.0	4.0
446	6295	14.3	17.6	11.3	1.4	55.4	717.0	778.0	4.1
447	6310	14.1	17.8	11.2	1.3	55.6	713.5	778.0	4.1
448	6324	14.3	17.9	11.3	1.4	55.1	714.0	778.5	4.0
449	6339	14.8	17.8	11.3	1.6	54.5	721.0	778.5	4.1
450	6353	15.0	17.4	11.2	1.7	54.7	718.5	778.0	4.0

451	6367	14.8	17.3	11.3	1.7	54.9	718.0	778.5	4.1
452	6381	14.4	17.2	11.2	1.6	55.6	718.0	778.0	4.0
453	6396	14.2	17.3	11.2	1.5	55.8	719.5	777.5	4.0
454	6410	14.1	17.4	11.2	1.5	55.8	718.0	777.5	4.1
455	6424	14.6	17.5	11.3	1.5	55.1	718.0	777.5	4.0
456	6439	14.7	17.1	11.3	1.6	55.3	716.5	778.0	4.0
457	6453	14.9	17.1	11.3	1.6	55.1	725.5	777.0	3.7
458	6467	14.4	16.9	11.3	1.5	55.9	722.5	781.5	4.1
459	6481	13.9	17.2	11.3	1.4	56.2	722.5	779.0	4.0
460	6496	14.2	17.2	11.4	1.4	55.8	722.5	779.0	4.1
461	6510	14.3	17.6	11.4	1.5	55.2	724.0	778.5	4.0
462	6524	0.5	0.2	0.0	0.0	99.3	720.5	778.0	4.0
463	6538	0.5	0.2	0.0	0.0	99.3	724.0	778.5	4.1
464	6552	0.5	0.2	0.0	0.0	99.3	728.0	781.5	4.3

TEMPERATURE DATA :

		THERMOCOUPLE NUMBERS (TEMPERATURES deg C)							
NO.	TIME	1	2	3	4	5	6	7	8
1	2	3.5	3.4	3.4	5.1	-2.4	3.5	9.7	9.7
2	16	20.5	20.4	20.4	21.9	14.6	21.0	27.1	27.1
3	31	20.5	20.4	20.7	22.0	14.0	21.0	27.1	27.1
4	45	20.5	20.4	20.7	21.8	14.0	21.0	27.1	27.7
5	59	20.6	20.5	20.8	21.8	15.0	21.0	27.1	27.7
6	73	20.8	20.5	20.8	21.9	15.6	20.4	27.1	27.7
7	87	20.6	20.4	20.8	22.0	15.6	21.0	27.1	27.7
8	101	20.6	20.4	20.8	21.8	14.0	21.0	27.1	28.3
9	115	20.6	20.4	20.8	21.9	14.0	21.0	27.7	30.0
10	130	20.6	20.4	20.8	21.6	14.1	21.1	29.0	59.0
11	144	20.7	20.5	20.8	22.1	14.1	22.3	44.0	113.0
12	158	20.5	20.4	20.9	21.8	14.7	47.0	66.0	165.0
13	172	20.6	20.4	20.9	21.5	16.2	71.0	73.0	178.0
14	187	20.6	20.6	20.9	21.6	17.5	72.0	83.0	191.0
15	201	20.6	20.6	20.9	21.8	19.3	78.0	94.0	264.0
16	215	20.6	20.7	21.0	21.5	21.4	84.0	111.0	374.0
17	229	20.6	20.8	21.0	21.9	23.0	91.0	134.0	505.0
18	244	20.6	20.8	21.0	21.5	24.8	104.0	160.0	596.0
19	258	20.6	20.8	21.0	21.8	25.7	120.0	192.0	642.0
20	272	20.6	20.9	21.0	21.9	26.4	147.0	223.0	684.0
21	286	20.6	20.7	21.0	21.5	26.4	177.0	262.0	685.0
22	300	20.5	20.7	21.1	21.7	26.7	205.0	305.0	682.0
23	314	20.6	20.8	21.1	21.7	27.0	234.0	354.0	729.0
24	328	20.5	20.8	21.1	21.7	26.7	260.0	400.0	704.0
25	343	20.6	20.8	21.1	21.9	26.7	272.0	435.0	664.0
26	357	20.5	20.7	21.1	21.8	26.4	284.0	466.0	670.0
27	371	20.6	20.7	21.2	21.8	26.7	297.0	480.0	685.0
28	385	20.6	20.7	21.2	22.1	26.7	311.0	485.0	679.0
29	400	20.6	20.7	21.2	21.7	27.0	322.0	437.0	702.0
30	411	20.5	20.7	21.2	22.1	27.0	329.0	423.0	705.0
31	426	20.6	20.8	21.3	21.9	27.1	338.0	416.0	689.0
32	440	20.7	20.8	21.3	21.9	27.1	348.0	415.0	689.0
33	454	20.6	20.8	21.3	21.7	27.1	356.0	415.0	708.0
34	468	20.6	20.7	21.3	22.0	28.0	370.0	434.0	768.0
35	482	20.6	20.9	21.4	22.5	29.5	388.0	459.0	817.0
36	496	20.5	20.9	21.3	22.5	30.0	401.0	472.0	798.0
37	511	20.5	20.8	21.4	22.5	31.0	411.0	472.0	817.0
38	525	20.6	20.8	21.4	22.5	31.0	420.0	467.0	763.0
39	539	20.8	20.9	21.4	22.7	32.0	427.0	464.0	740.0
40	554	20.6	20.8	21.5	22.9	32.0	433.0	465.0	728.0
41	568	20.6	20.8	21.5	22.7	32.0	434.0	474.0	733.0

42	582	20.7	20.9	21.5	22.7	34.0	445.0	490.0	797.0
43	596	20.5	21.1	21.5	22.9	38.0	482.0	550.0	965.0
44	611	20.6	21.3	21.6	22.9	40.0	519.0	601.0	941.0
45	625	20.6	21.3	21.7	22.9	42.0	546.0	626.0	934.0
46	640	21.6	21.4	21.8	22.9	43.0	567.0	614.0	881.0
47	654	20.6	21.4	21.9	23.2	46.0	584.0	606.0	908.0
48	668	20.6	21.4	22.0	22.8	48.0	594.0	607.0	862.0
49	682	20.7	21.4	22.1	23.2	49.0	597.0	631.0	911.0
50	697	20.5	21.5	22.2	23.1	51.0	609.0	616.0	921.0
51	711	21.8	21.4	22.3	23.5	52.0	620.0	605.0	839.0
52	725	20.6	21.5	22.3	23.0	55.0	631.0	614.0	850.0
53	739	20.6	21.4	22.5	23.0	57.0	635.0	617.0	792.0
54	753	20.6	21.5	22.5	22.9	59.0	638.0	632.0	679.0
55	768	20.5	21.5	22.6	23.2	61.0	640.0	641.0	741.0
56	782	20.7	21.7	22.7	23.0	63.0	642.0	666.0	692.0
57	797	20.6	21.6	22.9	24.2	65.0	651.0	820.0	649.0
58	811	20.6	21.8	22.9	23.3	67.0	648.0	811.0	698.0
59	826	20.8	21.9	23.1	23.3	70.0	643.0	800.0	674.0
60	840	20.6	21.9	23.3	23.3	73.0	636.0	792.0	660.0
61	854	20.6	21.9	23.5	23.3	75.0	646.0	701.0	619.0
62	868	20.6	21.8	22.8	23.4	68.0	626.0	641.0	604.0
63	883	20.6	21.5	22.9	23.4	68.0	613.0	616.0	658.0
64	897	20.6	21.5	22.8	23.1	69.0	606.0	598.0	657.0
65	912	21.8	21.6	23.1	23.3	69.0	593.0	575.0	639.0
66	926	20.6	21.5	23.1	23.2	68.0	585.0	569.0	633.0
67	941	20.6	21.5	23.1	23.4	68.0	580.0	557.0	649.0
68	952	20.6	21.4	23.3	23.3	69.0	574.0	547.0	643.0
69	966	20.6	21.7	23.3	23.1	68.0	566.0	539.0	654.0
70	981	20.6	21.3	23.3	23.2	67.0	561.0	537.0	631.0
71	995	20.7	21.4	23.4	23.5	67.0	557.0	532.0	630.0
72	1009	20.6	21.4	23.3	24.2	67.0	554.0	531.0	640.0
73	1023	20.5	21.3	23.4	24.4	67.0	551.0	532.0	657.0
74	1038	20.7	21.3	23.5	24.0	67.0	548.0	534.0	704.0
75	1052	21.2	21.4	23.5	24.1	66.0	544.0	534.0	723.0
76	1067	20.5	21.3	23.6	24.0	66.0	538.0	543.0	719.0
77	1081	20.6	21.4	23.7	24.2	66.0	534.0	561.0	696.0
78	1093	20.6	21.3	23.7	23.8	65.0	530.0	595.0	690.0
79	1107	20.6	21.2	23.7	24.8	65.0	527.0	601.0	680.0
80	1122	20.7	21.3	23.8	23.3	65.0	524.0	581.0	674.0
81	1136	20.6	21.2	23.8	23.6	65.0	522.0	568.0	711.0
82	1150	20.6	21.3	23.8	23.9	65.0	521.0	574.0	703.0
83	1164	20.6	21.2	23.8	23.6	64.0	519.0	604.0	704.0
84	1179	20.6	21.3	23.9	23.5	64.0	518.0	617.0	723.0
85	1193	20.6	21.2	23.9	23.4	64.0	516.0	603.0	693.0
86	1207	20.6	21.2	24.0	23.7	63.0	515.0	593.0	674.0
87	1221	25.9	21.2	23.9	23.4	64.0	513.0	595.0	662.0
88	1235	20.6	21.3	24.1	23.4	63.0	510.0	567.0	642.0
89	1250	20.7	21.3	24.1	23.6	63.0	507.0	582.0	651.0
90	1264	20.6	21.2	24.2	23.6	63.0	505.0	635.0	652.0
91	1279	20.6	21.2	24.1	23.6	63.0	504.0	642.0	665.0
92	1293	20.6	21.2	24.2	23.6	63.0	503.0	666.0	682.0
93	1308	20.7	21.2	24.2	23.5	63.0	501.0	664.0	692.0
94	1322	20.8	21.2	24.2	23.6	62.0	498.0	625.0	799.0
95	1336	20.6	21.2	24.2	23.7	62.0	495.0	683.0	827.0
96	1350	20.7	21.1	24.3	23.6	62.0	494.0	666.0	801.0
97	1365	20.7	21.2	24.4	23.7	62.0	491.0	619.0	758.0
98	1379	20.6	21.2	24.4	23.5	62.0	488.0	598.0	718.0
99	1393	21.5	21.0	24.4	24.6	62.0	486.0	611.0	669.0
100	1407	20.6	21.2	24.4	23.5	62.0	484.0	595.0	654.0

101	1422	20.7	21.2	24.5	23.5	62.0	482.0	649.0	737.0
102	1436	20.7	21.2	24.5	23.7	62.0	481.0	682.0	726.0
103	1450	20.6	21.3	24.5	23.6	62.0	479.0	638.0	714.0
104	1464	20.6	21.2	24.6	23.6	61.0	478.0	617.0	671.0
105	1479	20.7	21.3	24.6	23.6	61.0	477.0	584.0	634.0
106	1493	20.6	21.2	24.6	23.9	61.0	477.0	581.0	632.0
107	1507	20.7	21.1	24.7	24.4	61.0	477.0	558.0	605.0
108	1522	20.7	21.2	24.7	23.8	61.0	476.0	544.0	589.0
109	1536	20.6	21.2	24.8	23.6	62.0	474.0	541.0	584.0
110	1551	20.7	21.2	24.9	23.7	62.0	471.0	532.0	573.0
111	1565	20.6	21.2	24.8	23.6	61.0	468.0	528.0	564.0
112	1579	20.6	21.2	25.0	23.9	61.0	466.0	529.0	563.0
113	1593	20.6	21.2	25.0	23.7	61.0	464.0	530.0	562.0
114	1608	20.7	21.3	25.0	23.8	61.0	463.0	523.0	557.0
115	1622	20.7	21.2	25.0	23.6	61.0	461.0	517.0	549.0
116	1636	20.6	21.2	25.1	23.8	61.0	458.0	515.0	545.0
117	1650	20.7	21.2	25.2	23.8	61.0	456.0	516.0	544.0
118	1662	20.6	21.2	25.2	23.9	61.0	455.0	516.0	544.0
119	1676	20.7	21.2	25.2	23.8	61.0	453.0	509.0	536.0
120	1690	20.6	21.2	25.3	23.9	61.0	451.0	507.0	537.0
121	1705	20.6	21.2	25.3	23.6	61.0	447.0	500.0	530.0
122	1719	20.7	21.2	25.4	23.4	61.0	445.0	498.0	528.0
123	1733	20.6	21.1	25.4	23.7	60.0	443.0	493.0	523.0
124	1747	20.6	21.2	25.4	23.7	60.0	442.0	493.0	521.0
125	1762	20.7	21.2	25.5	23.8	60.0	440.0	492.0	523.0
126	1776	20.7	21.2	25.5	24.0	60.0	437.0	492.0	526.0
127	1791	20.6	21.1	25.5	24.0	59.0	436.0	491.0	525.0
128	1805	20.7	21.1	25.5	23.9	59.0	434.0	488.0	525.0
129	1819	20.7	21.1	25.6	24.0	60.0	433.0	491.0	529.0
130	1833	20.7	21.2	25.6	23.9	60.0	434.0	492.0	537.0
131	1848	20.6	21.1	25.8	23.9	61.0	436.0	511.0	550.0
132	1862	20.7	21.2	25.9	23.8	60.0	438.0	515.0	562.0
133	1874	20.7	21.2	25.8	24.1	60.0	439.0	525.0	574.0
134	1888	20.7	21.2	25.9	24.0	61.0	442.0	521.0	568.0
135	1902	20.6	21.3	25.8	25.1	61.0	445.0	523.0	567.0
136	1916	20.7	21.2	26.0	23.9	61.0	449.0	536.0	576.0
137	1930	20.7	21.2	26.1	23.9	61.0	452.0	571.0	607.0
138	1944	20.6	21.3	26.1	23.8	64.0	455.0	536.0	586.0
139	1958	20.6	21.2	26.1	23.9	62.0	460.0	532.0	582.0
140	1972	20.6	21.2	26.2	24.0	62.0	465.0	532.0	581.0
141	1986	20.7	21.2	26.2	23.7	62.0	468.0	538.0	584.0
142	2001	20.6	21.2	26.2	23.9	62.0	470.0	533.0	586.0
143	2015	20.7	21.3	26.2	23.8	62.0	470.0	534.0	590.0
144	2027	20.8	21.3	26.4	24.0	62.0	470.0	533.0	591.0
145	2041	20.7	21.3	26.4	23.9	62.0	469.0	528.0	588.0
146	2056	20.7	21.3	26.5	24.1	62.0	468.0	526.0	585.0
147	2070	20.7	21.3	26.5	24.2	62.0	466.0	522.0	579.0
148	2085	20.7	21.3	26.5	24.1	62.0	466.0	519.0	570.0
149	2099	20.6	21.2	26.5	24.0	62.0	466.0	530.0	584.0
150	2113	20.7	21.4	26.6	23.9	62.0	464.0	537.0	594.0
151	2127	20.7	21.2	26.5	23.7	62.0	467.0	529.0	574.0
152	2141	20.7	21.3	26.7	24.2	63.0	469.0	521.0	561.0
153	2156	20.6	21.3	26.7	23.9	63.0	469.0	518.0	553.0
154	2170	20.7	21.4	26.8	24.3	63.0	468.0	513.0	549.0
155	2185	20.6	21.4	27.3	24.4	66.0	476.0	530.0	566.0
156	2199	20.6	21.5	27.3	24.2	67.0	485.0	541.0	580.0
157	2214	20.7	21.5	27.4	24.3	67.0	491.0	540.0	581.0
158	2228	20.8	21.5	27.7	23.9	68.0	495.0	542.0	590.0

159	2242	20.6	21.5	27.5	24.2	69.0	502.0	546.0	593.0
160	2257	20.7	21.5	27.5	24.2	69.0	503.0	545.0	590.0
161	2271	20.7	21.5	27.6	24.2	70.0	502.0	547.0	592.0
162	2285	20.7	21.5	27.6	24.0	70.0	503.0	548.0	597.0
163	2297	20.7	21.5	27.7	24.3	71.0	504.0	548.0	595.0
164	2311	20.7	21.6	27.7	24.3	71.0	504.0	548.0	590.0
165	2326	20.7	21.6	27.9	24.4	71.0	504.0	546.0	586.0
166	2340	20.7	21.6	27.9	24.1	72.0	505.0	544.0	580.0
167	2354	20.7	21.6	27.9	24.2	72.0	509.0	544.0	577.0
168	2368	20.7	21.6	28.0	24.6	72.0	510.0	543.0	577.0
169	2382	20.7	21.6	28.1	24.7	73.0	512.0	542.0	577.0
170	2394	20.7	21.9	28.0	24.7	73.0	514.0	541.0	578.0
171	2408	20.8	21.6	28.0	24.4	73.0	514.0	544.0	586.0
172	2423	20.7	21.6	28.1	24.5	73.0	516.0	546.0	593.0
173	2435	21.0	21.5	28.2	24.5	74.0	517.0	543.0	593.0
174	2449	20.7	21.6	28.3	24.7	74.0	517.0	541.0	594.0
175	2463	20.7	21.6	28.3	24.3	74.0	518.0	537.0	593.0
176	2478	20.7	21.6	28.4	24.2	74.0	516.0	528.0	586.0
177	2492	20.7	21.6	28.5	24.1	74.0	515.0	525.0	586.0
178	2507	20.8	21.6	28.5	25.0	74.0	514.0	527.0	592.0
179	2521	20.7	21.5	28.6	24.6	75.0	514.0	529.0	598.0
180	2535	20.7	21.5	28.6	24.4	75.0	512.0	532.0	609.0
181	2549	20.7	21.6	28.7	24.6	75.0	510.0	537.0	620.0
182	2563	20.7	21.6	28.7	24.6	75.0	509.0	542.0	634.0
183	2578	20.7	21.6	28.7	24.3	75.0	505.0	537.0	613.0
184	2592	20.7	21.6	28.7	24.4	75.0	504.0	536.0	614.0
185	2606	20.7	21.6	28.8	24.4	76.0	502.0	534.0	608.0
186	2620	20.7	21.7	28.9	24.2	76.0	505.0	526.0	591.0
187	2635	20.8	21.6	29.0	24.4	76.0	503.0	522.0	590.0
188	2649	20.6	21.6	29.1	24.6	76.0	502.0	525.0	596.0
189	2664	20.7	21.5	29.0	24.8	77.0	502.0	527.0	601.0
190	2678	20.7	21.7	29.3	24.6	77.0	505.0	526.0	597.0
191	2693	20.7	21.6	29.2	24.9	77.0	504.0	527.0	601.0
192	2707	20.7	21.6	29.3	24.6	77.0	504.0	530.0	606.0
193	2721	20.7	21.6	29.3	24.4	77.0	504.0	526.0	602.0
194	2732	20.7	21.7	29.4	24.7	78.0	504.0	520.0	589.0
195	2747	20.7	21.6	29.6	24.7	79.0	507.0	517.0	592.0
196	2761	20.8	21.6	29.6	24.8	79.0	514.0	523.0	602.0
197	2775	20.8	21.7	29.6	24.8	78.0	517.0	526.0	602.0
198	2789	23.4	21.6	29.7	25.0	79.0	518.0	522.0	592.0
199	2804	20.7	21.7	29.7	24.6	79.0	517.0	520.0	592.0
200	2818	20.7	21.5	29.8	24.7	79.0	516.0	519.0	590.0
201	2832	20.7	21.8	29.8	24.9	79.0	515.0	520.0	596.0
202	2847	20.7	21.6	29.9	25.3	80.0	514.0	522.0	602.0
203	2861	20.7	21.6	29.8	24.7	80.0	510.0	522.0	602.0
204	2875	20.7	21.7	30.0	24.7	81.0	510.0	521.0	598.0
205	2889	20.7	21.7	30.0	24.6	81.0	512.0	519.0	593.0
206	2904	20.7	21.7	30.0	24.6	81.0	514.0	518.0	589.0
207	2918	20.7	21.7	30.0	25.0	81.0	514.0	516.0	585.0
208	2932	20.8	21.7	30.0	24.7	82.0	514.0	512.0	578.0
209	2946	20.8	21.6	30.0	24.7	81.0	510.0	512.0	576.0
210	2958	20.7	21.7	30.0	24.5	81.0	509.0	512.0	574.0
211	2972	20.7	21.5	30.0	24.7	81.0	509.0	511.0	569.0
212	2.87	20.8	21.6	30.0	24.8	82.0	518.0	512.0	565.0
213	2998	20.7	21.7	30.0	24.5	82.0	520.0	510.0	561.0
214	3013	20.7	21.8	31.0	24.6	83.0	522.0	508.0	557.0
215	3027	20.7	21.8	31.0	24.8	84.0	521.0	505.0	549.0
216	3041	20.7	21.8	31.0	24.4	85.0	527.0	504.0	549.0
217	3056	20.7	21.8	31.0	24.6	83.0	528.0	502.0	548.0

218	3070	20.9	21.7	31.0	24.5	83.0	527.0	500.0	545.0
219	3084	20.7	21.7	31.0	24.8	82.0	526.0	500.0	543.0
220	3098	20.8	21.7	31.0	24.7	82.0	525.0	499.0	540.0
221	3113	20.7	21.6	31.0	26.0	81.0	525.0	498.0	541.0
222	3127	20.7	21.6	31.0	26.2	81.0	525.0	498.0	540.0
223	3142	20.8	21.6	31.0	24.7	81.0	526.0	498.0	538.0
224	3156	20.7	21.6	31.0	24.8	81.0	517.0	497.0	536.0
225	3171	20.7	21.8	31.0	24.7	81.0	512.0	494.0	534.0
226	3185	20.9	21.6	31.0	24.7	81.0	512.0	492.0	536.0
227	3199	20.8	21.6	31.0	24.7	81.0	510.0	493.0	539.0
228	3213	20.7	21.6	31.0	25.0	81.0	512.0	493.0	539.0
229	3228	20.7	21.6	31.0	25.0	80.0	512.0	495.0	540.0
230	3242	20.7	21.6	31.0	24.4	80.0	514.0	496.0	539.0
231	3256	20.7	21.6	32.0	26.1	80.0	521.0	496.0	537.0
232	3270	20.7	21.5	31.0	25.1	80.0	524.0	495.0	536.0
233	3284	20.8	21.6	31.0	24.8	80.0	523.0	493.0	532.0
234	3299	20.7	21.7	31.0	24.5	80.0	527.0	494.0	532.0
235	3313	20.7	21.7	31.0	24.7	80.0	527.0	495.0	529.0
236	3327	20.8	21.6	32.0	25.0	79.0	529.0	496.0	529.0
237	3341	20.7	21.5	32.0	24.5	79.0	529.0	498.0	527.0
238	3356	20.7	21.5	32.0	24.5	79.0	534.0	496.0	528.0
239	3370	20.7	21.5	32.0	24.7	78.0	532.0	495.0	524.0
240	3384	20.7	21.6	32.0	25.0	79.0	533.0	494.0	520.0
241	3396	20.7	21.6	32.0	25.9	78.0	536.0	494.0	522.0
242	3411	20.7	21.5	32.0	25.4	78.0	535.0	495.0	521.0
243	3425	20.7	21.5	32.0	25.1	78.0	533.0	495.0	519.0
244	3439	20.7	21.6	32.0	25.1	79.0	533.0	495.0	525.0
245	3453	20.7	21.5	32.0	25.0	79.0	541.0	501.0	532.0
246	3467	20.8	21.6	32.0	25.1	80.0	551.0	507.0	540.0
247	3482	20.8	21.7	32.0	25.2	81.0	562.0	514.0	545.0
248	3496	20.7	21.7	32.0	25.0	81.0	562.0	517.0	547.0
249	3510	20.7	21.7	32.0	25.3	82.0	570.0	519.0	546.0
250	3522	20.7	21.7	32.0	25.2	82.0	567.0	519.0	545.0
251	3536	20.7	21.9	32.0	25.3	83.0	568.0	521.0	545.0
252	3550	20.8	21.6	32.0	24.6	83.0	565.0	522.0	545.0
253	3565	20.7	21.9	32.0	25.0	84.0	568.0	523.0	550.0
254	3579	20.7	21.8	33.0	25.2	85.0	568.0	529.0	559.0
255	3593	20.8	21.7	33.0	24.9	85.0	567.0	537.0	577.0
256	3607	20.8	21.9	33.0	25.2	85.0	570.0	543.0	587.0
257	3622	20.7	21.8	33.0	24.9	85.0	571.0	553.0	614.0
258	3636	20.7	21.7	33.0	24.8	85.0	566.0	545.0	589.0
259	3651	20.8	21.8	33.0	24.9	85.0	567.0	539.0	579.0
260	3665	20.8	21.7	33.0	25.2	85.0	567.0	540.0	585.0
261	3679	20.7	21.8	33.0	25.1	86.0	569.0	547.0	600.0
262	3693	20.7	21.8	33.0	25.4	86.0	572.0	554.0	611.0
263	3707	20.8	21.7	33.0	25.0	86.0	567.0	548.0	601.0
264	3722	20.8	21.8	33.0	25.2	86.0	562.0	547.0	597.0
265	3736	20.8	21.8	33.0	25.2	86.0	560.0	551.0	604.0
266	3750	20.7	21.8	33.0	24.7	86.0	556.0	550.0	603.0
267	3764	20.8	21.8	33.0	25.1	86.0	559.0	549.0	599.0
268	3779	20.8	21.8	33.0	25.2	86.0	560.0	547.0	594.0
269	3793	20.7	21.7	33.0	25.1	86.0	556.0	546.0	592.0
270	3808	20.7	21.7	33.0	25.2	86.0	556.0	541.0	581.0
271	3819	20.7	21.7	33.0	24.9	86.0	560.0	538.0	577.0
272	3834	20.7	21.9	33.0	25.3	86.0	556.0	536.0	573.0
273	3848	20.8	21.9	33.0	25.4	86.0	558.0	534.0	573.0
274	3862	20.8	21.8	33.0	24.9	87.0	555.0	533.0	573.0
275	3874	21.2	21.8	33.0	25.1	87.0	552.0	531.0	570.0
276	3889	20.7	21.9	34.0	25.1	87.0	542.0	527.0	562.0

277	3903	20.8	21.9	34.0	25.3	88.0	545.0	523.0	556.0
278	3917	20.7	21.9	34.0	25.3	88.0	542.0	521.0	551.0
279	3931	20.7	22.0	34.0	25.4	89.0	540.0	521.0	556.0
280	3945	20.8	21.9	34.0	25.2	89.0	541.0	522.0	567.0
281	3960	20.8	21.9	34.0	25.5	88.0	544.0	522.0	566.0
282	3974	20.8	21.9	34.0	25.4	88.0	545.0	521.0	560.0
283	3989	20.7	21.8	34.0	25.2	89.0	549.0	517.0	552.0
284	4003	20.8	21.9	34.0	25.2	89.0	544.0	514.0	547.0
285	4017	20.7	21.9	34.0	25.3	89.0	545.0	513.0	549.0
286	4032	20.8	21.8	34.0	25.8	89.0	545.0	512.0	549.0
287	4046	20.7	21.9	34.0	25.6	90.0	539.0	512.0	553.0
288	4060	20.7	21.9	34.0	25.5	90.0	540.0	518.0	563.0
289	4075	21.0	22.0	35.0	25.1	91.0	548.0	523.0	568.0
290	4089	20.7	22.0	35.0	25.6	92.0	553.0	519.0	556.0
291	4104	20.8	22.0	35.0	25.2	91.0	558.0	514.0	547.0
292	4118	20.8	22.1	35.0	25.2	92.0	555.0	511.0	544.0
293	4133	20.7	22.1	35.0	26.8	91.0	544.0	513.0	547.0
294	4147	20.8	21.9	35.0	26.0	90.0	544.0	512.0	544.0
295	4161	20.7	22.1	35.0	25.9	90.0	547.0	509.0	537.0
296	4175	20.8	22.0	35.0	25.3	91.0	550.0	506.0	528.0
297	4189	20.8	22.2	35.0	25.8	91.0	555.0	504.0	521.0
298	4204	20.8	22.1	35.0	25.5	92.0	563.0	501.0	518.0
299	4218	20.9	22.2	35.0	25.3	91.0	563.0	501.0	517.0
300	4233	20.8	22.2	35.0	25.8	91.0	563.0	504.0	522.0
301	4247	20.8	22.1	35.0	25.4	91.0	567.0	506.0	530.0
302	4262	20.8	22.1	36.0	25.3	91.0	564.0	505.0	534.0
303	4276	20.9	22.1	35.0	25.2	90.0	558.0	504.0	535.0
304	4290	20.9	21.9	35.0	24.9	90.0	557.0	504.0	531.0
305	4304	20.8	22.2	35.0	25.7	91.0	558.0	504.0	527.0
306	4319	20.8	22.2	36.0	25.0	91.0	569.0	503.0	521.0
307	4333	20.8	22.3	36.0	25.1	91.0	570.0	502.0	520.0
308	4348	20.7	22.2	36.0	26.8	90.0	576.0	501.0	519.0
309	4362	20.8	22.2	36.0	25.3	91.0	575.0	502.0	516.0
310	4376	20.8	22.3	37.0	25.4	91.0	572.0	498.0	508.0
311	4391	20.8	22.2	36.0	25.3	91.0	576.0	495.0	504.0
312	4402	20.8	22.2	36.0	25.7	92.0	577.0	494.0	499.0
313	4417	20.9	22.2	36.0	25.3	93.0	572.0	489.0	491.0
314	4431	20.8	22.1	36.0	25.3	93.0	574.0	487.0	490.0
315	4445	20.9	22.3	37.0	25.3	93.0	576.0	486.0	494.0
316	4459	20.7	22.4	37.0	25.3	92.0	570.0	486.0	494.0
317	4474	20.8	22.4	37.0	25.4	92.0	571.0	486.0	498.0
318	4488	20.8	22.3	37.0	25.2	92.0	565.0	486.0	504.0
319	4502	20.8	22.3	36.0	25.5	91.0	564.0	490.0	517.0
320	4517	20.7	22.1	36.0	25.5	90.0	570.0	492.0	518.0
321	4531	20.8	22.3	37.0	25.5	90.0	574.0	492.0	513.0
322	4545	20.8	22.4	37.0	25.4	90.0	566.0	490.0	505.0
323	4558	20.8	22.3	37.0	25.3	91.0	558.0	486.0	502.0
324	4572	20.7	22.3	37.0	25.3	90.0	556.0	485.0	505.0
325	4586	20.7	22.3	36.0	25.4	90.0	558.0	484.0	503.0
326	4600	20.7	22.2	37.0	25.1	90.0	562.0	483.0	499.0
327	4614	20.9	22.4	37.0	25.3	90.0	562.0	482.0	495.0
328	4629	20.8	22.4	37.0	25.6	90.0	566.0	481.0	494.0
329	4643	20.9	22.5	37.0	25.5	91.0	566.0	481.0	493.0
330	4657	20.7	22.3	37.0	25.9	91.0	566.0	481.0	496.0
331	4671	20.8	22.4	37.0	25.4	91.0	561.0	481.0	499.0
332	4686	20.9	22.4	37.0	25.3	91.0	558.0	482.0	508.0
333	4700	20.9	22.4	37.0	25.6	91.0	557.0	484.0	513.0
334	4714	20.8	22.5	37.0	25.4	91.0	559.0	485.0	512.0
335	4729	20.8	22.3	37.0	26.0	90.0	558.0	485.0	512.0

