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Increasing the Efficiency of Engine Remanufacture by Optimising Pre-Processing Inspection – A comprehensive study of 2196 engines at Caterpillar Remanufacturing in the UK

by

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A thesis presented in fulfilment of the requirements for the degree of Doctor of Philosophy

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Declaration of Authenticity and Author's Rights

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of this degree.

Signed:

Dated:

Abstract

Remanufacturing describes the process of bringing used product to an "as-new" functional condition using reclaimed and new components. It is an industrial process operating across the automotive, industrial, commercial and domestic sectors which, despite its low profile, contributes around £2.35 billion annually to the UK economy. Remanufacturing is an enabler for manufacturing, reducing the use of virgin materials and energy thus allowing more cost-effective manufacturing. Key issues for remanufacturers revolve around the lack of industry-specific tools and techniques and this particularly affects effective decision-making for production issues such as the inspection of returned cores and their constituent components.

The main aim of the research was to establish the factors that affect pre-processing inspection and this was achieved using causal true-experimental research into the overall remanufacturing process for over two thousand engines at a Caterpillar Remanufacturing plant in the U.K.

The research found that the three critical factors in determining the effectiveness of the pre-processing inspection are the complexity of the component geometry including internal ports, the number of sub-components and the number of material employed in the construction of the component. These factors were then used to establish a practical method of assessing the true costs of remanufacturing. The findings were validated at several European Caterpillar Remanufacturing facilities.

The beneficiaries of this research are both academia and industry: it adds to the body of remanufacturing knowledge enabling future research to be targeted at operations that materially affect the process and also assists remanufacturers to make their operations more efficient, thus aiding profitability. The novelty of the research is the new knowledge concerning the factors affecting pre-processing inspection together with the limitation of the benefits as well as the information gathered from over two thousand engines in an industrial setting.

Acknowledgements

This work is inevitably not only mine but owes its life to many people. I would firstly like to gratefully acknowledge the huge support and encouragement given to me by my supervisor, Dr. Winifred Ijomah, whose unstinting belief in my work and boundless enthusiasm have been central to my achievements; thanks are also due to my second supervisor Professor Jiju Antony: his insightful and challenging comments have shaped and re-shaped my thinking. I must also pay tribute to the remanufacturing research group at Strathclyde and particularly Gillian Hatcher, Kirsty Doyle, David Stewart, Anjar Priyono and Elzbieta Pawlik who have welcomed me so generously every time I have been at the university. Thanks are also due to Dr. Matthew Revie who helped me through the statistical jungle, to Professor Umit Bititci: his direct focus meant there was nowhere to hide my shortcomings and particularly to Professor Jonathan Corney who helped me to refine and sharpen my writing.

I would like to acknowledge and thank The Royal Commission for the Exhibition of 1851 for their funding. Their support of me and my work has enabled this project to be completed and I want to mention Jenifer Hewett particularly for her personal friendship and support. I was lucky enough to be able to thank the Chairman personally and told him that undertaking this research had given me great joy. I meant it.

I also want to very clearly state just how much being part of the remanufacturing team at Caterpillar in Rushden has meant to me. The generosity of everyone in the facility has been wonderful and I couldn't have been happier working there – thanks guys. I must mention a few people in particular though – Dave Jackson, who said yes; Stephen Peters who continued to say yes; Tony Golland for unrelenting positivity; Jim Ash for the encouragement, the laughter and the blushes; Stephen Storkey for the camaraderie and the ability to set me straight, and Jeremy Whiting for being a shining example of a good engineer – would that I were as good.

Finally I would like to thank the people who mean the most to me in the world: Peter, my husband, and our sons, Thomas, Philip, Iain and Adam. Nothing worthwhile in my life would be possible without their unfailing love and support and it is their unselfishness that has allowed me to follow this particular dream.

Nevertheless, despite the encouragement, support and help I have received, any errors or shortcomings contained within this thesis remain entirely my own.

Sara Ridley
Northampton, July 2013

Glossary

Assembly: The process of putting together new and remanufactured components to achieve a complete remanufactured product. Sometimes referred to as Build or Re-build.

Build: See *Assembly*.

Contract Remanufacturer:

This type of remanufacturer accepts contracts from OEMs (Original Equipment Manufacturer) or prime users (such as the Military or large fleet users). They do not necessarily have access to OEM information or control over cores despite acting on behalf of them. This is because many OEMs treat remanufacturing as an aftermarket activity and there is no direct link to the responsible engineers

Core: Used product at the end of its working life returned for processing such as remanufacturing or recycling.

Core Credit: The payment to a dealer for returning a core for remanufacture. This is paid by the OEM to ensure cores are returned at end-of-life. Its level depends upon the condition of the returned core as measured against previously agreed standards.

Disassembly: Reduction of cores to component parts ready for remanufacture.

Independent Remanufacturer:

This type of remanufacturer does not have any links with OEMs but acquires cores that they did not design or make. They remanufacture them and offer them into the aftermarket, often in competition with the OEMs.

OEM: Original Equipment Manufacturer. These companies design and develop products. Some chose to undertake the remanufacture of their products others chose to contract their remanufacture out to other companies. This enables the OEM to maintain brand control, protecting their name and design information. Many OEMs consider independent remanufacturers as direct competitors in the aftermarket.

Re-build: See *Assembly.*

Reclamation: The prevention of a used product or component from becoming waste. All operations such as remanufacturing, reconditioning, repairing and recycling are reclaim operations because they return used products to a condition that allows their reuse. Some remanufacturers use “reclaim” to describe their processes. See also *Salvage*.

Reconditioning The process of returning a used product to an acceptable standard, not generally equivalent to new. Warranties are typically on major wear components only. Some few remanufacturers refer to their process as reconditioning.

Refurbishment: Refurbishment describes the rebuilding of a used product or component back to a range of satisfactory working conditions. The quality of the resultant product may not necessarily be as good as the original product and the refurbished product rarely has the same guarantee as the original product.

Remanufacture: The overall process of returning a used product to at least OEM original performance specification and quality from the customers' perspective and giving the resultant product a warranty that is at least equal to that of a newly manufactured equivalent. (Ijomah, 2002).

Repair Correction of specific faults in a product without other processing of the whole product. Any warranty typically covers only the repaired components.

Reprocess See *Salvage*

Reverse Engineering:

This is the process of analysing a correctly functioning, often new, product to obtain information. It is used to inform the remanufacturing process, e.g. for machining requirements or tolerances. The information gained is compared to the returned, failed core. This is usually undertaken by independent and contract remanufacturers when OEM product information is not available.

Reverse Logistics: The recovery and return of cores for remanufacture.

Reuse Using a product multiple times without significantly changing it from its original purpose. For example a milk bottle has many reuses following a return and cleaning process.

Salvage: Some remanufacturers use this term to refer to the activities undertaken to individual components to ensure they are returned to "as-good-as-new" condition. This may include activities such as machining operations to remove wear, the additional of layers of metal through laser deposition or similar methods, re-profiling of camshafts etc. See also *Reclamation and Reprocess*.

List of Abbreviations

ANOVA	Analysis of Variance
A&PRM	Asset and Product Recovery Management
CNC	Computer Numerical Control
CPS	Caterpillar Production System
DEFRA	Department for Environment, Food and Rural Affairs
DfRem	Design for Remanufacture
EGR	Exhaust Gas Recirculation
ELV	Directive of The European Parliament and of The Council on End-of Life Vehicles.
EOQ	Economic Order Quantity
EPQ	Economic Production Quantity
EU	European Union
HMRC	Her Majesty's Revenue and Customs Service
IDEF0	ICAM Definition for Functional Modelling
ICAM	Integrated Computer Aided Manufacturing
MADE	BS 8887-220:2010 - Design for manufacture, assembly, disassembly and end-of-life processing
MILP	Mixed Integer Linear Programming
MRI	Magnetic Resonance Imaging
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
ONS	Office of National Statistics

OPE	Overall Process Effectiveness
PCB	Printed Circuit Board
PSS	Product Service Systems
RAPP	Remanufacturing Aggregate Production Planning
SPSS	Statistical Product and Service Solutions
TV	Television
UK	United Kingdom
UN	United Nations
USA	United States of America
WEEE	Directive of The European Parliament and of The Council on Waste Electrical and Electronic Equipment

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Chapter 1 Introduction

1.1 Introduction

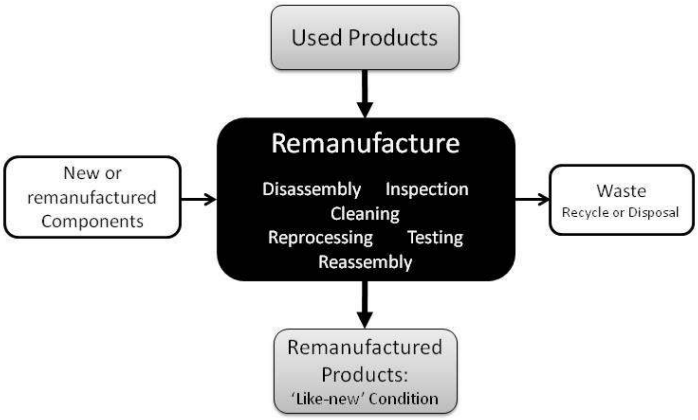
This chapter introduces the research that is the subject of this thesis, describing the remanufacturing process that is at the heart of the issues studied and sets the background for the following work.

It describes the concept of remanufacturing and explains its significance to sustainable development. This chapter also sets out some of the key remanufacturing problems and describes how this research addresses some of these by outlining the objectives of the research and identifying the deliverables and originality of the research.

Finally this chapter briefly explains the research design and concludes by describing the structure of the thesis.

1.2 The Remanufacturing Concept

Remanufacturing is the process of returning a used product to an "as-new" condition in terms of performance and quality with a warranty that is at least equal to new (Ijomah, 2002). Remanufacturers collect used products referred to as "cores", dismantle, clean and reprocess the individual components before adding some new parts, re-assembling and testing. Figure 1.1 below illustrates this process.



(Hatcher *et al.*, 2013)

Figure 1.1 An Illustration of a Typical Remanufacturing Process.

Remanufacturing, for all practitioners, can consist of all or some of these steps depending on the particular product, however the overall process applies. Some form of disassembly is almost always undertaken, as is cleaning. It is usual practice in remanufacturing to inspect at many stages through the process, often functionally and in all cases visually, Brent and Steinhilper (2004) state that remanufacturing always requires 100% inspection at one or more of the remanufacturing phases. Some form of reprocessing takes place and then the product is reassembled and tested.

The figure is typical of the process at the Caterpillar facility in Rushden. In this facility, as in many other OEM and contract remanufacturers, inspection is typically carried out at many stages of the remanufacturing process on individual components and sub-assemblies to ensure that quality is not compromised; however pre-processing inspection is limited to a cursory external inspection and the determination of the specific part number or model variant.

The remanufacturing industry gained momentum around the Second World War as the need to conserve existing equipment became urgent. Today the most mature sector of the remanufacturing industry is the automotive sector with most major companies either undertaking remanufacture directly or employing contract remanufacturers to act on their behalf. Remanufacturing is an economically significant activity (Ferrer, 2001).

1.3 Remanufacturing Significance

The exploitation of the world's mineral resources increased greatly through the 20th century (Vandermerwe and Oliff, 1991). This has been triggered by rapid population growth and the increasing pace of development of many countries with booming economies such as China and India. The extracted metals have been used to manufacture many of the conveniences of modern-day life but as well as the consumption of minerals, the harmful effects include an increased use of non-renewable energy resulting in consumption of fossil fuels and the increase of CO_2 emissions. Unfortunately, many of these products are been completely discarded once they cease to be useful or are no longer desirable. This disposal method is becoming more and more expensive and suitable sites for landfill, more difficult to find. Figure 1.2 below shows the open loop nature of this consumption mode.

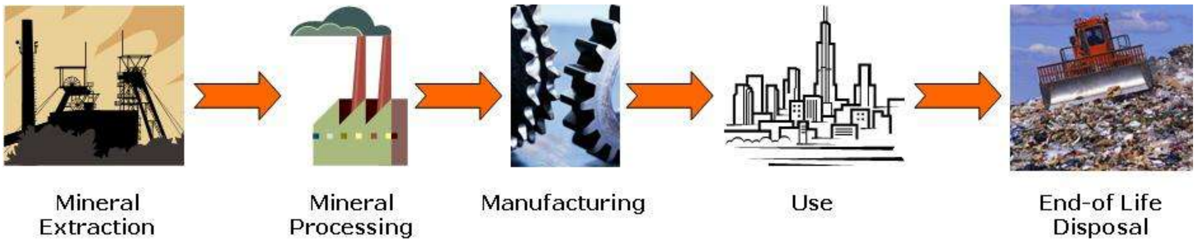


Figure 1.2 Traditional Model for Extracted Minerals.

End-of-life solutions (e.g. recycling or remanufacture etc.) that reuse these minerals and thus reduce new consumption are becoming more and more important. Many countries are increasing legislation that affects used products and the collection and disposal of waste, for example The European Union (EU) has adopted The Basel Convention prohibiting the export of waste outside EU countries.

Remanufacturing falls within 'reduction' and 'reuse', which are the top two preferred waste management options identified in the EU's Fifth Environmental Action Programme. Research by Lund (1984) demonstrates that 85% of the weight of a remanufactured product can come from used components, whilst requiring 50–80% less energy to produce and that remanufacturing can provide 20–80% production cost savings in comparison to conventional manufacturing. Remanufactured products also have comparable quality to equivalent new products. Remanufacturing can also limit environmental impacts by, for example, reducing the production of greenhouse gases such as CO_2 and methane that The Kyoto Protocol (2005) has highlighted for reduction. This reduction occurs because for most goods, raw material production and subsequent shaping and machining processes produce the highest CO_2 emissions, but remanufacturing removes the need for these processes. This is illustrated by Figure 1.3 below.

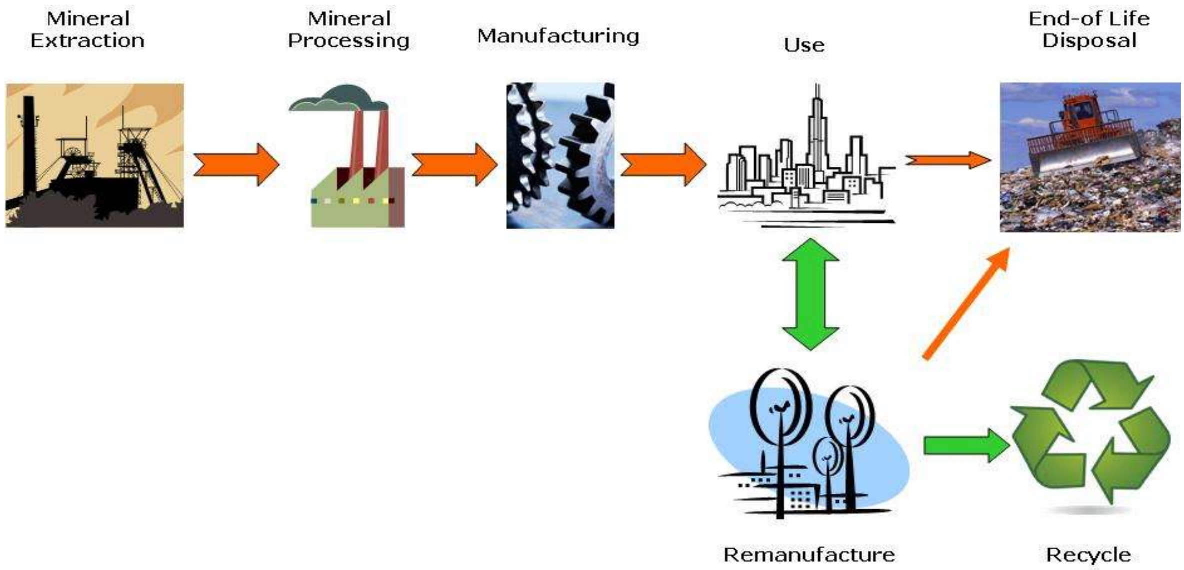


Figure 1.3 New Model for Extracted Mineral Including Remanufacture and Recycling

Remanufacturing can also benefit society reducing social exclusion by reducing the major causes of poverty and lack of skills. This is because the benefits of remanufacturing include the creation of employment especially for low-skilled labour and the provision of high quality products at prices that those on low incomes can afford. Low-skilled labour is prevalent in remanufacturing because many of the tasks involved in the process such as sorting and cleaning are easy to learn and replicate.

The significance of remanufacturing is discussed in more detail in Chapter 3.

1.4 Issues for Remanufacturers

Remanufacturing has traditionally relied on local adaptations of standard manufacturing tools and techniques for its activities and processes. Tools and techniques designed specifically with the remanufacturing industry in mind are scarce. Research into remanufacturing has increased from the first comprehensive study published in 1984 (Lund) but despite this there is still a paucity of remanufacturing specific knowledge. The majority of extant research concentrates on a wider spectrum of end of life solutions such as recycling. Nevertheless several researchers (Ijomah, 2002 and 2008, Lundmark et al., 2008 and Ilgin and Gupta, 2010) have identified several areas that are of significance to remanufacturers. These include:

- Design for remanufacture;
- The uncertainty of the quantity and quality of cores;
- Core collection;
- The need for component inspection;
- A lack of remanufacturing-specific tools and techniques;
- Redistribution of remanufactured products; and
- A lack of coherent systems for the whole remanufacturing process rather than individual activities.

The decision to focus on inspection of cores rather than any of the other areas noted above was driven by the researcher's employment in a remanufacturing facility. This experience clearly highlighted the issues caused by uncertainty. The vast majority of products being remanufactured currently were not designed with any form of remanufacturing in mind and consequently understanding more about their condition prior to remanufacturing would benefit industry, it would also enable researchers to give a clearer focus to their research because the body of knowledge concerning remanufacture would grow. Fundamentally remanufacture cannot happen without cores, they form the beginning of the entire process.

This research extends the work of Ijomah, (2008) who noted that core investigation, whilst important to remanufacturers, was complex and no guidelines exist for it. Further, the work by Ijomah (2008) did not consider the important aspect of pre-processing inspection or the implications of appropriate inspection to the effectiveness and productivity of remanufacturing operations. The research also extends the work of Errington (2009) who advocated core sorting on a strategic basis for improving the effectiveness of remanufacturing and extends the work of Robotis *et al.* (2012) who demonstrated that benefits to remanufacturing could be driven by understanding the condition of cores. The researcher's employment in a remanufacturing facility also meant that access to a large number of cores to facilitate the research could be guaranteed.