336	4743	20.8	22.3	37.0	25.4	90.0	559.0	485.0	509.0
337	4757	20.9	22.3	37.0	25.1	90.0	561.0	484.0	506.0
338	4772	21.2	22.4	37.0	25.3	90.0	561.0	483.0	502.0
339	4786	20.8	22.3	37.0	25.2	90.0	559.0	483.0	502.0
340	4800	20.8	22.3	37.0	25.4	89.0	554.0	482.0	506.0
341	4814	20.8	22.4	37.0	25.5	90.0	551.0	482.0	505.0
342	4828	20.8	22.4	38.0	25.7	90.0	551.0	482.0	504.0
343	4843	20.8	22.5	38.0	26.0	90.0	547.0	482.0	506.0
344	4857	20.8	22.4	37.0	25.8	90.0	548.0	481.0	508.0
345	4872	20.8	22.3	37.0	25.5	89.0	548.0	482.0	503.0
346	4886	20.8	22.3	37.0	25.3	88.0	542.0	479.0	496.0
347	4900	20.8	22.1	37.0	25.4	87.0	536.0	477.0	488.0
348	4914	20.7	22.0	37.0	25.1	86.0	533.0	475.0	484.0
349	4929	20.8	22.0	37.0	25.6	86.0	531.0	474.0	481.0
350	4943	20.7	22.1	37.0	25.4	86.0	529.0	471.0	477.0
351	4957	20.8	22.1	38.0	25.4	85.0	528.0	467.0	470.0
352	4972	20.8	22.1	38.0	25.5	85.0	526.0	465.0	466.0
353	4986	20.8	22.1	38.0	25.8	84.0	523.0	462.0	463.0
354	5000	20.8	22.1	38.0	26.1	84.0	522.0	461.0	463.0
355	5015	20.8	22.2	38.0	25.4	84.0	519.0	460.0	464.0
356	5029	20.9	22.0	38.0	25.6	83.0	521.0	460.0	466.0
357	5044	20.8	22.2	38.0	25.7	83.0	519.0	458.0	464.0
358	5058	20.8	22.0	38.0	25.5	83.0	519.0	457.0	464.0
359	5072	20.8	22.1	38.0	28.2	82.0	518.0	458.0	468.0
360	5084	20.8	22.0	38.0	25.7	82.0	516.0	457.0	470.0
361	5098	20.8	22.0	38.0	25.8	82.0	511.0	457.0	473.0
362	5112	20.8	22.0	38.0	25.8	81.0	505.0	457.0	473.0
363	5126	20.8	22.0	38.0	25.8	80.0	501.0	459.0	477.0
364	5141	20.8	22.0	38.0	25.6	80.0	498.0	459.0	476.0
365	5155	20.9	22.0	38.0	25.7	79.0	496.0	459.0	477.0
366	5169	20.8	22.0	38.0	25.7	79.0	493.0	459.0	477.0
367	5183	20.9	22.0	38.0	25.6	78.0	490.0	458.0	474.0
368	5198	20.8	22.0	38.0	25.6	78.0	487.0	457.0	475.0
369	5212	20.9	21.9	38.0	25.3	77.0	486.0	455.0	478.0
370	5227	20.9	21.9	38.0	25.6	77.0	486.0	453.0	483.0
371	5241	20.8	21.9	38.0	26.4	77.0	483.0	455.0	488.0
372	5255	20.9	22.0	38.0	25.8	77.0	482.0	456.0	494.0
373	5269	20.9	22.0	38.0	25.7	76.0	481.0	457.0	496.0
374	5283	20.9	21.9	38.0	26.6	76.0	481.0	458.0	499.0
375	5298	20.9	21.9	38.0	25.8	75.0	481.0	461.0	503.0
376	5312	20.9	21.9	38.0	25.8	75.0	484.0	462.0	504.0
377	5326	20.9	21.9	38.0	28.4	75.0	484.0	462.0	501.0
378	5337	20.8	21.9	38.0	26.7	74.0	484.0	461.0	501.0
379	5352	20.9	21.8	38.0	27.0	74.0	485.0	461.0	501.0
380	5366	20.8	21.9	38.0	26.4	74.0	484.0	461.0	504.0
381	5380	20.9	21.9	38.0	26.0	74.0	482.0	461.0	505.0
382	5394	21.0	21.9	38.0	25.9	74.0	481.0	462.0	507.0
383	5409	21.0	21.9	38.0	25.2	73.0	479.0	462.0	509.0
384	5420	20.8	22.0	38.0	25.5	73.0	478.0	462.0	509.0
385	5432	20.9	21.9	38.0	25.7	73.0	476.0	462.0	510.0
386	5446	20.9	22.0	38.0	25.6	72.0	475.0	462.0	514.0
387	5461	20.9	21.8	38.0	25.9	72.0	471.0	460.0	512.0
388	5475	20.9	21.9	38.0	25.6	71.0	470.0	459.0	512.0
389	5490	21.0	21.9	38.0	25.5	71.0	469.0	459.0	513.0
390	5504	20.9	21.9	38.0	25.6	71.0	469.0	459.0	519.0
391	5518	21.1	22.0	38.0	25.8	71.0	469.0	461.0	522.0
392	5532	20.9	22.1	38.0	25.5	70.0	466.0	458.0	536.0
393	5546	20.9	21.9	38.0	25.1	70.0	465.0	459.0	545.0
394	5561	20.9	21.8	38.0	25.3	70.0	464.0	461.0	549.0

395	5575	21.0	21.9	38.0	25.2	70.0	465.0	461.0	546.0
396	5589	20.9	21.9	38.0	25.3	70.0	468.0	461.0	541.0
397	5603	21.0	21.9	38.0	25.5	69.0	469.0	461.0	539.0
398	5618	21.1	21.9	38.0	25.6	69.0	469.0	462.0	536.0
399	5632	21.0	21.8	38.0	25.6	69.0	468.0	466.0	541.0
400	5646	20.9	21.9	38.0	25.2	69.0	464.0	470.0	548.0
401	5660	20.9	21.9	38.0	25.5	69.0	461.0	468.0	545.0
402	5672	20.9	21.9	38.0	25.6	68.0	459.0	468.0	543.0
403	5686	20.9	21.9	38.0	26.4	68.0	458.0	468.0	541.0
404	5701	20.9	22.0	38.0	25.9	68.0	456.0	468.0	541.0
405	5715	21.0	21.8	38.0	25.7	68.0	455.0	467.0	537.0
406	5729	20.9	21.9	38.0	25.2	67.0	454.0	465.0	535.0
407	5744	20.9	21.8	38.0	25.5	67.0	453.0	464.0	533.0
408	5758	20.9	21.9	38.0	25.8	67.0	452.0	462.0	529.0
409	5772	21.0	21.7	38.0	25.6	67.0	450.0	461.0	533.0
410	5783	20.9	21.8	38.0	25.2	67.0	450.0	460.0	535.0
411	5798	21.0	21.9	38.0	25.7	68.0	454.0	470.0	556.0
412	5812	21.0	21.9	38.0	25.8	68.0	457.0	480.0	574.0
413	5826	21.0	21.9	38.0	26.2	68.0	460.0	489.0	582.0
414	5841	20.9	22.1	38.0	25.5	69.0	463.0	494.0	597.0
415	5855	20.9	22.0	38.0	25.9	69.0	464.0	498.0	602.0
416	5869	20.9	22.0	38.0	25.9	69.0	465.0	501.0	605.0
417	5884	20.9	21.9	38.0	25.5	69.0	465.0	501.0	611.0
418	5898	21.0	21.9	38.0	26.0	68.0	466.0	500.0	612.0
419	5912	21.0	21.9	38.0	25.7	69.0	467.0	502.0	611.0
420	5924	21.0	21.9	38.0	25.8	69.0	467.0	502.0	610.0
421	5939	20.9	22.0	38.0	25.6	68.0	466.0	503.0	611.0
422	5953	20.9	22.0	38.0	25.9	68.0	466.0	503.0	611.0
423	5967	21.1	22.0	38.0	25.6	68.0	469.0	505.0	613.0
424	5981	21.3	21.9	38.0	25.8	69.0	470.0	507.0	610.0
425	5995	20.9	22.0	38.0	24.9	69.0	473.0	507.0	611.0
426	6010	21.0	21.9	38.0	25.4	69.0	474.0	505.0	611.0
427	6024	21.0	21.9	38.0	25.8	69.0	476.0	504.0	613.0
428	6039	21.0	22.0	38.0	25.7	70.0	476.0	506.0	610.0
429	6053	21.0	22.1	38.0	25.4	69.0	476.0	504.0	607.0
430	6067	21.0	22.0	38.0	25.8	70.0	479.0	505.0	614.0
431	6081	21.0	22.1	39.0	26.2	70.0	480.0	500.0	608.0
432	6096	21.0	22.1	39.0	26.0	70.0	480.0	499.0	605.0
433	6110	21.0	22.0	38.0	25.7	70.0	480.0	503.0	614.0
434	6124	21.0	22.1	38.0	25.5	70.0	480.0	504.0	618.0
435	6138	21.0	22.1	38.0	25.5	71.0	480.0	504.0	614.0
436	6153	21.0	22.2	39.0	25.5	71.0	483.0	508.0	620.0
437	6167	21.0	22.1	39.0	26.0	71.0	485.0	510.0	625.0
438	6181	21.0	22.1	39.0	25.7	72.0	488.0	513.0	627.0
439	6196	21.1	22.1	39.0	25.7	72.0	489.0	516.0	627.0
440	6210	21.0	22.1	39.0	26.4	72.0	491.0	518.0	623.0
441	6224	21.0	22.0	39.0	25.8	72.0	492.0	518.0	619.0
442	6238	21.1	22.2	39.0	25.8	72.0	493.0	518.0	616.0
443	6253	21.0	22.2	39.0	26.1	72.0	493.0	517.0	614.0
444	6267	21.0	22.2	39.0	25.7	72.0	496.0	517.0	613.0
445	6281	21.0	22.1	39.0	25.4	73.0	499.0	517.0	609.0
446	6295	21.0	22.2	39.0	25.6	73.0	503.0	518.0	609.0
447	6310	21.0	22.1	39.0	25.7	73.0	506.0	517.0	604.0
448	6324	21.0	22.2	39.0	25.6	73.0	507.0	517.0	603.0
449	6339	21.0	22.0	39.0	25.6	74.0	507.0	516.0	603.0
450	6353	21.0	22.2	39.0	25.5	74.0	504.0	513.0	601.0
451	6367	21.0	22.2	39.0	25.6	74.0	501.0	514.0	602.0
452	6381	20.9	22.2	39.0	25.5	74.0	501.0	513.0	602.0
453	6396	21.0	22.2	39.0	25.7	74.0	501.0	510.0	603.0

454	6410	21.0	22.1	39.0	25.5	75.0	500.0	511.0	609.0
455	6424	21.0	22.3	39.0	25.4	75.0	500.0	511.0	609.0
456	6439	21.0	22.2	39.0	25.6	75.0	498.0	511.0	612.0
457	6453	21.1	22.3	39.0	25.5	75.0	496.0	509.0	612.0
458	6467	21.1	22.3	39.0	25.8	75.0	495.0	483.0	567.0
459	6481	21.1	22.2	39.0	25.6	75.0	494.0	192.0	285.0
460	6496	21.0	22.2	39.0	26.5	75.0	494.0	118.0	181.0
461	6510	21.1	22.2	39.0	26.3	75.0	493.0	80.0	124.0
462	6524	21.0	22.3	39.0	26.0	75.0	493.0	63.0	93.0
463	6538	21.0	22.1	39.0	25.9	75.0	492.0	49.0	72.0
464	6552	21.0	22.1	39.0	26.4	75.0	491.0	42.0	61.0

TEMPERATURE DATA :

		THERMOCOUPLE NUMBERS (TEMPERATURES deg C)						
NO.	TIME	9	10	11	12	13	14	15
1	2	9.7	4.2	3.5	4.2	4.8	4.2	4.9
2	16	27.1	21.0	21.6	21.6	21.6	21.0	21.9
3	31	27.1	21.0	21.6	21.6	21.6	21.6	21.8
4	45	27.7	21.6	21.6	22.3	21.6	21.6	21.8
5	59	27.7	21.7	21.7	22.3	22.3	21.7	21.8
6	73	29.0	22.3	22.3	22.3	22.3	21.7	21.8
7	87	29.0	23.5	22.3	22.3	22.3	22.3	21.8
8	101	29.6	26.0	26.7	29.8	22.3	23.5	21.9
9	115	33.0	29.2	28.5	42.0	22.3	24.2	21.8
10	130	64.0	45.0	35.0	46.0	21.7	27.3	21.8
11	144	240.0	70.0	52.0	62.0	22.3	38.0	21.8
12	158	225.0	81.0	62.0	74.0	22.3	42.0	21.8
13	172	169.0	70.0	50.0	67.0	22.3	39.0	21.8
14	187	116.0	56.0	41.0	54.0	22.3	35.0	22.0
15	201	89.0	44.0	34.0	45.0	22.3	33.0	21.8
16	215	74.0	39.0	32.0	41.0	22.4	32.0	22.0
17	229	67.0	36.0	30.0	39.0	22.4	31.0	21.9
18	244	62.0	34.0	29.3	39.0	22.4	31.0	22.3
19	258	61.0	32.0	28.0	39.0	22.4	29.9	21.8
20	272	62.0	31.0	28.0	39.0	22.4	29.3	21.9
21	286	62.0	29.9	27.4	39.0	22.4	28.6	21.8
22	300	62.0	29.3	26.8	40.0	22.4	28.6	21.8
23	314	63.0	28.0	26.8	41.0	22.4	28.0	21.8
24	328	64.0	27.4	26.8	41.0	22.4	27.4	21.8
25	343	66.0	27.4	26.8	42.0	22.4	27.4	21.8
26	357	70.0	28.0	26.8	44.0	22.4	27.4	22.1
27	371	73.0	28.1	26.8	44.0	22.4	26.8	21.8
28	385	76.0	28.7	27.5	46.0	22.4	27.5	22.0
29	400	80.0	28.7	25.6	45.0	22.4	26.2	21.8
30	411	89.0	28.1	24.3	46.0	22.4	25.0	21.8
31	426	95.0	27.5	23.7	46.0	23.1	23.7	21.9
32	440	97.0	28.1	23.8	47.0	22.5	23.1	21.9
33	454	102.0	28.7	23.7	49.0	22.5	23.1	21.7
34	468	102.0	30.0	23.7	50.0	23.1	22.5	22.0
35	482	103.0	30.0	24.4	51.0	23.1	22.5	21.9
36	496	106.0	30.0	24.4	51.0	23.1	23.1	21.9
37	511	122.0	31.0	25.0	51.0	23.1	23.1	21.9
38	525	135.0	31.0	25.0	52.0	23.2	23.8	22.0
39	539	142.0	32.0	25.0	52.0	23.2	23.2	22.0
40	554	137.0	31.0	25.0	52.0	23.8	23.2	21.9
41	568	132.0	31.0	25.7	52.0	23.8	23.8	22.0
42	582	121.0	33.0	25.7	52.0	23.8	23.8	22.3
43	596	102.0	32.0	25.7	51.0	23.8	23.8	22.2
44	611	93.0	31.0	25.7	51.0	23.8	23.2	22.2

45	625	84.0	29.4	25.1	49.0	23.8	23.8	22.2
46	640	80.0	30.0	25.7	45.0	23.8	23.8	22.2
47	654	80.0	30.0	25.1	44.0	23.9	23.9	22.4
48	668	79.0	28.8	24.5	45.0	23.8	23.8	22.1
49	682	77.0	28.9	24.5	50.0	23.9	23.9	22.4
50	697	71.0	29.5	25.1	47.0	24.5	23.9	22.2
51	711	72.0	30.0	25.8	48.0	24.5	23.9	22.4
52	725	69.0	28.9	25.8	49.0	24.5	23.9	22.4
53	739	65.0	28.3	25.8	47.0	24.5	23.9	22.4
54	753	65.0	28.3	25.8	45.0	24.5	23.9	22.5
55	768	65.0	28.3	25.2	43.0	24.6	23.9	22.4
56	782	65.0	28.3	25.2	43.0	24.6	23.9	22.5
57	797	65.0	29.0	25.2	46.0	24.6	24.0	22.6
58	811	63.0	31.0	25.8	46.0	24.6	24.0	22.7
59	826	62.0	30.0	25.9	46.0	24.6	24.0	22.8
60	840	60.0	29.0	25.9	46.0	24.6	24.0	22.7
61	854	60.0	30.0	25.9	47.0	24.6	24.6	23.0
62	868	60.0	30.0	25.9	48.0	24.6	24.0	22.9
63	883	59.0	31.0	25.9	48.0	24.7	34.0	22.9
64	897	58.0	31.0	25.9	47.0	24.6	24.6	22.9
65	912	62.0	32.0	25.9	47.0	24.7	24.0	23.0
66	926	66.0	31.0	26.6	47.0	24.7	24.1	23.1
67	941	71.0	32.0	26.6	47.0	24.7	24.1	23.2
68	952	75.0	32.0	26.6	47.0	24.7	24.7	23.2
69	966	81.0	33.0	26.6	47.0	24.7	24.1	23.1
70	981	90.0	33.0	26.6	47.0	24.7	24.1	23.1
71	995	100.0	32.0	26.6	46.0	24.7	24.1	23.2
72	1009	108.0	32.0	26.6	46.0	24.7	24.1	23.2
73	1023	120.0	32.0	27.2	46.0	24.7	24.7	23.2
74	1038	129.0	32.0	27.3	46.0	24.8	24.2	23.4
75	1052	128.0	33.0	27.3	47.0	24.8	24.8	23.3
76	1067	126.0	34.0	27.9	47.0	24.8	24.8	23.3
77	1081	114.0	33.0	28.0	45.0	24.8	24.8	24.7
78	1093	111.0	32.0	28.0	45.0	24.8	25.5	23.4
79	1107	108.0	32.0	28.0	46.0	24.8	25.5	23.4
80	1122	107.0	32.0	28.0	47.0	24.9	25.5	23.6
81	1136	109.0	32.0	28.0	47.0	24.9	25.5	23.5
82	1150	116.0	32.0	28.0	49.0	24.9	25.5	23.6
83	1164	121.0	35.0	28.6	50.0	24.9	25.5	23.6
84	1179	136.0	35.0	28.0	52.0	24.9	26.2	24.4
85	1193	160.0	35.0	28.1	53.0	24.9	26.2	23.7
86	1207	178.0	36.0	29.3	52.0	24.9	26.2	23.7
87	1221	203.0	37.0	30.0	52.0	25.0	26.2	23.7
88	1235	273.0	37.0	31.0	51.0	25.0	26.2	23.8
89	1250	346.0	37.0	30.0	51.0	25.0	26.9	23.7
90	1264	289.0	38.0	30.0	52.0	25.0	26.9	23.7
91	1279	310.0	39.0	29.4	53.0	25.0	26.3	23.7
92	1293	318.0	39.0	30.0	55.0	25.0	26.9	23.7
93	1308	332.0	39.0	30.0	56.0	25.1	26.9	23.8
94	1322	329.0	40.0	28.8	54.0	25.1	27.0	23.8
95	1336	384.0	41.0	28.8	52.0	25.1	27.0	23.8
96	1350	444.0	41.0	29.5	51.0	25.1	27.0	23.8
97	1365	456.0	41.0	30.0	56.0	25.1	27.0	23.8
98	1379	561.0	41.0	30.0	57.0	25.1	28.3	24.0
99	1393	642.0	43.0	29.5	59.0	25.2	27.7	24.0
100	1407	705.0	43.0	30.0	61.0	25.2	27.7	24.0
101	1422	640.0	44.0	30.0	64.0	25.2	27.7	23.9
102	1436	562.0	44.0	31.0	66.0	25.2	27.7	23.9
103	1450	649.0	45.0	31.0	66.0	25.2	27.7	24.1

104	1464	776.0	45.0	30.0	65.0	25.3	27.8	24.1
105	1479	742.0	45.0	30.0	66.0	25.9	27.8	24.0
106	1493	765.0	45.0	32.0	68.0	25.3	27.8	24.0
107	1507	805.0	47.0	32.0	68.0	25.3	28.4	24.1
108	1522	811.0	49.0	32.0	68.0	25.3	28.4	24.0
109	1536	771.0	54.0	32.0	67.0	26.0	28.5	24.2
110	1551	723.0	55.0	32.0	69.0	26.0	28.5	24.2
111	1565	699.0	57.0	32.0	72.0	25.4	28.5	24.2
112	1579	691.0	62.0	33.0	75.0	25.4	28.5	24.1
113	1593	753.0	68.0	33.0	76.0	25.4	28.5	24.2
114	1608	702.0	75.0	32.0	79.0	25.4	27.9	24.1
115	1622	669.0	83.0	33.0	87.0	25.4	27.9	24.3
116	1636	662.0	95.0	33.0	88.0	25.5	28.0	24.2
117	1650	668.0	105.0	34.0	89.0	25.5	28.6	24.2
118	1662	683.0	111.0	34.0	93.0	25.5	28.6	24.2
119	1676	673.0	123.0	35.0	96.0	25.5	28.6	24.2
120	1690	672.0	142.0	35.0	98.0	25.5	28.7	24.4
121	1705	653.0	171.0	34.0	98.0	25.5	28.7	24.4
122	1719	633.0	254.0	34.0	109.0	25.6	28.7	24.4
123	1733	628.0	231.0	34.0	117.0	25.6	28.1	24.3
124	1747	642.0	203.0	35.0	128.0	25.6	28.7	24.4
125	1762	658.0	192:0	37.0	149.0	25.6	28.7	24.4
126	1776	666.0	228.0	37.0	223.0	25.6	29.4	24.3
127	1791	674.0	249.0	36.0	327.0	25.7	30.0	24.4
128	1805	661.0	263.0	36.0	436.0	25.7	30.0	24.5
129	1819	662.0	294.0	36.0	417.0	25.7	30.0	24.7
130	1833	664.0	352.0	36.0	415.0	25.7	30.0	24.4
131	1848	682.0	303.0	36.0	378.0	25.7	30.0	24.5
132	1862	704.0	350.0	36.0	414.0	25.7	30.0	24.7
133	1874	712.0	387.0	36.0	339.0	25.7	29.5	24.4
134	1888	696.0	511.0	36.0	290.0	25.8	29.5	24.6
135	1902	686.0	509.0	38.0	415.0	25.8	28.9	24.6
136	1916	693.0	722.0	39.0	630.0	25.8	29.5	24.5
137	1930	731.0	742.0	39.0	666.0	25.8	28.9	24.6
138	1944	715.0	769.0	37.0	671.0	25.9	29.6	24.9
139	1958	690.0	702.0	38.0	790.0	26.5	30.0	24.7
140	1972	694.0	738.0	41.0	833.0	25.9	30.0	24.7
141	1986	699.0	723.0	41.0	799.0	26.5	31.0	24.7
142	2001	687.0	646.0	42.0	763.0	25.9	31.0	24.7
143	2015	691.0	608.0	42.0	817.0	25.9	31.0	24.8
144	2027	692.0	548.0	42.0	814.0	26.6	30.0	24.8
145	2041	693.0	571.0	40.0	696.0	26.6	31.0	24.8
146	2056	679.0	539.0	40.0	667.0	26.0	32.0	24.8
147	2070	655.0	715.0	40.0	859.0	26.6	32.0	24.9
148	2085	634.0	788.0	42.0	605.0	26.6	32.0	24.8
149	2099	631.0	791.0	42.0	776.0	26.6	32.0	25.0
150	2113	623.0	726.0	44.0	776.0	26.7	33.0	24.9
151	2127	603.0	790.0	45.0	829.0	26.7	32.0	25.0
152	2141	587.0	759.0	47.0	764.0	26.7	32.0	24.9
153	2156	574.0	730.0	50.0	814.0	26.7	32.0	25.0
154	2170	567.0	851.0	53.0	924.0	26.8	32.0	24.9
155	2185	589.0	784.0	54.0	1014.0	26.8	31.0	25.1
156	2199	601.0	788.0	52.0	815.0	26.8	31.0	25.1
157	2214	60[illegible].0	748.0	51.0	837 0	26.8	32.0	25.1
158	2228	616.0	721.0	53.0	849.0	26.8	31.0	25.2
159	2242	617.0	782.0	56.0	823.0	26.8	32.0	25.3
160	2257	623.0	786.0	51.0	849.0	26.9	31.0	25.2
161	2271	627.0	768.0	51.0	729.0	26.9	31.0	25.3
162	2285	635.0	741.0	57.0	736.0	26.9	32.0	25.2

163	2297	625.0	787.0	58.0	806.0	26.9	32.0	25.2
164	2311	615.0	772.0	55.0	753.0	26.9	32.0	25.2
165	2326	615.0	784.0	52.0	677.0	27.0	33.0	25.3
166	2340	605.0	743.0	53.0	443.0	27.0	33.0	25.4
167	2354	599.0	754.0	51.0	440.0	27.0	33.0	25.4
168	2368	598.0	796.0	53.0	376.0	27.0	33.0	25.6
169	2382	605.0	802.0	53.0	330.0	27.0	33.0	25.6
170	2394	614.0	792.0	52.0	305.0	27.0	33.0	25.5
171	2408	638.0	855.0	53.0	287.0	27.0	32.0	25.8
172	2423	640.0	902.0	50.0	213.0	27.1	32.0	25.6
173	2435	641.0	870.0	52.0	190.0	27.1	31.0	25.7
174	2449	649.0	869.0	51.0	178.0	27.1	33.0	25.8
175	2463	637.0	800.0	51.0	161.0	27.1	33.0	25.8
176	2478	640.0	731.0	50.0	152.0	27.2	32.0	25.8
177	2492	643.0	714.0	45.0	140.0	27.2	32.0	25.8
178	2507	648.0	751.0	43.0	137.0	27.2	32.0	25.9
179	2521	650.0	838.0	43.0	132.0	27.2	31.0	26.0
180	2535	649.0	799.0	43.0	111.0	27.2	31.0	26.0
181	2549	657.0	796.0	42.0	119.0	26.6	31.0	26.3
182	2563	671.0	709.0	45.0	107.0	26.6	32.0	25.9
183	2578	653.0	796.0	45.0	102.0	26.6	32.0	25.9
184	2592	652.0	792.0	44.0	96.0	26.7	32.0	26.0
185	2606	659.0	711.0	45.0	102.0	26.7	33.0	26.1
186	2620	640.0	716.0	45.0	95.0	26.7	34.0	26.1
187	2635	633.0	789.0	46.0	108.0	27.4	33.0	26.6
188	2649	639.0	640.0	44.0	96.0	26.7	33.0	26.3
189	2664	641.0	775.0	45.0	100.0	26.8	33.0	26.3
190	2678	628.0	699.0	46.0	86.0	26.8	33.0	26.2
191	2693	635.0	701.0	46.0	93.0	26.8	34.0	26.3
192	2707	641.0	725.0	47.0	96.0	26.8	33.0	26.3
193	2721	636.0	713.0	47.0	120.0	26.8	32.0	26.5
194	2732	617.0	740.0	44.0	108.0	26.8	32.0	26.4
195	2747	615.0	699.0	45.0	96.0	26.9	32.0	26.4
196	2761	625.0	743.0	44.0	86.0	26.9	32.0	26.4
197	2775	627.0	668.0	43.0	76.0	26.9	32.0	26.4
198	2789	607.0	622.0	41.0	87.0	26.9	31.0	26.5
199	2804	604.0	518.0	43.0	84.0	26.3	33.0	26.6
200	2818	606.0	462.0	41.0	78.0	27.0	32.0	26.6
201	2832	622.0	384.0	43.0	84.0	26.3	32.0	26.7
202	2847	637.0	363.0	44.0	82.0	26.4	33.0	26.6
203	2861	648.0	471.0	41.0	71.0	26.4	32.0	26.7
204	2875	634.0	604.0	41.0	76.0	26.4	31.0	26.7
205	2889	626.0	631.0	41.0	79.0	26.4	31.0	26.8
206	2904	609.0	656.0	40.0	92.0	26.4	31.0	26.7
207	2918	597.0	597.0	42.0	87.0	26.5	31.0	26.7
208	2932	584.0	659.0	42.0	72.0	26.5	30.0	26.7
209	2946	582.0	488.0	42.0	76.0	26.5	31.0	26.7
210	2958	584.0	444.0	42.0	81.0	26.5	31.0	26.8
211	2972	597.0	363.0	41.0	76.0	26.5	30.0	26.9
212	2987	612.0	366.0	41.0	74.0	26.5	30.0	26.8
213	2998	616.0	325.0	40.0	71.0	26.5	29.7	26.8
214	3013	621.0	266.0	39.0	74.0	26.6	29.7	26.8
215	3027	633.0	247.0	38.0	75.0	26.6	29.7	27.0
216	3041	643.0	261.0	38.0	75.0	26.6	29.7	27.0
217	3056	625.0	270.0	37.0	85.0	26.0	29.7	27.0
218	3070	614.0	262.0	37.0	79.0	26.6	29.8	27.0
219	3084	605.0	279.0	37.0	76.0	26.6	29.8	27.0
220	3098	607.0	246.0	37.0	71.0	26.7	29.8	27.1
221	3113	619.0	290.0	38.0	72.0	26.1	29.2	27.1

222	3127	613.0	319.0	39.0	77.0	26.7	29.2	27.1
223	3142	606.0	398.0	39.0	83.0	26.7	29.2	27.1
224	3156	603.0	312.0	38.0	80.0	26.1	29.2	27.1
225	3171	611.0	258.0	38.0	74.0	26.1	29.9	27.1
226	3185	611.0	252.0	37.0	73.0	26.1	29.3	27.1
227	3199	606.0	249.0	39.0	76.0	26.2	29.9	27.2
228	3213	600.0	267.0	37.0	82.0	26.2	29.9	27.2
229	3228	589.0	399.0	37.0	77.0	26.2	29.9	27.2
230	3242	574.0	475.0	38.0	82.0	26.2	31.0	27.2
231	3256	557.0	516.0	37.0	78.0	26.2	30.0	27.2
232	3270	546.0	497.0	38.0	90.0	26.3	30.0	27.4
233	3284	542.0	438.0	39.0	90.0	26.3	31.0	27.3
234	3299	549.0	732.0	39.0	92.0	26.3	31.0	27.3
235	3313	550.0	709.0	38.0	91.0	26.3	30.0	27.3
236	3327	545.0	627.0	38.0	89.0	26.3	30.0	27.2
237	3341	541.0	706.0	39.0	80.0	26.3	30.0	27.3
238	3356	540.0	613.0	39.0	90.0	26.3	31.0	27.3
239	3370	539.0	587.0	39.0	90.0	26.3	31.0	27.5
240	3384	543.0	691.0	39.0	93.0	26.4	31.0	27.4
241	3396	546.0	652.0	39.0	102.0	26.4	31.0	27.3
242	3411	549.0	698.0	40.0	85.0	26.4	31.0	27.3
243	3425	548.0	760.0	42.0	82.0	26.4	31.0	27.4
244	3439	560.0	726.0	42.0	82.0	26.4	31.0	27.3
245	3453	580.0	708.0	41.0	81.0	26.5	31.0	27.3
246	3467	603.0	684.0	41.0	81.0	26.5	31.0	35.0
247	3482	604.0	642.0	40.0	85.0	26.5	31.0	27.5
248	3496	606.0	653.0	41.0	94.0	26.5	31.0	27.6
249	3510	608.0	561.0	40.0	91.0	26.5	31.0	27.5
250	3522	612.0	572.0	40.0	86.0	26.5	31.0	27.5
251	3536	614.0	590.0	38.0	76.0	26.5	30.0	27.4
252	3550	624.0	431.0	40.0	74.0	26.5	30.0	27.5
253	3565	644.0	400.0	40.0	76.0	26.6	29.7	27.6
254	3579	665.0	402.0	40.0	87.0	26.6	29.7	27.6
255	3593	721.0	353.0	42.0	79.0	26.6	29.7	27.6
256	3607	720.0	319.0	37.0	83.0	26.6	29.7	27.6
257	3622	770.0	300.0	38.0	75.0	26.6	29.7	27.7
258	3636	675.0	264.0	37.0	81.0	26.6	29.1	27.6
259	3651	661.0	280.0	38.0	78.0	26.7	28.6	27.8
260	3665	705.0	287.0	38.0	63.0	26.7	28.6	27.8
261	3679	762.0	261.0	37.0	69.0	26.7	29.2	27.9
262	3693	815.0	240.0	39.0	74.0	26.7	29.2	27.8
263	3707	741.0	244.0	39.0	75.0	26.7	29.8	28.1
264	3722	707.0	260.0	40.0	73.0	26.7	29.9	27.9
265	3736	708.0	400.0	40.0	71.0	26.7	30.0	27.9
266	3750	710.0	345.0	38.0	73.0	26.7	29.9	27.9
267	3764	704.0	297.0	37.0	67.0	26.8	31.0	27.9
268	3779	711.0	250.0	38.0	66.0	26.8	29.9	27.9
269	3793	676.0	260.0	38.0	65.0	26.8	29.9	28.0
270	3808	649.0	249.0	37.0	72.0	26.8	29.9	27.9
271	3819	637.0	267.0	37.0	70.0	26.8	29.9	28.1
272	3834	623.0	282.0	39.0	67.0	26.9	31.0	28.1
273	3848	617.0	320.0	42.0	56.0	26.9	31.0	28.1
274	3862	619.0	319.0	39.0	62.0	26.9	30.0	28.1
275	3874	617.0	318.0	38.0	62.0	26.9	30.0	28.1
276	3889	617.0	296.0	40.0	67.0	26.9	30.0	28.1
277	3903	617.0	293.0	40.0	64.0	26.9	30.0	28.3
278	3917	636.0	370.0	39.0	64.0	26.9	30.0	28.1
279	3931	645.0	378.0	38.0	61.0	26.9	29.4	28.4
280	3945	632.0	478.0	39.0	63.0	26.9	28.8	28.2