These issues and the surrounding literature are explored more fully in Chapter 4.

1.5 Research Significance

This research is significant because it adds to the body of knowledge concerning remanufacturing. This is important as there is very little knowledge concerning remanufacturing, particularly in comparison to manufacturing. Understanding the relationship between core processing and component geometry and design will aid a fuller understanding of the remanufacturing process. This benefit is also quantified. The new knowledge will enable further focussed research to further develop the understanding of remanufacturing. The robustness of the research is enhanced because it is the first industry-centred study of a large remanufacturing population.

Remanufacturing is an important part of a strategy of sustainable manufacture. It provides economic, environmental and societal benefits. The results of increasing legislative pressure and the drive towards corporate social responsibility (Ahiska and King, 2009) have made remanufacturing more attractive for many manufacturers. Remanufacturing addresses the dwindling supply of raw materials and their increasing cost by reusing components with a high intrinsic value. Component inspection is, as noted in the preceding section, of critical importance to remanufacturers and new knowledge concerning the factors affecting this may result in more efficient and effective remanufacture.

More effective remanufacture will reduce the energy consumption of the process and consequently the emissions whilst improving profitability for remanufacturers.

1.6 Research Novelty

Sorting or selecting cores at a strategic level has been considered in other work (Zikopoulos and Tagaras, 2007, Errington, 2009, Robotis *et al.*, 2012) but this has not been studied either at individual core level or in terms of the impact on subsequent remanufacturing operations. The relationship between the complexity of the cores and core processing has not been researched. The new knowledge that this thesis reports quantifies the savings in remanufacturing processing time, activity by activity, as a result of inspecting cores at receipt and also determines which component characteristics are relevant to pre-processing inspection. The collected data enabled a novel cost assessment method to be developed to more accurately reflect the remanufacturing process. This gives remanufacturers an improved understanding of the processes which can aid profitability.

1.7 Timeliness of the Research

This research is timely because the increasing pressure on natural resources is generating increasing legislation aimed at controlling and reducing waste. This, combined with increasing consumer preference for environmentally friendly products and the need for businesses to demonstrate social responsibility, makes conventional manufacture more costly. Manufacturing is at the heart of industrialised economies and sustaining it as a profitable enterprise is essential both to maintain the standard of living achieved in industrialised countries and to allow developing countries to attain equality. (Jayal *et al.*, 2010) Remanufacturing, as previously noted, is an efficient and profitable end-of-life strategy that aids profitability and sustainability. Remanufacturers rate inspection as a critical aspect of their business (Ijomah, 2002) and relevant quantitative information and easily accessible tools and techniques will help to bring further profitability.

1.8 Research Objectives

The effect of uncertainty concerning the quantity and quality of cores impairs the effectiveness of remanufacturing (Zikopoulos and Tagaras, 2007). It drives remanufacturers to hold artificially high levels of inventory – both cores and new parts – to ensure that they can respond rapidly to an order (Sundin, 2004).It also affects their ability to schedule production (Tang and Teunter, 2006 and Kim *et al.*, 2009)

The research described in this thesis, focussed on pre-processing inspection, is therefore concerned with both production planning as the inspection of core units informs the planning activity and also inventory control because more information early in the overall processes enables informed inventory decisions.

The research objectives are therefore:

- To determine what factors are relevant to the core inspection decision - understanding whether recovery is affected by inspection (or not) will enable a clear understanding of what impact inspection has on the overall remanufacturing process.

- To establish to what extent inspection of cores makes a material difference to the efficiency of the overall remanufacturing process at component level - this will enable components to be grouped according to common factors that are impacted by inspection.
- To use the new knowledge to of and about the factors affecting inspection to develop a robust component level inspection methodology.
- To extend the new knowledge to develop a more accurate cost assessment tool for remanufacturers.

1.9 Research Deliverables

This research delivers the following new knowledge:

- The component characteristics that, when present, make pre-processing inspection a valued-added activity. This is important because remanufacturers rate component inspection as a critical part of the process (Ijomah, 2002) but despite this, research has only considered core inspection at a strategic level;

- Quantification of the benefit of pre-processing core inspection in engines. This knowledge was gathered component by component and activity by activity. It identifies how much benefit, in terms of a reduction in processing time, can be achieved by gathering data at the very beginning of the process. This benefit is linked causally to the characteristics identified in this research. The reduction in processing time will aid remanufacturing profitability.

- A new method of cost estimation for remanufacturers that is easily understood and applied. This method differs from those proposed in literature because it is based upon the individual activities carried out and information already available to the individual remanufacturer. It does not require advanced mathematical skills. This is important as a clear understanding of costs is critical to business management (Jones and Butler, 1998).

The validation and relevance of this methodology is discussed more fully in Chapter 11.

1.10 Research Beneficiaries

The new knowledge gained could only benefit academia and industry if it was presented in a format that would make it useful as described in "The needs of practitioners" (Thomas and Tymon, 1982). This was addressed by presenting the characteristics in a simple decision-making format.

The beneficiaries of this research are academia and industry.

Academia benefits because this is the first large quantitative study into pre-processing inspection and it increases the amount of new knowledge about remanufacture. The characteristics identified will enable further research to be targeted towards effective inspection tools and methods. This is particularly important as it will enable researchers to concentrate on areas that will produce the greatest impact and create the largest savings of new materials and energy and thus produce the greatest improvement to profitable remanufacture. Manufacturing could also benefit from the increased knowledge of failure models being fed back to the product design team.

The benefits, arising from the deliverables mentioned above, to industry are more from the tools developed to disseminate the research findings. Identification of the factors affecting inspection and the resulting decision-making tool will enable remanufacturers to concentrate their efforts on components that produce the greatest savings. Efficiency savings promote profitability.

The cost estimation tool will help remanufacturers to gain a better understanding of their costs and the profitability of particular products. This, in turn, will assist effective decision-making in terms of where to concentrate improvement efforts.

The validation of the findings and relevance of them to industry discussed more fully in Chapter 11.

1.11 Research Design

The design of this research was a mixed mode approach with a predominantly quantitative paradigm. This was because the benefits or otherwise of pre-processing inspection needed to be defined in order that the relevant factors could be identified. This demanded quantitative data. Nevertheless, remanufacturing is a human activity system (HAS) and so some qualitative data was gathered and used to inform the results.

A true experimental design (Polit and Hungler, 1999) was used to conduct the research because it enabled causal links between improvement in activity time and pre-processing regimes to be identified. This method was very likely to identify the component characteristics affecting the effectiveness of inspection and therefore achieving valid results.

1.12 Limitations of the Research

There are, of necessity, some limitations to this work; some decided by circumstance and some within the control of the researcher. The remanufacturing spectrum is wide and many areas are under-researched but one piece of work cannot cover them all, as a consequence this research is circumscribed in the following ways:

- The research covers inspection only. Effective research must be focussed and the decision to constrain the scope to inspection only, despite other interesting areas of study being available, is discussed fully elsewhere;
- The research considers pre-processing inspection. It is acknowledged that there remain ambiguities concerning inspection at other points of the remanufacturing process but time did not permit extending the research;
- The researcher only had access to engine and engine component cores, consequently the research is limited to considering these products only;
- The research and the majority of validation were carried out at Caterpillar Remanufacturing facilities in Europe only. This was primarily because, whilst three other remanufacturers would talk in general terms to the researcher, Caterpillar were regarded as competitors and so she was unable to conduct research or validation elsewhere; and
- There was a limited amount of tools available for inspection at the Rushden facility. Consequently, the research considers only inspection techniques that were available. New tools such as ultrasound examination are excluded from this piece of work.

1.13 Thesis Structure

The structure of this thesis is illustrated in Figure 1.3 below. The contents of each chapter are described below.

Chapter One briefly describes the context of the research including the remanufacturing concept, its significance and that of the research; as well as an overview of the research objectives and deliverables, the beneficiaries of the research and the research design.

Chapter Two explains the research domain by describing the remanufacturing concept in detail giving a history of remanufacturing, the types of remanufacturers currently operating and enumerates each remanufacturing activity that makes up the overall remanufacturing process.

Chapter Three provides the context of the research by describing the significance of remanufacturing in terms of economic, ecological and societal terms. It also discusses the motives for remanufacture.

Chapter Four considers the extant literature concerning remanufacture and identifies the gaps in knowledge that provide the case for this research. It also lists the research objectives, their significance, novelty and timeliness.

Chapter Five describes the research design. It justifies the choice of research paradigm and discusses the philosophical background to the research. The research methodology is discussed as are the types of experimental design and the requirements for validity in experimental design. The chapter then describes the chosen research design and the methods chosen for analysis and presentation of the results.

Chapter Six details the actual experimental phase. It describes the phases of the experiments and the audit process giving details of the randomisation of subjects, the data collection process and the potential impact of researcher involvement.

Chapter Seven presents the experimental results. It also describes the responses to the pre-experiment and post-experiment interviews.

Chapter Eight describes the analysis of the results including a discussion of the analysis method chosen. It includes both within-engine and across-engine analysis and the determination of the activities and components affected by the changes in pre-processing inspection protocols.