281	3960	608.0	575.0	38.0	67.0	27.0	29.5	28.2
282	3974	596.0	429.0	36.0	62.0	27.0	28.8	28.2
283	3989	591.0	475.0	35.0	59.0	26.4	28.9	28.2
284	4003	591.0	392.0	36.0	69.0	26.4	28.9	28.4
285	4017	602.0	343.0	36.0	64.0	27.0	28.3	28.4
286	4032	609.0	314.0	35.0	65.0	27.1	28.9	28.3
287	4046	639.0	267.0	35.0	59.0	27.1	28.9	28.4
288	4060	684.0	238.0	36.0	61.0	27.1	28.3	28.4
289	4075	697.0	216.0	34.0	59.0	27.1	28.3	28.6
290	4089	651.0	329.0	34.0	60.0	27.1	28.3	28.4
291	4104	646.0	473.0	35.0	57.0	26.5	29.0	28.5
292	4118	634.0	459.0	35.0	58.0	27.1	29.6	28.6
293	4133	632.0	388.0	36.0	60.0	26.5	29.6	28.5
294	4147	631.0	363.0	35.0	61.0	26.5	29.6	28.5
295	4161	611.0	436.0	35.0	55.0	26.5	29.6	28.5
296	4175	591.0	530.0	34.0	53.0	26.5	29.7	28.6
297	4189	595.0	499.0	33.0	53.0	26.5	29.7	28.5
298	4204	601.0	416.0	34.0	57.0	26.6	29.7	28.7
299	4218	607.0	391.0	35.0	56.0	26.6	30.0	28.6
300	4233	629.0	350.0	36.0	54.0	26.6	30.0	28.7
301	4247	649.0	321.0	35.0	55.0	26.6	29.7	28.6
302	4262	645.0	255.0	36.0	55.0	26.6	30.0	28.7
303	4276	633.0	246.0	38.0	55.0	26.6	29.8	28.7
304	4290	621.0	296.0	37.0	56.0	26.6	29.8	28.7
305	4304	610.0	305.0	36.0	57.0	26.7	30.0	28.8
306	4319	607.0	300.0	35.0	56.0	26.7	29.8	29.0
307	4333	594.0	329.0	35.0	54.0	26.7	30.0	28.9
308	4348	591.0	393.0	37.0	51.0	26.7	31.0	28.9
309	4362	591.0	376.0	38.0	50.0	26.7	30.0	28.9
310	4376	594.0	328.0	37.0	50.0	26.7	30.0	28.9
311	4391	600.0	290.0	38.0	52.0	26.7	31.0	29.6
312	4402	601.0	245.0	37.0	50.0	26.7	31.0	29.0
313	4417	607.0	231.0	37.0	49.0	26.8	31.0	29.0
314	4431	612.0	203.0	35.0	47.0	26.7	30.0	29.0
315	4445	642.0	182.0	36.0	49.0	26.8	31.0	29.1
316	4459	629.0	174.0	35.0	50.0	26.8	29.9	29.1
317	4474	641.0	199.0	34.0	51.0	26.8	29.9	29.0
318	4488	636.0	206.0	34.0	52.0	26.8	29.9	29.0
319	4502	646.0	200.0	33.0	51.0	26.8	30.0	29.2
320	4517	624.0	198.0	36.0	54.0	26.2	29.3	29.2
321	4531	619.0	191.0	35.0	55.0	26.8	29.3	29.4
322	4545	607.0	193.0	34.0	51.0	26.9	28.7	29.2
323	4558	599.0	174.0	34.0	52.0	26.9	28.7	29.1
324	4572	590.0	179.0	34.0	53.0	26.3	28.8	29.3
325	4586	588.0	175.0	33.0	59.0	26.9	28.8	29.2
326	4600	594.0	152.0	33.0	57.0	26.9	28.8	29.3
327	4614	595.0	136.0	34.0	52.0	26.9	28.8	29.4
328	4629	613.0	140.0	35.0	51.0	26.9	29.4	29.4
329	4643	618.0	127.0	34.0	55.0	26.3	30.0	29.4
330	4657	639.0	133.0	33.0	54.0	26.3	30.0	29.3
331	4671	651.0	135.0	35.0	57.0	26.3	29.4	29.3
332	4686	672.0	134.0	34.0	55.0	27.0	29.5	29.4
333	4700	685.0	123.0	34.0	51.0	27.0	29.5	29.4
334	4714	647.0	140.0	34.0	53.0	26.4	31.0	29.6
335	4729	636.0	137.0	34.0	51.0	26.3	30.0	29.4
336	4743	637.0	143.0	33.0	54.0	26.4	31.0	29.5
337	4757	619.0	138.0	33.0	53.0	27.0	31.0	29.5
338	4772	620.0	141.0	36.0	54.0	27.0	31.0	29.5

339	4786	638.0	135.0	36.0	58.0	26.4	31.0	29.6
340	4800	634.0	125.0	35.0	56.0	26.4	31.0	29.5
341	4814	608.0	119.0	35.0	58.0	27.1	30.0	29.5
342	4828	585.0	131.0	35.0	55.0	26.4	30.0	29.5
343	4843	573.0	135.0	35.0	57.0	26.4	30.0	29.5
344	4857	572.0	145.0	34.0	57.0	27.1	30.0	29.5
345	4872	579.0	138.0	34.0	61.0	27.1	30.0	29.6
346	4886	578.0	140.0	34.0	60.0	26.5	30.0	29.6
347	4900	593.0	136.0	34.0	55.0	26.5	29.6	29.6
348	4914	599.0	133.0	35.0	56.0	26.4	30.0	29.5
349	4929	586.0	135.0	34.0	60.0	26.5	30.0	29.6
350	4943	579.0	132.0	35.0	58.0	26.5	29.6	29.6
351	4957	575.0	132.0	33.0	59.0	27.2	29.1	29.6
352	4972	572.0	115.0	33.0	61.0	26.6	29.1	29.6
353	4986	579.0	108.0	33.0	59.0	26.6	29.1	29.6
354	5000	596.0	120.0	33.0	61.0	26.6	28.4	29.6
355	5015	623.0	148.0	34.0	66.0	26.6	28.5	29.7
356	5029	645.0	174.0	35.0	81.0	26.6	29.1	29.8
357	5044	633.0	192.0	34.0	69.0	26.6	29.7	29.6
358	5058	661.0	186.0	35.0	70.0	27.9	29.7	29.7
359	5072	669.0	195.0	34.0	66.0	26.6	30.0	29.6
360	5084	652.0	198.0	34.0	68.0	26.6	30.0	29.7
361	5098	641.0	198.0	34.0	74.0	26.7	30.0	29.6
362	5112	647.0	179.0	35.0	77.0	26.7	32.0	29.6
363	5126	614.0	216.0	34.0	73.0	26.7	32.0	29.6
364	5141	594.0	223.0	36.0	75.0	26.7	32.0	29.6
365	5155	589.0	256.0	36.0	77.0	26.7	32.0	29.9
366	5169	590.0	288.0	35.0	72.0	26.7	32.0	29.6
367	5183	582.0	287.0	37.0	70.0	26.7	32.0	29.6
368	5198	589.0	276.0	37.0	71.0	26.7	31.0	29.7
369	5212	588.0	371.0	37.0	77.0	26.7	31.0	29.7
370	5227	581.0	389.0	37.0	76.0	26.7	30.0	29.7
371	5241	574.0	474.0	37.0	68.0	26.8	31.0	29.6
372	5255	578.0	478.0	38.0	75.0	26.8	31.0	29.6
373	5269	588.0	501.0	38.0	65.0	26.8	31.0	29.6
374	5283	598.0	419.0	39.0	75.0	26.8	31.0	29.6
375	5298	597.0	367.0	38.0	78.0	26.8	29.3	29.6
376	5312	590.0	348.0	38.0	77.0	26.8	29.9	29.8
377	5326	590.0	326.0	38.0	80.0	26.8	31.0	29.6
378	5337	591.0	354.0	38.0	78.0	26.8	29.9	30.0
379	5352	602.0	348.0	38.0	91.0	26.8	30.0	29.7
380	5366	628.0	335.0	39.0	87.0	26.8	30.0	29.7
381	5380	630.0	327.0	37.0	86.0	26.9	30.0	29.7
382	5394	626.0	360.0	39.0	79.0	26.9	30.0	29.7
383	5409	621.0	439.0	40.0	97.0	26.9	30.0	29.6
384	5420	638.0	469.0	39.0	87.0	26.9	30.0	29.6
385	5432	665.0	445.0	39.0	90.0	26.9	31.0	29.6
386	5446	679.0	457.0	38.0	94.0	26.9	31.0	29.6
387	5461	633.0	504.0	39.0	104.0	26.9	31.0	29.7
388	5475	628.0	537.0	39.0	113.0	26.9	31.0	29.7
389	5490	640.0	676.0	41.0	133.0	26.9	31.0	29.6
390	5504	616.0	703.0	42.0	140.0	26.9	31.0	29.6
391	5518	602.0	672.0	42.0	148.0	27.0	31.0	29.8
392	55[illegible]2	604.0	675.0	41.0	215.0	27.0	31.0	29.5
393	5546	632.0	613.0	43.0	179.0	27.0	31.0	29.7
394	5561	647.0	730.0	44.0	231.0	27.0	32.0	29.7
395	5575	618.0	757.0	44.0	160.0	27.0	32.0	29.7
396	5589	625.0	656.0	44.0	171.0	27.0	32.0	29.7
397	5603	620.0	725.0	45.0	284.0	27.0	32.0	29.7

398	5618	627.0	730.0	46.0	292.0	27.0	32.0	29.6
399	5632	641.0	742.0	46.0	442.0	27.0	33.0	29.6
400	5646	632.0	661.0	46.0	684.0	27.6	32.0	29.6
401	5660	620.0	723.0	48.0	829.0	27.0	32.0	29.7
402	5672	618.0	698.0	51.0	823.0	27.7	33.0	29.6
403	5686	614.0	697.0	52.0	758.0	27.0	33.0	29.6
404	5701	607.0	664.0	57.0	610.0	27.7	33.0	29.6
405	5715	605.0	725.0	59.0	595.0	27.7	33.0	29.6
406	5729	602.0	718.0	58.0	515.0	27.7	33.0	29.6
407	5744	593.0	716.0	60.0	538.0	27.7	33.0	29.8
408	5758	590.0	791.0	65.0	326.0	27.7	33.0	29.7
409	5772	594.0	826.0	64.0	271.0	27.7	34.0	29.7
410	5783	593.0	783.0	69.0	341.0	27.7	34.0	29.7
411	5798	586.0	785.0	74.0	571.0	27.8	35.0	29.6
412	5812	581.0	765.0	80.0	792.0	27.8	36.0	29.8
413	5826	585.0	738.0	77.0	685.0	27.8	35.0	29.7
414	5841	585.0	720.0	87.0	502.0	27.8	35.0	29.6
415	5855	594.0	747.0	102.0	635.0	27.8	35.0	29.7
416	5869	623.0	799.0	105.0	747.0	27.8	37.0	29.7
417	5884	626.0	780.0	111.0	690.0	27.8	36.0	30.0
418	5898	605.0	786.0	119.0	876.0	27.8	36.0	29.8
419	5912	599.0	801.0	124.0	756.0	27.8	37.0	29.8
420	5924	611.0	838.0	131.0	431.0	27.8	37.0	29.8
421	5939	604.0	756.0	123.0	333.0	27.8	36.0	29.8
422	5953	595.0	738.0	123.0	255.0	27.8	36.0	29.8
423	5967	592.0	722.0	132.0	204.0	27.8	37.0	29.8
424	5981	586.0	692.0	157.0	210.0	27.8	38.0	29.8
425	5995	588.0	681.0	178.0	172.0	27.8	37.0	29.9
426	6010	590.0	693.0	174.0	198.0	27.9	38.0	29.9
427	6024	590.0	693.0	176.0	257.0	27.9	37.0	29.8
428	6039	578.0	692.0	183.0	288.0	27.9	37.0	29.8
429	6053	586.0	694.0	166.0	498.0	27.9	37.0	29.8
430	6067	597.0	711.0	144.0	823.0	27.9	36.0	30.0
431	6081	593.0	724.0	158.0	811.0	27.9	35.0	30.0
432	6096	587.0	702.0	183.0	732.0	27.9	35.0	30.0
433	6110	598.0	681.0	181.0	822.0	27.9	35.0	29.9
434	6124	581.0	645.0	188.0	332.0	27.9	35.0	29.9
435	6138	580.0	667.0	160.0	282.0	27.9	35.0	29.9
436	6153	585.0	660.0	158.0	197.0	28.0	35.0	29.9
437	6167	590.0	671.0	161.0	191.0	28.0	36.0	30.0
438	6181	580.0	676.0	161.0	238.0	28.0	36.0	30.0
439	6196	581.0	674.0	167.0	166.0	28.0	35.0	30.0
440	6210	563.0	669.0	178.0	122.0	28.0	37.0	30.0
441	6224	561.0	664.0	203.0	129.0	28.0	37.0	30.0
442	6238	556.0	647.0	241.0	192.0	28.0	37.0	30.0
443	6253	555.0	654.0	241.0	312.0	28.0	37.0	30.0
444	6267	558.0	670.0	304.0	204.0	28.0	37.0	30.0
445	6281	553.0	653.0	256.0	166.0	28.0	36.0	30.0
446	6295	549.0	646.0	277.0	115.0	28.0	36.0	30.0
447	6310	543.0	640.0	319.0	130.0	28.0	36.0	30.0
448	6324	545.0	646.0	326.0	159.0	28.0	35.0	30.0
449	6339	551.0	656.0	305.0	191.0	28.0	36.0	30.0
450	6353	572.0	683.0	243.0	157.0	28.0	36.0	30.0
451	6367	583.0	684.0	257.0	134.0	28.0	36.0	30.0
452	6381	596.0	691.0	234.0	120.0	28.0	36.0	30.0
453	6396	611.0	714.0	243.0	124.0	28.1	37.0	30.0
454	6410	629.0	730.0	294.0	130.0	28.1	38.0	30.0
455	6424	619.0	735.0	315.0	146.0	28.1	39.0	30.0
456	6439	644.0	765.0	287.0	122.0	28.1	39.0	30.0

457	6453	625.0	741.0	262.0	117.0	28.1	41.0	30.0
458	6467	552.0	602.0	251.0	208.0	28.1	41.0	31.0
459	6481	298.0	332.0	185.0	222.0	28.1	42.0	31.0
460	6496	207.0	231.0	147.0	298.0	28.1	43.0	30.0
461	6510	149.0	177.0	120.0	119.0	28.8	42.0	31.0
462	6524	113.0	133.0	101.0	80.0	28.8	45.0	31.0
463	6538	88.0	104.0	88.0	65.0	29.4	45.0	31.0
464	6552	74.0	87.0	77.0	57.0	29.4	44.0	31.0

RUN R9

WOOD ADDITION DATA:

TIME	SIZE (grammes)
230	200
524	200
1085	50
1242	50
1385	50
1650	100
1860	50
1950	50
2005	100
2255	100
2505	100
2715	100
2940	100
3170	100
3470	100
3695	100
3900	100
4095	100
4275	100
4430	100
4650	100
5025	100
5220	100
5380	100
5630	50
5800	100
6145	50
6305	50
6695	100
6935	100
7170	100
7480	100
7860	100
8360	100

HEIGHT OF CHAR BED DATA:

TIME	HEIGHT (cms)	
	L	R
390	7.0	7.0
480	7.0	7.0
600	8.0	8.0
720	8.5	8.5
840	9.0	8.5
960	9.5	8.5
1080	10.0	9.5
1200	9.5	10.0
1320	10.0	10.5
1440	10.0	11.0
1620	10.5	10.5
1800	10.0	10.5
1920	10.0	10.0
2040	10.0	10.0
2160	10.0	11.0
2400	10.0	11.0
2520	11.0	11.0

2640	11.5	11.0
2760	11.0	11.0
2880	10.5	11.0
3000	10.5	11.0
3120	12.5	11.0
3240	12.0	11.0
3540	13.0	11.0
4080	14.5	13.0
4320	15.0	13.5
4440	15.5	13.5
4560	15.0	14.0
4680	14.5	13.5
4800	15.5	15.0
4920	14.5	14.5
5040	16.0	14.5
5160	16.0	15.0
5400	15.5	14.5
5640	14.5	14.0
5820	14.0	14.0
6000	14.5	13.5
6240	14.5	14.0
6900	15.0	14.5
7200	15.5	15.0
7560	16.0	15.0
7740	16.0	15.5
7998	16.0	16.5
8232	18.0	15.0
8520	19.0	20.0
8640	20.0	21.0
8760	21.5	22.0
8880	21.5	22.5
9000	23.0	23.0

GAS COMPOSITION ,PRESSURE & FLOWRATE DATA :

NO.	TIME	H2	CO	CO2	CH4	N2	PT1	PT2	FLOW
1	2	0.0	0.0	0.0	0.0	100.0	759.0	766.0	1.0
2	16	0.0	0.0	0.0	0.0	100.0	759.0	766.0	1.0
3	31	0.0	0.0	0.0	0.0	100.0	758.0	766.5	1.0
4	45	0.0	0.0	0.0	0.0	100.0	759.0	767.0	1.1
5	60	0.0	0.0	0.0	0.0	100.0	760.0	766.0	1.0
6	74	0.0	0.0	0.0	0.0	100.0	758.5	766.0	1.0
7	87	0.0	0.0	0.0	0.0	100.0	758.5	766.5	1.1
8	102	0.0	0.0	0.0	0.0	100.0	759.0	766.5	1.1
9	116	0.0	0.0	0.0	0.0	100.0	759.0	767.0	1.1
10	131	0.0	0.0	0.0	0.0	100.0	759.0	766.5	1.1
11	145	0.0	0.0	0.0	0.0	100.0	758.5	766.0	1.1
12	159	0.0	0.0	0.0	0.0	100.0	758.0	766.5	1.1
13	173	0.0	0.0	0.0	0.0	100.0	759.0	766.5	1.1
14	188	0.0	0.0	0.0	0.0	100.0	759.0	766.0	1.1
15	201	0.0	0.0	0.0	0.0	100.0	758.0	768.0	1.5
16	216	0.0	0.0	0.0	0.0	100.0	759.0	768.0	1.3
17	230	0.0	0.0	0.0	0.0	100.0	759.0	768.0	1.4
18	244	0.0	0.0	0.0	0.0	100.0	758.0	768.0	1.5
19	256	0.0	0.0	0.0	0.0	100.0	758.0	767.5	1.4
20	270	0.0	0.0	0.0	0.0	100.0	759.5	768.0	1.5
21	284	0.0	0.0	0.0	0.0	100.0	757.5	767.0	1.2
22	298	0.0	0.0	0.0	0.0	100.0	759.0	766.0	1.2
23	313	0.3	0.9	0.5	0.0	98.3	757.5	766.0	1.1
24	327	14.1	13.8	2.1	1.8	68.2	757.0	765.5	0.9

25	342	15.5	16.6	3.3	2.6	62.0	757.0	765.5	1.0
26	356	16.1	17.2	4.6	2.7	59.4	757.0	765.5	1.0
27	370	16.1	17.1	6.1	2.7	58.0	757.5	766.0	1.0
28	384	15.9	16.8	7.6	2.7	57.0	755.5	768.0	1.6
29	399	15.5	16.5	8.7	2.6	56.7	757.0	768.5	1.5
30	413	15.1	16.2	9.8	2.4	56.5	757.0	768.0	1.4
31	427	14.8	16.4	10.5	2.1	56.2	755.5	769.0	1.5
32	441	14.9	16.5	11.0	1.9	55.7	757.0	767.5	1.3
33	456	15.1	16.5	11.3	1.7	55.4	757.0	767.5	1.5
34	470	14.9	16.6	11.5	1.7	55.3	756.0	767.5	1.5
35	485	14.8	16.9	11.7	1.8	54.8	755.5	768.0	1.6
36	499	14.6	17.0	11.8	1.8	54.8	756.5	767.5	1.4
37	513	14.5	17.0	11.9	1.8	54.8	757.0	768.0	1.6
38	528	14.2	17.0	12.0	1.7	55.1	755.5	768.0	1.5
39	542	14.0	16.9	12.1	1.6	55.4	755.5	768.5	1.5
40	556	13.7	16.8	12.2	1.5	55.8	755.5	768.0	1.6
41	570	13.8	16.7	12.2	1.6	55.7	756.0	767.5	1.4
42	582	13.4	16.6	12.2	1.5	56.3	755.0	767.5	1.5
43	596	13.4	16.7	12.4	1.5	56.0	756.5	768.0	1.5
44	611	13.3	16.7	12.4	1.4	56.2	755.5	768.0	1.5
45	625	13.6	17.0	12.4	1.5	55.5	755.5	768.0	1.7
46	639	13.5	17.1	12.4	1.7	55.3	755.0	768.0	1.5
47	653	13.5	16.8	12.5	1.7	55.5	756.5	768.0	1.5
48	668	13.3	16.6	12.5	1.6	56.0	756.0	768.0	1.5
49	679	12.4	16.5	12.6	1.5	57.0	756.0	768.0	1.6
50	694	12.0	16.5	12.5	1.3	57.7	755.0	768.5	1.6
51	708	12.6	16.7	12.5	1.4	56.8	755.0	768.0	1.6
52	723	12.5	17.1	12.5	1.6	56.3	755.0	768.0	1.5
53	737	11.9	17.0	12.5	1.5	57.1	755.0	768.0	1.6
54	751	12.3	17.2	12.5	1.3	56.7	754.5	768.0	1.5
55	766	12.3	16.9	12.5	1.3	57.0	757.0	768.0	1.6
56	779	13.4	16.7	12.3	1.5	56.1	755.0	768.0	1.6
57	794	14.1	17.0	12.4	1.8	54.7	755.5	768.0	1.6
58	808	14.1	17.1	12.5	2.0	54.3	756.5	767.5	0.8
59	822	13.8	16.9	12.6	1.9	54.8	754.0	769.0	3.1
60	836	13.5	16.7	12.7	1.7	55.4	754.0	768.5	2.6
61	851	13.2	16.6	12.7	1.5	56.0	756.5	767.5	0.9
62	865	13.5	16.7	12.7	1.5	55.6	755.0	769.0	2.5
63	880	13.4	16.6	12.8	1.5	55.7	747.5	780.5	4.1
64	894	12.9	16.3	12.9	1.5	56.4	754.0	769.0	1.8
65	908	13.0	17.5	12.4	1.3	55.8	756.5	769.0	1.8
66	922	14.0	17.3	12.4	1.4	54.9	754.5	768.5	1.8
67	937	14.1	16.8	12.3	1.5	55.3	755.0	769.0	1.8
68	951	13.9	16.5	12.3	1.6	55.7	756.0	769.0	1.8
69	966	13.3	16.2	12.4	1.5	56.6	754.5	769.0	1.8
70	980	13.4	16.1	12.5	1.5	56.5	754.5	769.0	1.8
71	994	12.6	15.9	12.6	1.4	57.5	755.0	769.0	1.9
72	1008	12.5	15.9	12.7	1.3	57.6	754.5	769.5	1.9
73	1023	12.9	16.1	12.7	1.4	56.9	756.0	769.0	1.9
74	1037	13.3	16.1	12.8	1.5	56.3	754.5	769.5	1.9
75	1051	13.0	16.1	12.8	1.5	56.6	755.5	769.0	1.8
76	1066	12.9	16.1	12.8	1.4	56.8	755.5	769.0	1.8
77	1080	12.9	16.2	12.8	1.4	56.7	756.0	769.0	1.8
78	1095	13.1	15.9	12.9	1.4	56.7	753.5	772.5	2.4
79	1109	13.3	15.8	13.0	1.4	56.5	753.0	772.0	2.5
80	1123	13.0	16.2	13.0	1.3	56.5	752.5	772.5	2.4
81	1137	12.6	16.4	13.0	1.1	56.9	753.0	772.5	2.5
82	1152	12.8	16.8	13.0	1.0	56.4	752.0	772.5	2.4
83	1166	12.7	17.0	12.8	1.0	56.5	753.5	772.5	2.5

84	1181	12.0	17.0	12.6	1.0	57.4	755.0	772.0	2.4
85	1195	12.3	16.8	12.5	0.9	57.5	754.0	772.5	2.5
86	1209	12.2	16.5	12.4	0.9	58.0	753.0	772.5	2.4
87	1224	13.4	16.8	12.3	1.3	56.2	755.0	772.0	2.3
88	1238	14.2	17.3	12.2	1.5	54.8	753.0	772.5	2.4
89	1252	13.8	17.5	12.3	1.4	55.0	752.5	772.5	2.4
90	1267	14.1	17.6	12.3	1.3	54.7	754.0	772.5	2.4
91	1281	14.6	17.6	12.2	1.2	54.4	752.5	772.5	2.5
92	1295	14.7	18.0	12.2	1.2	53.9	753.0	772.5	2.4
93	1310	14.8	18.0	12.2	1.2	53.8	754.0	772.5	2.4
94	1324	15.2	18.1	12.1	1.2	53.4	753.5	771.5	2.3
95	1338	15.3	18.5	12.0	1.2	53.0	753.5	772.0	2.3
96	1352	15.0	18.6	11.9	1.2	53.3	752.5	772.0	2.3
97	1367	15.4	18.7	11.9	1.4	52.6	755.0	771.0	2.2
98	1381	15.9	18.7	11.8	1.5	52.1	752.5	772.5	2.5
99	1396	16.0	18.8	11.8	1.5	51.9	752.0	775.5	3.0
100	1410	15.9	19.1	11.9	1.4	51.7	751.5	775.0	2.9
101	1425	15.6	19.4	11.8	1.3	51.9	751.0	775.0	2.9
102	1439	15.9	19.3	11.8	1.2	51.8	751.5	775.5	2.9
103	1453	15.8	19.2	11.7	1.3	52.0	752.5	775.0	3.0
104	1467	15.9	19.3	11.6	1.3	51.9	752.0	775.0	2.9
105	1481	15.8	19.5	11.4	1.3	52.0	751.0	776.0	3.1
106	1494	15.9	19.6	11.4	1.3	51.8	751.5	775.5	2.9
107	1508	16.1	19.3	11.4	1.3	51.9	751.5	775.5	3.0
108	1522	16.1	19.0	11.3	1.4	52.2	753.5	775.0	2.9
109	1536	16.0	19.2	11.3	1.5	52.0	752.0	775.5	2.9
110	1551	16.3	19.6	11.3	1.3	51.5	753.5	774.5	2.9
111	1565	16.5	19.6	11.3	1.3	51.3	753.0	775.0	2.9
112	1579	16.0	19.8	11.1	1.4	51.7	752.0	775.0	2.9
113	1591	15.8	19.3	11.1	1.4	52.4	751.0	775.0	3.0
114	1605	15.8	19.0	11.1	1.3	52.8	751.5	775.0	3.0
115	1619	16.0	19.4	11.1	1.5	52.0	753.5	769.5	1.9
116	1634	16.3	19.5	11.1	1.4	51.7	750.5	775.5	3.0
117	1648	16.4	19.3	11.2	1.4	51.7	752.0	775.0	2.9
118	1662	16.0	19.5	11.1	1.3	52.1	751.5	775.0	2.8
119	1677	16.1	19.8	11.1	1.3	51.7	748.5	775.0	2.9
120	1691	16.1	19.7	11.1	1.3	51.8	752.5	775.0	2.9
121	1706	16.6	19.7	11.1	1.4	51.2	749.5	775.5	2.9
122	1720	16.5	19.7	11.1	1.5	51.2	751.0	775.5	2.9
123	1734	16.3	19.2	11.1	1.5	51.9	750.5	775.5	2.9
124	1748	16.2	18.8	11.2	1.6	52.2	751.0	776.0	2.9
125	1763	16.0	18.9	11.2	1.6	52.3	751.5	775.5	2.9
126	1777	15.9	18.8	11.3	1.6	52.4	750.0	775.5	2.9
127	1791	15.5	18.6	11.4	1.6	52.9	750.5	776.0	2.9
128	1803	15.4	18.5	11.4	1.6	53.1	750.0	775.0	2.8
129	1817	15.1	18.3	11.5	1.6	53.5	751.0	775.0	2.8
130	1831	14.9	18.0	11.5	1.6	54.0	751.0	774.0	2.4
131	1846	14.7	17.9	11.6	1.6	54.2	749.5	776.0	2.9
132	1860	14.5	18.1	11.7	1.6	54.1	750.0	776.0	2.9
133	1875	14.1	18.1	11.8	1.6	54.4	750.0	778.5	3.0
134	1889	14.5	18.1	11.8	1.7	53.9	749.5	775.5	2.9
135	1903	14.3	17.8	11.9	1.8	54.2	750.0	775.5	2.9
136	1918	14.0	17.6	12.0	1.7	54.7	750.0	775.0	2.9
137	1932	13.5	17.8	12.0	1.5	55.2	751.0	775.0	2.9
138	1948	14.0	18.2	12.1	1.4	54.3	750.0	775.5	2.9
139	1962	14.0	18.4	12.0	1.5	54.1	752.0	775.5	3.1
140	1977	14.0	18.6	12.0	1.6	53.8	751.0	776.0	3.0
141	1991	14.2	18.4	12.0	1.8	53.6	749.0	775.5	3.0
142	2005	14.3	18.3	11.9	1.9	53.6	748.5	775.0	3.0

143	2019	13.8	17.9	12.1	1.8	54.4	750.0	775.0	2.9
144	2034	13.7	17.6	12.1	1.6	55.0	749.5	775.5	2.9
145	2048	13.7	17.9	12.1	1.5	54.8	749.0	775.5	2.9
146	2063	14.1	18.3	12.1	1.6	53.9	748.5	775.5	2.9
147	2077	14.1	18.0	12.1	1.7	54.1	748.5	775.0	2.8
148	2091	14.1	18.0	12.2	1.7	54.0	751.0	775.0	2.9
149	2105	14.5	17.7	12.3	1.6	53.9	749.0	775.0	2.8
150	2119	14.1	17.7	12.2	1.5	54.5	750.0	775.0	2.8
151	2134	14.4	17.9	12.2	1.4	54.1	749.0	775.0	2.8
152	2148	14.9	18.3	12.2	1.5	53.1	750.0	775.0	2.8
153	2163	15.1	18.3	12.1	1.5	53.0	750.5	775.0	2.8
154	2177	14.9	18.3	12.0	1.6	53.2	751.0	774.5	2.9
155	2191	14.9	18.2	12.0	1.6	53.3	747.5	775.5	3.0
156	2203	14.9	17.7	12.0	1.6	53.8	749.0	775.0	2.9
157	2218	14.8	17.6	12.0	1.7	53.9	748.5	775.0	2.9
158	2232	14.6	17.7	12.1	1.7	53.9	747.5	775.0	2.9
159	2246	14.5	17.7	12.2	1.5	54.1	749.0	774.5	2.9
160	2258	14.4	17.6	12.2	1.4	54.4	749.0	774.5	2.8
161	2272	14.8	17.8	12.2	1.5	53.7	748.0	774.5	2.8
162	2286	15.1	17.8	12.1	1.6	53.4	749.5	774.5	2.7
163	2301	15.1	17.7	12.2	1.6	53.4	747.0	774.5	2.8
164	2315	15.1	17.6	12.2	1.6	53.5	749.0	773.0	2.5
165	2329	15.0	17.6	12.2	1.6	53.6	749.5	776.0	2.7
166	2343	15.0	17.3	12.2	1.6	53.9	748.5	775.0	2.9
167	2357	15.0	17.6	12.2	1.7	53.5	749.0	774.5	2.7
168	2369	14.8	17.6	12.2	1.7	53.7	748.0	774.5	2.7
169	2383	13.8	17.4	12.2	1.4	55.2	747.0	775.0	2.7
170	2398	14.0	17.6	12.2	1.4	54.8	748.0	774.5	2.7
171	2412	14.6	17.8	12.2	1.4	54.0	746.5	774.0	2.7
172	2427	14.8	17.9	12.2	1.5	53.6	747.0	774.5	2.8
173	2441	14.3	17.5	12.1	1.4	54.7	746.0	775.5	2.9
174	2456	14.6	17.6	12.1	1.4	54.3	746.0	775.0	2.8
175	2470	14.4	17.7	12.1	1.4	54.4	746.5	774.5	2.9
176	2484	14.5	18.0	12.1	1.4	54.0	745.5	774.5	2.8
177	2498	14.7	18.1	12.1	1.4	53.7	747.5	776.0	3.0
178	2513	15.0	18.3	12.1	1.4	53.2	744.0	776.0	3.0
179	2527	14.9	18.8	12.0	1.4	52.9	745.5	777.5	3.2
180	2541	15.1	19.2	12.0	1.4	52.3	744.0	778.5	3.3
181	2555	14.9	18.6	12.0	1.4	53.1	743.5	778.5	3.3
182	2569	14.9	18.7	11.9	1.4	53.1	743.0	778.5	3.3
183	2584	14.9	18.7	11.7	1.5	53.2	743.5	778.5	3.3
184	2598	14.8	18.6	11.6	1.5	53.5	744.5	778.5	3.3
185	2613	14.7	18.6	11.5	1.5	53.7	743.5	779.0	3.3
186	2627	15.1	18.7	11.5	1.5	53.2	744.0	778.5	3.4
187	2639	15.0	18.7	11.4	1.6	53.3	743.0	779.5	3.4
188	2653	15.0	18.5	11.4	1.6	53.5	744.0	779.0	3.5
189	2668	14.6	18.4	11.4	1.5	54.1	744.5	779.0	3.5
190	2682	14.5	18.4	11.4	1.5	54.2	745.5	778.5	3.5
191	2696	14.5	18.3	11.4	1.5	54.3	744.0	779.5	3.6
192	2710	14.4	18.2	11.3	1.4	54.7	743.5	779.5	3.6
193	2725	14.5	18.0	11.3	1.5	54.7	744.0	779.0	3.6
194	2739	14.6	18.0	11.2	1.6	54.6	745.5	779.5	3.6
195	2753	14.4	18.0	11.3	1.5	54.8	741.5	778.5	3.5
196	2767	13.9	18.0	11.2	1.3	55.6	741.5	779.0	3.5
197	2782	14.0	18.0	11.2	1.3	55.5	743.0	779.5	3.5
198	2796	14.4	18.5	11.1	1.3	54.7	745.0	778.5	3.4
199	2810	14.5	18.5	10.9	1.4	54.7	742.5	778.5	3.4
200	2824	14.6	18.4	11.0	1.4	54.6	742.0	779.0	3.4
201	2838	14.7	18.7	11.0	1.4	54.2	742.5	779.5	3.4