Chapter Nine presents the resultant Decision-Making Methodology giving details of its use and its benefits to industry.

Chapter Ten extends the research to provide a Cost Assessment Methodology developed from the experimental results. The potential benefits to remanufacturers are also discussed.

Chapter Eleven discusses the experimental findings commenting upon their application and validation and their ability to satisfy practitioner needs.

Chapter Twelve concludes the work by summarising the way in which the research objectives have been met and the significance and relevance of the research. It describes the contribution to knowledge and its beneficiaries. This thesis ends by considering the limitation of the work described and describes the areas of productive further work that have been identified during the completion of the research.

The Appendices are split into six sections containing the following:

Appendix I	Standard Work Sheet and Feedback Sheets
Appendix II	Experimental Results
Appendix III	Pre-Experimental Interview Transcripts
Appendix IV	Production Presentation Slides
Appendix V	Post-Experimental Interview Transcripts
Appendix VI	ANOVA Analysis of Results
Appendix VII	Cost Assessment Presentation Slides

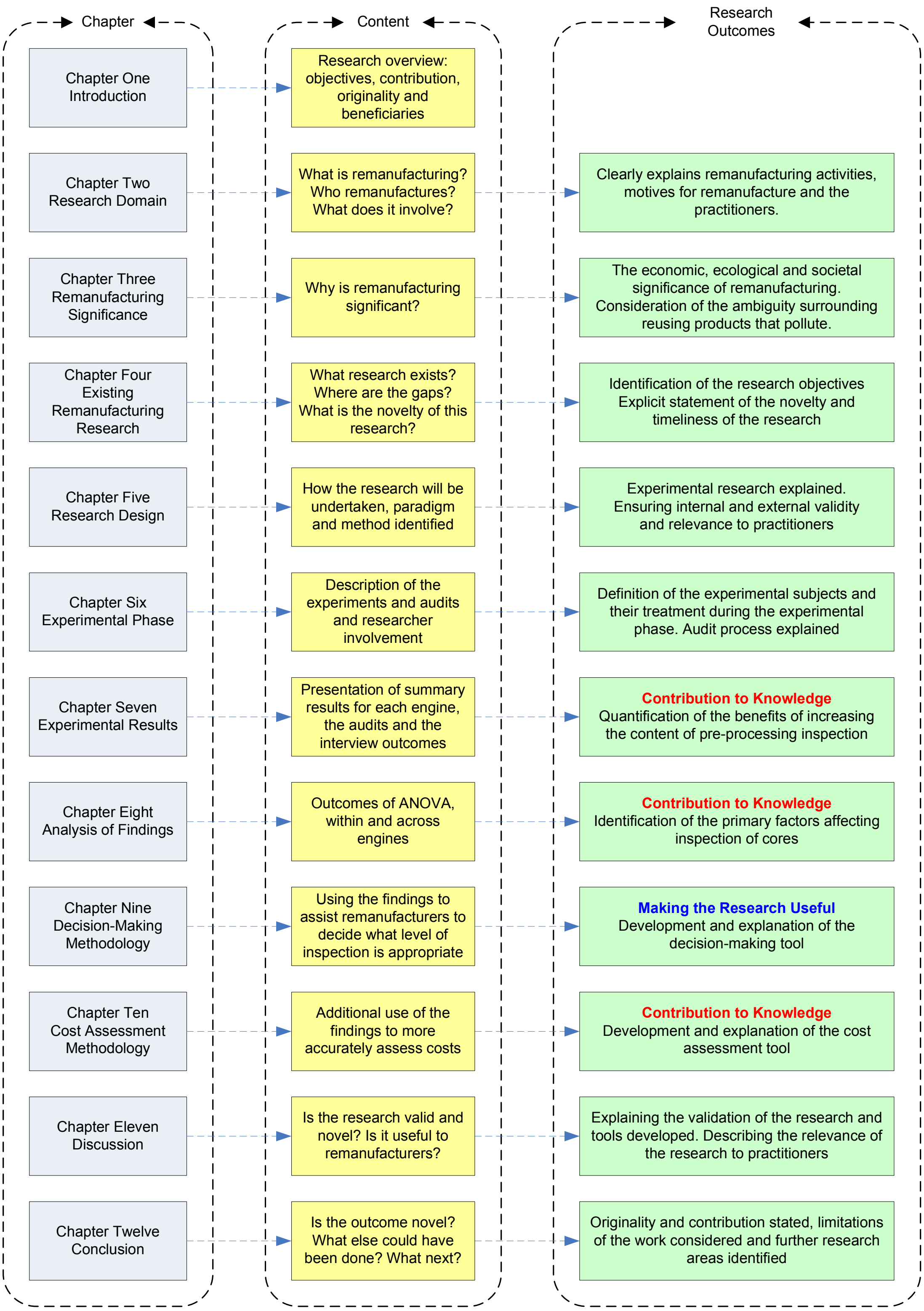


Figure 1.4 Structure of the Thesis

1.14 Summary

This chapter has introduced the research that is the subject of this work, setting the background for dissertation.

It has briefly described the concept and significance of remanufacturing, explained some of the key remanufacturing problems and the objectives of the research, identifying the deliverables and originality of the research.

This chapter also gave a limited explanation of the research design and concluded with a description of the structure of the thesis.

The next chapter explains the remanufacturing domain.

Chapter 2 Remanufacturing Domain

2.1 Introduction

This chapter defines remanufacturing in terms of this research. It explains the history of remanufacturing and the type of remanufacturers currently active in the field. The chapter also describes the activities within the overall remanufacturing process and the product characteristics that typify a remanufacturable product. It concludes with a discussion about the ambiguity of the environmental issues surrounding the remanufacture of engines.

2.2 Remanufacturing Defined

There have been several definitions of remanufacturing given in recent years (e.g. Haynesworth and Lyons, 1987, Guide 1999) but the definition used throughout this research is:

"*the process of returning a used product to at least OEM original performance specification from the customers' perspective and giving the resultant product a warranty that is at least equal to that of a newly manufactured equivalent*" (Ijomah, 2002).

This definition has been adopted by BS 8887-220:2010 - Design for manufacture, assembly, disassembly and end-of-life processing (MADE), BS 8887-2:2009 - Terms and definitions and BS 8887-1:2006 - General concepts, process and requirements. However it should be noted that many countries recognise a similar definition that includes providing a product to an equivalent quality rather than equivalent warranty.

Remanufacturing is differentiated from repair and refurbishment by the level of guarantee and quality, a remanufactured product has an equal or better guarantee and is of equal quality in comparison with the equivalent new. Remanufactured product can also incorporate upgrades to the latest specification. The incorporation of a comprehensive definition of remanufacturing into British Standards is an important distinction for remanufacturing practitioners as it identifies the critical features that differentiate between a remanufactured item and a repaired or reconditioned item.

This definition has been used as, being part of the British Standard, it is the default definition and that most closely identified with by practitioners at Caterpillar Remanufacturing.

2.3 A Brief History of Remanufacturing

Remanufacturing in the UK carried out by those other than the OEM as a tool to extend individual component life, began in the early part of the 20th century primarily in the car market. For example, in 1934 Capital Motors (later Wealdstone Engineering and now a part of Caterpillar Remanufacturing) began to remanufacture Vauxhall engine components in City Road, London. The remanufacturing industry grew during and after the Second World War, largely fuelled by the need to prolong the working life of military vehicles and machinery because of the scarcity of new parts. OEMs and/or their agents and dealers remanufactured their own products generally on a fairly small scale. Typical products that were remanufactured include compressors and gearboxes. A similar pattern was seen in the United States from the 1920s. Haynesworth and Lyons (1987) identify Arrow Automotive Industries as the first independent remanufacturer established in Boston in 1929.

Remanufacturing has grown from these relatively small-scale beginnings into a large industry. The greater part of the industry is made up of independent, often small, firms although the market is dominated by the OEM remanufacturers who have the time and money to develop tools and techniques to improve their efficiency (Lund, 1984).

2.4 Remanufacturing Practitioners

There are three types of remanufacturers as defined by Lund (1984):

- OEM remanufacturers;
- Independent remanufacturers; and
- Contract remanufacturers, sometimes called third-party remanufacturers.

The following sections briefly describe each in turn.

2.4.1 OEM Remanufacturers

OEM remanufacturers offer a mix of new (sometimes referred to as prime) and remanufactured products to the market. They remanufacture their own product, often as part of a larger aftermarket operation. The integration of remanufacturing into the same production line or even production facility a manufacturing operation is rarely accomplished, however Volvo (Mähl and Ostlin, 2007) successfully integrate a small part of their component remanufacturing operations alongside new production. This is in part because the new production follows a similar pace to that of the remanufacturing operation and the new production is a small volume only. However, the majority of OEMs remanufacture in separate production areas or sites. Many of these others who remanufacture separately, such as Caterpillar, also often use their remanufacturing division to deal with warranty returns and test and audit failures. Remanufacture offers OEMs the opportunity to protect their intellectual property and market share by controlling their used parts as well as providing a wide offering to the aftermarket.