202	2853	14.7	18.6	11.0	1.4	54.3	743.5	779.0	3.5
203	2867	14.7	18.2	10.9	1.5	54.7	743.0	779.0	3.4
204	2882	14.5	18.4	10.9	1.4	54.8	742.0	779.5	3.4
205	2896	14.4	18.1	10.9	1.4	55.2	744.5	779.0	3.3
206	2910	14.2	17.9	10.8	1.5	55.6	745.5	779.5	3.3
207	2924	13.9	17.6	10.8	1.7	56.0	746.5	779.5	3.4
208	2939	13.4	17.3	10.9	1.7	56.7	745.0	779.5	3.4
209	2953	12.6	17.2	10.9	1.5	57.8	747.5	779.5	3.4
210	2967	12.7	17.6	11.0	1.5	57.2	744.5	780.0	3.7
211	2981	12.3	17.3	11.1	1.4	57.9	744.5	780.0	3.6
212	2996	12.4	17.0	11.0	1.4	58.2	745.0	780.0	3.5
213	3010	12.0	16.8	11.1	1.4	58.7	747.0	779.5	3.6
214	3021	11.9	16.6	11.0	1.4	59.1	749.0	776.0	2.9
215	3036	12.5	17.0	10.9	1.5	58.1	753.0	772.0	2.3
216	3050	13.6	17.9	10.9	1.6	56.0	753.0	772.0	2.3
217	3065	13.1	17.3	11.0	1.8	56.8	752.0	772.0	2.3
218	3079	12.7	17.0	11.2	1.9	57.2	752.0	772.0	2.3
219	3094	12.3	16.6	11.4	1.9	57.8	753.0	772.0	2.3
220	3108	12.5	17.1	11.7	2.0	56.7	752.5	772.0	2.2
221	3122	12.3	17.0	11.9	2.0	56.8	751.0	772.5	2.3
222	3137	12.7	16.6	12.2	2.1	56.4	753.5	772.0	2.2
223	3151	12.4	16.3	12.3	2.0	57.0	752.5	771.5	2.2
224	3165	12.4	16.3	12.5	1.8	57.0	749.0	771.5	2.2
225	3180	12.5	16.4	12.6	1.6	56.9	750.0	771.5	2.3
226	3194	12.1	16.4	12.6	1.4	57.5	750.0	771.5	2.3
227	3208	12.0	16.8	12.5	1.3	57.4	750.5	771.5	2.2
228	3222	12.7	17.3	12.5	1.3	56.2	750.0	771.5	2.2
229	3237	13.2	17.4	12.4	1.4	55.6	749.5	771.0	2.2
230	3251	13.1	17.4	12.4	1.4	55.7	749.5	771.5	2.2
231	3265	13.4	17.4	12.3	1.5	55.4	750.0	772.0	2.2
232	3280	12.9	17.3	12.2	1.5	56.1	750.0	771.0	2.1
233	3294	13.0	17.3	12.3	1.4	56.0	752.0	771.5	2.1
234	3309	13.6	17.3	12.2	1.6	55.3	750.5	771.5	2.1
235	3323	13.6	17.3	12.3	1.6	55.2	748.5	771.0	2.0
236	3338	13.6	17.5	12.3	1.7	54.9	749.5	771.0	2.0
237	3352	13.5	17.5	12.3	1.7	55.0	750.0	770.5	2.1
238	3366	13.4	17.1	12.3	1.7	55.5	750.0	771.5	2.1
239	3380	13.4	17.1	12.4	1.7	55.4	747.5	771.0	2.1
240	3395	13.5	17.3	12.5	1.8	54.9	749.5	771.0	2.1
241	3409	13.6	16.6	12.6	1.9	55.3	750.0	771.0	2.1
242	3421	12.9	16.2	12.6	2.0	56.3	747.5	770.5	2.0
243	3435	13.1	16.7	12.8	2.1	55.3	745.0	771.5	2.0
244	3450	12.5	17.1	13.0	2.4	55.0	748.5	773.0	2.6
245	3464	12.3	17.2	13.1	2.4	55.0	740.0	777.0	4.1
246	3478	13.0	17.1	13.3	2.3	54.3	746.0	771.0	2.8
247	3493	12.9	16.6	13.0	2.1	55.4	748.5	770.0	2.1
248	3507	13.1	16.4	12.9	1.7	55.9	737.5	778.5	2.6
249	3521	12.0	15.6	13.2	1.6	57.6	739.5	779.5	3.3
250	3536	10.8	15.1	13.1	1.4	59.6	736.5	779.0	3.3
251	3550	11.8	15.7	12.9	1.3	58.3	739.0	779.0	3.3
252	3564	12.1	16.0	12.5	1.3	58.1	736.5	779.5	3.4
253	3579	12.4	16.2	12.2	1.3	57.9	740.0	779.5	3.7
254	3593	12.7	16.3	12.0	1.4	57.6	739.5	779.5	3.5
255	3608	12.5	16.5	11.8	1.4	57.8	737.0	779.5	3.4
256	3622	12.2	16.7	11.6	1.3	58.2	739.0	779.5	3.5
257	3636	12.4	16.9	11.5	1.3	57.9	734.5	780.0	3.7
258	3650	12.2	16.3	11.2	1.3	59.0	736.5	780.0	3.8
259	3665	12.8	17.2	11.1	1.3	57.6	736.5	779.5	3.7
260	3679	13.2	17.6	10.9	1.3	57.0	733.5	779.5	3.7

261	3693	13.8	17.6	10.7	1.5	56.4	734.5	780.0	3.7
262	3707	14.2	17.4	10.7	1.7	56.0	735.5	780.0	3.7
263	3721	13.6	17.4	10.7	1.7	56.6	734.0	780.0	4.0
264	3736	13.4	17.3	10.7	1.6	57.0	734.0	781.0	3.9
265	3750	13.2	17.4	10.7	1.5	57.2	733.0	780.5	3.8
266	3765	13.2	17.7	10.8	1.4	56.9	733.0	780.5	3.8
267	3779	13.3	17.9	10.7	1.3	56.8	734.5	780.5	3.7
268	3793	13.5	18.2	10.7	1.3	56.3	737.0	780.0	3.6
269	3807	13.9	18.1	10.6	1.6	55.8	731.0	780.5	3.6
270	3822	13.9	18.0	10.6	1.7	55.8	732.0	780.0	3.6
271	3836	13.6	17.6	10.6	1.6	56.6	732.0	780.5	3.6
272	3850	13.4	17.5	10.6	1.6	56.9	730.5	780.5	3.7
273	3864	13.9	17.2	10.7	1.6	56.6	728.0	780.5	3.7
274	3879	13.7	16.8	10.7	1.7	57.1	733.5	780.5	3.6
275	3893	13.3	16.9	10.7	1.6	57.5	732.5	780.0	3.7
276	3908	13.4	16.8	10.8	1.7	57.3	733.0	781.0	3.8
277	3922	13.2	16.6	10.9	1.7	57.6	730.5	780.5	3.7
278	3936	13.0	16.4	10.9	1.8	57.9	730.0	779.5	3.4
279	3950	12.4	15.9	11.1	1.7	58.9	733.5	777.5	3.0
280	3964	11.6	15.7	11.1	1.4	60.2	732.5	780.0	3.4
281	3979	11.5	15.8	11.2	1.3	60.2	734.0	779.5	3.4
282	3993	11.5	15.8	11.1	1.2	60.4	731.0	779.0	3.3
283	4008	12.1	16.1	10.9	1.3	59.6	730.5	778.5	3.3
284	4022	12.3	16.2	10.8	1.4	59.3	730.0	778.5	3.3
285	4037	12.8	16.4	10.8	1.5	58.5	730.5	778.5	3.3
286	4051	12.5	16.2	10.7	1.5	59.1	730.5	778.5	3.4
287	4066	12.3	16.3	10.7	1.6	59.1	729.5	778.0	3.2
288	4080	12.3	16.1	10.7	1.7	59.2	727.0	779.0	3.3
289	4094	11.9	15.6	10.8	1.7	60.0	729.5	778.5	3.2
290	4108	11.6	15.5	10.8	1.5	60.6	726.0	780.5	3.4
291	4123	11.3	15.1	10.9	1.4	61.3	727.0	780.0	3.4
292	4134	11.3	15.0	10.8	1.3	61.6	724.0	779.5	3.3
293	4149	11.4	14.7	10.8	1.4	61.7	730.5	779.5	3.3
294	4163	11.4	14.2	10.6	1.5	62.3	723.0	779.5	3.3
295	4177	11.3	14.2	10.7	1.6	62.2	721.5	780.0	3.3
296	4192	11.1	13.8	10.6	1.5	63.0	723.0	780.0	3.3
297	4203	10.6	13.3	10.6	1.3	64.2	723.0	780.0	3.4
298	4218	10.7	13.7	10.6	1.2	63.8	723.5	780.0	3.4
299	4232	10.6	14.0	10.5	1.2	63.7	719.0	779.5	3.4
300	4244	10.5	14.0	10.4	1.1	64.0	720.5	780.0	3.4
301	4259	10.5	14.1	10.3	1.0	64.1	719.5	779.5	3.4
302	4273	10.9	14.7	10.2	1.1	63.1	719.0	780.5	3.5
303	4287	10.7	15.0	10.1	1.1	63.1	720.5	780.0	3.4
304	4302	11.3	14.8	10.0	1.1	62.8	721.5	779.5	3.4
305	4316	11.9	14.9	10.0	1.3	61.9	722.0	779.5	3.4
306	4331	12.0	14.6	9.9	1.3	62.2	722.0	779.0	3.4
307	4345	12.0	14.9	9.9	1.3	61.9	724.0	779.5	3.4
308	4359	11.8	15.4	9.9	1.3	61.6	720.5	779.5	3.4
309	4373	12.2	15.7	9.9	1.3	60.9	723.0	779.5	3.4
310	4387	12.7	15.7	9.9	1.4	60.3	719.5	779.5	3.4
311	4402	12.9	15.6	9.9	1.5	60.1	717.5	780.0	3.5
312	4416	13.0	15.8	10.0	1.5	59.7	720.0	779.5	3.4
313	4428	12.6	15.7	10.0	1.5	60.2	719.5	779.5	3.5
314	4442	12.9	15.7	10.1	1.6	59.7	724.0	779.5	3.3
315	4454	13.2	15.6	10.0	1.6	59.6	725.0	779.5	3.4
316	4468	13.3	15.8	10.1	1.6	59.2	726.5	779.5	3.4
317	4483	12.9	16.3	10.1	1.5	59.2	724.0	780.0	3.5
318	4497	13.0	16.5	10.1	1.5	58.9	725.0	779.5	3.4
319	4512	12.9	16.5	10.0	1.5	59.1	728.5	780.0	3.5

320	4526	13.1	16.1	10.0	1.5	59.3	723.5	780.5	3.5
321	4540	13.3	15.8	10.1	1.5	59.3	727.5	780.5	3.5
322	4554	13.4	16.1	10.1	1.5	58.9	724.0	780.5	3.6
323	4569	13.1	16.2	10.1	1.5	59.1	726.0	780.5	3.6
324	4583	13.1	15.8	10.1	1.5	59.5	725.5	781.5	3.5
325	4597	13.4	15.9	10.1	1.6	59.0	726.5	781.5	3.5
326	4612	13.3	16.5	10.1	1.6	58.5	732.5	781.5	3.5
327	4626	13.1	16.7	10.0	1.5	58.7	730.5	781.0	3.6
328	4640	13.0	16.8	10.0	1.5	58.7	727.5	781.5	3.6
329	4654	13.2	17.3	10.0	1.5	58.0	729.5	781.0	3.6
330	4669	12.9	17.7	10.0	1.4	58.0	727.0	781.5	3.7
331	4683	13.4	18.0	10.0	1.5	57.1	730.0	781.0	3.6
332	4697	13.1	17.7	9.9	1.5	57.8	727.0	780.5	3.5
333	4712	13.4	17.5	9.9	1.5	57.7	731.0	781.0	3.5
334	4726	13.5	17.3	9.8	1.6	57.8	729.0	781.0	3.5
335	4740	13.2	17.0	9.9	1.5	58.4	731.5	781.0	3.6
336	4755	13.0	16.6	9.9	1.5	59.0	739.0	782.0	3.5
337	4769	12.7	16.4	9.9	1.5	59.5	733.0	781.5	3.5
338	4783	12.7	16.1	10.1	1.5	59.6	734.0	782.0	3.8
339	4797	12.7	16.5	10.2	1.6	59.0	730.0	784.5	4.1
340	4812	12.5	16.3	10.3	1.5	59.4	730.0	784.5	4.1
341	4826	12.0	16.0	10.3	1.4	60.3	731.5	784.5	4.1
342	4840	12.2	15.7	10.1	1.4	60.6	731.0	784.5	4.1
343	4855	12.2	15.3	10.1	1.5	60.9	731.5	784.5	4.0
344	4869	12.1	15.1	10.0	1.6	61.2	733.0	784.5	4.1
345	4883	11.9	15.1	10.1	1.5	61.4	732.0	784.5	4.1
346	4898	12.1	15.2	10.1	1.5	61.1	737.0	785.0	4.1
347	4912	12.1	15.0	10.1	1.4	61.4	733.0	785.5	4.1
348	4926	11.7	15.4	10.1	1.3	61.5	730.5	785.0	4.1
349	4941	11.6	15.8	10.1	1.3	61.2	731.5	784.5	4.1
350	4955	11.6	16.1	10.1	1.3	60.9	727.0	784.0	4.1
351	4970	12.0	15.9	9.9	1.3	60.9	729.5	784.0	4.0
352	4981	12.3	16.0	9.8	1.3	60.6	725.0	784.0	4.0
353	4996	12.2	16.0	9.7	1.3	60.8	729.5	784.0	4.0
354	5010	12.4	15.9	9.6	1.3	60.8	729.0	781.5	3.6
355	5025	12.1	16.2	9.5	1.3	60.9	725.5	784.5	4.0
356	5039	11.8	15.7	9.5	1.3	61.7	723.5	784.0	3.9
357	5053	11.8	15.5	9.5	1.3	61.9	721.5	783.5	3.8
358	5067	12.1	15.3	9.5	1.4	61.7	721.0	783.0	3.7
359	5081	12.2	14.8	9.5	1.4	62.1	720.0	783.0	3.7
360	5096	12.3	14.2	9.5	1.6	62.4	724.0	783.0	3.7
361	5110	12.3	14.7	9.6	1.6	61.8	720.5	783.5	3.8
362	5125	11.8	15.6	9.7	1.3	61.6	722.5	783.5	3.9
363	5139	11.6	15.9	9.7	1.2	61.6	723.5	783.5	3.9
364	5154	11.8	16.0	9.5	1.2	61.5	719.0	784.5	3.9
365	5168	12.3	15.9	9.5	1.2	61.1	720.5	784.0	3.9
366	5182	11.8	15.4	9.4	1.3	62.1	721.5	784.0	4.0
367	5196	12.0	15.3	9.3	1.4	62.0	721.0	783.0	3.8
368	5211	11.8	15.0	9.3	1.4	62.5	718.5	784.0	3.9
369	5225	11.7	15.0	9.3	1.4	62.6	720.5	783.0	3.9
370	5240	12.1	15.2	9.3	1.4	62.0	726.5	783.0	4.0
371	5254	11.9	15.2	9.3	1.4	62.2	720.5	783.0	4.0
372	5268	12.2	15.2	9.3	1.4	61.9	715.5	783.0	3.9
373	5282	12.2	15.6	9.4	1.4	61.4	719.0	783.0	3.9
374	5296	12.0	15.5	9.4	1.4	61.7	720.0	783.5	3.9
375	5311	12.0	15.1	9.3	1.4	62.2	716.5	784.0	4.0
376	5325	12.2	15.3	9.4	1.4	61.7	716.0	783.5	3.9
377	5340	11.5	14.8	9.4	1.3	63.0	721.5	784.0	4.7
378	5354	11.6	15.0	9.4	1.3	62.7	719.5	784.0	3.9

379	5368	11.8	15.5	9.3	1.3	62.1	721.5	784.0	3.9
380	5382	11.9	16.1	9.3	1.3	61.4	720.5	783.5	3.9
381	5397	12.0	16.4	9.3	1.3	61.0	720.0	783.5	3.9
382	5411	12.3	16.3	9.2	1.2	61.0	722.0	783.0	3.8
383	5423	13.1	15.9	9.1	1.3	60.6	725.0	783.0	3.7
384	5437	12.8	16.3	9.2	1.3	60.4	720.5	783.5	3.8
385	5452	12.6	16.3	9.1	1.3	60.7	719.0	784.0	3.9
386	5466	12.6	16.2	9.2	1.3	60.7	716.5	784.0	3.8
387	5481	12.4	15.3	9.2	1.3	61.8	716.0	783.5	3.7
388	5495	12.2	15.5	9.1	1.3	61.9	716.0	783.0	3.5
389	5509	12.3	15.6	9.2	1.3	61.6	716.5	783.0	3.5
390	5523	12.4	15.4	9.2	1.3	61.7	711.0	782.0	3.4
391	5537	12.5	14.9	9.2	1.4	62.0	707.5	783.0	3.5
392	5552	12.1	14.4	9.1	1.3	63.1	707.5	782.0	3.4
393	5566	12.6	14.2	9.2	1.4	62.6	705.0	783.0	3.5
394	5580	11.7	13.6	9.2	1.4	64.1	709.0	783.0	3.4
395	5594	11.6	13.8	9.3	1.4	63.9	705.0	782.5	3.4
396	5609	11.7	13.9	9.3	1.4	63.7	708.5	782.5	3.5
397	5623	11.0	14.1	9.3	1.2	64.4	709.5	783.0	3.4
398	5637	10.6	14.4	9.2	1.0	64.8	708.0	782.5	3.4
399	5649	10.6	14.7	9.1	1.0	64.6	702.5	782.0	3.4
400	5664	11.2	15.0	9.0	1.0	63.8	702.5	781.5	3.4
401	5678	11.4	14.5	8.9	1.1	64.1	702.0	782.0	3.4
402	5692	11.5	14.5	8.8	1.1	64.1	705.0	782.5	3.5
403	5706	11.5	14.2	8.7	1.2	64.4	711.5	782.5	3.6
404	5720	11.5	14.4	8.6	1.2	64.3	707.5	782.0	3.7
405	5734	11.8	14.8	8.6	1.1	63.7	704.5	782.5	3.6
406	5748	11.8	15.0	8.7	1.2	63.3	709.5	783.0	3.6
407	5763	11.8	14.8	8.6	1.1	63.7	705.5	782.5	3.5
408	5777	11.9	15.0	8.6	1.1	63.4	704.5	782.0	3.4
409	5792	12.2	14.7	8.6	1.2	63.3	706.0	782.0	3.5
410	5806	11.7	14.9	8.6	1.1	63.7	702.0	783.0	3.7
411	5820	11.1	14.9	8.5	1.0	64.5	699.5	782.0	3.3
412	5834	10.8	14.4	8.5	1.0	65.3	697.5	782.0	3.3
413	5848	11.4	13.8	8.5	1.1	65.2	699.5	782.0	3.3
414	5862	11.8	13.7	8.4	1.3	64.8	701.0	781.5	3.2
415	5877	11.7	13.7	8.4	1.4	64.8	701.5	781.5	3.3
416	5891	11.5	13.9	8.5	1.3	64.8	699.5	781.5	3.2
417	5905	11.6	14.3	8.6	1.2	64.3	699.0	782.0	3.2
418	5919	11.5	14.3	8.5	1.1	64.6	701.5	781.5	3.1
419	5934	11.2	14.0	8.5	1.0	65.3	693.5	781.5	3.2
420	5948	11.7	13.9	8.5	1.1	64.8	694.5	782.0	3.3
421	5962	11.0	13.0	8.5	1.2	66.3	697.5	781.5	3.3
422	5976	11.0	12.9	8.5	1.2	66.4	699.5	781.5	3.3
423	5990	11.1	12.9	8.4	1.1	66.5	697.5	781.0	3.3
424	6005	10.6	13.1	8.4	1.0	66.9	693.5	781.5	3.2
425	6019	10.9	13.0	8.3	1.0	66.8	696.5	781.5	3.2
426	6034	10.9	13.2	8.2	1.0	66.7	695.5	781.5	3.2
427	6048	11.0	13.3	8.3	1.0	66.4	700.0	781.0	3.3
428	6062	11.3	13.4	8.3	1.0	66.0	697.5	782.0	3.4
429	6076	10.9	13.6	8.3	1.0	66.2	697.5	782.0	3.3
430	6090	10.4	13.4	8.3	0.9	67.0	695.5	781.5	3.3
431	6105	10.6	13.5	8.3	0.8	66.8	696.5	781.5	3.4
432	6119	10.6	13.5	8.1	0.8	67.0	701.5	781.5	3.3
433	6133	10.6	14.0	8.0	0.9	66.5	697.0	781.0	3.3
434	6147	11.1	14.0	7.9	1.0	66.0	695.5	781.0	3.2
435	6161	11.3	13.6	7.8	1.0	66.3	694.0	781.0	3.2
436	6176	11.8	13.3	7.8	1.1	66.0	694.5	781.0	3.2
437	6190	12.0	13.0	7.9	1.1	66.0	691.0	781.5	3.2

438	6204	12.2	13.2	7.9	1.2	65.5	691.0	781.0	3.1
439	6216	11.3	12.7	8.0	1.1	66.9	692.0	782.0	3.2
440	6230	10.7	12.6	8.0	1.1	67.6	692.0	781.0	3.3
441	6245	10.5	12.6	8.0	1.0	67.9	693.0	781.0	3.1
442	6258	10.6	12.8	8.0	0.9	67.7	689.0	781.0	3.1
443	6273	10.8	12.8	7.9	0.8	67.7	688.5	781.0	3.0
444	6287	11.0	13.0	7.8	0.8	67.4	689.5	781.0	2.9
445	6301	10.9	13.1	7.8	0.9	67.3	690.0	781.0	3.2
446	6313	11.4	13.0	7.7	0.9	67.0	691.0	787.0	3.1
447	6327	10.4	12.8	7.7	0.8	68.3	691.0	781.0	3.2
448	6341	10.8	12.6	7.7	0.8	68.1	689.5	780.5	3.1
449	6356	10.8	12.5	7.6	0.9	68.2	688.5	780.5	3.2
450	6370	10.7	12.9	7.5	0.9	68.0	686.5	780.0	3.1
451	6385	10.8	12.8	7.5	0.9	68.0	687.0	780.5	3.2
452	6399	11.3	12.4	7.5	1.0	67.8	685.0	779.0	2.7
453	6413	10.9	12.4	7.4	1.0	68.3	686.5	781.0	3.3
454	6427	10.7	12.3	7.5	0.9	68.6	687.0	780.5	3.2
455	6441	9.9	12.2	7.5	0.8	69.6	694.5	781.0	3.2
456	6456	10.4	13.1	7.5	1.0	68.0	691.0	781.0	3.1
457	6470	10.4	13.8	7.4	0.9	67.5	689.5	780.5	3.1
458	6484	11.1	13.7	7.3	0.9	67.0	689.0	780.5	3.1
459	6498	11.3	13.7	7.2	1.0	66.8	686.0	780.0	3.0
460	6513	11.1	14.1	7.2	1.0	66.6	685.0	780.5	3.1
461	6527	11.4	14.1	7.1	1.0	66.4	686.5	781.0	3.1
462	6542	12.2	14.3	7.1	1.1	65.3	682.5	780.0	3.0
463	6556	10.9	14.7	7.1	1.0	66.3	684.5	779.5	2.9
464	6570	10.7	14.1	7.0	0.9	67.3	685.0	779.5	2.9
465	6584	11.8	14.0	6.9	1.1	66.2	687.5	779.5	2.9
466	6599	11.9	14.2	6.8	1.1	66.0	688.5	779.5	2.9
467	6613	11.6	13.8	6.8	1.1	66.7	685.5	779.5	2.8
468	6627	11.3	13.9	6.8	1.1	66.9	679.0	779.5	2.9
469	6641	11.2	13.8	6.8	1.1	67.1	681.0	779.0	2.8
470	6655	11.4	12.8	6.8	1.1	67.9	675.5	780.5	3.0
471	6669	11.3	12.1	6.9	1.2	68.5	675.0	780.0	3.0
472	6683	10.7	11.6	7.0	1.2	69.5	676.5	780.0	3.0
473	6698	10.2	11.6	7.0	1.1	70.1	676.5	779.5	2.9
474	6712	9.9	11.7	7.0	1.0	70.4	676.0	780.0	3.0
475	6726	10.0	12.0	7.0	1.1	69.9	676.5	779.5	2.9
476	6740	10.0	12.1	7.0	1.0	69.9	681.0	779.5	2.9
477	6754	10.0	12.2	7.0	1.0	69.8	673.0	779.5	3.0
478	6768	10.0	12.2	7.0	1.0	69.8	677.5	779.5	2.9
479	6783	9.3	11.6	6.9	1.0	71.2	674.0	780.5	3.2
480	6797	8.6	11.9	6.9	0.9	71.7	673.5	780.0	3.0
481	6811	6.8	11.5	6.8	0.6	74.3	673.5	779.5	3.0
482	6825	8.2	11.0	6.8	0.7	73.3	674.0	779.5	2.9
483	6840	9.8	11.9	6.7	0.9	70.7	676.5	779.5	2.9
484	6854	10.2	12.2	6.6	1.0	70.0	673.5	779.0	2.8
485	6868	10.4	12.2	6.5	1.0	69.9	673.0	779.0	2.7
486	6882	10.3	12.1	6.5	1.0	70.1	672.0	778.5	2.8
487	6896	10.6	11.6	6.5	1.1	70.2	668.0	778.5	2.7
488	6911	10.5	11.4	6.5	1.1	70.5	671.0	780.0	2.8
489	6925	9.8	10.9	6.6	1.1	71.6	672.0	778.5	2.7
490	6939	9.5	10.4	6.6	1.0	72.5	674.0	779.0	2.8
491	6953	9.6	10.3	6.7	1.0	[illegible]	677.0	779.5	[illegible]
492	6968	9.5	10.5	6.7	1.0	72.3	672.0	779.0	2.7
493	6982	9.5	10.5	6.8	0.9	72.3	669.5	779.5	2.7
494	6996	9.4	10.5	6.9	0.9	72.3	672.5	776.0	2.3
495	7010	9.3	10.6	6.8	0.9	72.4	671.0	780.0	2.9
496	7024	9.2	11.1	6.8	0.9	72.0	669.0	780.0	2.9

497	7038	7.3	11.4	6.8	0.7	73.8	664.5	779.5	2.9
498	7053	6.4	11.7	6.8	0.5	74.6	671.0	779.5	2.8
499	7067	7.6	11.1	6.6	0.7	74.0	671.0	779.0	2.8
500	7081	8.6	11.5	6.3	0.7	72.9	669.0	778.5	2.8
501	7095	9.4	12.0	6.2	0.8	71.6	671.5	778.5	2.8
502	7109	9.6	12.0	6.1	0.8	71.5	669.5	778.5	2.8
503	7124	9.8	12.0	6.1	0.9	71.2	669.0	778.5	2.7
504	7138	9.9	11.9	6.1	0.9	71.2	670.0	778.5	2.8
505	7152	10.3	11.9	6.1	1.0	70.7	675.5	777.0	2.7
506	7166	10.1	12.2	6.1	1.0	70.6	670.0	779.0	2.9
507	7181	9.7	11.9	6.2	1.0	71.2	668.0	778.5	2.9
508	7192	9.4	11.6	6.2	0.9	71.9	671.0	779.0	2.8
509	7207	9.5	11.6	6.2	0.9	71.8	666.0	778.5	2.9
510	7221	9.7	11.6	6.2	1.0	71.5	671.0	778.5	2.7
511	7235	9.9	11.0	6.2	1.0	71.9	670.5	778.5	2.8
512	7249	10.0	10.7	6.2	1.1	72.0	673.0	778.5	2.8
513	7263	9.8	10.5	6.3	1.0	72.4	668.5	779.0	2.9
514	7277	9.5	10.5	6.3	1.0	72.7	673.0	779.0	3.0
515	7292	9.1	10.1	6.4	0.9	73.5	667.0	779.5	2.9
516	7303	8.9	9.6	6.5	0.9	74.1	667.0	779.0	2.9
517	7318	8.4	9.4	6.6	0.9	74.7	671.0	780.5	2.8
518	7332	8.5	9.6	6.6	0.9	74.4	676.0	780.5	2.9
519	7346	8.4	9.9	6.7	0.8	74.2	671.0	779.5	2.8
520	7361	8.5	10.1	6.7	0.7	74.0	674.5	779.5	2.8
521	7375	9.0	10.6	6.7	0.7	73.0	679.0	779.5	2.8
522	7389	9.0	10.8	6.6	0.8	72.8	674.5	779.5	2.7
523	7403	9.3	11.0	6.7	0.8	72.2	676.0	779.0	2.7
524	7418	9.2	10.8	6.7	0.9	72.4	674.0	779.0	2.8
525	7432	9.0	10.7	6.7	0.8	72.8	673.5	779.5	2.8
526	7446	8.3	10.8	6.7	0.7	73.5	670.5	779.5	2.6
527	7460	8.7	10.8	6.6	0.7	73.2	668.5	779.5	2.8
528	7475	9.4	10.3	6.7	0.7	72.9	670.0	780.0	2.9
529	7489	8.6	10.0	6.7	0.7	74.0	677.0	780.0	2.9
530	7503	8.8	10.3	6.7	0.7	73.5	676.5	780.0	2.9
531	7517	9.1	10.7	6.7	0.7	72.8	681.0	779.5	3.0
532	7532	9.6	11.1	6.7	0.7	71.9	672.0	779.0	2.9
533	7546	9.7	11.2	6.7	0.8	71.6	674.0	779.5	2.9
534	7560	9.4	11.2	6.6	0.8	72.0	671.0	779.0	2.9
535	7572	9.7	10.9	6.6	0.9	71.9	672.0	779.5	2.8
536	7583	9.4	10.7	6.6	0.8	72.5	670.5	779.0	2.8
537	7597	9.3	10.8	6.7	0.8	72.4	668.5	779.0	2.8
538	7611	9.1	11.0	6.6	0.8	72.5	670.5	779.5	2.8
539	7626	9.2	11.1	6.7	0.8	72.2	669.0	779.0	2.8
540	7640	9.0	10.8	6.7	0.8	72.7	669.5	779.0	2.7
541	7654	10.0	10.8	6.7	0.9	71.6	664.5	780.0	2.8
542	7668	9.1	10.1	6.7	0.9	73.2	669.0	779.5	2.8
543	7683	8.8	10.2	6.7	0.9	73.4	667.0	779.5	2.8
544	7697	8.6	10.1	6.6	0.8	73.9	668.0	778.5	2.7
545	7711	8.9	9.9	6.7	0.8	73.7	670.0	779.5	2.7
546	7725	8.7	10.0	6.6	0.8	73.9	668.5	779.0	2.7
547	7740	8.9	10.3	6.6	0.8	73.4	669.5	779.0	2.8
548	7754	9.0	10.3	6.6	0.8	73.3	672.5	779.5	2.8
549	7768	9.0	10.2	6.7	0.9	73.2	667.5	779.0	2.8
550	7782	8.6	10.4	6.7	0.8	73.5	667.5	779.5	2.8
551	7796	8.7	10.5	6.7	0.8	73.3	671.0	778.5	2.8
552	7810	8.9	10.6	6.6	0.9	73.0	665.5	778.5	2.8
553	7824	8.8	10.3	6.7	0.9	73.3	681.0	774.0	2.2
554	7839	9.0	10.7	6.4	0.9	73.0	686.0	773.0	2.3
555	7853	11.8	12.2	6.4	1.1	68.5	680.5	773.0	2.2

556	7867	11.4	12.2	6.6	1.2	68.6	701.0	770.0	1.8
557	7881	11.1	12.5	6.9	1.1	68.4	697.5	769.5	1.8
558	7896	12.2	13.3	7.2	1.2	66.1	698.0	770.0	1.7
559	7910	12.3	13.3	7.7	1.3	65.4	702.5	770.0	0.9
560	7924	12.1	13.1	8.1	1.4	65.3	725.5	765.0	0.9
561	7938	13.5	14.3	8.3	1.4	62.5	727.0	765.0	0.9
562	7953	14.0	14.7	8.8	1.6	60.9	728.5	764.5	0.9
563	7964	14.0	14.5	9.3	1.7	60.5	727.0	765.0	0.9
564	7979	13.4	14.2	10.0	1.9	60.5	726.0	765.0	0.8
565	7993	12.9	14.1	10.6	1.9	60.5	729.0	765.0	0.9
566	8007	12.1	13.8	11.0	1.8	61.3	726.5	765.0	0.8
567	8022	11.5	13.5	11.4	1.7	61.9	728.5	765.5	0.9
568	8036	11.1	13.4	11.5	1.7	62.3	721.5	765.5	0.0
569	8050	11.0	13.3	11.8	1.7	62.2	728.5	765.0	0.0
570	8062	10.9	13.2	11.8	1.7	62.4	727.0	765.5	0.0
571	8076	10.7	13.3	12.0	1.7	62.3	729.5	763.5	0.0
572	8090	10.6	13.4	12.0	1.7	62.3	716.5	767.0	1.8
573	8104	10.2	13.2	12.3	1.7	62.6	728.5	765.5	0.9
574	8118	10.0	13.2	12.2	1.7	62.9	719.0	768.5	1.4
575	8133	10.2	13.5	12.3	1.6	62.4	751.0	755.5	0.0
576	8144	10.3	13.3	11.9	1.6	62.9	752.0	751.5	0.0
577	8159	10.3	13.6	11.7	1.6	62.8	751.0	752.5	0.0
578	8173	10.7	13.9	11.8	1.7	61.9	741.5	763.5	0.0
579	8187	11.1	14.1	12.1	1.8	60.9	742.5	763.5	0.0
580	8201	10.1	14.0	12.2	2.0	61.7	742.0	763.5	0.0
581	8216	9.4	14.2	12.3	2.1	62.0	743.0	763.5	0.0
582	8230	9.4	14.4	12.3	2.1	61.8	740.5	763.5	0.0
583	8244	9.4	14.5	12.4	2.2	61.5	741.5	763.5	0.0
584	8258	9.5	14.5	12.4	2.2	61.4	742.5	764.0	0.0
585	8272	9.7	14.5	12.5	2.2	61.1	744.0	763.5	0.0
586	8287	9.9	14.5	12.5	2.2	60.9	731.0	764.5	0.9
587	8301	9.9	14.5	12.7	2.2	60.7	734.0	764.0	0.0
588	8315	9.9	14.4	12.7	2.2	60.8	731.0	764.5	0.0
589	8329	10.2	14.5	12.6	2.1	60.6	727.5	765.5	1.2
590	8344	10.2	14.5	12.7	2.0	60.6	729.0	765.5	0.9
591	8358	10.3	14.4	12.7	2.0	60.6	728.5	765.5	1.0
592	8372	10.4	14.4	12.6	1.9	60.7	729.5	765.5	0.0
593	8383	10.6	14.5	12.6	1.8	60.5	723.5	765.5	0.9
594	8398	10.7	14.7	12.6	1.8	60.2	722.5	766.0	1.3
595	8412	10.9	14.7	12.5	1.8	60.1	722.0	767.0	1.8
596	8427	10.9	14.5	12.4	1.8	60.4	724.0	766.5	1.5
597	8441	11.0	14.5	12.4	1.7	60.4	725.0	766.0	1.4
598	8455	11.1	14.5	12.3	1.7	60.4	722.0	766.0	1.8
599	8469	11.2	14.3	12.3	1.6	60.6	719.0	766.0	1.3
600	8481	11.1	14.2	12.2	1.6	60.9	723.0	765.5	0.9
601	8495	11.0	14.1	12.2	1.6	61.1	715.0	766.5	1.8
602	8509	10.9	14.1	12.2	1.6	61.2	719.0	765.5	0.0
603	8523	11.0	14.2	12.2	1.6	61.0	722.0	766.0	0.0
604	8537	11.2	14.5	12.2	1.6	60.5	720.0	766.5	1.1
605	8552	11.4	14.5	12.2	1.6	60.3	722.5	765.5	0.0
606	8566	11.3	14.5	12.1	1.6	60.5	724.0	765.5	0.0
607	8580	11.2	14.5	12.1	1.6	60.6	732.0	763.5	0.0
608	8594	11.2	14.5	12.1	1.6	60.6	718.5	766.0	1.1
609	8609	11.1	14.4	12.1	1.7	60.7	717.5	765.5	0.8
610	8623	11.0	14.5	12.1	1.7	60.7	716.5	766.0	1.1
611	8637	11.0	14.5	12.2	1.7	60.6	719.5	766.5	1.5
612	8651	11.2	14.4	12.2	1.7	60.5	720.0	766.0	1.2
613	8666	11.1	14.4	12.1	1.7	60.7	719.5	766.0	1.5

614	8680	11.1	14.3	12.2	1.7	60.7	720.5	766.0	0.0
615	8694	11.2	14.5	12.2	1.7	60.4	719.5	765.5	0.9
616	8708	11.2	14.7	12.2	1.8	60.1	722.0	766.0	0.9
617	8722	11.1	14.6	12.1	1.8	60.4	722.5	766.0	0.0
618	8736	11.1	14.6	12.1	1.7	60.5	723.0	766.0	0.0
619	8750	11.1	14.4	12.1	1.7	60.7	716.5	766.0	1.7
620	8765	10.9	14.3	12.1	1.7	61.0	721.5	766.5	1.3
621	8779	10.9	14.0	12.3	1.7	61.1	693.0	774.0	1.7
622	8793	10.3	13.1	12.8	1.7	62.1	675.5	777.5	2.6
623	8807	6.8	10.0	12.8	1.2	69.2	698.0	771.5	1.7
624	8822	8.7	11.9	11.9	0.8	66.7	697.0	770.5	1.7
625	8836	10.4	13.3	11.3	0.8	64.2	699.5	771.5	1.8
626	8850	10.8	13.4	10.9	0.9	64.0	703.0	771.0	1.7
627	8864	10.8	13.3	10.6	0.9	64.4	700.0	770.5	1.7
628	8879	10.5	13.3	10.5	1.0	64.7	697.5	770.5	1.7
629	8893	10.6	13.2	10.4	1.0	64.8	699.5	771.0	1.7
630	8907	10.6	13.0	10.3	1.0	65.1	698.5	771.0	1.8
631	8921	10.3	12.9	10.2	0.9	65.7	698.0	771.0	1.8
632	8935	10.2	12.9	10.2	0.9	65.8	702.5	770.5	1.7
633	8950	10.4	12.9	10.1	0.9	65.7	694.5	771.5	1.7
634	8964	10.3	12.8	10.1	1.0	65.8	697.5	770.0	1.7
635	8978	10.2	12.6	10.0	1.1	66.1	696.0	770.5	1.8
636	8992	10.0	12.5	10.0	1.1	66.4	693.5	770.5	1.8
637	9007	9.6	12.7	10.0	1.1	66.6	692.0	770.5	1.7
638	9021	9.1	12.7	9.9	1.0	67.3	690.0	776.0	2.5
639	9035	9.5	12.6	10.1	1.2	66.6	659.5	778.5	2.9
640	9049	7.5	9.5	10.4	1.1	71.5	659.0	778.5	2.9
641	9064	5.4	7.9	10.1	0.7	75.9	660.0	779.0	2.8
642	9078	5.4	7.8	9.8	0.6	76.4	660.5	778.5	2.8
643	9092	5.6	8.0	9.1	0.6	76.7	660.0	778.0	2.8
644	9106	6.1	8.2	8.6	0.6	76.5	662.0	777.5	2.8
645	9121	6.2	8.3	8.1	0.6	76.8	658.0	777.5	2.7
646	9135	6.4	8.6	7.7	0.7	76.6	687.5	767.0	0.0
647	9149	7.0	10.2	7.0	0.8	75.0	695.5	769.5	3.2
648	9163	12.6	14.5	6.7	1.4	64.8	719.5	765.5	0.9
649	9177	13.4	15.6	6.9	1.8	62.3	677.0	772.5	2.1
650	9192	10.5	12.9	8.0	1.7	66.9	700.0	771.5	2.0
651	9206	7.7	11.5	8.6	1.6	70.6	699.5	772.5	2.1
652	9221	5.1	11.6	8.8	1.2	73.3	696.5	772.5	2.0
653	9235	2.1	12.5	8.9	0.4	76.1	700.0	773.0	2.0
654	9249	1.0	13.6	8.9	0.1	76.4	696.5	772.5	2.0
655	9263	0.8	14.3	8.6	0.0	76.3	699.0	772.5	2.0
656	9277	0.9	14.7	8.3	0.0	76.1	699.0	772.0	2.0
657	9291	1.2	15.3	8.1	0.0	75.4	691.0	772.0	2.1
658	9306	1.3	16.2	7.8	0.0	74.7	692.0	772.0	2.0
659	9320	1.3	16.3	7.4	0.0	75.0	694.5	772.0	2.0
660	9334	1.4	16.0	7.1	0.0	75.5	690.5	772.5	2.1
661	9348	1.2	16.7	6.9	0.0	75.2	689.0	772.0	1.9
662	9362	1.1	17.1	6.6	0.0	75.2	693.0	771.5	1.9
663	9377	1.2	17.8	6.4	0.0	74.6	690.5	772.0	2.0
664	9391	1.3	18.6	6.0	0.0	74.1	691.0	772.0	1.9
665	9405	1.4	19.1	5.9	0.0	73.6	688.5	771.0	1.9
666	9419	1.5	19.7	5.6	0.0	73.2	694.0	771.5	1.9
667	9431	1.6	19.1	5.[illegible]	0.0	73.8	686.5	772.0	1.9
668	9443	1.9	18.4	5.3	0.0	74.4	690.5	771.5	1.9
669	9457	1.7	18.0	5.2	0.0	75.1	690.5	771.5	1.9
670	9471	1.8	18.8	5.2	0.0	74.2	691.0	772.5	1.9
671	9486	1.7	19.6	5.3	0.0	73.4	689.5	772.0	2.1
672	9500	1.7	19.3	5.3	0.0	73.7	691.0	772.0	2.0

673	9514	1.7	19.0	5.3	0.0	74.0	693.5	772.0	1.9
674	9528	1.4	19.5	5.2	0.0	73.9	695.5	772.5	1.9
675	9542	1.4	19.8	5.1	0.0	73.7	691.5	771.5	1.9
676	9554	1.6	19.4	5.0	0.0	74.0	694.0	772.5	2.0
677	9569	1.5	19.4	4.8	0.0	74.3	684.5	771.5	1.9
678	9583	1.4	19.4	4.6	0.0	74.6	706.0	773.5	2.2
679	9597	1.4	19.1	4.5	0.0	75.0	696.0	772.5	2.0
680	9611	1.3	20.3	4.2	0.0	74.2	735.5	777.0	2.6
681	9625	1.5	21.3	4.0	0.0	73.2	745.5	779.5	2.9
682	9640	1.8	24.1	3.6	0.0	70.5	736.5	777.5	2.7
683	9654	2.2	21.3	3.2	0.0	73.3	730.5	778.0	2.7
684	9668	2.3	22.9	2.9	0.0	71.9	741.5	778.0	2.7
685	9682	1.7	22.5	2.9	0.0	72.9	750.5	779.5	3.0
686	9696	1.8	23.0	3.0	0.0	72.2	753.5	780.5	3.1
687	9710	0.7	16.2	3.0	0.0	80.1	751.5	780.5	3.0
688	9725	0.3	9.1	3.3	0.0	87.3	752.0	781.0	3.0
689	9739	0.0	0.5	0.3	0.0	99.2	751.5	781.0	3.0

TEMPERATURE DATA:

		THERMOCOUPLE NUMBERS (TEMPERATURES deg C)							
NO.	TIME	1	2	3	4	5	6	7	8
1	2	2.8	2.7	2.6	4.5	-2.9	3.3	9.5	9.5
2	16	21.1	21.0	20.8	22.9	15.6	22.0	28.1	28.1
3	31	21.1	21.0	20.8	23.0	15.6	22.0	28.1	28.1
4	45	21.1	21.0	20.8	23.0	15.6	22.0	28.1	28.1
5	60	21.1	21.0	20.9	23.2	15.4	22.1	30.0	72.0
6	74	21.1	21.0	20.9	23.2	15.7	22.7	34.0	93.0
7	87	21.3	20.9	20.9	22.9	15.7	23.3	37.0	108.0
8	102	21.1	20.9	20.8	22.7	15.7	25.8	42.0	127.0
9	116	21.1	20.9	20.9	22.7	16.0	32.0	49.0	155.0
10	131	21.1	20.9	20.9	23.0	16.0	37.0	55.0	201.0
11	145	21.3	20.9	20.8	22.8	16.0	57.0	64.0	279.0
12	159	21.1	21.0	20.9	23.0	16.6	74.0	74.0	397.0
13	173	21.1	21.0	20.9	23.0	17.3	79.0	83.0	509.0
14	188	21.1	21.0	20.9	23.0	18.2	83.0	92.0	624.0
15	201	21.1	21.2	20.9	23.0	20.9	86.0	107.0	718.0
16	216	21.0	21.2	21.0	23.0	22.7	90.0	126.0	746.0
17	230	21.1	21.3	21.0	23.0	24.0	90.0	127.0	715.0
18	244	21.1	21.2	21.0	22.9	24.3	91.0	154.0	719.0
19	256	21.1	21.2	21.0	22.9	24.6	93.0	167.0	703.0
20	270	21.1	21.3	21.1	23.0	24.9	97.0	186.0	717.0
21	284	21.1	21.2	21.0	23.3	24.9	102.0	199.0	706.0
22	298	21.0	21.2	21.1	23.2	25.9	112.0	230.0	813.0
23	313	21.1	21.2	21.0	23.7	26.8	131.0	283.0	814.0
24	327	21.1	21.2	21.1	23.6	27.1	151.0	328.0	802.0
25	342	21.1	21.2	21.1	23.7	27.4	177.0	355.0	788.0
26	356	21.1	21.2	21.1	23.4	28.0	201.0	378.0	823.0
27	370	21.1	21.2	21.1	23.3	28.3	227.0	386.0	883.0
28	384	21.1	21.2	21.1	23.5	29.3	258.0	425.0	872.0
29	399	21.1	21.3	21.1	23.7	30.0	289.0	475.0	870.0
30	413	21.2	21.3	21.2	23.7	31.0	317.0	523.0	907.0
31	427	21.1	21.3	21.2	23.9	32.0	345.0	548.0	882.0
32	441	21.1	21.3	21.2	23.4	33.0	367.0	564.0	851.0
33	456	21.1	21.4	21.3	23.0	34.0	387.0	585.0	8[illegible]5.0
34	470	21.1	21.5	21.2	23.4	35.0	406.0	582.0	922.0
35	485	21.1	21.4	21.3	23.9	36.0	416.0	574.0	1010.0
36	499	21.1	21.5	21.3	23.8	37.0	428.0	572.0	998.0
37	513	21.0	21.5	21.3	23.6	38.0	440.0	563.0	1016.0
38	528	21.1	21.5	21.4	23.8	39.0	446.0	564.0	979.0

39	542	21.1	21.5	21.4	23.5	39.0	454.0	560.0	989.0
40	556	21.1	21.5	21.4	23.7	40.0	460.0	561.0	1040.0
41	570	21.1	21.6	21.4	23.8	40.0	465.0	558.0	908.0
42	582	21.1	21.5	21.5	24.0	41.0	471.0	560.0	959.0
43	596	21.1	21.4	21.6	23.8	42.0	478.0	581.0	744.0
44	611	21.0	21.6	21.5	23.6	42.0	485.0	567.0	799.0
45	625	21.0	21.6	21.6	23.7	43.0	489.0	556.0	823.0
46	639	21.0	21.5	21.7	24.0	43.0	494.0	548.0	945.0
47	653	21.1	21.5	21.7	24.4	43.0	496.0	541.0	966.0
48	668	21.0	21.5	21.7	24.4	43.0	499.0	573.0	925.0
49	679	21.2	21.5	21.7	23.8	44.0	504.0	570.0	770.0
50	694	21.0	21.6	21.8	24.0	45.0	520.0	564.0	804.0
51	708	21.1	21.5	21.8	23.9	45.0	526.0	553.0	785.0
52	723	21.1	21.6	21.9	23.8	46.0	528.0	541.0	760.0
53	737	21.1	21.6	21.9	23.9	46.0	530.0	532.0	736.0
54	751	21.1	21.6	21.9	24.0	47.0	533.0	525.0	743.0
55	766	21.1	21.6	21.9	23.8	47.0	536.0	522.0	737.0
56	779	21.1	21.7	22.0	24.0	48.0	537.0	517.0	743.0
57	794	21.1	21.7	22.0	24.7	48.0	535.0	515.0	732.0
58	808	21.1	21.6	22.0	24.7	48.0	532.0	511.0	735.0
59	822	21.1	21.6	22.0	24.4	48.0	532.0	509.0	737.0
60	836	21.1	21.7	22.1	24.4	49.0	532.0	508.0	746.0
61	851	21.1	21.6	22.1	24.3	49.0	532.0	506.0	726.0
62	865	21.1	21.6	22.1	24.0	49.0	530.0	504.0	713.0
63	880	21.1	21.8	22.5	24.0	51.0	543.0	515.0	874.0
64	894	21.1	22.1	22.7	24.2	52.0	553.0	542.0	955.0
65	908	21.2	21.8	22.6	24.4	52.0	551.0	546.0	825.0
66	922	21.1	21.8	22.6	24.2	53.0	550.0	555.0	921.0
67	937	21.1	21.7	22.6	24.3	53.0	549.0	553.0	960.0
68	951	21.1	21.8	22.7	25.3	53.0	548.0	551.0	885.0
69	966	21.1	21.7	22.7	25.0	54.0	547.0	548.0	972.0
70	980	21.1	21.7	22.7	25.2	54.0	546.0	547.0	871.0
71	994	21.1	21.8	22.8	25.3	55.0	546.0	549.0	1038.0
72	1008	21.1	21.7	22.8	25.0	56.0	547.0	573.0	905.0
73	1023	21.1	21.8	22.9	25.0	56.0	545.0	586.0	855.0
74	1037	21.1	21.7	22.8	25.5	56.0	544.0	593.0	848.0
75	1051	21.2	21.7	22.9	26.2	57.0	545.0	595.0	824.0
76	1066	21.1	21.7	22.9	25.6	57.0	544.0	594.0	786.0
77	1080	21.1	21.8	23.0	24.5	58.0	544.0	587.0	752.0
78	1095	21.1	21.7	23.1	24.5	59.0	547.0	586.0	754.0
79	1109	21.2	21.8	23.2	25.1	59.0	551.0	597.0	942.0
80	1123	21.1	21.8	23.3	25.0	60.0	554.0	612.0	1078.0
81	1137	21.2	21.7	23.3	25.6	61.0	555.0	628.0	864.0
82	1152	21.1	21.8	23.4	25.9	62.0	557.0	870.0	756.0
83	1166	21.1	21.9	23.4	25.4	62.0	560.0	901.0	854.0
84	1181	21.1	21.8	23.6	25.3	64.0	566.0	919.0	971.0
85	1195	21.1	21.9	23.6	24.2	64.0	575.0	824.0	730.0
86	1209	21.1	22.0	23.6	24.3	65.0	581.0	720.0	935.0
87	1224	21.1	21.9	23.6	24.1	66.0	577.0	689.0	971.0
88	1238	21.1	21.8	23.8	24.4	66.0	571.0	675.0	1090.0
89	1252	21.1	21.9	23.3	26.4	67.0	569.0	671.0	1051.0
90	1267	21.1	21.9	23.8	26.0	67.0	566.0	653.0	966.0
91	1281	21.1	21.8	23.8	25.1	67.0	562.0	658.0	1070.0
92	1295	21.2	21.9	23.8	24.6	68.0	561.0	645.0	988.0
93	1310	21.1	21.8	23.9	24.5	68.0	559.0	638.0	1052.0
94	1324	21.1	21.8	24.0	24.8	68.0	559.0	636.0	1113.0
95	1338	21.2	21.8	24.1	25.0	69.0	559.0	640.0	1006.0
96	1352	21.1	21.8	24.0	24.4	69.0	559.0	633.0	1005.0
97	1367	21.1	21.7	24.1	24.3	70.0	557.0	623.0	974.0

98	1381	21.1	21.7	24.2	24.8	70.0	556.0	617.0	967.0
99	1396	21.1	21.9	24.4	27.2	71.0	560.0	616.0	988.0
100	1410	21.1	21.9	24.4	24.8	71.0	566.0	615.0	974.0
101	1425	21.1	21.9	24.4	26.5	72.0	570.0	615.0	1086.0
102	1439	21.2	21.8	24.6	25.5	72.0	572.0	622.0	1123.0
103	1453	21.1	21.9	24.7	26.2	72.0	574.0	627.0	1070.0
104	1467	21.1	21.9	24.7	26.1	73.0	575.0	641.0	1118.0
105	1481	21.1	21.9	24.8	25.0	73.0	576.0	648.0	992.0
106	1494	21.1	22.0	24.9	25.0	74.0	578.0	648.0	886.0
107	1508	21.1	22.0	24.9	25.1	74.0	580.0	632.0	898.0
108	1522	21.1	21.9	24.9	25.0	74.0	577.0	628.0	974.0
109	1536	21.1	21.9	25.2	24.3	74.0	578.0	623.0	983.0
110	1551	21.1	21.9	25.0	24.5	75.0	579.0	615.0	973.0
111	1565	21.6	21.9	25.0	25.2	75.0	581.0	615.0	953.0
112	1579	21.1	21.9	24.9	24.6	75.0	580.0	611.0	935.0
113	1591	21.2	21.9	25.2	24.6	76.0	578.0	607.0	953.0
114	1605	21.1	21.9	25.1	24.7	76.0	577.0	604.0	923.0
115	1619	21.2	21.9	25.2	24.9	76.0	577.0	599.0	938.0
116	1634	21.2	21.9	25.3	24.6	77.0	577.0	597.0	940.0
117	1648	21.1	22.0	25.4	24.8	77.0	579.0	597.0	971.0
118	1662	21.2	21.9	25.5	24.4	77.0	579.0	599.0	905.0
119	1677	21.1	22.0	25.6	24.7	78.0	580.0	594.0	910.0
120	1691	21.1	22.0	25.6	25.2	78.0	580.0	592.0	900.0
121	1706	21.1	22.0	25.7	25.5	79.0	582.0	591.0	910.0
122	1720	21.2	22.0	25.8	25.4	80.0	587.0	590.0	856.0
123	1734	21.1	22.0	25.9	25.4	81.0	590.0	587.0	824.0
124	1748	21.1	22.0	26.0	25.0	80.0	592.0	584.0	842.0
125	1763	21.1	22.1	26.0	25.2	81.0	592.0	580.0	798.0
126	1777	21.2	22.0	26.1	25.9	82.0	594.0	577.0	775.0
127	1791	21.1	22.0	26.1	25.2	83.0	594.0	574.0	773.0
128	1803	21.1	22.0	26.3	25.3	83.0	594.0	570.0	775.0
129	1817	21.1	22.0	26.2	25.1	84.0	596.0	566.0	774.0
130	1831	21.2	22.2	26.5	25.4	85.0	594.0	561.0	751.0
131	1846	21.1	22.0	26.4	25.4	85.0	593.0	558.0	745.0
132	1860	21.2	22.0	26.5	25.1	86.0	595.0	554.0	747.0
133	1875	21.2	22.1	26.6	25.1	87.0	593.0	552.0	758.0
134	1889	21.1	22.1	26.7	25.0	87.0	589.0	552.0	786.0
135	1903	21.1	22.0	26.8	24.9	87.0	586.0	554.0	796.0
136	1918	21.1	22.0	26.7	25.4	87.0	582.0	554.0	791.0
137	1932	21.1	22.0	26.5	25.9	88.0	581.0	553.0	777.0
138	1948	21.1	22.1	26.8	24.9	89.0	580.0	552.0	748.0
139	1962	21.2	22.2	26.9	25.3	90.0	582.0	548.0	738.0
140	1977	21.1	22.2	27.2	25.1	91.0	582.0	546.0	767.0
141	1991	21.1	22.1	27.4	25.3	92.0	580.0	545.0	764.0
142	2005	22.8	22.0	27.2	25.4	92.0	576.0	543.0	763.0
143	2019	21.1	22.0	27.3	25.9	92.0	574.0	546.0	775.0
144	2034	21.2	22.0	27.0	25.5	92.0	573.0	546.0	754.0
145	2048	21.1	22.0	27.4	24.8	93.0	574.0	544.0	748.0
146	2063	21.2	22.0	27.5	25.3	93.0	573.0	542.0	747.0
147	2077	21.1	22.0	27.2	25.8	93.0	570.0	543.0	768.0
148	2091	21.1	22.0	27.4	24.8	93.0	566.0	545.0	782.0
149	2105	21.1	22.0	27.6	25.4	93.0	564.0	547.0	789.0
150	2119	21.1	22.0	27.6	25.0	93.0	562.0	548.0	808.0
151	2134	21.1	22.0	27.7	25.[illegible]	93.0	560.0	550.0	799.0
152	2148	21.1	22.0	27.7	26.0	93.0	558.0	549.0	786.0
153	2163	21.2	22.0	27.6	25.2	94.0	557.0	556.0	781.0
154	2177	21.1	22.1	27.6	25.1	94.0	559.0	558.0	796.0
155	2191	21.2	21.9	27.9	25.8	94.0	557.0	558.0	764.0
156	2203	21.2	22.1	28.0	24.9	95.0	559.0	553.0	741.0

157	2218	21.2	22.0	28.2	25.2	95.0	557.0	550.0	750.0
158	2232	21.2	22.0	28.1	25.3	95.0	556.0	551.0	759.0
159	2246	21.2	22.1	28.1	24.9	95.0	559.0	551.0	761.0
160	2258	21.1	21.9	28.2	25.3	95.0	559.0	551.0	733.0
161	2272	21.2	22.0	28.2	25.2	95.0	559.0	547.0	731.0
162	2286	21.2	22.0	28.4	25.1	95.0	559.0	549.0	739.0
163	2301	21.2	22.0	28.4	25.4	95.0	559.0	550.0	743.0
164	2315	21.1	22.1	28.4	25.2	95.0	559.0	550.0	739.0
165	2329	21.2	21.9	28.7	24.9	95.0	558.0	549.0	732.0
166	2343	21.2	21.9	28.6	24.8	95.0	558.0	549.0	745.0
167	2357	21.2	22.0	28.8	28.1	95.0	557.0	549.0	739.0
168	2369	21.2	21.9	28.5	25.9	95.0	556.0	547.0	731.0
169	2383	21.1	21.9	28.7	25.2	95.0	556.0	546.0	732.0
170	2398	21.2	22.0	28.5	25.3	95.0	555.0	546.0	738.0
171	2412	21.2	22.0	28.8	25.1	95.0	555.0	547.0	745.0
172	2427	21.2	22.0	28.8	25.2	95.0	553.0	544.0	722.0
173	2441	21.2	22.0	28.7	25.3	95.0	551.0	544.0	723.0
174	2456	21.2	21.9	29.2	25.1	95.0	548.0	542.0	719.0
175	2470	21.2	21.9	29.1	24.9	95.0	547.0	541.0	724.0
176	2484	21.2	22.0	28.9	25.4	95.0	548.0	540.0	730.0
177	2498	21.2	22.0	29.2	25.6	96.0	547.0	542.0	731.0
178	2513	21.3	21.9	29.3	25.5	96.0	545.0	544.0	740.0
179	2527	21.2	22.0	29.3	25.4	96.0	545.0	544.0	727.0
180	2541	21.2	22.0	29.5	25.3	97.0	551.0	544.0	728.0
181	2555	21.2	22.0	29.8	25.3	97.0	555.0	544.0	730.0
182	2569	21.2	22.0	29.7	25.6	98.0	555.0	544.0	726.0
183	2584	21.2	21.9	29.8	25.2	98.0	558.0	542.0	723.0
184	2598	21.2	22.1	29.9	25.5	98.0	557.0	544.0	729.0
185	2613	21.2	22.0	29.9	25.2	99.0	563.0	544.0	711.0
186	2627	21.2	22.0	29.9	25.4	99.0	564.0	540.0	693.0
187	2639	21.2	22.1	30.0	25.6	99.0	567.0	539.0	701.0
188	2653	21.2	22.0	30.0	25.9	100.0	571.0	540.0	709.0
189	2668	21.6	22.1	30.0	25.7	100.0	572.0	539.0	711.0
190	2682	21.1	22.0	30.0	27.9	101.0	571.0	536.0	715.0
191	2696	21.2	22.1	30.0	26.2	101.0	572.0	538.0	717.0
192	2710	21.1	22.1	31.0	26.0	102.0	573.0	537.0	707.0
193	2725	21.1	22.2	30.0	25.5	102.0	574.0	536.0	715.0
194	2739	21.2	22.1	30.0	25.1	102.0	573.0	536.0	719.0
195	2753	21.2	22.1	30.0	25.8	102.0	574.0	536.0	720.0
196	2767	21.3	22.1	30.0	25.7	103.0	573.0	536.0	718.0
197	2782	21.2	22.0	30.0	26.0	102.0	573.0	534.0	716.0
198	2796	21.2	22.0	30.0	25.5	102.0	573.0	531.0	706.0
199	2810	21.3	22.1	31.0	25.3	102.0	573.0	531.0	705.0
200	2824	21.2	22.1	31.0	25.3	103.0	576.0	533.0	710.0
201	2838	21.2	22.1	31.0	26.0	103.0	577.0	532.0	690.0
202	2853	21.2	22.0	31.0	25.5	104.0	576.0	529.0	678.0
203	2867	21.1	22.0	31.0	26.6	104.0	580.0	529.0	670.0
204	2882	21.3	22.1	31.0	26.0	105.0	583.0	523.0	662.0
205	2896	21.2	22.2	31.0	25.8	106.0	583.0	521.0	647.0
206	2910	21.2	22.2	31.0	25.7	107.0	578.0	515.0	634.0
207	2924	21.2	22.2	31.0	26.0	108.0	577.0	510.0	624.0
208	2939	21.2	22.2	31.0	25.7	108.0	575.0	504.0	613.0
209	2953	21.2	22.2	31.0	26.2	109.0	569.0	499.0	606.0
210	2967	21.3	22.2	32.0	25.8	110.0	56[illegible].0	495.0	600.0
211	2981	21.1	22.2	32.0	25.7	110.0	562.0	492.0	599.0
212	2996	21.2	22.1	32.0	25.7	111.0	555.0	490.0	596.0
213	3010	21.3	22.2	32.0	26.0	111.0	558.0	488.0	595.0
214	3021	21.2	22.2	32.0	26.1	112.0	563.0	487.0	596.0
215	3036	21.2	22.2	32.0	26.0	109.0	559.0	485.0	588.0