2.4.2 Independent Remanufacturers

Independent or non-contract remanufacturers form the majority of remanufacturers although OEM and contract remanufacturers have the larger market share (Lund, 1984). These independent remanufacturers purchase or otherwise collect cores of products that they have not developed, designed, manufactured or sold themselves. They then remanufacture and sell their products as an alternative to OEM products. OEMs often guard technical information as they see independent remanufacturers as competitors and this can present significant technical challenges for independents. These are frequently overcome by reverse engineering. This is the practice of obtaining a new or correctly functioning product and attempting to understand the limits and fits, the critical dimensions and other information in order that a successful remanufacturing programme can be established. This can be a difficult process; several "as-new" products are required to give a reasonable understanding of new and even then, trial and error in the remanufacturing cannot be eliminated. Reverse engineering is often a time-consuming and expensive activity.

Independent remanufacturers, in contrast to contract remanufacturers, are able to vary their price to market based on the condition and availability of cores and the differing amount of remanufacturing work an individual core might require.

2.4.3 Contract or Third-Party Remanufacturers

These remanufacturers are separate entities to the OEM but remanufacture under licence either for the OEM or on behalf of exclusive users. One of the engine varieties studied during this research is a unique variant made by an OEM for one customer only and remanufacture is carried out for that customer rather than the OEM. Sales of remanufactured goods are strictly regulated by the OEM or their selected aftermarket provider. Contract remanufacturers can sometimes benefit from technical information or training from the OEM. When technical information is unavailable, contract remanufacturers have to resort to "reverse engineering" in the same way as independent remanufacturers.

Many OEMs also dictate the provenance of replacement parts and some also dictate the purchase price. OEMs may also insist on approving technology used or remanufacturing methods employed. Contract remanufacturers usually operate on a fixed-price basis and cannot vary their price to the customer. They have two routes to improving profit: efficiency savings during the processing and increasing the amount of remanufactured components in a product. This latter is often the preferred method as reducing the new component content can be seen as an immediate and direct benefit. Contract remanufacturers sometimes also act as independent remanufacturers alongside their contract work, often for one-off customers.

Return of cores is usually via the OEM or their agent and whilst prior knowledge of the type, quantity and quality of cores in transit can be given, this is not always the case. The OEM often encourages returns by offering a core credit payment that can be claimed by the dealer. A core credit is a payment made to a dealer (or sometimes a customer) upon receipt of an individual returned core. The value of the core credit is linked to the condition of the core and the value of the remanufactured product. There are usually other conditions attached to the core credit payment beyond condition, for example, the part number of the core must match the purchased replacement and it must be returned within a specified time period. The condition of the returned core is assessed at receipt by the OEM or their agent and any payment credited to the returning dealer. Cores in these cases are visually assessed against standards that are available to the dealer and have been agreed by all parties. There is usually no disassembly at all and the assessment is to ensure that the part number returned is correct, to look for damage such as dents or breaches in component covers or to identify missing parts.

The core credit process is often separate from the remanufacturer and so any information gathered at this time is usually not available to the remanufacturer. Thus the remanufacturer often has no control over and no knowledge of the type, quantity and quality of the cores being returned to him. Guide (2000) conducted a study of 48 remanufacturing companies and demonstrated that over half of them had no control over the timing or quality of cores bring returned.

2.5 Product Characteristics for Remanufacturing

Remanufacturing is carried out on a wide range of products but they typically share several basic characteristics. Andreu (1995) was the first person to consider these characteristics and he proposed eight prerequisites that typically made a product suitable for remanufacture:

- The product is durable in nature;
- It has failed functionally;
- The product is able to be disassembled and restored to its original condition;
- The retained value-added in the cores is high relative to both the original cost and market value – it is cost-effective to remanufacture;

- The product is standardised and factory-built rather than assembled in the field;
- A ready and continuous supply of cores is available;
- The product technology is stable; and
- The process technology is stable.

The main tenets of these criteria can still be applied despite the ever-increasing range of products remanufactured, although they do not necessarily apply in all cases. It is now increasingly common for highly-customised, large field built equipment for the mining industry to be both remanufactured and also maintained using remanufactured components in-situ. This is often a different model for remanufacturers, largely because successful remanufacturing is reliant on volume. However, much of this customised equipment is very valuable, both in terms of initial cost and in terms of lost time for breakdowns and maintenance. In these cases owners are prepared to pay a premium for remanufacturing to ensure their equipment remains available. The fast pace of implementation of new technologies in areas such as mobile phones also means that product and process technology is rarely stable despite the actuality of remanufacture within the sector.

Amezquita *et al.* (1996) later argued that four criteria only are commonly used to decide whether to remanufacture or not. These are:

- The retained value-added in the cores is high relative to both the original cost and market value – remanufacture is economically viable;

- Demand for the remanufactured product must exist – the customer base is aware of the offering;
- The quality of the resultant remanufactured product must be at least as good as the original whilst the purchase cost remains lower; and
- The lead-time to market must be short.

These do not contradict the findings of Andreu but rather highlight some of the current concerns that affect the suitability of a product for remanufacture. Remanufacturers rate lead-time to market in particular as highly important (Ijomah, 2002).

2.6 A Typical Remanufacturing Process

Remanufacturing is undertaken in many different ways depending on the nature of the product being remanufactured, the cores return procedure, the type of remanufacturer involved and the technology available. The following model (Ijomah, 2002 and Ijomah *et al.*, 2007) closely resembles the Rushden process before this research was undertaken.

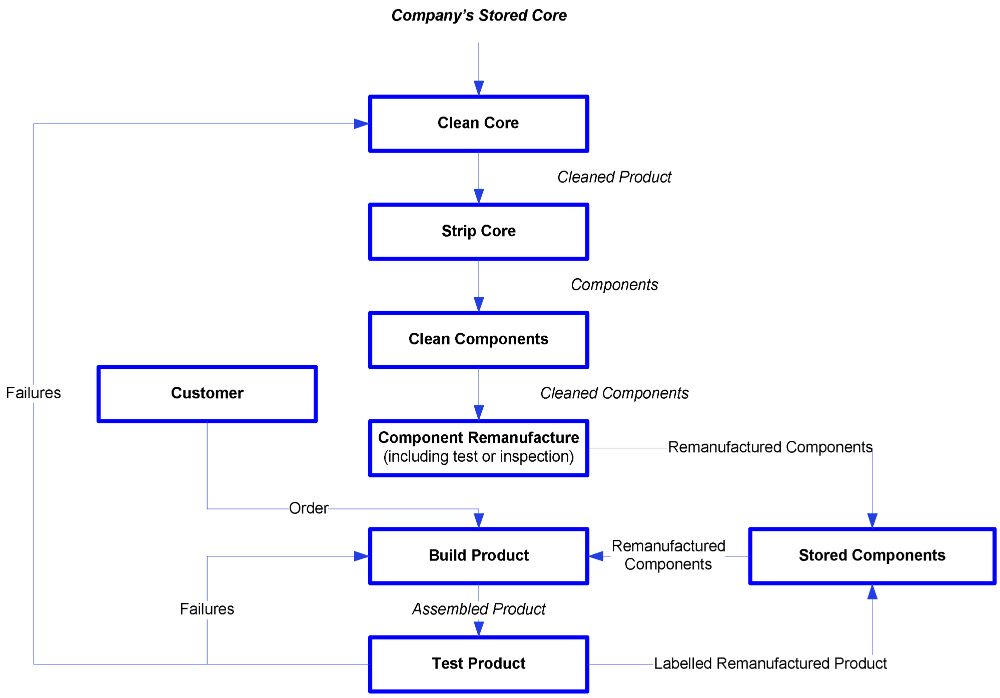


Figure 2.1 Generic Remanufacturing Process Chart

The essential remanufacturing process activities in the figure above are described in greater detail in the following sections.

2.6.1 Receive and Store Cores

The cores are received from a variety of sources depending on the particular remanufacturing model. The core is usually identified – sometimes by specific part number, sometimes under a more generic code – and may receive a cursory inspection for general condition. This may occur at a core consolidator prior to arrival at the remanufacturer. A core consolidator is a facility that receives cores from dealers and other sources, sorts them by part number (sometimes specific, sometimes generic) and sends it to the appropriate remanufacturer; this is sometimes sub-contracted by an OEM. The cores are usually stored by type prior to use.

2.6.2 Clean and Initial Inspection

Some remanufacturing operations include a basic external cleaning operation prior to disassembly. This is normally to assess specific part number and potentially year of first manufacture as well as to establish the general condition of the cores. The operator is looking for very obvious damage, e.g. holes in outer casings, or missing parts. Cores that are in a very bad condition may be removed from the process at this point as unsuitable for remanufacture and may be kept as a source of spare parts.

Some remanufacturers store cores in their "as received" dirty condition until required. This is to minimise further deterioration, particularly when stored outside. This was the case at Rushden.

2.6.3 Disassembly

Cores are disassembled into their component parts. Smaller sub-assemblies such as starter motors or turbochargers in the case of engines may be removed whole and sent to a specialist area for remanufacture. The disassembled parts would usually lose any identity other than piece part number at this time. There are also circumstances under which the identity could be retained, for example if the customer demands this as often happens in the aircraft industry. This retains traceability. There are a few instances, encountered at the Caterpillar Rushden facility, where disassembled parts retain their unique product identity. Two examples of this are when an individual customer required their engine to be rebuilt from as many of the original parts as possible and when a unique engine variant needed all of its component parts to be kept together. This latter was to ensure the finished product reached the specification of the original. Disassembled parts might also retain their original identity when the customer requires that the history of the product be maintained and accessible despite the new, unique remanufactured identity (as was the case in the first example). When a customer requires that an original identity is kept, the product is still given a new unique remanufactured identity but this is cross-referenced in all records with the original identity.