216	3050	21.2	22.1	32.0	26.2	109.0	551.0	481.0	576.0
217	3065	21.2	22.2	32.0	25.7	109.0	549.0	478.0	565.0
218	3079	21.3	22.1	32.0	25.8	109.0	542.0	474.0	560.0
219	3094	21.2	22.1	32.0	26.6	109.0	538.0	470.0	561.0
220	3108	21.2	22.1	32.0	25.7	109.0	534.0	467.0	567.0
221	3122	21.2	22.0	32.0	25.8	108.0	528.0	464.0	572.0
222	3137	21.2	22.0	32.0	25.8	108.0	524.0	464.0	577.0
223	3151	21.2	22.0	32.0	25.9	107.0	518.0	463.0	584.0
224	3165	21.2	21.9	32.0	25.9	106.0	511.0	462.0	590.0
225	3180	21.2	21.9	32.0	26.2	106.0	505.0	462.0	593.0
226	3194	21.2	21.9	32.0	25.7	105.0	500.0	460.0	589.0
227	3208	21.3	21.9	32.0	25.5	105.0	496.0	458.0	590.0
228	3222	21.5	21.8	32.0	26.0	104.0	495.0	457.0	593.0
229	3237	21.2	21.9	32.0	25.9	104.0	493.0	457.0	595.0
230	3251	21.2	21.9	32.0	26.0	104.0	490.0	456.0	591.0
231	3265	21.2	21.8	32.0	25.9	103.0	489.0	455.0	590.0
232	3280	21.2	21.8	32.0	25.8	104.0	489.0	455.0	594.0
233	3294	21.2	21.9	32.0	25.9	103.0	487.0	456.0	598.0
234	3309	21.2	21.8	32.0	26.0	103.0	488.0	456.0	597.0
235	3323	21.1	21.9	32.0	25.7	103.0	488.0	456.0	594.0
236	3338	21.2	21.8	33.0	26.0	103.0	489.0	456.0	591.0
237	3352	21.2	21.8	33.0	26.4	103.0	488.0	455.0	584.0
238	3366	21.3	21.9	33.0	26.1	103.0	489.0	454.0	573.0
239	3380	21.1	22.1	33.0	26.0	103.0	489.0	452.0	563.0
240	3395	21.2	21.9	33.0	25.9	104.0	487.0	451.0	554.0
241	3409	21.3	22.0	33.0	26.2	103.0	487.0	449.0	548.0
242	3421	21.2	22.1	33.0	26.3	104.0	487.0	448.0	545.0
243	3435	21.2	22.0	33.0	26.1	105.0	487.0	448.0	546.0
244	3450	21.2	22.0	34.0	26.1	104.0	486.0	447.0	552.0
245	3464	21.2	22.0	34.0	25.6	105.0	485.0	448.0	570.0
246	3478	21.2	21.9	33.0	26.3	103.0	484.0	455.0	595.0
247	3493	21.2	21.9	33.0	25.8	102.0	481.0	459.0	608.0
248	3507	21.2	21.9	33.0	26.0	103.0	480.0	465.0	616.0
249	3521	21.2	21.9	33.0	25.8	104.0	484.0	472.0	632.0
250	3536	21.2	22.0	33.0	26.4	105.0	489.0	481.0	654.0
251	3550	21.3	21.9	34.0	26.5	105.0	490.0	487.0	666.0
252	3564	21.2	21.9	33.0	26.0	105.0	493.0	493.0	673.0
253	3579	21.2	22.0	34.0	25.9	105.0	494.0	497.0	673.0
254	3593	21.2	22.0	34.0	26.0	105.0	497.0	501.0	676.0
255	3608	21.2	22.0	34.0	26.0	105.0	500.0	505.0	682.0
256	3622	21.3	21.9	34.0	26.1	106.0	502.0	509.0	684.0
257	3636	21.3	22.0	34.0	26.1	105.0	506.0	511.0	679.0
258	3650	21.4	21.9	34.0	26.2	105.0	509.0	512.0	679.0
259	3665	21.2	21.9	34.0	26.3	105.0	513.0	515.0	683.0
260	3679	21.2	21.9	34.0	25.5	106.0	515.0	517.0	680.0
261	3693	21.3	21.9	34.0	26.1	106.0	516.0	517.0	678.0
262	3707	21.2	22.0	34.0	26.1	106.0	518.0	518.0	676.0
263	3721	21.2	22.0	34.0	25.9	106.0	518.0	520.0	681.0
264	3736	21.2	21.9	34.0	25.5	106.0	518.0	522.0	683.0
265	3750	21.2	22.0	34.0	25.9	106.0	519.0	523.0	683.0
266	3765	21.2	22.0	34.0	26.7	106.0	519.0	524.0	684.0
267	3779	21.2	22.0	34.0	26.0	106.0	521.0	527.0	693.0
268	3793	21.3	21.9	34.0	25.8	106.0	522.0	519.0	680.0
269	3807	21.3	21.9	34.0	26.7	107.0	523.0	524.0	665.0
270	3822	21.3	22.0	34.0	26.6	107.0	527.0	521.0	653.0
271	3836	21.2	22.0	34.0	26.5	108.0	528.0	520.0	648.0
272	3850	21.2	22.0	34.0	26.5	107.0	531.0	519.0	645.0
273	3864	21.3	22.0	34.0	26.5	108.0	532.0	523.0	642.0
274	3879	21.2	22.1	35.0	26.4	108.0	530.0	520.0	634.0

275	3893	21.2	22.2	35.0	26.4	108.0	530.0	518.0	632.0
276	3908	21.2	22.1	35.0	26.6	108.0	531.0	517.0	625.0
277	3922	21.2	22.0	35.0	26.2	109.0	536.0	516.0	619.0
278	3936	21.2	22.0	35.0	26.3	109.0	537.0	513.0	623.0
279	3950	21.3	22.1	35.0	26.2	110.0	534.0	514.0	630.0
280	3964	21.2	22.1	35.0	26.1	110.0	531.0	513.0	627.0
281	3979	21.2	22.0	35.0	26.2	110.0	528.0	512.0	626.0
282	3993	21.2	22.0	35.0	26.4	110.0	526.0	512.0	628.0
283	4008	21.3	22.0	35.0	26.6	110.0	523.0	512.0	629.0
284	4022	21.3	22.0	35.0	26.5	111.0	522.0	512.0	628.0
285	4037	21.2	22.1	35.0	26.3	111.0	522.0	510.0	619.0
286	4051	21.2	22.1	35.0	26.8	112.0	521.0	507.0	606.0
287	4066	21.2	22.1	35.0	26.3	112.0	521.0	503.0	596.0
288	4080	21.2	22.1	35.0	27.3	112.0	523.0	503.0	600.0
289	4094	21.3	22.1	35.0	27.9	112.0	524.0	505.0	610.0
290	4108	21.3	22.1	35.0	28.2	113.0	523.0	507.0	609.0
291	4123	21.2	22.1	35.0	26.4	113.0	522.0	505.0	606.0
292	4134	21.3	22.1	36.0	27.3	114.0	523.0	505.0	608.0
293	4149	21.3	22.1	36.0	26.4	114.0	527.0	508.0	612.0
294	4163	21.2	22.2	36.0	27.7	114.0	528.0	509.0	615.0
295	4177	21.3	22.3	36.0	26.4	115.0	528.0	511.0	617.0
296	4192	21.2	22.2	36.0	26.5	115.0	526.0	512.0	626.0
297	4203	21.2	22.1	35.0	26.5	115.0	525.0	515.0	638.0
298	4218	21.3	22.1	35.0	26.3	114.0	523.0	518.0	647.0
299	4232	21.2	22.0	36.0	26.9	114.0	521.0	521.0	651.0
300	4244	21.2	22.1	36.0	26.5	113.0	519.0	529.0	656.0
301	4259	21.2	22.0	36.0	27.0	113.0	519.0	533.0	659.0
302	4273	21.2	22.0	36.0	26.0	113.0	518.0	535.0	662.0
303	4287	21.2	22.1	36.0	26.4	113.0	519.0	537.0	665.0
304	4302	21.2	22.1	36.0	26.2	113.0	520.0	538.0	663.0
305	4316	21.3	22.1	36.0	26.8	113.0	520.0	537.0	660.0
306	4331	21.2	22.0	36.0	26.2	113.0	520.0	545.0	660.0
307	4345	21.2	22.1	36.0	26.4	113.0	519.0	547.0	663.0
308	4359	21.2	22.1	36.0	26.6	113.0	520.0	548.0	662.0
309	4373	21.2	22.1	36.0	26.6	114.0	520.0	549.0	662.0
310	4387	21.3	22.1	36.0	26.5	114.0	521.0	549.0	659.0
311	4402	21.2	22.1	36.0	26.3	114.0	523.0	547.0	656.0
312	4416	21.3	22.0	36.0	26.4	114.0	524.0	548.0	659.0
313	4428	21.3	22.1	36.0	26.5	114.0	524.0	547.0	658.0
314	4442	21.2	22.1	36.0	26.4	115.0	522.0	544.0	657.0
315	4454	21.2	22.1	36.0	26.5	114.0	522.0	544.0	656.0
316	4468	21.2	22.1	36.0	26.7	114.0	525.0	544.0	653.0
317	4483	21.3	22.1	36.0	26.7	114.0	529.0	542.0	645.0
318	4497	21.2	22.0	36.0	26.7	115.0	528.0	541.0	636.0
319	4512	21.3	22.2	37.0	26.7	115.0	527.0	538.0	624.0
320	4526	21.3	22.2	36.0	26.6	115.0	527.0	533.0	610.0
321	4540	21.3	22.2	36.0	26.5	116.0	527.0	529.0	608.0
322	4554	21.3	22.1	36.0	26.2	116.0	528.0	530.0	618.0
323	4569	21.3	22.2	37.0	26.1	117.0	527.0	529.0	622.0
324	4583	21.2	22.2	37.0	26.5	117.0	530.0	529.0	620.0
325	4597	21.3	22.1	36.0	27.0	117.0	531.0	528.0	619.0
326	4612	21.3	22.2	36.0	26.8	117.0	527.0	529.0	623.0
327	4626	21.2	22.1	36.0	26.9	117.0	524.0	529.0	617.0
328	4640	21.3	22.[illegible]	37.0	26.7	118.0	523.0	528.0	607.0
329	4654	21.3	22.1	37.0	27.2	118.0	521.0	526.0	601.0
330	4669	21.3	22.2	37.0	26.8	118.0	522.0	525.0	602.0
331	4683	21.3	22.1	37.0	27.2	119.0	523.0	525.0	600.0
332	4697	21.3	22.2	37.0	26.6	119.0	523.0	524.0	596.0
333	4712	21.3	22.2	37.0	27.1	119.0	521.0	523.0	590.0

334	4726	21.2	22.2	37.0	26.7	120.0	520.0	520.0	583.0
335	4740	21.3	22.2	37.0	27.1	120.0	520.0	516.0	572.0
336	4755	21.3	22.3	37.0	26.8	121.0	521.0	510.0	567.0
337	4769	21.2	22.3	37.0	26.6	121.0	522.0	508.0	563.0
338	4783	21.2	22.1	37.0	27.5	122.0	523.0	505.0	560.0
339	4797	21.3	22.2	37.0	27.2	122.0	524.0	503.0	561.0
340	4812	21.2	22.3	37.0	27.0	124.0	527.0	503.0	561.0
341	4826	21.2	22.4	37.0	27.9	124.0	529.0	503.0	562.0
342	4840	21.3	22.3	38.0	26.1	125.0	529.0	502.0	567.0
343	4855	21.2	22.3	38.0	26.2	125.0	528.0	501.0	573.0
344	4869	21.3	22.3	38.0	26.6	126.0	527.0	499.0	575.0
345	4883	21.3	22.4	38.0	26.1	125.0	524.0	497.0	570.0
346	4898	21.3	22.3	38.0	26.4	126.0	522.0	494.0	560.0
347	4912	21.4	22.4	37.0	26.4	126.0	520.0	489.0	556.0
348	4926	21.2	22.4	37.0	26.5	127.0	519.0	487.0	563.0
349	4941	21.4	22.2	37.0	27.3	126.0	517.0	488.0	566.0
350	4955	21.4	22.4	38.0	26.9	126.0	516.0	490.0	570.0
351	4970	21.2	22.3	37.0	26.7	126.0	515.0	492.0	576.0
352	4981	21.3	22.2	38.0	26.8	125.0	513.0	495.0	581.0
353	4996	21.3	22.3	38.0	26.8	126.0	511.0	499.0	589.0
354	5010	21.3	22.4	38.0	26.8	125.0	512.0	501.0	590.0
355	5025	21.2	22.3	38.0	27.0	125.0	513.0	500.0	578.0
356	5039	21.2	22.3	38.0	26.7	125.0	513.0	497.0	563.0
357	5053	21.3	22.4	38.0	26.7	125.0	512.0	495.0	559.0
358	5067	21.3	22.3	38.0	27.1	125.0	512.0	497.0	563.0
359	5081	21.3	22.2	38.0	26.6	124.0	512.0	501.0	579.0
360	5096	21.3	22.3	38.0	26.5	123.0	510.0	507.0	595.0
361	5110	21.3	22.2	38.0	26.7	123.0	509.0	509.0	593.0
362	5125	21.2	22.3	38.0	28.0	123.0	512.0	509.0	586.0
363	5139	21.3	22.2	38.0	26.8	123.0	515.0	508.0	582.0
364	5154	21.3	22.2	38.0	27.1	122.0	514.0	509.0	583.0
365	5168	21.3	22.2	38.0	26.7	122.0	513.0	510.0	578.0
366	5182	21.3	22.3	38.0	27.1	122.0	513.0	507.0	567.0
367	5196	21.2	22.3	38.0	27.4	122.0	515.0	506.0	559.0
368	5211	21.2	22.3	38.0	26.8	122.0	516.0	508.0	565.0
369	5225	21.2	22.2	38.0	26.6	122.0	516.0	509.0	570.0
370	5240	21.3	22.3	38.0	26.4	122.0	518.0	508.0	571.0
371	5254	21.2	22.2	38.0	26.6	121.0	516.0	507.0	566.0
372	5268	21.2	22.3	38.0	27.0	121.0	515.0	508.0	569.0
373	5282	21.2	22.2	38.0	26.7	121.0	518.0	513.0	578.0
374	5296	21.2	22.1	38.0	26.4	120.0	519.0	514.0	581.0
375	5311	21.3	22.1	38.0	26.6	120.0	520.0	518.0	581.0
376	5325	21.6	22.2	38.0	26.6	120.0	521.0	521.0	584.0
377	5340	21.2	22.2	38.0	26.7	120.0	521.0	521.0	585.0
378	5354	21.2	22.3	38.0	27.4	120.0	522.0	551.0	646.0
379	5368	21.3	22.2	38.0	26.3	119.0	522.0	355.0	523.0
380	5382	21.3	22.2	38.0	27.2	119.0	522.0	150.0	241.0
381	5397	21.3	22.2	38.0	26.7	119.0	522.0	68.0	132.0
382	5411	21.3	22.2	38.0	27.1	119.0	522.0	46.0	84.0
383	5423	21.2	22.2	38.0	28.3	118.0	522.0	39.0	62.0
384	5437	21.2	22.2	38.0	26.9	118.0	523.0	36.0	48.0
385	5452	21.2	22.3	38.0	26.6	117.0	522.0	35.0	40.0
386	5466	21.2	22.2	38.0	26.5	117.0	525.0	33.0	36.0
387	5481	21.3	22.3	38.0	27.9	116.0	529.0	32.0	34.0
388	5495	21.3	22.2	38.0	26.9	117.0	530.0	31.0	34.0
389	5509	21.2	22.2	39.0	26.4	116.0	535.0	33.0	33.0
390	5523	21.3	22.3	38.0	26.7	116.0	537.0	33.0	33.0
391	5537	21.3	22.2	39.0	26.5	115.0	538.0	34.0	33.0
392	5552	21.2	22.2	39.0	26.5	115.0	538.0	33.0	33.0

393	5566	21.3	22.1	39.0	27.2	115.0	539.0	34.0	33.0
394	5580	21.3	22.2	39.0	26.9	114.0	537.0	33.0	33.0
395	5594	21.3	22.2	39.0	26.7	114.0	534.0	33.0	33.0
396	5609	21.3	22.1	38.0	26.9	114.0	527.0	33.0	33.0
397	5623	21.3	22.1	38.0	26.6	113.0	523.0	33.0	33.0
398	5637	21.3	22.1	39.0	26.2	113.0	518.0	34.0	33.0
399	5649	21.2	22.1	39.0	26.5	112.0	520.0	34.0	33.0
400	5664	21.2	22.1	39.0	26.6	112.0	527.0	34.0	33.0
401	5678	21.2	22.1	39.0	26.4	111.0	530.0	33.0	33.0
402	5692	21.2	22.2	39.0	27.6	111.0	531.0	33.0	33.0
403	5706	21.3	22.1	39.0	26.4	111.0	526.0	34.0	33.0
404	5720	21.4	22.1	39.0	26.8	111.0	530.0	33.0	33.0
405	5734	21.3	22.1	39.0	26.3	110.0	525.0	33.0	33.0
406	5748	21.3	22.1	39.0	26.5	110.0	518.0	34.0	33.0
407	5763	21.3	22.2	39.0	26.0	110.0	514.0	34.0	33.0
408	5777	21.5	22.2	39.0	26.6	110.0	510.0	34.0	34.0
409	5792	21.3	22.2	39.0	26.6	109.0	508.0	34.0	34.0
410	5806	21.3	22.1	39.0	27.7	109.0	507.0	34.0	34.0
411	5820	21.3	22.3	39.0	26.6	109.0	507.0	34.0	34.0
412	5834	21.3	22.1	39.0	26.7	109.0	506.0	34.0	33.0
413	5848	21.3	22.3	39.0	27.0	108.0	506.0	33.0	33.0
414	5862	21.3	22.2	39.0	27.8	108.0	506.0	33.0	33.0
415	5877	21.3	22.1	39.0	26.8	108.0	504.0	34.0	33.0
416	5891	21.2	22.0	39.0	27.0	107.0	505.0	33.0	33.0
417	5905	21.2	22.0	39.0	26.7	107.0	501.0	34.0	33.0
418	5919	21.3	22.1	39.0	27.6	106.0	501.0	34.0	33.0
419	5934	21.2	22.1	39.0	26.4	106.0	501.0	33.0	33.0
420	5948	21.3	22.0	39.0	26.9	106.0	501.0	34.0	33.0
421	5962	21.2	22.1	39.0	26.3	105.0	500.0	34.0	33.0
422	5976	21.3	22.1	39.0	26.6	105.0	499.0	34.0	33.0
423	5990	21.2	22.1	39.0	26.5	105.0	498.0	34.0	33.0
424	6005	21.3	22.1	39.0	27.0	104.0	497.0	34.0	33.0
425	6019	21.2	22.0	39.0	26.4	104.0	496.0	33.0	33.0
426	6034	21.2	22.1	39.0	26.8	104.0	495.0	33.0	33.0
427	6048	21.2	22.0	39.0	26.7	103.0	494.0	34.0	33.0
428	6062	21.2	22.0	39.0	26.7	103.0	492.0	33.0	33.0
429	6076	21.2	22.0	39.0	26.9	103.0	491.0	33.0	33.0
430	6090	21.2	22.1	39.0	26.6	102.0	490.0	34.0	33.0
431	6105	21.3	22.1	39.0	26.2	102.0	490.0	33.0	33.0
432	6119	21.4	22.1	39.0	26.8	101.0	489.0	33.0	33.0
433	6133	21.2	22.0	39.0	27.3	101.0	489.0	33.0	33.0
434	6147	21.2	22.1	39.0	26.7	101.0	488.0	34.0	33.0
435	6161	21.3	22.0	39.0	26.4	101.0	488.0	34.0	33.0
436	6176	23.0	22.0	39.0	26.7	100.0	487.0	34.0	33.0
437	6190	21.2	22.0	39.0	26.5	100.0	485.0	34.0	33.0
438	6204	21.2	22.0	39.0	26.1	100.0	483.0	33.0	33.0
439	6216	21.2	22.0	39.0	26.0	100.0	483.0	34.0	33.0
440	6230	21.2	22.0	39.0	28.8	99.0	481.0	33.0	32.0
441	6245	21.2	22.1	39.0	26.3	99.0	480.0	33.0	33.0
442	6258	21.3	21.9	39.0	26.8	98.0	478.0	33.0	33.0
443	6273	21.6	22.0	39.0	26.8	98.0	476.0	33.0	32.0
444	6287	21.2	22.0	39.0	27.4	98.0	474.0	32.0	32.0
445	6301	21.2	22.0	39.0	27.4	97.0	473.0	33.0	33.0
446	6313	21.2	22.0	39.0	27.0	97.0	472.0	33.0	33.0
447	6327	21.2	22.0	39.0	26.8	97.0	471.0	34.0	33.0
448	6341	21.2	22.0	39.0	27.5	97.0	469.0	34.0	33.0
449	6356	21.3	22.1	39.0	26.6	96.0	467.0	34.0	33.0
450	6370	21.2	22.0	39.0	26.7	96.0	466.0	34.0	33.0
451	6385	21.2	21.9	39.0	27.1	96.0	465.0	34.0	33.0

452	6399	21.2	22.1	39.0	26.8	96.0	463.0	34.0	33.0
453	6413	21.3	21.9	39.0	27.1	95.0	461.0	34.0	33.0
454	6427	21.2	22.0	39.0	27.2	95.0	460.0	34.0	34.0
455	6441	21.4	21.9	39.0	27.8	94.0	458.0	34.0	33.0
456	6456	21.2	21.9	39.0	27.0	94.0	457.0	34.0	34.0
457	6470	21.2	22.3	39.0	26.8	94.0	456.0	34.0	33.0
458	6484	21.2	21.9	39.0	26.6	94.0	455.0	33.0	33.0
459	6498	21.2	21.9	39.0	27.2	93.0	454.0	33.0	33.0
460	6513	21.3	21.9	39.0	27.0	93.0	454.0	33.0	33.0
461	6527	21.3	22.0	39.0	26.8	93.0	453.0	33.0	33.0
462	6542	21.4	21.9	39.0	26.8	92.0	454.0	33.0	33.0
463	6556	21.2	22.0	39.0	26.9	92.0	455.0	34.0	33.0
464	6570	21.3	21.9	39.0	26.9	92.0	456.0	33.0	33.0
465	6584	21.3	22.0	39.0	27.3	91.0	456.0	33.0	33.0
466	6599	21.2	21.8	39.0	26.7	91.0	457.0	33.0	33.0
467	6613	21.2	22.0	39.0	26.3	91.0	457.0	33.0	33.0
468	6627	21.3	22.0	39.0	26.8	91.0	459.0	34.0	33.0
469	6641	21.2	22.0	39.0	26.9	91.0	460.0	34.0	33.0
470	6655	21.2	22.1	39.0	26.2	91.0	460.0	34.0	33.0
471	6669	21.3	22.0	39.0	26.2	91.0	458.0	34.0	33.0
472	6683	21.3	21.9	39.0	26.6	91.0	457.0	34.0	33.0
473	6698	21.3	21.9	39.0	26.7	91.0	457.0	34.0	33.0
474	6712	21.3	21.9	39.0	26.7	90.0	456.0	34.0	33.0
475	6726	21.3	22.0	39.0	26.8	90.0	453.0	34.0	33.0
476	6740	21.3	21.9	39.0	26.4	90.0	453.0	34.0	33.0
477	6754	21.2	22.0	39.0	26.3	90.0	454.0	34.0	33.0
478	6768	21.3	22.0	39.0	26.2	90.0	454.0	33.0	33.0
479	6783	21.2	21.8	39.0	26.2	89.0	454.0	34.0	33.0
480	6797	21.2	22.0	39.0	26.2	90.0	454.0	33.0	33.0
481	6811	21.3	22.0	39.0	26.2	89.0	453.0	34.0	33.0
482	6825	21.2	21.9	39.0	26.1	89.0	452.0	33.0	33.0
483	6840	21.3	21.9	39.0	26.3	89.0	451.0	34.0	33.0
484	6854	21.3	21.9	39.0	26.5	88.0	449.0	35.0	33.0
485	6868	21.3	22.0	39.0	26.9	88.0	449.0	35.0	34.0
486	6882	21.3	21.9	39.0	26.0	88.0	449.0	34.0	33.0
487	6896	21.2	22.0	39.0	26.0	88.0	449.0	34.0	33.0
488	6911	21.3	21.9	39.0	26.7	88.0	449.0	34.0	33.0
489	6925	21.3	21.9	39.0	26.0	88.0	449.0	34.0	33.0
490	6939	21.3	22.0	39.0	26.5	88.0	449.0	33.0	33.0
491	6953	21.4	22.0	39.0	27.4	88.0	449.0	33.0	32.0
492	6968	21.3	21.9	39.0	25.9	88.0	449.0	34.0	33.0
493	6982	21.3	21.9	39.0	26.3	88.0	450.0	34.0	33.0
494	6996	21.3	21.9	39.0	26.7	88.0	450.0	34.0	33.0
495	7010	21.3	21.8	39.0	25.7	87.0	449.0	34.0	33.0
496	7024	21.3	21.8	39.0	26.4	87.0	448.0	33.0	33.0
497	7038	21.2	21.9	39.0	25.8	87.0	444.0	33.0	33.0
498	7053	21.3	22.0	39.0	25.7	87.0	441.0	33.0	33.0
499	7067	21.2	21.9	39.0	26.3	87.0	442.0	33.0	33.0
500	7081	21.2	21.9	39.0	26.7	86.0	444.0	33.0	33.0
501	7095	21.4	21.9	39.0	26.8	86.0	445.0	34.0	33.0
502	7109	21.3	21.9	39.0	26.6	86.0	446.0	33.0	33.0
503	7124	21.2	21.9	39.0	26.3	86.0	444.0	34.0	33.0
504	7138	21.2	21.9	39.0	26.3	85.0	445.0	34.0	33.0
505	7152	21.3	21.9	39.0	26.8	85.0	445.0	34 0	33.0
506	7166	21.3	21.8	39.0	26.0	85.0	446.0	34.0	33.0
507	7181	21.3	21.9	39.0	26.5	85.0	447.0	33.0	33.0
508	7192	21.3	22.0	39.0	26.2	85.0	447.0	33.0	33.0
509	7207	21.3	21.9	39.0	26.7	85.0	449.0	33.0	33.0
510	7221	21.3	21.9	39.0	26.3	85.0	451.0	33.0	33.0

511	7235	21.3	21.9	39.0	26.1	85.0	453.0	33.0	33.0
512	7249	21.3	21.9	39.0	26.2	85.0	453.0	33.0	33.0
513	7263	21.3	22.0	39.0	26.4	85.0	451.0	33.0	33.0
514	7277	21.3	22.0	39.0	26.2	85.0	450.0	34.0	33.0
515	7292	21.3	21.9	39.0	26.1	85.0	455.0	34.0	33.0
516	7303	21.3	22.0	39.0	26.6	85.0	458.0	33.0	33.0
517	7318	21.4	21.9	39.0	26.6	85.0	459.0	33.0	33.0
518	7332	21.3	21.9	39.0	26.0	85.0	460.0	34.0	33.0
519	7346	21.4	22.0	39.0	26.1	85.0	462.0	34.0	33.0
520	7361	21.3	22.0	39.0	26.4	85.0	462.0	34.0	33.0
521	7375	21.3	22.0	39.0	26.5	84.0	463.0	34.0	33.0
522	7389	21.3	22.0	39.0	26.5	84.0	463.0	34.0	34.0
523	7403	21.4	21.9	39.0	26.0	84.0	462.0	33.0	33.0
524	7418	21.3	22.0	39.0	27.4	84.0	462.0	34.0	33.0
525	7432	21.3	22.0	39.0	26.0	84.0	460.0	34.0	34.0
526	7446	21.3	22.1	39.0	26.0	83.0	460.0	34.0	34.0
527	7460	21.3	21.9	40.0	26.6	83.0	459.0	34.0	34.0
528	7475	21.3	22.0	39.0	25.9	83.0	459.0	33.0	32.0
529	7489	21.3	22.1	39.0	26.2	83.0	459.0	34.0	33.0
530	7503	21.3	21.9	39.0	25.8	83.0	459.0	34.0	34.0
531	7517	21.3	21.9	39.0	25.8	83.0	459.0	34.0	34.0
532	7532	21.3	21.9	39.0	26.8	82.0	458.0	34.0	34.0
533	7546	21.3	21.9	39.0	26.6	82.0	458.0	34.0	34.0
534	7560	21.3	22.0	39.0	26.2	82.0	458.0	35.0	34.0
535	7572	21.3	22.0	39.0	26.1	82.0	457.0	34.0	34.0
536	7583	21.4	22.0	39.0	26.5	81.0	456.0	34.0	34.0
537	7597	21.3	22.0	39.0	28.5	81.0	455.0	33.0	33.0
538	7611	21.3	21.9	39.0	27.6	80.0	455.0	34.0	33.0
539	7626	21.4	22.0	39.0	25.9	80.0	455.0	33.0	33.0
540	7640	21.3	22.0	39.0	26.3	80.0	454.0	33.0	32.0
541	7654	21.3	22.1	39.0	26.1	79.0	453.0	33.0	32.0
542	7668	21.4	22.0	39.0	25.7	79.0	453.0	34.0	33.0
543	7683	21.4	22.0	39.0	26.5	79.0	454.0	34.0	34.0
544	7697	21.4	21.9	39.0	25.8	79.0	453.0	34.0	34.0
545	7711	21.3	22.1	40.0	26.2	78.0	452.0	34.0	34.0
546	7725	21.3	22.0	39.0	26.5	78.0	452.0	34.0	34.0
547	7740	21.3	22.1	39.0	27.6	78.0	451.0	34.0	34.0
548	7754	21.5	22.0	39.0	27.7	78.0	450.0	34.0	33.0
549	7768	21.3	21.9	39.0	26.6	77.0	450.0	34.0	34.0
550	7782	21.3	22.0	39.0	26.6	77.0	449.0	34.0	34.0
551	7796	21.3	22.0	39.0	25.8	77.0	449.0	34.0	34.0
552	7810	21.3	21.9	39.0	26.1	77.0	449.0	34.0	34.0
553	7824	21.3	21.9	39.0	26.8	76.0	449.0	35.0	34.0
554	7839	21.4	22.0	39.0	26.4	76.0	446.0	35.0	34.0
555	7853	21.3	21.9	39.0	25.8	75.0	443.0	34.0	34.0
556	7867	21.3	21.9	39.0	26.0	75.0	440.0	34.0	34.0
557	7881	21.3	22.1	39.0	26.5	75.0	437.0	34.0	34.0
558	7896	21.6	21.9	39.0	26.1	74.0	433.0	34.0	34.0
559	7910	21.3	21.8	39.0	26.5	73.0	429.0	34.0	34.0
560	7924	21.4	21.8	39.0	25.8	72.0	424.0	35.0	34.0
561	7938	21.4	21.8	39.0	26.1	71.0	418.0	35.0	34.0
562	7953	21.3	21.8	39.0	25.9	70.0	413.0	34.0	34.0
563	7964	21.4	21.8	39.0	26.0	69.0	408.0	33.0	33.0
564	7979	21.4	21.7	39.0	26.6	68.0	403.0	32.0	32.0
565	7993	21.4	21.8	39.0	25.9	68.0	398.0	34.0	32.0
566	8007	21.4	21.7	39.0	25.8	67.0	394.0	34.0	33.0
567	8022	21.4	21.7	39.0	26.1	66.0	390.0	34.0	34.0
568	8036	21.3	21.7	39.0	25.8	65.0	386.0	34.0	34.0