Once disassembled, components are sent for cleaning and inspection for more specific damage or wear.

2.6.4 Cleaning

This activity describes the cleaning of individual components using methods appropriate to their nature and configuration to remove contaminants such as oil, grease and rust. Cleaning methods typically include hot salt baths, abrasive blasting or tumbling activities, chemical dipping and very high-pressure water blasting.

2.6.5 Component Reprocessing

This activity is all-encompassing and covers a great many different activities and technologies all designed to return individual components to at least new functionality. It could include laser deposition of metal to recover components or removing material to eliminate wear. Other examples might include grinding crankshaft journals or skimming the fire deck of a cylinder block; replacement of seals, re-tapping holes and a myriad of other recovery techniques. It also includes inspection both prior to and/or post any activity. New components are added to sub-assemblies as required. This activity can include testing for functionality. Remanufacturers sometimes elect to test component functionality at the post-production test rather than prior to assembly. This may be because product volumes are too low to justify the cost of test equipment or because the product is difficult to test in any other way.

2.6.6 Assembly

Individual remanufactured components, sub-assemblies and new parts are assembled into the required product. New parts are almost always incorporated into remanufactured products. These are usually direct replacements for the original component and are added for one of several reasons: the original component may be beyond repair; the design might be such that remanufacture is infeasible; the customer (or legislation) may require a specific component to be new every time) or it might be more costly to remanufacture than replace. Upgrades can also be incorporated at this stage. One example of this is included in Engine A used in this research. The main bearing cap bolts were always replaced and upgraded to the latest level following an earlier (pre-experimental) change to the crankshaft construction.

2.6.7 Testing

Fully assembled products are usually all tested prior to either being sent to the customer or stored for future orders. Remanufacturers usually aim to replicate the test, measurement and quality systems used during original manufacture as closely as possible. Generally product is tested upon completion because the default assumption is that they are faulty until proven otherwise. If it passes test it is considered to be fully remanufactured and is badged in a way to distinguish it from the equivalent new part. There are some remanufactured products that are not tested once assembled as there is no practical and cost-effective method of doing so. One example of this is an assembled cylinder head. Every component in these assemblies is tested prior to use and so, once assembled, it is not re-tested.

2.7 UK Remanufacturing Industry

There is a wide variation in remanufactured products, large and small, simple and complex that can broadly be divided into four major industry sectors (Petrakis, 1993):

- Industrial - hydraulics, complex medical equipment etc. often customised for individual customers;
- Commercial – office machinery, communication equipment etc.;

- Automotive – from complete engines both petrol and diesel to individual components such as alternators and turbochargers; and
- Domestic – washing machines, power tools etc.

The largest by far of these markets is automotive. A large amount of local knowledge and expertise arose from the experience gained from maintaining and extending the working life of military vehicles and components during the Second World War and this enabled automotive OEMs to undertake a comprehensive aftermarket strategy remanufacturing. These could be offered as a lower cost alternative to dealers and individual purchasers whilst maintaining quality without jeopardising new vehicle production by diverting components from the assembly line. Remanufacturing also offers OEMs the ability to maintain their brand reputation, in terms of ensuring a quality product comes to market, preventing other independent remanufacturers from taking business and also economically extending product use for consumers. The perceived advantage of remanufacturing has also fuelled growth in other areas. The extension of end-of-life legislation to encompass off-road and industrial equipment – generators, backhoe loaders etc. – has increased the interest in remanufacturing in these areas and large, high-cost medical equipment such as magnetic resonance imaging (MRI) scanners are also routinely remanufactured and sold on to emerging markets.

The domestic remanufacturing segment remains the smallest despite a large proportion of consumer goods that could be remanufactured. Some small-scale remanufacturing of white goods, mobile phones and other consumer electronic is undertaken but the uptake of remanufactured items remains low. This seems to be a result of confusion between repair, reconditioning and remanufacture; a perception that a remanufactured items is of lower quality and, to a lesser extent, a desire for the latest technology (Hazen *et al.,* 2011). The only domestic remanufacturing activity that has seen huge growth is in the ink cartridge refill market; this is a simple form of remanufacturing, in terms of the complexity of the tools and techniques required, as the cartridges are only cleaned and refilled, effectively a reuse operation.

2.8 Discussion of the Issues Surrounding Engine Remanufacture

Remanufacturing, as can be seen from the preceding sections, is a useful end-of-life strategy for many durable products. The benefits are threefold: economic, ecological and societal but despite this, and the ability to incorporate upgrades into remanufactured product, nevertheless the author believes it is still necessary to question whether remanufacture in all cases is an appropriate policy. There are a number of products currently remanufactured that produce a considerable amount of pollution during the use phase of their life-cycle. It could be argued that engines fall into this category. It would not be inappropriate to question whether supplying remanufactured engines (the subject of this research) at a reduced price prevents the up-take of newer, cleaner technology.

A study in 1998 by Sullivan *et al.* estimated that 85% of the life time emissions of a typical family saloon occurred during the use phase. New engine technology, the uptake of unleaded and diesel fuels and better assessment techniques have reduced that figure but nevertheless it is not unreasonable to assume that a large amount of emissions occur during the use phase (Yang and Chen, 2005). Other studies, e.g. Adler (2007), have shown that remanufacturing uses considerably less energy than the equivalent new manufacturing process and so the question then becomes, if the only choice was a new product would the take up of new technology, for instance electric vehicles, be greater?

Shepherd *et al.* (2012) investigated factors affecting future demand for electric vehicles in the U.K. and concluded (amongst other conclusions) that whilst a shorter working life for conventionally powered vehicles (the opposite of the current trend) was likely to result in an increase in the up-take of electric vehicles, unless battery life, distances travelled/speeds were improved and model range widened, the projected benefits of "retiring" internal combustion engines might not be achievable.

The cost of an electric vehicle – at present partly subsidised by the U.K. Government – removes the opportunity from a sizeable part of the population and this, coupled with the lack of second-hand electric vehicles, means that the current rate of registrations – 700 only from 1 million in total during the first 6 months of 2011 (Shepherd *et al.* (2012) – is unlikely to rise very quickly. They also noted that the U.K. Government would have to accept that a high adoption of electric vehicles would be offset by falling revenue due to lost fuel duty.

In conclusion, whilst the overall aim should be to reduce the emissions of every product, factors such as the cost of new technology, the inherent caution of many in the uptake of innovative products and the need for any government to find sources of revenue to replace fuel duty, will prevent the rapid switch to alternatively powered vehicles. It is therefore the author's opinion that there will be a need for remanufacturing as part of a comprehensive end-of-life strategy for engines for many years to come.

2.9 Summary

The chapter has defined remanufacturing in terms of this research. It explained the history of remanufacturing and the type of remanufacturers currently active in the field. A description of the activities within the overall remanufacturing process and the product characteristics that typify a remanufactured item was offered. It ended with a discussion of the ambiguity of environmental issues that surrounds the remanufacture of engines.

The following chapter discusses the significance of remanufacturing and the impact of remanufacture on sustainability. The motives for remanufacturing are also explored.

Chapter 3 The Significance of Remanufacturing

3.1 Introduction

This chapter explains the significance of the remanufacturing industry and discusses the impact of remanufacture on sustainability. The motives for remanufacturing are also explored.

3.2 Remanufacturing Significance

The latter years of the 20th century and the beginning of the 21st have been marked by an increasing focus on the environment and issues surrounding sustainability (United Nations, 2001). This interest has been fuelled by the knowledge that the world's natural resources are being consumed at an ever increasing rate. Vandermerwe and Oliff (1991) noted that more of the world's mineral resources have been consumed in the last century than has been in all of preceding history. The explosion of technology that has driven this increased use of virgin material has also generated a consumer society, the majority of whom believe that they are being responsible with waste despite the majority going to landfill (de Oliveira Simonetto and Borenstein, 2007).

It has been estimated that manufacturing generated in excess of 65% of annual UK waste in 2002 of which almost half went to landfill (DEFRA, 2009). Suitable landfill sites are becoming increasingly hard to find and those already identified are being rapidly exhausted and consequently more expensive. In an effort to address sustainable development, asset and product recovery management (A&PRM) processes are being increasingly adopted by manufacturers (Hormozi, 1996). These product recovery processes, defined as industrial operations to reclaim whole products or their component parts for reuse in production process, include repair, reconditioning and remanufacture.

Remanufacturing has received an increasing focus from researchers over the last three decades as the need to conserve energy and natural resources has become greater.

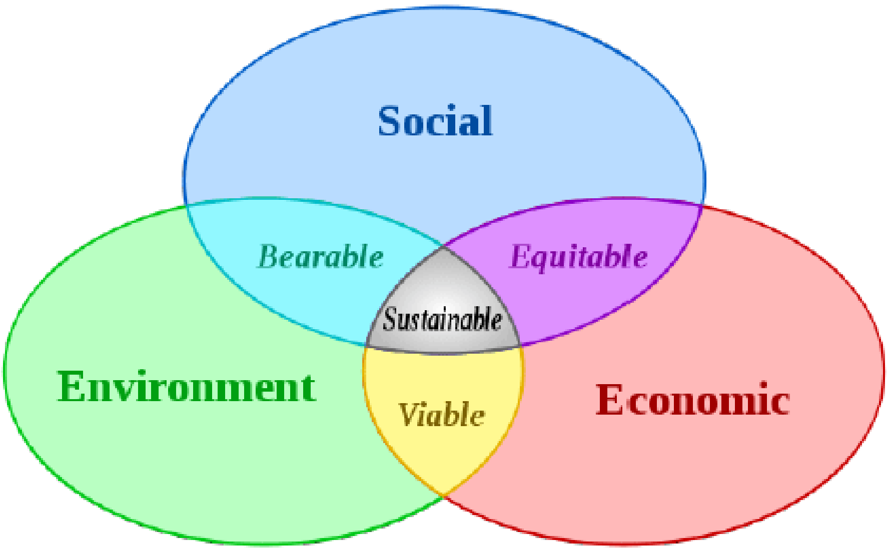
3.3 Sustainable Development through Remanufacturing

Sustainable development has become an increasingly important issue for countries, business and individuals (United Nations, 2001). The Bruntland Commission of the United Nations (1987) succinctly defined sustainability as:

"…*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*."

This definition was further developed by the World Summit of 2005 (United Nations, 2005) as the continued ability of planet Earth to sustain healthy human life. The

Summit also described three pillars of sustainability as being the reconciliation of environmental, social and economic needs. This is illustrated in figure 3.1.



Adams (2006)

Figure 3.1 Sustainability Model

Remanufacturing is defined under "reclamation" and "reuse", the top two preferred waste management options identified in the European Union's (EU) Fifth Environmental Action Programme (EU, 1993). Remanufacturing is also becoming more attractive within Europe because The Basel Convention requires that waste produced inside the European Union must also be managed within the European Union, effectively preventing its export. This is important as much of the exported waste used to be sent to developing countries where proper regulation and safeguards (both for people and the environment) are not in place. These legislative concerns, coupled with the effect of more local environmental penalties such as landfill tax in the UK are driving an increased focus on remanufacturing. Landfill tax is now subject to an additional levy of £8 per tonne per year; the March 2012 UK budget fixed the figure at £64 per tonne for the 2012-2013 tax period (UK HRMC, 2012).

Each of the three tenets of sustainable development: economic, environmental and social benefits are separately explored in the following sections.

3.3.1 Economic Benefits of Remanufacturing

Various researchers (Lund, 1984, Hormozi, 1996, Ayres *et al.*, 1997, Guide, 1999 and Ferrer, 2001, etc.) have shown that remanufacturing is an economically beneficial activity.

Lund, in 1996, estimated that remanufacturing in the United State of America was worth around $53 billion per annum and directly employed approximately 480,000 people.

3.3.2 Ecological Benefits of Remanufacturing

It has been estimated that manufacturing generated around 48 million tonnes of waste going to UK landfill in 2009, of which between 2% and 9% was diverted to remanufacturing and other reuse methods whereas 44% was recycled (DEFRA, 2010). Recycling is generally less desirable than remanufacturing because its energy requirements are often substantial – from melting or otherwise rendering material and then reshaping as required – and, in addition, the quality of the material often degrades during the recycling process (Hundal, 2000).

Lund (1984) suggested that up to 85% by weight of a remanufactured product may come from reclaimed components. Adler (2007) suggested that for engine remanufacture this value was nearer to 60%. These figures indicate that the amount of energy used in production by removing the need for raw material production and the subsequent shaping and machining activities can be substantially reduced by remanufacturing (Haynesworth and Lyons, 1987, McCaskey, 1994, Lund, 1996, Hormozi, 1996, and Guide, 1999). Adler (2007) estimated that the reductions in energy use for remanufactured engines were between 45% and 95% of that used to product an equivalent new product. He argued that the level of saving was linked to the state of the cores and the availability of appropriate technology to recover components.

Remanufacturing can also reduce greenhouse gas emissions such as CO_2 and methane, as required by The Kyoto Protocol (2005), as the majority of such emissions from manufacturing occur during raw material production, machining and shaping activities. Giuntini and Gaudette (2003) estimated the annual worldwide reduction of carbon dioxide emissions because of remanufacturing as being approximately 28 million tons or the equivalent of the annual emissions of 10 500-

megawatt coal-burning power stations. Refer to Sundin and Lee (2012) for a good summary of remanufacturing ecological research studies.

3.3.3 Societal Benefits of Remanufacturing

The benefits to society from remanufacturing are wider and less obvious than the economic and ecological; firstly through the wide range of jobs it creates, particularly for semi-skilled and unskilled labour – sorting, disassembly and cleaning tasks do not usually require skilled labour and Lund (1984) indicated that up to 60% of the labour of a typical remanufacturer in the automotive sector may be semi-skilled or unskilled. This is further confirmed by research by Tang *et al.* (2007) that demonstrated no increase in material recovery from the use of skilled labour in the sorting, disassembly and cleaning phases. Secondly, remanufacturing provides quality products at lower prices, typically between 30% and 40% lower than the new equivalent (Ijomah *et al.*, 2005); once again a benefit to those on restricted incomes.

The reduction in landfill from remanufacturing also benefits society as proliferating landfill sites can drive down property prices and subject local residents to nuisance such as noise (DEFRA, 2003).

The Office of National Statistics Labour Market Bulletin (ONS, 2010) of October 2010 showed a decline in UK manufacturing jobs of 3.7% between June 2008 and June 2010. This takes the percentage of people employed in the manufacturing industry in the UK to 14% as opposed to the 26% employed in manufacturing in 1978. Remanufacturing provides unskilled and semi-skilled employment with the ability for those employed to increase their skills whilst in work. An increase in the remanufacturing industry, driven by the need for sustainability would help improve skills and job prospects.

3.4 Motives for Remanufacturing

The motives that influence remanufacturers are complex; however research has highlighted three major drivers: environmental concerns, legislative pressure and profitability through lower production costs (Amezquita *et al.*, 1996). This is confirmed by various other researchers (e.g. Lund, 1984, McMaster, 1989, Steinhilper, 1998, Guide and Gupta, 1999 and Hauser and Lund, 2003, Östlin *et al.*, 2008) indicating that remanufacturing is an ethically responsible and profitable undertaking, conferring the benefits of social responsibility and legislative compliance on OEMs. The environmental benefits of remanufacturing were discussed in section 3.3; however legislative pressure and profitability motives are outlined in the following sections.

3.4.1 Legislative Pressure

There has been an increase in legislation concerning the end-of-life options for all types of products; for example, the End of Life Vehicles Directive (2000/53/EC) and the Waste Electric and Electronic Equipment (WEEE) Directive (2002/96/EC) etc.

These coupled with increasing legislation concerning landfill – e.g. the Landfill Regulations (England and Wales) 2002 – are driving manufacturers to consider the whole product life-cycle. Remanufacturing reduces the amount of waste from a product at end-of-life, reusing up to 85% (Lund, 1984) and provides a profitable take-back route for OEMs.

3.4.2 Profitability

Studies over time have shown that remanufacturing is a profitable undertaking, for example Hammond, Amezquita and Bras (1998), Thorn and Rogerson (2002), Steinhilper (2005) and Guide *et al.*, (2003) amongst others. It can aid profitability in several distinct but related ways. Research has indicated that remanufacturing uses less new material and energy whilst reducing waste when compared to conventional manufacturing (Lund, 1984, Haynesworth and Lyons, 1987, Hormozi, 1996, Steinhilper, 1998 and Guide and Gupta, 1999 etc.). Energy is often a substantial cost for business and remanufacturing can offer reduction in energy use of as much as 80% (Adler, 2007).

Tang *et al.* (2007) showed that lower skilled labour – and thus lower cost labour – is as effective as skilled labour for many remanufacturing tasks. Studies conducted by Hormozi (1996) have shown that remanufactured engines can be produced with two-thirds of the labour costs of a conventionally manufactured equivalent new product.

3.4.3 Additional Motives for Remanufacturing

Environmental concerns, legislative pressure and profitability have all traditionally been thought of as sufficient motivators to remanufacture components and assemblies but more recent research has shown that the remanufacturing decision is more intricate than a purely profit or legislative-driven matter. Sundin (2004) argues that the decision to remanufacture is complex and dependent on many factors specific to an individual product and manufacturer. This is in accord with the findings of other researchers (Westkämper *et al.*, 1999, Seitz, 2006), particularly when considering OEMs. These researchers cite other, potentially stronger incentives for OEM remanufacturing.

Seitz (2006) in particular highlights additional powerful motivators for remanufacturing that are rather less laudable in ecological terms: brand maintenance and aftermarket availability. The researcher's experience of working in an OEM and contract remanufacturer on a day-to-day basis concurs with this. Seitz (2006) notes differences in motivation between American and European remanufacturers. Her research indicates that European remanufacturers are motivated by the need for replacement parts to service the aftermarket and retain customers; whereas their American equivalents place little emphasis on brand protection. She postulates that there are differences in the type of remanufacturer, more independent focused in the USA and more OEM focused in Europe.