569	8050	21.4	21.7	39.0	25.5	65.0	382.0	34.0	34.0
570	8062	21.4	21.7	39.0	25.9	64.0	378.0	34.0	34.0
571	8076	21.6	21.8	39.0	25.7	64.0	374.0	34.0	34.0
572	8090	21.3	21.8	39.0	26.1	64.0	371.0	35.0	34.0
573	8104	21.4	21.8	39.0	25.4	63.0	369.0	35.0	34.0
574	8118	21.3	21.8	39.0	25.8	62.0	364.0	34.0	34.0
575	8133	21.3	21.7	39.0	25.9	62.0	362.0	34.0	34.0
576	8144	21.4	21.7	39.0	25.5	61.0	356.0	34.0	34.0
577	8159	21.3	21.7	39.0	25.7	59.0	349.0	34.0	34.0
578	8173	21.3	21.7	39.0	26.0	60.0	345.0	34.0	34.0
579	8187	21.3	21.6	39.0	26.0	58.0	341.0	34.0	34.0
580	8201	21.3	21.7	39.0	26.0	57.0	338.0	34.0	34.0
581	8216	21.3	21.6	39.0	25.9	57.0	333.0	34.0	34.0
582	8230	21.3	21.6	39.0	26.3	56.0	330.0	34.0	34.0
583	8244	21.4	21.7	39.0	25.9	55.0	326.0	34.0	34.0
584	8258	21.4	21.6	39.0	26.0	55.0	322.0	34.0	34.0
585	8272	21.5	21.7	39.0	26.0	54.0	319.0	34.0	33.0
586	8287	21.3	21.6	39.0	25.7	53.0	315.0	34.0	34.0
587	8301	21.4	21.7	39.0	25.9	53.0	312.0	34.0	34.0
588	8315	21.4	21.7	39.0	26.1	53.0	308.0	34.0	33.0
589	8329	21.3	21.6	39.0	25.5	53.0	305.0	34.0	34.0
590	8344	21.4	21.6	39.0	26.0	52.0	304.0	34.0	33.0
591	8358	21.6	21.6	39.0	25.9	52.0	302.0	34.0	33.0
592	8372	21.4	21.7	39.0	26.2	52.0	299.0	34.0	33.0
593	8383	21.3	21.6	39.0	25.5	51.0	298.0	34.0	33.0
594	8398	21.3	21.7	39.0	25.7	51.0	296.0	34.0	33.0
595	8412	21.3	21.6	39.0	25.9	51.0	295.0	34.0	34.0
596	8427	21.3	21.6	39.0	25.7	51.0	293.0	34.0	33.0
597	8441	21.4	21.6	39.0	25.9	51.0	292.0	34.0	34.0
598	8455	21.4	21.7	39.0	25.9	50.0	290.0	34.0	34.0
599	8469	21.3	21.7	39.0	25.5	50.0	290.0	34.0	34.0
600	8481	21.3	21.6	39.0	25.8	50.0	289.0	34.0	34.0
601	8495	21.5	21.7	39.0	25.9	50.0	288.0	34.0	34.0
602	8509	21.5	21.7	39.0	25.6	50.0	287.0	34.0	34.0
603	8523	21.4	21.7	39.0	25.5	49.0	286.0	34.0	34.0
604	8537	21.4	21.7	39.0	25.7	49.0	286.0	35.0	34.0
605	8552	21.4	21.7	39.0	26.1	49.0	285.0	34.0	34.0
606	8566	21.4	21.6	39.0	25.8	49.0	284.0	35.0	34.0
607	8580	21.4	21.6	39.0	26.0	49.0	284.0	34.0	34.0
608	8594	21.4	21.7	39.0	25.8	49.0	283.0	34.0	34.0
609	8609	21.5	21.7	39.0	25.9	49.0	283.0	35.0	34.0
610	8623	21.4	21.7	39.0	25.7	49.0	281.0	34.0	34.0
611	8637	21.3	21.6	39.0	25.7	49.0	281.0	34.0	34.0
612	8651	21.6	21.7	39.0	25.8	48.0	280.0	34.0	34.0
613	8666	21.3	21.7	39.0	25.9	48.0	279.0	34.0	34.0
614	8680	21.3	21.7	39.0	25.7	48.0	278.0	34.0	34.0
615	8694	21.5	21.7	39.0	25.7	48.0	278.0	34.0	34.0
616	8708	21.4	21.6	39.0	25.5	48.0	277.0	34.0	34.0
617	8722	21.5	21.6	39.0	25.9	48.0	276.0	34.0	34.0
618	8736	21.4	21.7	39.0	25.8	48.0	275.0	34.0	34.0
619	8750	21.4	21.7	39.0	25.7	48.0	274.0	34.0	34.0
620	8765	21.4	21.7	39.0	25.7	47.0	274.0	34.0	34.0
621	8779	21.4	21.7	39.0	25.9	48.0	274.0	34.0	34.0
622	8793	21.3	21.8	39.0	25.4	48.0	275.0	34.0	34.0
623	8807	21.3	21.8	39.0	25.3	48.0	277.0	34.0	34.0
624	8822	21.4	21.8	39.0	26.3	49.0	278.0	34.0	34.0
625	8836	21.4	21.8	39.0	25.7	49.0	278.0	34.0	34.0
626	8850	21.4	21.7	39.0	25.4	49.0	280.0	34.0	33.0
627	8864	21.4	21.8	39.0	27.6	49.0	281.0	33.0	33.0

628	8879	21.4	21.7	39.0	26.1	49.0	283.0	34.0	33.0
629	8893	21.4	21.7	39.0	25.6	49.0	284.0	34.0	33.0
630	8907	21.3	21.7	39.0	25.4	49.0	285.0	34.0	34.0
631	8921	21.4	21.7	39.0	25.1	49.0	286.0	34.0	34.0
632	8935	21.4	21.7	39.0	25.9	49.0	287.0	33.0	33.0
633	8950	21.5	21.7	39.0	25.1	50.0	289.0	34.0	33.0
634	8964	21.4	21.7	39.0	26.0	50.0	290.0	34.0	33.0
635	8978	21.4	21.7	39.0	25.8	50.0	290.0	34.0	34.0
636	8992	21.4	21.8	39.0	25.5	50.0	292.0	34.0	34.0
637	9007	21.4	21.7	39.0	26.0	50.0	293.0	34.0	34.0
638	9021	21.5	21.7	39.0	26.2	50.0	293.0	34.0	33.0
639	9035	21.4	21.8	39.0	25.7	51.0	295.0	34.0	34.0
640	9049	21.6	21.8	39.0	25.6	51.0	298.0	34.0	34.0
641	9064	21.3	21.8	39.0	26.0	52.0	302.0	35.0	34.0
642	9078	21.3	21.8	39.0	25.5	52.0	305.0	35.0	34.0
643	9092	21.4	21.9	39.0	25.6	52.0	309.0	35.0	34.0
644	9106	21.3	21.9	39.0	26.0	53.0	312.0	35.0	34.0
645	9121	21.3	21.8	39.0	26.0	53.0	315.0	34.0	34.0
646	9135	21.4	21.9	39.0	26.1	54.0	317.0	34.0	34.0
647	9149	21.4	21.9	39.0	25.7	54.0	316.0	34.0	34.0
648	9163	21.6	21.8	39.0	26.1	53.0	314.0	34.0	34.0
649	9177	21.4	21.8	39.0	26.7	53.0	315.0	34.0	34.0
650	9192	21.4	21.8	39.0	26.8	53.0	316.0	34.0	34.0
651	9206	21.4	21.7	39.0	26.8	52.0	315.0	34.0	34.0
652	9221	21.4	21.6	39.0	26.5	51.0	314.0	34.0	34.0
653	9235	21.4	21.6	39.0	26.5	51.0	311.0	34.0	34.0
654	9249	21.4	21.6	39.0	26.9	51.0	310.0	34.0	34.0
655	9263	21.4	21.5	39.0	27.0	51.0	308.0	34.0	34.0
656	9277	21.4	21.5	39.0	26.5	50.0	307.0	34.0	34.0
657	9291	21.4	21.5	38.0	26.7	50.0	306.0	34.0	34.0
658	9306	21.4	21.5	38.0	26.8	50.0	306.0	34.0	34.0
659	9320	21.4	21.5	38.0	26.9	50.0	306.0	34.0	34.0
660	9334	21.4	21.5	38.0	27.2	50.0	307.0	35.0	34.0
661	9348	21.5	21.5	38.0	26.7	50.0	307.0	35.0	34.0
662	9362	21.4	21.5	38.0	26.5	50.0	307.0	35.0	34.0
663	9377	21.4	21.5	38.0	26.5	50.0	308.0	35.0	34.0
664	9391	21.4	21.5	38.0	26.5	50.0	310.0	34.0	34.0
665	9405	21.4	21.5	38.0	26.8	50.0	311.0	34.0	34.0
666	9419	21.4	21.5	38.0	26.9	50.0	313.0	34.0	34.0
667	9431	21.4	21.5	38.0	26.4	50.0	315.0	34.0	34.0
668	9443	21.4	21.5	38.0	26.5	50.0	317.0	35.0	34.0
669	9457	21.4	21.5	38.0	26.2	50.0	319.0	35.0	34.0
670	9471	21.4	21.5	38.0	26.4	50.0	321.0	35.0	34.0
671	9486	21.5	21.5	38.0	26.2	50.0	325.0	34.0	34.0
672	9500	21.4	21.5	38.0	26.2	50.0	329.0	34.0	34.0
673	9514	21.5	21.5	38.0	26.5	50.0	331.0	34.0	34.0
674	9528	21.4	21.5	38.0	26.5	50.0	334.0	34.0	34.0
675	9542	21.4	21.5	38.0	26.2	50.0	339.0	35.0	34.0
676	9554	21.5	21.6	38.0	26.8	50.0	343.0	34.0	34.0
677	9569	21.4	21.5	38.0	26.3	50.0	347.0	35.0	34.0
678	9583	21.5	21.5	38.0	26.4	50.0	350.0	34.0	34.0
679	9597	21.4	21.6	38.0	26.4	51.0	358.0	34.0	34.0
680	9611	21.4	21.6	38.0	26.7	51.0	372.0	34.0	34.0
681	9625	21.4	21.7	38.0	26.2	54.0	411.0	35.0	34.0
682	9640	21.4	21.7	38.0	26.2	54.0	434.0	35.0	34.0
683	9654	21.5	21.8	38.0	26.4	56.0	562.0	35.0	34.0
684	9668	21.4	21.9	38.0	26.2	57.0	644.0	35.0	34.0
685	9682	21.4	22.0	38.0	26.4	59.0	661.0	35.0	34.0
686	9696	21.4	21.9	38.0	26.2	59.0	556.0	35.0	34.0

687	9710	21.4	21.8	38.0	26.2	59.0	539.0	34.0	34.0
688	9725	21.4	21.9	38.0	26.2	62.0	642.0	34.0	34.0
689	9739	21.4	21.9	38.0	26.1	62.0	577.0	35.0	34.0

TEMPERATURE DATA :

THERMOCOUPLE NUMBERS (TEMPERATURES deg C)

NO.	TIME	9	10	11	12	13	14	15
1	2	9.5	3.3	3.3	3.9	3.9	3.3	4.5
2	16	28.1	22.0	22.0	22.7	22.7	22.0	22.7
3	31	28.1	22.0	22.0	22.7	22.7	22.0	22.9
4	45	28.1	22.0	22.0	22.7	23.3	22.0	22.8
5	60	96.0	49.0	40.0	36.0	22.7	31.0	22.9
6	74	110.0	58.0	53.0	46.0	23.3	38.0	22.8
7	87	124.0	64.0	55.0	49.0	23.3	38.0	22.8
8	102	135.0	72.0	57.0	52.0	22.7	41.0	23.2
9	116	132.0	67.0	51.0	49.0	23.3	38.0	22.8
10	131	172.0	83.0	60.0	58.0	23.4	43.0	22.8
11	145	218.0	97.0	73.0	76.0	23.4	54.0	22.7
12	159	182.0	91.0	66.0	69.0	23.4	51.0	23.3
13	173	137.0	78.0	58.0	60.0	23.4	46.0	22.9
14	188	113.0	71.0	54.0	55.0	23.4	44.0	22.9
15	201	103.0	65.0	51.0	51.0	23.4	42.0	22.9
16	216	93.0	55.0	46.0	46.0	23.4	40.0	22.9
17	230	86.0	45.0	38.0	40.0	23.4	35.0	22.9
18	244	82.0	39.0	34.0	38.0	23.4	31.0	22.9
19	256	81.0	36.0	32.0	37.0	23.4	29.7	22.9
20	270	82.0	33.0	29.7	37.0	23.4	27.8	22.8
21	284	82.0	32.0	28.4	37.0	23.4	27.2	22.9
22	298	79.0	32.0	27.2	37.0	23.4	25.9	22.9
23	313	79.0	31.0	26.6	37.0	23.4	25.3	22.9
24	327	78.0	30.0	26.0	36.0	23.5	24.7	23.0
25	342	87.0	29.7	26.0	36.0	24.1	24.7	23.1
26	356	107.0	29.7	26.0	36.0	24.1	24.1	23.1
27	370	136.0	29.1	25.3	36.0	24.1	24.1	23.1
28	384	145.0	29.7	25.4	37.0	24.1	24.1	23.2
29	399	186.0	28.5	24.7	36.0	24.1	24.1	23.2
30	413	175.0	29.1	24.8	36.0	24.8	24.1	23.4
31	427	189.0	29.1	24.8	36.0	24.8	24.1	23.1
32	441	219.0	29.8	24.8	37.0	24.8	24.1	23.2
33	456	216.0	30.0	24.8	39.0	24.8	24.1	23.4
34	470	184.0	31.0	24.9	40.0	24.8	24.1	23.2
35	485	139.0	31.0	24.8	42.0	24.8	24.2	23.4
36	499	94.0	30.0	24.8	43.0	24.8	24.2	23.3
37	513	83.0	29.2	24.8	43.0	25.4	24.2	23.3
38	528	84.0	29.2	24.2	42.0	25.5	24.2	23.4
39	542	97.0	29.2	24.2	42.0	25.5	24.2	23.4
40	556	114.0	29.9	24.2	42.0	25.5	24.2	23.9
41	570	121.0	28.6	24.9	42.0	25.5	23.6	23.5
42	582	141.0	28.6	24.9	43.0	25.5	23.6	23.7
43	596	131.0	28.6	24.9	43.0	25.5	24.2	23.6
44	611	134.0	28.6	24.9	43.0	26.1	24.3	23.6
45	625	117.0	29.3	25.5	44.0	25.5	24.3	23.6
46	639	131.0	31.0	25.5	45.0	26.1	24.3	23.6
47	653	186.0	31.0	25.5	46.0	26.2	24.3	23.6
48	668	316.0	31.0	26.2	47.0	26.2	24.3	23.9
49	679	341.0	32.0	26.2	48.0	26.2	23.7	24.0
50	694	243.0	31.0	25.6	49.0	26.2	24.3	23.8
51	708	268.0	31.0	25.6	49.0	26.2	24.3	23.9
52	723	323.0	31.0	25.6	50.0	26.2	24.3	24.1

53	737	482.0	31.0	25.6	51.0	26.2	24.3	23.8
54	751	683.0	32.0	25.6	52.0	26.2	24.4	24.0
55	766	765.0	32.0	25.6	57.0	26.2	24.4	24.0
56	779	818.0	32.0	25.6	58.0	26.2	25.0	24.0
57	794	834.0	33.0	25.7	59.0	26.3	24.4	24.0
58	808	916.0	34.0	26.3	59.0	26.3	25.0	24.0
59	822	935.0	34.0	26.3	60.0	26.3	25.0	24.0
60	836	883.0	34.0	26.3	61.0	26.3	25.1	24.1
61	851	977.0	35.0	26.9	61.0	26.9	25.7	24.1
62	865	916.0	37.0	27.6	62.0	27.0	25.1	24.2
63	880	1017.0	39.0	27.6	62.0	27.0	25.1	24.2
64	894	929.0	39.0	27.6	65.0	27.0	25.7	24.2
65	908	965.0	40.0	27.6	66.0	27.0	25.1	24.2
66	922	934.0	42.0	28.2	69.0	27.0	25.7	24.3
67	937	892.0	46.0	27.6	72.0	27.0	25.8	24.2
68	951	897.0	51.0	27.6	69.0	27.0	25.8	24.3
69	966	880.0	55.0	28.3	68.0	27.0	26.4	24.2
70	980	964.0	58.0	28.3	68.0	27.0	25.8	24.5
71	994	907.0	61.0	29.5	67.0	27.7	26.4	24.4
72	1008	894.0	66.0	29.6	66.0	27.1	26.5	24.5
73	1023	876.0	68.0	29.0	64.0	27.7	27.1	24.5
74	1037	880.0	80.0	29.0	61.0	27.7	27.1	24.4
75	1051	873.0	87.0	29.6	60.0	27.8	27.8	24.6
76	1066	885.0	89.0	30.0	73.0	27.8	27.8	24.7
77	1080	905.0	77.0	30.0	78.0	27.8	27.8	24.7
78	1095	958.0	70.0	31.0	78.0	27.8	28.4	24.7
79	1109	918.0	70.0	32.0	76.0	27.8	29.1	24.6
80	1123	900.0	64.0	32.0	75.0	28.4	29.1	24.8
81	1137	797.0	65.0	32.0	81.0	28.5	29.7	24.8
82	1152	876.0	64.0	32.0	83.0	28.5	29.7	24.8
83	1166	883.0	62.0	32.0	83.0	28.5	29.7	24.8
84	1181	914.0	58.0	32.0	89.0	28.5	29.8	25.1
85	1195	780.0	67.0	32.0	80.0	29.1	29.8	24.8
86	1209	520.0	69.0	32.0	93.0	29.2	29.2	24.9
87	1224	459.0	60.0	33.0	93.0	29.2	29.2	24.9
88	1238	776.0	55.0	34.0	91.0	29.2	29.2	24.9
89	1252	518.0	54.0	32.0	91.0	28.6	29.2	24.9
90	1267	520.0	50.0	32.0	90.0	29.2	29.2	24.9
91	1281	561.0	47.0	31.0	88.0	29.3	29.3	24.9
92	1295	688.0	44.0	31.0	91.0	28.7	29.3	25.0
93	1310	900.0	41.0	32.0	94.0	28.7	28.7	25.1
94	1324	727.0	40.0	31.0	95.0	28.7	28.7	25.0
95	1338	442.0	38.0	32.0	97.0	29.3	28.7	25.1
96	1352	260.0	37.0	31.0	97.0	28.7	28.7	25.3
97	1367	359.0	37.0	31.0	99.0	28.7	28.7	25.0
98	1381	368.0	37.0	31.0	98.0	28.7	28.7	25.2
99	1396	394.0	36.0	31.0	88.0	28.8	28.8	25.1
100	1410	521.0	34.0	31.0	81.0	28.8	28.8	25.2
101	1425	335.0	36.0	29.4	75.0	28.8	28.2	25.2
102	1439	242.0	34.0	28.8	70.0	28.8	28.2	25.3
103	1453	231.0	33.0	28.2	64.0	28.8	28.2	25.3
104	1467	193.0	35.0	28.2	59.0	28.9	28.2	25.3
105	1481	522.0	38.0	28.3	56.0	28.9	27.6	25.3
106	1494	804.0	40.0	28.3	62.0	28.9	27.6	25.4
107	1508	765.0	38.0	28.3	81.0	28.9	27.7	25.5
108	1522	878.0	37.0	28.9	98.0	28.9	27.0	25.3
109	1536	894.0	36.0	28.9	101.0	28.9	27.1	25.5
110	1551	908.0	36.0	29.0	102.0	29.0	27.1	25.5
111	1565	988.0	36.0	28.4	104.0	29.0	27.1	25.5

112	1579	964.0	35.0	29.0	103.0	29.0	27.8	25.6
113	1591	872.0	36.0	29.0	102.0	29.0	27.8	25.8
114	1605	955.0	36.0	28.4	100.0	29.0	28.4	25.7
115	1619	959.0	38.0	28.4	103.0	29.1	28.4	25.6
116	1634	927.0	37.0	28.4	100.0	28.4	29.1	25.7
117	1648	974.0	37.0	28.5	89.0	29.1	29.1	25.8
118	1662	923.0	37.0	29.1	85.0	29.1	28.5	25.8
119	1677	925.0	38.0	28.5	81.0	28.5	28.5	26.2
120	1691	993.0	39.0	27.9	70.0	28.5	27.9	25.8
121	1706	874.0	39.0	29.2	68.0	28.6	27.3	25.8
122	1720	812.0	40.0	29.2	67.0	28.6	26.7	25.9
123	1734	793.0	42.0	28.6	57.0	28.6	26.7	26.0
124	1748	803.0	46.0	28.6	54.0	28.6	26.7	26.1
125	1763	889.0	50.0	28.6	53.0	29.2	26.7	25.9
126	1777	899.0	54.0	28.6	55.0	28.6	26.8	26.0
127	1791	892.0	59.0	28.7	55.0	28.7	27.4	26.0
128	1803	952.0	67.0	28.0	55.0	28.7	28.0	26.1
129	1817	866.0	75.0	28.1	56.0	28.7	28.7	26.0
130	1831	863.0	85.0	28.1	52.0	32.0	28.7	26.0
131	1846	837.0	101.0	29.3	55.0	28.7	29.3	26.1
132	1860	828.0	109.0	30.0	54.0	28.7	29.4	26.2
133	1875	853.0	102.0	31.0	54.0	28.7	29.4	26.3
134	1889	862.0	108.0	30.0	50.0	28.8	28.8	26.2
135	1903	828.0	120.0	30.0	48.0	28.8	28.8	26.2
136	1918	801.0	143.0	30.0	51.0	28.8	28.8	26.2
137	1932	795.0	144.0	28.8	51.0	28.8	28.2	26.2
138	1948	831.0	185.0	29.5	50.0	28.9	27.0	26.5
139	1962	805.0	256.0	30.0	52.0	28.9	27.0	26.3
140	1977	817.0	250.0	28.9	51.0	28.9	27.0	26.4
141	1991	838.0	419.0	29.5	53.0	28.9	27.0	26.3
142	2005	851.0	375.0	28.9	50.0	28.9	27.1	26.5
143	2019	862.0	295.0	28.9	50.0	28.9	27.7	26.4
144	2034	824.0	277.0	29.6	48.0	29.0	27.7	26.5
145	2048	835.0	270.0	30.0	49.0	29.0	27.1	26.6
146	2063	833.0	245.0	30.0	51.0	29.0	27.2	26.7
147	2077	848.0	241.0	29.7	50.0	29.0	27.2	26.7
148	2091	830.0	253.0	30.0	53.0	29.0	27.8	26.7
149	2105	797.0	254.0	30.0	50.0	29.1	27.2	26.6
150	2119	803.0	291.0	31.0	50.0	29.1	27.2	26.7
151	2134	799.0	340.0	32.0	50.0	29.1	26.6	26.6
152	2148	804.0	333.0	30.0	48.0	29.1	32.0	26.8
153	2163	804.0	336.0	29.8	46.0	29.1	26.6	26.8
154	2177	799.0	362.0	29.8	49.0	29.2	27.3	26.8
155	2191	794.0	375.0	29.8	50.0	29.2	26.7	26.8
156	2203	807.0	532.0	30.0	52.0	29.2	26.7	26.7
157	2218	809.0	702.0	30.0	54.0	29.2	26.7	26.9
158	2232	781.0	745.0	31.0	53.0	29.2	27.4	26.9
159	2246	781.0	705.0	31.0	52.0	29.3	27.4	26.8
160	2258	786.0	576.0	31.0	55.0	29.3	27.4	26.9
161	2272	812.0	758.0	32.0	52.0	28.7	28.0	26.9
162	2286	803.0	717.0	32.0	52.0	29.3	28.1	27.0
163	2301	819.0	643.0	32.0	55.0	28.7	28.1	27.0
164	2315	808.0	671.0	32.0	58.0	29.3	28.1	27.0
165	2329	804.0	714.0	33.0	63.0	28.8	28.8	27.1
166	2343	800.0	711.0	34.0	62.0	29.4	28.8	27.0
167	2357	804.0	789.0	33.0	57.0	28.8	28.8	27.2
168	2369	803.0	837.0	34.0	58.0	28.8	28.8	27.0
169	2383	802.0	859.0	34.0	56.0	28.8	28.8	27.1
170	2398	803.0	890.0	34.0	53.0	28.8	28.8	27.1

171	2412	787.0	870.0	35.0	53.0	28.8	28.2	27.2
172	2427	786.0	839.0	35.0	52.0	28.9	28.2	27.2
173	2441	782.0	845.0	36.0	53.0	28.9	28.3	27.3
174	2456	759.0	808.0	38.0	54.0	28.9	28.3	27.2
175	2470	763.0	789.0	40.0	54.0	28.9	28.3	27.4
176	2484	756.0	839.0	42.0	55.0	29.0	27.7	27.2
177	2498	751.0	817.0	45.0	58.0	29.0	27.7	27.3
178	2513	748.0	855.0	41.0	65.0	29.0	28.4	27.2
179	2527	748.0	812.0	41.0	66.0	29.0	29.0	27.4
180	2541	759.0	791.0	44.0	66.0	29.0	28.4	27.3
181	2555	762.0	769.0	44.0	70.0	29.0	29.0	27.3
182	2569	753.0	896.0	38.0	72.0	29.1	28.4	27.4
183	2584	757.0	886.0	39.0	63.0	29.7	28.4	27.4
184	2598	759.0	949.0	38.0	63.0	29.1	28.5	27.5
185	2613	756.0	839.0	37.0	60.0	29.1	28.5	27.5
186	2627	762.0	838.0	38.0	58.0	29.1	28.5	27.5
187	2639	769.0	761.0	37.0	60.0	29.2	28.5	27.5
188	2653	767.0	733.0	35.0	61.0	29.2	27.9	27.5
189	2668	756.0	934.0	38.0	61.0	29.2	27.9	27.6
190	2682	761.0	937.0	38.0	59.0	29.2	27.9	27.9
191	2696	765.0	882.0	38.0	58.0	29.2	28.0	27.7
192	2710	754.0	872.0	37.0	53.0	29.2	28.6	27.6
193	2725	756.0	793.0	36.0	55.0	29.2	28.6	27.6
194	2739	752.0	827.0	39.0	54.0	29.3	29.3	28.0
195	2753	746.0	790.0	39.0	54.0	29.3	29.3	32.0
196	2767	738.0	740.0	39.0	54.0	28.7	29.3	27.7
197	2782	725.0	800.0	41.0	53.0	28.7	29.3	27.7
198	2796	710.0	789.0	42.0	53.0	28.7	28.7	27.7
199	2810	717.0	786.0	44.0	53.0	28.7	28.7	27.7
200	2824	706.0	766.0	44.0	53.0	28.8	28.8	27.9
201	2838	687.0	846.0	42.0	54.0	28.8	28.8	27.9
202	2853	685.0	897.0	44.0	50.0	28.8	28.8	27.9
203	2867	688.0	852.0	44.0	50.0	28.8	28.8	27.9
204	2882	681.0	908.0	43.0	52.0	28.8	28.8	28.0
205	2896	670.0	798.0	44.0	51.0	28.8	28.8	28.0
206	2910	664.0	837.0	48.0	56.0	28.9	28.9	28.0
207	2924	664.0	842.0	50.0	59.0	28.9	29.5	28.1
208	2939	669.0	893.0	51.0	61.0	28.9	30.0	28.1
209	2953	666.0	879.0	55.0	56.0	28.9	30.0	28.3
210	2967	670.0	976.0	48.0	58.0	28.9	30.0	28.2
211	2981	675.0	990.0	48.0	58.0	28.9	30.0	28.0
212	2996	674.0	943.0	58.0	54.0	29.0	31.0	28.2
213	3010	674.0	897.0	56.0	56.0	29.0	31.0	28.2
214	3021	672.0	849.0	58.0	56.0	29.0	30.0	28.3
215	3036	667.0	860.0	60.0	55.0	29.0	29.6	28.2
216	3050	654.0	834.0	61.0	56.0	28.4	29.6	28.4
217	3065	650.0	754.0	68.0	59.0	28.4	29.7	28.3
218	3079	654.0	767.0	77.0	58.0	29.0	29.0	28.4
219	3094	651.0	871.0	78.0	58.0	28.4	29.1	28.4
220	3108	653.0	830.0	86.0	57.0	29.1	28.4	28.4
221	3122	659.0	852.0	88.0	57.0	28.5	28.5	28.5
222	3137	671.0	833.0	83.0	60.0	28.5	27.9	28.5
223	3151	677.0	847.0	88.0	60.0	28.5	28.5	28.5
224	3165	678.0	840.0	93.0	62.0	28.5	29.2	28.5
225	3180	669.0	834.0	95.0	62.0	28.5	29.2	28.5
226	3194	668.0	837.0	94.0	60.0	28.6	29.2	28.4
227	3208	669.0	791.0	91.0	58.0	28.6	29.8	28.5
228	3222	665.0	811.0	101.0	59.0	28.6	29.2	28.7
229	3237	658.0	828.0	106.0	65.0	28.6	29.2	28.6

230	3251	653.0	827.0	107.0	63.0	28.6	29.2	28.5
231	3265	656.0	851.0	109.0	65.0	28.6	29.9	28.7
232	3280	660.0	818.0	111.0	68.0	28.6	29.9	28.5
233	3294	662.0	761.0	117.0	67.0	28.6	29.9	28.5
234	3309	655.0	797.0	122.0	68.0	28.7	29.3	28.5
235	3323	651.0	722.0	125.0	69.0	28.1	29.3	28.5
236	3338	643.0	730.0	142.0	69.0	28.1	29.3	28.6
237	3352	629.0	799.0	165.0	72.0	28.1	29.3	28.6
238	3366	621.0	806.0	162.0	78.0	28.1	29.4	28.6
239	3380	619.0	761.0	149.0	80.0	28.1	29.4	28.6
240	3395	616.0	772.0	166.0	84.0	28.8	30.0	28.6
241	3409	615.0	792.0	135.0	80.0	28.2	29.4	28.5
242	3421	623.0	792.0	136.0	75.0	28.2	28.8	28.6
243	3435	636.0	798.0	169.0	72.0	28.2	28.8	28.7
244	3450	648.0	822.0	206.0	67.0	28.2	29.4	28.5
245	3464	672.0	853.0	207.0	67.0	28.2	29.4	28.7
246	3478	691.0	821.0	227.0	75.0	28.2	29.5	28.7
247	3493	698.0	805.0	239.0	126.0	28.2	30.0	28.7
248	3507	697.0	806.0	207.0	97.0	28.3	31.0	28.7
249	3521	715.0	836.0	230.0	76.0	28.3	29.5	28.8
250	3536	739.0	825.0	239.0	63.0	28.3	29.5	28.8
251	3550	748.0	815.0	388.0	58.0	28.9	29.6	30.0
252	3564	746.0	794.0	424.0	76.0	28.9	29.6	28.8
253	3579	743.0	807.0	338.0	117.0	29.0	30.0	28.7
254	3593	747.0	818.0	391.0	142.0	29.0	30.0	28.9
255	3608	750.0	786.0	534.0	73.0	29.0	31.0	28.8
256	3622	743.0	774.0	549.0	61.0	29.0	30.0	28.8
257	3636	731.0	790.0	412.0	59.0	29.0	30.0	29.0
258	3650	734.0	805.0	441.0	89.0	29.0	30.0	28.9
259	3665	736.0	790.0	371.0	101.0	29.0	30.0	28.9
260	3679	732.0	795.0	480.0	116.0	29.1	30.0	28.9
261	3693	734.0	786.0	513.0	87.0	29.7	31.0	28.9
262	3707	737.0	791.0	726.0	83.0	29.1	31.0	29.0
263	3721	742.0	789.0	501.0	67.0	29.1	31.0	31.0
264	3736	739.0	786.0	684.0	60.0	29.1	31.0	29.2
265	3750	738.0	790.0	664.0	59.0	29.1	31.0	29.1
266	3765	743.0	767.0	505.0	50.0	29.8	32.0	29.2
267	3779	739.0	756.0	509.0	53.0	29.1	32.0	29.0
268	3793	712.0	743.0	505.0	56.0	29.2	32.0	29.1
269	3807	694.0	744.0	489.0	54.0	29.8	32.0	29.1
270	3822	687.0	746.0	588.0	55.0	29.2	31.0	29.2
271	3836	687.0	747.0	680.0	51.0	29.8	30.0	29.2
272	3850	684.0	746.0	755.0	51.0	29.8	31.0	29.2
273	3864	678.0	756.0	717.0	53.0	29.8	31.0	29.3
274	3879	673.0	747.0	718.0	51.0	29.2	30.0	29.2
275	3893	673.0	722.0	765.0	49.0	29.3	31.0	29.2
276	3908	664.0	722.0	707.0	54.0	29.3	31.0	29.3
277	3922	667.0	728.0	780.0	55.0	29.3	31.0	29.4
278	3936	678.0	730.0	835.0	51.0	29.3	31.0	29.4
279	3950	680.0	730.0	849.0	57.0	29.3	32.0	29.4
280	3964	674.0	743.0	880.0	49.0	29.3	33.0	29.4
281	3979	677.0	762.0	926.0	52.0	29.3	32.0	29.4
282	3993	680.0	756.0	961.0	55.0	29.3	33.0	29.4
283	4008	677.0	745.0	813.0	56.0	34.0	33.0	29.4
284	4022	667.0	722.0	793.0	51.0	29.4	34.0	29.4
285	4037	654.0	707.0	724.0	49.0	29.4	34.0	29.6
286	4051	644.0	689.0	721.0	47.0	29.4	34.0	29.5
287	4066	641.0	687.0	743.0	50.0	29.4	36.0	29.7
288	4080	647.0	682.0	945.0	51.0	29.4	37.0	29.5

289	4094	650.0	691.0	885.0	51.0	29.4	38.0	29.5
290	4108	647.0	704.0	759.0	53.0	29.5	39.0	29.5
291	4123	654.0	712.0	760.0	56.0	29.5	40.0	29.5
292	4134	661.0	707.0	724.0	62.0	29.5	41.0	29.7
293	4149	665.0	706.0	788.0	67.0	29.5	41.0	29.6
294	4163	664.0	715.0	845.0	110.0	29.5	41.0	29.7
295	4177	674.0	730.0	849.0	351.0	29.5	40.0	29.6
296	4192	694.0	745.0	861.0	185.0	29.5	42.0	29.7
297	4203	703.0	746.0	877.0	141.0	29.5	43.0	29.6
298	4218	708.0	745.0	980.0	118.0	30.0	42.0	29.6
299	4232	711.0	755.0	921.0	153.0	29.5	43.0	29.7
300	4244	713.0	752.0	807.0	110.0	29.6	45.0	29.6
301	4259	716.0	736.0	835.0	107.0	29.6	45.0	29.6
302	4273	718.0	730.0	799.0	75.0	29.6	46.0	29.8
303	4287	717.0	727.0	763.0	97.0	29.6	46.0	29.7
304	4302	712.0	708.0	798.0	69.0	29.6	44.0	29.8
305	4316	705.0	700.0	768.0	67.0	29.6	45.0	29.8
306	4331	705.0	703.0	685.0	85.0	29.7	44.0	29.8
307	4345	702.0	706.0	624.0	95.0	29.7	45.0	30.0
308	4359	700.0	711.0	586.0	98.0	29.7	48.0	30.0
309	4373	700.0	716.0	621.0	86.0	29.7	52.0	29.9
310	4387	699.0	700.0	647.0	87.0	29.7	50.0	29.9
311	4402	697.0	693.0	681.0	86.0	29.7	52.0	29.9
312	4416	695.0	675.0	747.0	86.0	29.7	52.0	29.9
313	4428	693.0	662.0	811.0	107.0	29.7	48.0	29.9
314	4442	693.0	662.0	783.0	100.0	29.7	48.0	30.0
315	4454	690.0	666.0	749.0	84.0	29.7	47.0	30.0
316	4468	685.0	669.0	738.0	73.0	29.8	43.0	30.0
317	4483	676.0	679.0	776.0	73.0	29.8	42.0	30.0
318	4497	668.0	682.0	862.0	78.0	29.8	42.0	30.0
319	4512	655.0	681.0	899.0	71.0	29.8	40.0	30.0
320	4526	647.0	684.0	860.0	70.0	29.8	39.0	30.0
321	4540	653.0	689.0	811.0	67.0	29.8	37.0	30.0
322	4554	659.0	678.0	867.0	62.0	29.8	37.0	30.0
323	4569	655.0	664.0	901.0	68.0	29.2	37.0	30.0
324	4583	648.0	669.0	889.0	60.0	29.2	37.0	31.0
325	4597	654.0	680.0	881.0	63.0	29.2	38.0	30.0
326	4612	654.0	678.0	823.0	62.0	29.3	38.0	30.0
327	4626	647.0	678.0	738.0	64.0	29.9	37.0	30.0
328	4640	636.0	682.0	758.0	62.0	29.3	38.0	31.0
329	4654	636.0	672.0	740.0	55.0	29.3	39.0	30.0
330	4669	636.0	663.0	778.0	54.0	29.3	39.0	30.0
331	4683	631.0	664.0	782.0	60.0	29.3	38.0	30.0
332	4697	625.0	667.0	747.0	58.0	29.3	38.0	30.0
333	4712	620.0	668.0	748.0	56.0	29.3	37.0	30.0
334	4726	613.0	674.0	738.0	53.0	29.3	37.0	30.0
335	4740	609.0	664.0	788.0	55.0	29.3	36.0	30.0
336	4755	606.0	654.0	769.0	59.0	29.4	36.0	30.0
337	4769	598.0	663.0	802.0	59.0	29.4	34.0	30.0
338	4783	595.0	676.0	848.0	56.0	29.4	34.0	30.0
339	4797	597.0	691.0	813.0	61.0	29.4	35.0	30.0
340	4812	605.0	696.0	793.0	72.0	29.4	36.0	30.0
341	4826	619.0	697.0	781.0	67.0	29.4	36.0	31.0
342	4840	631.0	689.0	899.0	63.0	29.4	36.0	30.0
343	4855	635.0	688.0	746.0	59.0	29.5	37.0	31.0
344	4869	628.0	697.0	676.0	67.0	29.5	36.0	31.0
345	4883	621.0	712.0	661.0	66.0	29.5	36.0	31.0
346	4898	619.0	722.0	725.0	77.0	29.5	35.0	31.0
347	4912	631.0	730.0	726.0	69.0	28.9	35.0	31.0

348	4926	633.0	727.0	795.0	75.0	28.9	35.0	30.0
349	4941	634.0	728.0	702.0	72.0	29.5	35.0	31.0
350	4955	644.0	721.0	651.0	68.0	28.9	35.0	31.0
351	4970	648.0	713.0	736.0	67.0	28.9	35.0	31.0
352	4981	654.0	700.0	739.0	73.0	28.9	34.0	31.0
353	4996	654.0	672.0	811.0	79.0	28.9	34.0	31.0
354	5010	637.0	657.0	860.0	77.0	29.0	33.0	31.0
355	5025	613.0	658.0	789.0	84.0	29.0	35.0	31.0
356	5039	602.0	669.0	756.0	83.0	29.0	35.0	31.0
357	5053	606.0	676.0	783.0	79.0	29.0	35.0	31.0
358	5067	622.0	681.0	763.0	76.0	29.0	34.0	31.0
359	5081	643.0	684.0	857.0	77.0	29.0	33.0	31.0
360	5096	644.0	687.0	827.0	84.0	29.0	35.0	31.0
361	5110	636.0	696.0	833.0	86.0	29.0	33.0	31.0
362	5125	634.0	693.0	915.0	84.0	29.0	35.0	31.0
363	5139	634.0	692.0	825.0	76.0	29.0	35.0	31.0
364	5154	627.0	684.0	789.0	74.0	29.0	35.0	31.0
365	5168	612.0	682.0	862.0	79.0	29.0	35.0	31.0
366	5182	602.0	688.0	822.0	91.0	29.1	33.0	31.0
367	5196	604.0	687.0	778.0	87.0	29.1	32.0	31.0
368	5211	613.0	678.0	797.0	92.0	29.1	33.0	31.0
369	5225	617.0	673.0	719.0	97.0	29.1	35.0	31.0
370	5240	615.0	671.0	808.0	94.0	29.1	35.0	31.0
371	5254	618.0	675.0	842.0	79.0	29.1	35.0	31.0
372	5268	628.0	677.0	836.0	83.0	29.1	35.0	31.0
373	5282	633.0	672.0	868.0	86.0	29.1	34.0	31.0
374	5296	636.0	681.0	754.0	93.0	29.1	35.0	31.0
375	5311	637.0	694.0	781.0	88.0	29.1	35.0	31.0
376	5325	640.0	696.0	746.0	99.0	29.1	35.0	31.0
377	5340	640.0	699.0	807.0	88.0	29.2	35.0	31.0
378	5354	651.0	703.0	599.0	87.0	28.5	35.0	31.0
379	5368	530.0	524.0	331.0	83.0	28.5	37.0	31.0
380	5382	286.0	289.0	189.0	85.0	28.6	34.0	31.0
381	5397	159.0	187.0	150.0	104.0	27.9	35.0	31.0
382	5411	106.0	128.0	112.0	88.0	27.3	35.0	32.0
383	5423	78.0	97.0	89.0	96.0	27.3	34.0	31.0
384	5437	59.0	73.0	69.0	107.0	26.7	33.0	31.0
385	5452	48.0	55.0	55.0	81.0	26.7	32.0	31.0
386	5466	42.0	46.0	47.0	72.0	26.1	30.0	31.0
387	5481	37.0	38.0	39.0	73.0	25.5	29.3	31.0
388	5495	35.0	33.0	33.0	66.0	26.1	27.4	31.0
389	5509	34.0	30.0	31.0	62.0	24.9	27.4	31.0
390	5523	34.0	28.6	29.9	66.0	24.9	26.1	31.0
391	5537	34.0	28.0	28.6	78.0	24.9	26.1	31.0
392	5552	33.0	28.0	28.0	74.0	24.3	25.5	31.0
393	5566	33.0	28.0	28.0	75.0	24.3	25.5	31.0
394	5580	33.0	27.4	27.4	80.0	24.3	25.6	31.0
395	5594	33.0	27.4	27.4	77.0	24.3	24.9	31.0
396	5609	33.0	27.4	26.3	71.0	24.3	24.9	31.0
397	5623	33.0	27.4	26.8	73.0	23.7	24.9	31.0
398	5637	33.0	27.5	26.8	73.0	23.7	24.3	31.0
399	5649	33.0	27.5	26.9	85.0	23.7	24.3	32.0
400	5664	33.0	27.5	26.8	87.0	23.1	24.3	31.0
401	5678	33.0	26.8	26.8	68.0	23.1	24.3	31.0
402	5692	33.0	26.9	26.2	65.0	23.1	24.4	31.0
403	5706	33.0	26.9	26.9	66.0	23.1	24.4	31.0
404	5720	33.0	26.9	26.9	61.0	23.1	24.4	31.0
405	5734	33.0	26.9	26.2	73.0	23.1	24.4	31.0
406	5748	33.0	26.9	26.3	77.0	23.1	24.4	31.0

407	5763	33.0	26.9	26.3	82.0	22.5	24.4	31.0
408	5777	34.0	27.5	26.9	72.0	22.5	23.8	31.0
409	5792	34.0	26.9	26.9	142.0	22.5	24.4	31.0
410	5806	34.0	26.9	26.9	132.0	22.5	24.4	31.0
411	5820	34.0	26.9	26.9	110.0	22.5	24.4	31.0
412	5834	34.0	26.9	26.9	111.0	22.5	24.4	31.0
413	5848	33.0	26.9	26.3	108.0	22.6	25.1	31.0
414	5862	33.0	26.9	26.3	97.0	22.6	24.4	32.0
415	5877	33.0	26.9	26.3	98.0	22.6	25.1	31.0
416	5891	33.0	26.9	26.3	117.0	22.6	25.1	31.0
417	5905	33.0	26.9	26.3	157.0	22.6	25.1	31.0
418	5919	33.0	27.0	27.0	108.0	22.6	24.5	31.0
419	5934	33.0	27.0	26.4	92.0	22.6	24.5	32.0
420	5948	33.0	26.9	26.3	90.0	22.5	25.0	31.0
421	5962	33.0	27.0	26.4	87.0	22.6	24.5	31.0
422	5976	33.0	27.0	26.4	84.0	22.0	25.1	31.0
423	5990	33.0	27.0	26.4	100.0	22.0	24.5	31.0
424	6005	34.0	27.0	26.4	137.0	22.6	24.5	31.0
425	6019	33.0	27.0	26.4	147.0	22.7	24.5	31.0
426	6034	33.0	26.4	26.4	169.0	22.0	25.2	32.0
427	6048	33.0	27.0	26.4	137.0	22.0	25.2	31.0
428	6062	33.0	27.0	26.4	122.0	22.0	25.2	32.0
429	6076	33.0	27.0	26.4	136.0	22.0	25.2	31.0
430	6090	33.0	27.1	26.4	124.0	22.1	25.2	31.0
431	6105	33.0	27.1	26.4	122.0	22.1	25.2	31.0
432	6119	33.0	27.1	26.4	87.0	22.1	25.2	31.0
433	6133	33.0	26.4	26.4	107.0	22.1	25.2	31.0
434	6147	34.0	27.1	26.4	91.0	22.1	24.6	32.0
435	6161	33.0	27.1	26.5	111.0	22.1	24.6	31.0
436	6176	33.0	27.1	26.5	136.0	22.1	24.6	31.0
437	6190	33.0	27.1	26.5	252.0	22.1	24.6	31.0
438	6204	33.0	27.1	26.5	502.0	22.1	24.6	31.0
439	6216	33.0	26.5	26.5	545.0	22.1	24.6	31.0
440	6230	33.0	26.5	26.5	421.0	22.1	24.6	31.0
441	6245	33.0	26.5	26.5	229.0	22.1	24.6	32.0
442	6258	33.0	26.5	25.9	166.0	23.4	24.6	32.0
443	6273	32.0	25.9	25.9	120.0	22.1	24.6	32.0
444	6287	32.0	25.9	25.9	120.0	22.1	24.0	31.0
445	6301	33.0	25.9	25.9	126.0	22.1	24.0	31.0
446	6313	33.0	26.5	25.9	173.0	22.1	24.0	33.0
447	6327	33.0	27.1	26.5	242.0	21.5	24.6	31.0
448	6341	33.0	27.1	26.5	213.0	21.5	24.0	31.0
449	6356	33.0	27.2	26.6	282.0	22.2	24.1	31.0
450	6370	33.0	27.2	26.6	154.0	21.5	24.1	31.0
451	6385	33.0	27.2	26.6	139.0	21.5	24.7	32.0
452	6399	33.0	27.2	26.6	183.0	22.2	24.1	31.0
453	6413	33.0	27.2	26.6	207.0	22.2	24.1	32.0
454	6427	34.0	27.2	26.6	152.0	21.5	24.7	31.0
455	6441	33.0	27.2	26.6	141.0	21.6	24.1	31.0
456	6456	34.0	27.2	27.2	133.0	21.6	24.7	32.0
457	6470	33.0	27.2	26.6	110.0	21.6	24.1	31.0
458	6484	33.0	26.6	26.6	83.0	22.2	24.1	32.0
459	6498	33.0	26.6	26.0	84.0	21.6	24.1	31.0
460	6513	33.0	26.6	26.6	76.0	21.6	24.1	32.0
461	6527	33.0	26.6	26.0	69.0	22.2	24.1	32.0
462	6542	33.0	26.6	26.0	85.0	21.6	23.5	32.0
463	6556	33.0	26.6	26.0	78.0	21.6	24.1	32.0
464	6570	33.0	26.6	26.0	75.0	21.6	24.1	32.0
465	6584	32.0	26.0	26.0	92.0	21.6	23.5	32.0

466	6599	33.0	26.6	26.0	63.0	21.6	23.5	38.0
467	6613	33.0	26.6	26.0	58.0	21.6	23.5	32.0
468	6627	33.0	26.6	26.6	59.0	21.6	24.1	32.0
469	6641	33.0	27.3	26.6	67.0	21.6	24.1	32.0
470	6655	33.0	27.3	26.6	64.0	21.6	24.1	32.0
471	6669	33.0	27.3	26.6	67.0	21.6	24.1	32.0
472	6683	33.0	27.3	26.7	59.0	21.7	24.2	32.0
473	6698	33.0	27.3	26.7	57.0	21.7	24.2	32.0
474	6712	33.0	27.3	26.7	52.0	21.7	24.2	32.0
475	6726	33.0	27.3	26.7	51.0	21.7	24.8	32.0
476	6740	34.0	27.3	26.7	93.0	21.7	24.2	32.0
477	6754	33.0	27.3	26.7	241.0	21.7	24.8	32.0
478	6768	33.0	27.3	26.7	410.0	21.7	24.2	32.0
479	6783	33.0	27.3	26.7	517.0	21.7	24.2	32.0
480	6797	33.0	27.3	26.7	310.0	21.7	24.2	32.0
481	6811	33.0	26.7	26.7	188.0	21.7	24.2	32.0
482	6825	33.0	26.7	26.7	155.0	21.7	24.8	32.0
483	6840	33.0	27.4	26.7	148.0	21.7	24.9	32.0
484	6854	34.0	27.4	26.7	118.0	21.7	24.2	32.0
485	6868	34.0	27.4	26.7	101.0	21.7	24.9	32.0
486	6882	33.0	27.4	26.8	91.0	21.8	24.9	32.0
487	6896	33.0	27.4	26.8	77.0	21.8	24.9	32.0
488	6911	33.0	26.7	26.7	81.0	21.7	24.9	32.0
489	6925	33.0	26.7	26.7	92.0	21.7	24.9	32.0
490	6939	33.0	26.8	26.8	86.0	21.8	24.9	32.0
491	6953	33.0	26.8	26.8	148.0	21.8	24.9	32.0
492	6968	33.0	26.8	26.8	213.0	21.8	24.9	32.0
493	6982	33.0	27.4	26.8	316.0	21.8	24.9	32.0
494	6996	33.0	26.8	26.8	686.0	21.8	24.9	32.0
495	7010	33.0	27.4	26.8	410.0	21.8	24.9	32.0
496	7024	33.0	26.8	26.8	399.0	21.8	24.9	32.0
497	7038	33.0	26.8	26.8	301.0	21.8	24.9	32.0
498	7053	33.0	26.8	26.8	197.0	21.8	24.9	32.0
499	7067	33.0	26.8	26.8	147.0	21.8	24.9	32.0
500	7081	33.0	26.8	26.8	107.0	21.8	24.9	32.0
501	7095	33.0	26.8	26.8	92.0	21.8	24.9	32.0
502	7109	33.0	26.8	26.8	75.0	21.8	24.9	32.0
503	7124	33.0	27.4	26.8	79.0	21.8	24.9	32.0
504	7138	33.0	27.4	26.8	63.0	21.8	24.9	32.0
505	7152	33.0	27.4	26.8	60.0	21.8	24.9	32.0
506	7166	33.0	27.4	26.8	61.0	21.8	24.9	32.0
507	7181	33.0	26.8	26.8	56.0	21.8	24.9	32.0
508	7192	33.0	26.8	26.8	54.0	21.8	24.9	32.0
509	7207	33.0	26.8	26.8	55.0	21.8	24.9	32.0
510	7221	33.0	26.8	26.8	57.0	21.8	24.9	32.0
511	7235	33.0	27.4	26.8	54.0	21.8	24.9	32.0
512	7249	33.0	26.8	26.8	58.0	21.8	24.9	32.0
513	7263	33.0	26.8	26.8	56.0	21.8	25.0	32.0
514	7277	33.0	27.5	26.8	78.0	21.8	25.0	32.0
515	7292	33.0	26.8	26.8	117.0	21.8	25.0	32.0
516	7303	33.0	26.8	26.8	213.0	21.8	25.0	32.0
517	7318	33.0	26.8	26.8	346.0	21.8	25.0	32.0
518	7332	33.0	27.5	26.8	367.0	21.8	25.0	32.0
519	7346	33.0	27.5	26.8	339.0	21.8	25.0	32.0
520	7361	33.0	27.5	26.8	128.0	21.8	25.0	32.0
521	7375	33.0	27.5	26.8	103.0	21.8	25.0	32.0
522	7389	34.0	27.5	26.9	230.0	21.9	25.0	32.0
523	7403	33.0	26.8	26.8	443.0	21.8	24.3	32.0

524	7418	34.0	26.9	26.9	361.0	21.9	24.4	32.0
525	7432	34.0	27.5	26.9	203.0	21.9	24.4	32.0
526	7446	34.0	27.5	26.9	465.0	21.9	24.4	32.0
527	7460	33.0	27.5	26.9	650.0	21.9	24.4	32.0
528	7475	33.0	26.2	26.2	482.0	21.9	24.4	32.0
529	7489	33.0	26.9	26.2	204.0	21.9	24.4	32.0
530	7503	34.0	26.9	26.9	211.0	21.9	24.4	32.0
531	7517	34.0	27.5	26.9	189.0	21.9	24.4	32.0
532	7532	34.0	26.9	26.9	117.0	21.9	23.7	32.0
533	7546	34.0	27.5	26.9	114.0	21.9	24.4	32.0
534	7560	34.0	27.5	26.9	125.0	21.9	24.4	32.0
535	7572	34.0	27.5	26.9	183.0	21.9	24.4	32.0
536	7583	34.0	27.5	26.9	384.0	21.9	24.4	32.0
537	7597	33.0	26.9	26.3	207.0	21.9	24.4	32.0
538	7611	33.0	26.9	26.3	147.0	21.9	24.4	32.0
539	7626	33.0	26.9	26.3	193.0	21.9	24.4	32.0
540	7640	32.0	26.3	26.3	145.0	21.9	24.4	32.0
541	7654	32.0	26.3	26.3	177.0	21.9	24.4	32.0
542	7668	33.0	26.9	26.3	136.0	21.9	24.4	32.0
543	7683	34.0	26.9	26.3	171.0	21.9	24.4	32.0
544	7697	34.0	27.6	26.9	193.0	21.9	24.4	32.0
545	7711	34.0	27.6	26.9	231.0	21.9	24.4	32.0
546	7725	34.0	27.6	26.9	137.0	21.9	24.4	32.0
547	7740	34.0	27.6	26.9	246.0	21.9	24.4	32.0
548	7754	33.0	26.9	26.3	198.0	21.9	24.4	32.0
549	7768	34.0	27.6	26.9	115.0	21.9	24.4	32.0
550	7782	34.0	27.6	26.9	144.0	21.9	24.4	32.0
551	7796	34.0	27.6	26.9	142.0	21.9	24.4	32.0
552	7810	34.0	27.6	26.9	131.0	21.9	24.4	32.0
553	7824	34.0	27.6	26.9	266.0	21.9	24.4	32.0
554	7839	34.0	27.6	27.0	1022.0	22.0	24.5	32.0
555	7853	34.0	27.6	26.9	1070.0	21.9	25.1	32.0
556	7867	34.0	27.6	26.9	905.0	21.9	24.4	32.0
557	7881	34.0	27.6	26.9	812.0	21.9	24.4	32.0
558	7896	34.0	27.6	26.9	879.0	21.9	24.4	32.0
559	7910	34.0	27.6	27.0	906.0	22.0	24.5	32.0
560	7924	34.0	27.6	27.6	952.0	22.0	24.5	32.0
561	7938	34.0	27.6	27.0	897.0	22.0	24.5	32.0
562	7953	34.0	27.6	27.0	875.0	22.0	24.5	32.0
563	7964	33.0	27.0	27.0	901.0	22.0	24.5	32.0
564	7979	32.0	26.3	25.7	834.0	22.0	24.5	32.0
565	7993	33.0	26.3	26.3	874.0	22.0	24.5	32.0
566	8007	34.0	27.0	26.3	911.0	22.0	24.5	32.0
567	8022	34.0	27.6	26.3	875.0	22.0	24.5	32.0
568	8036	34.0	27.6	27.0	839.0	22.0	24.5	32.0
569	8050	34.0	27.6	27.0	835.0	22.0	24.5	32.0
570	8062	34.0	27.6	27.0	853.0	22.0	24.5	32.0
571	8076	34.0	27.6	27.0	853.0	22.0	24.5	32.0
572	8090	34.0	27.6	27.0	827.0	22.0	24.5	32.0
573	8104	34.0	27.6	27.0	791.0	22.0	24.5	32.0
574	8118	34.0	27.6	27.0	761.0	22.0	25.1	32.0
575	8133	34.0	27.6	27.0	761.0	22.0	24.5	32.0
576	8144	34.0	27.6	27.0	667.0	22.0	24.5	32.0
577	8159	34.0	27.6	27.0	607.0	22.0	24.5	32.0
578	8173	34.0	27.6	27.0	611.0	22.0	24.5	32.0
579	8187	33.0	27.6	27.0	606.0	22.0	24.5	31.0
580	8201	34.0	27.6	27.0	585.0	22.0	24.5	31.0
581	8216	34.0	27.6	27.0	578.0	22.0	24.5	31.0
582	8230	34.0	27.6	27.0	571.0	22.0	24.5	35.0

583	8244	34.0	27.6	27.0	568.0	22.0	24.5	31.0
584	8258	34.0	27.0	27.0	561.0	22.0	24.5	31.0
585	8272	33.0	27.0	27.0	559.0	22.0	24.5	32.0
586	8287	34.0	27.0	27.0	569.0	22.0	24.5	31.0
587	8301	34.0	27.6	27.0	572.0	22.0	24.5	31.0
588	8315	34.0	27.6	27.0	569.0	22.0	25.7	31.0
589	8329	34.0	27.6	27.0	568.0	22.0	24.5	31.0
590	8344	33.0	27.0	26.4	576.0	22.0	24.5	31.0
591	8358	33.0	27.0	26.4	576.0	22.0	24.5	31.0
592	8372	33.0	27.0	26.4	580.0	22.0	24.5	31.0
593	8383	34.0	27.0	27.0	576.0	22.0	24.5	31.0
594	8398	33.0	27.0	27.0	578.0	22.0	24.5	31.0
595	8412	33.0	27.0	26.1	581.0	22.0	25.1	31.0
596	8427	33.0	27.0	27.0	579.0	22.0	24.5	31.0
597	8441	34.0	27.0	27.0	576.0	22.0	25.1	31.0
598	8455	34.0	27.6	27.0	574.0	22.0	25.1	31.0
599	8469	34.0	27.6	27.0	573.0	22.0	25.1	32.0
600	8481	34.0	27.6	27.0	577.0	22.0	25.1	31.0
601	8495	34.0	27.6	27.0	572.0	22.0	25.1	31.0
602	8509	34.0	27.6	28.3	568.0	22.0	25.1	31.0
603	8523	34.0	27.6	27.0	565.0	22.0	24.5	31.0
604	8537	34.0	27.6	27.6	563.0	22.0	25.1	31.0
605	8552	34.0	28.2	27.0	565.0	22.0	25.1	31.0
606	8566	34.0	28.2	27.6	561.0	22.0	25.1	31.0
607	8580	34.0	27.6	27.6	558.0	22.0	24.5	31.0
608	8594	34.0	27.6	27.6	556.0	22.0	24.5	31.0
609	8609	34.0	28.2	27.6	559.0	22.0	24.5	31.0
610	8623	34.0	27.6	27.6	556.0	22.0	24.5	31.0
611	8637	34.0	28.2	27.6	556.0	22.0	25.1	30.0
612	8651	34.0	27.6	27.0	553.0	22.0	24.5	30.0
613	8666	34.0	27.6	27.6	549.0	22.0	25.1	30.0
614	8680	34.0	27.6	27.6	545.0	22.0	25.1	30.0
615	8694	34.0	28.2	27.6	547.0	22.0	25.1	31.0
616	8708	34.0	27.6	27.0	544.0	22.0	24.5	30.0
617	8722	34.0	27.6	27.0	545.0	22.0	24.5	30.0
618	8736	34.0	27.6	27.6	543.0	22.0	25.1	30.0
619	8750	34.0	27.6	27.6	537.0	22.0	24.5	30.0
620	8765	34.0	27.6	27.6	532.0	22.0	25.1	30.0
621	8779	34.0	27.6	27.6	540.0	22.0	24.5	30.0
622	8793	34.0	27.6	27.0	534.0	22.0	25.1	30.0
623	8807	34.0	27.0	27.0	603.0	22.0	25.1	30.0
624	8822	34.0	27.6	27.0	615.0	22.6	25.1	30.0
625	8836	34.0	27.6	27.0	598.0	22.0	24.5	30.0
626	8850	33.0	27.0	27.0	595.0	22.6	24.5	30.0
627	8864	33.0	27.0	26.3	596.0	22.0	25.1	30.0
628	8879	33.0	27.0	27.0	595.0	22.6	25.1	30.0
629	8893	34.0	27.0	27.0	590.0	22.0	25.1	30.0
630	8907	34.0	27.0	27.0	599.0	22.0	25.1	30.0
631	8921	34.0	27.0	27.0	604.0	22.0	25.1	30.0
632	8935	33.0	27.0	26.3	608.0	22.0	25.1	30.0
633	8950	33.0	27.0	26.3	622.0	22.6	25.1	30.0
634	8964	33.0	27.0	26.3	606.0	22.6	25.1	30.0
635	8978	34.0	27.0	27.0	604.0	22.0	25.1	30.0
636	8992	34.0	27.6	27.0	604.0	22.0	25.1	30.0
637	9007	34.0	27.6	27.0	600.0	22.6	25.1	30.0
638	9021	34.0	26.9	26.9	595.0	21.9	25.1	30.0
639	9035	34.0	27.6	26.9	635.0	21.9	25.1	30.0
640	9049	34.0	27.6	26.9	654.0	21.9	24.4	30.0
641	9064	34.0	28.2	27.6	653.0	21.9	25.1	30.0

642	9078	34.0	28.2	27.6	641.0	22.6	24.4	30.0
643	9092	34.0	28.2	27.6	629.0	22.6	26.3	30.0
644	9106	34.0	27.6	27.6	632.0	21.9	25.1	30.0
645	9121	34.0	27.6	27.6	627.0	21.9	25.1	30.0
646	9135	34.0	28.2	27.6	619.0	21.9	24.4	30.0
647	9149	34.0	28.2	27.6	591.0	21.9	24.4	30.0
648	9163	34.0	27.6	26.9	558.0	21.9	24.4	30.0
649	9177	34.0	27.6	26.9	291.0	21.9	24.4	30.0
650	9192	34.0	27.5	27.5	177.0	21.9	24.4	30.0
651	9206	34.0	27.6	26.9	141.0	21.9	24.4	30.0
652	9221	34.0	27.5	26.9	122.0	21.9	25.0	30.0
653	9235	34.0	27.5	26.9	107.0	21.9	25.0	30.0
654	9249	34.0	27.5	27.5	98.0	21.9	25.0	30.0
655	9263	34.0	27.5	27.5	96.0	21.9	25.0	30.0
656	9277	34.0	27.6	26.9	98.0	21.9	25.1	30.0
657	9291	34.0	27.5	26.9	92.0	21.9	25.0	30.0
658	9306	34.0	27.5	26.9	107.0	21.9	25.0	30.0
659	9320	34.0	27.5	27.5	101.0	21.9	25.0	30.0
660	9334	34.0	27.5	26.9	95.0	21.9	25.0	30.0
661	9348	34.0	28.2	27.5	88.0	21.9	24.4	31.0
662	9362	34.0	28.2	27.5	86.0	21.9	25.0	30.0
663	9377	34.0	28.2	27.5	93.0	21.9	24.4	31.0
664	9391	34.0	28.2	27.5	87.0	21.9	25.0	31.0
665	9405	34.0	28.2	27.5	85.0	21.9	25.0	31.0
666	9419	34.0	27.5	27.5	90.0	21.9	25.0	35.0
667	9431	34.0	27.5	27.5	92.0	21.9	25.0	31.0
668	9443	34.0	28.2	27.5	96.0	21.9	25.0	31.0
669	9457	34.0	28.2	27.5	98.0	21.9	25.0	31.0
670	9471	34.0	28.2	27.5	90.0	21.9	25.0	31.0
671	9486	34.0	28.2	27.5	87.0	22.5	25.0	31.0
672	9500	34.0	27.5	27.5	90.0	21.9	25.0	31.0
673	9514	34.0	27.5	26.9	89.0	21.9	24.4	31.0
674	9528	34.0	27.5	26.9	80.0	21.9	24.4	31.0
675	9542	34.0	27.5	27.5	82.0	21.9	25.0	31.0
676	9554	34.0	27.6	27.6	95.0	21.9	24.4	31.0
677	9569	34.0	28.2	27.5	82.0	21.9	24.4	31.0
678	9583	34.0	27.5	26.9	80.0	21.9	24.4	31.0
679	9597	34.0	27.5	27.5	92.0	21.9	25.0	31.0
680	9611	34.0	28.2	27.5	77.0	21.9	25.0	31.0
681	9625	34.0	28.2	27.5	76.0	21.9	25.0	31.0
682	9640	35.0	28.2	27.5	77.0	21.9	25.0	31.0
683	9654	34.0	28.2	27.5	75.0	21.9	24.4	31.0
684	9668	35.0	28.2	27.5	72.0	21.9	24.4	31.0
685	9682	35.0	28.2	27.5	67.0	22.5	25.0	31.0
686	9696	34.0	28.2	27.5	66.0	21.9	24.4	31.0
687	9710	34.0	28.2	26.9	69.0	21.9	25.0	31.0
688	9725	34.0	27.5	27.5	74.0	21.9	24.4	31.0
689	9739	34.0	28.2	27.5	70.0	21.9	25.0	31.0

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