3.4.3.1 Brand Loyalty

Remanufactured products components and assemblies are sold as part of a strategy to ensure the customer maintains allegiance to the brand by keeping product operational for as long as required in an economically positive manner (thus again strengthening customer regard for the brand) and, when the decision to replace is taken, their brand is the "obvious" choice for the customer. Remanufacturing also ensures that the majority of cores are returned to the OEM (or their contract remanufacturer) and this prevents competitors from obtaining the used products, undercutting OEM aftermarket prices. It also prevents customers rejecting the new OEM component choice because of the ease of obtaining a "reconditioned" aftermarket alternative.

3.4.3.2 Brand Maintenance

OEMs pour time and money into establishing and maintaining the credibility of their brand. It is seen as a key to maintaining consumer confidence. The reputation of a brand is very important to an OEM as it enables them to both gain and hold market share.

One component of brand maintenance lies in the need to ensure the quality of the remanufactured component. OEM remanufacturing, either directly or via a contractor, ensures that the quality reputation associated with their brand is maintained (and sometimes enhanced) by both ensuring that remanufactured parts or market are the equivalent of the new, incorporating upgrades as required and also by making it very difficult for third parties to supply badly or inadequately remanufactured components. This latter is often achieved by rigidly controlling the market for cores.

3.4.3.3 Aftermarket Availability

There are a large number of firms producing assemblies and components designed to service products made by other manufacturers. To illustrate this, a two minute internet search for a water pump suitable for a current production Ford Fiesta, 1.6l petrol vehicle, returned five suitable, non-Ford branded parts, all costing around £40. The equivalent Ford-branded remanufactured part could also be purchased for a similar but slightly lower price. Remanufacturing allows OEMs to compete with other aftermarket suppliers by providing a similar offering. OEMs believe that customers would rather have genuine parts where price is not the decisive factor (Seitz, 2006).

3.4.3.4 New Production Protection

OEMs have to respond to warranty claims made on their new product. New production can often be slowed by diverting components or assemblies from the production line to replace defective parts with new. In extreme cases it can delay the sale of a new vehicle. This practice also adds to the costs of any warranty claim. Remanufactured components or assemblies, indistinguishable from new in terms of quality, are often used, particularly in the automotive sector, to respond to warranty claims and this also ensures that the used cores remain within the remanufacturing loop. Customers are often unaware of this but it does not affect their experience of their product in any way because the quality is good and their rights are protected by the equivalent guarantee.

3.4.3.5 Informing the Design Process

OEMs or their contractors are able to extract a great deal of useful information from returned cores that can be used to inform the original and subsequent design processes. This information includes repeat or early failure modes, wear patterns and contamination issues, and the effects of machining processes on components. For example, one engine remanufactured at the Caterpillar Rushden facility demonstrated unusual wear on one end of the crankshaft when returned for remanufacture. This was investigated during remanufacture and the cause was found to be a feature of the oil pump housing, included to facilitate fitting, that was rubbing on the end of the crankshaft when high engine speed resulted in increased pressure on the accessory drive bringing the two into contact. Feedback given to the OEM resulted in the redesign of the oil pump housing.

3.6 Summary

This chapter has explained the significance of the remanufacturing industry and discussed the impact of remanufacture on sustainability. The motives for remanufacturing have also been explored.

The following chapter reviews the existing literature concerning remanufacture, detailing the gaps in current understanding. It also sets out the objectives of this research, resulting from the literature study.

Chapter 4 Existing Remanufacturing Research

4.1 Introduction

This chapter reviews the existing literature concerning remanufacture, detailing the gaps in current understanding. It also sets out the objectives of this research, resulting from the literature study.

The literature study was undertaken initially using scientific publication databases including ScienceDirect, Engineering Research database, Emerald Journals and Elsevier Journals. It progressed by tracking down papers referenced by others. The academic librarians at the University of Strathclyde were consulted for further sources of information as was the Andersonian Library printed resources.

4.2 Existing Remanufacturing Research

The amount of research concerning remanufacturing is increasing as the need to preserve the world's natural resources comes to the fore.

Lund (1984), in his seminal work, undertook a comprehensive analysis of remanufacturing and its implication for developing countries across the world. It employed over 40 researchers in a range of countries and considered both the range of products being of remanufactured and the types of remanufacturing businesses. The work also discussed the economic and environmental benefits of remanufacturing. The report concentrated on the industry within the United States of America and considered the benefits that remanufacturing could bring to developing countries. Lund acknowledged that the work content of remanufactured goods is higher than that from other secondary processes whist commenting on the perceived consumer prejudice against remanufactured goods although they (the consumer) were generally unable to differentiate between remanufactured, repaired and reconditioned goods. The Lund report remains the most comprehensive investigation into remanufacturing and is consequently the foundation for most subsequent research.

The existing research into remanufacturing found by the researcher during the course of the research can be grouped into two main categories: design for end-of-life, including design for remanufacturing (DfRem) and research looking to understand or improve the actual remanufacturing process, remanufacturing operations specific research.

It is noticeable that the majority of research available concentrates on the economic advantages and aspects of remanufacture and does not take the standpoint that remanufacture is desirable for environmental reasons regardless of the economics. This is particularly true of research concerning current products with an unknown scope for remanufacture because their design has typically focused on functionality and cost. Whilst it is naïve to expect that remanufacture will be undertaken on a purely altruistic basis, promotion of the environmental positives may well influence the future design of products to make them more readily remanufactured.

4.2.1 Design for Remanufacturing

Design for End-of-Life is often aimed at a wider audience than that concerned with remanufacture. It has tended to concentrate on incorporating recyclable or recycled materials and the ease with which products can be disassembled at end-of-life. It rarely takes account of whether the component parts can then be remanufactured easily and cheaply before reassembly. Research by Navin-Chandra (2003), Dowie and Simon (1994) and Kroll and Hanft (1998) is typical in that its focus is for recycling and little or no consideration is given to remanufacturing. Design-for-Remanufacture (DfRem) differs from design-for-end-of-life in that, while it also considers ease of disassembly, its main purpose is facilitating component reuse and therefore remanufacturability.

Research more specifically concerning design for remanufacture includes Shu and Flowers (2003) who consider design for remanufacture specifically and developed a design structure matrix to enable designers to account for remanufacture from the beginning. This work was developed from earlier research in 1995 (Shu and Flowers) when they report on three case studies in industry demonstrating products that had been specifically designed to be both easy to assemble and recyclable at end-of-life, proved difficult to remanufacture because of the fastening and joining methods. Their work also argues that individual part reliability is critical if it is to last more than one life cycle, including all remanufacturing steps, and still work satisfactorily. They contend that it does not matter if a product can be easily disassembled or washed if its inherent lack of ongoing reliability prevents reuse. More recent work includes a high-level design guide to promote remanufacturing (Ijomah, 2009) and the use of Quality Function Deployment to include the "voice of the remanufacturer" in the "voice of the customer" (Yuksel, 2010).

Research by Sundin *et al.* (2009) considers whether end-of-life design is embedded as part of the general design experience among Swedish companies and identifies many further opportunities for these considerations to be further integrated into product design. Jayal *et al.* (2010) also make the case for a holistic approach to end-of-life operations and advocate the use of new technology, such as cryogenic machining to facilitate heat-treatment, in prime manufacturing operations as a key to sustainable manufacturing and remanufacturing.

It should be noted however that any proliferation of cutting-edge technology amongst OEMs will present additional challenges for remanufacturers by making processes harder to replicate without significant investment in new machinery. New technology to aid remanufacture can also result in similar cost challenges, for example, Caterpillar Remanufacturing facilities are able to metal-spray engine components, cylinder bores in engine blocks for example, to enable further machining operations to take place or to return the component to within OEM specification. This has several benefits including removing the need to provide oversized or non-standard sub-components (pistons in the case of cylinder blocks) which is a very costly undertaking as the volumes are low compared to those for normal production. However, the metal spray process, in order to achieve the appropriate material bond, produces a much harder surface finish that the original parent material, as a consequence the machines and machine tools required for subsequent machining operations require an often costly upgrade.

The focus of this research is remanufacturing operations and, as such, not concerned with DfRem but interested readers are urged to consult *"Design for remanufacture: a literature review and further needs"* (Hatcher *et al.*, 2011) which provides an excellent summary.

4.2.2 Remanufacturing Operations Research

The main themes in manufacturing research are production control and planning, inventory control, reverse logistics and remanufacturing processes.

There is also some remanufacturing-specific research concerning reliability in original life. This thesis does not specifically consider this however, one researcher, Rugrungruang (2008), investigates component reliability in second life applications. She concludes that the life of individual components is often longer than that of the original assembly. However this work relies heavily on knowledge of the initial life of the assembly, information that is often not available to a remanufacturer.

4.2.2.1 Production Control and Planning

Researchers have developed several remanufacturing oriented scheduling methodologies to address the uncertainty and complexity often found in remanufacturing operations. These include Guide (1996) who compares an MRP-based current production planning and control system with a Drum-Buffer-Rope (DBR)-based proposed system for a real life remanufacturing facility. He questions the use of MRP in remanufacturing systems by stating that highly variable remanufacturing environment lacks the stability which is one of the fundamental requirements for a successful MRP system.

Various researchers have developed capacity planning and Rough Cut Capacity Planning (RCCP) techniques considering the characteristics of remanufacturing environments. Guide and Spencer (1997) develop an RCCP method for remanufacturing firms by considering probabilistic material replacement and probabilistic routing files. Kim *et al.* (2005) develop a mathematical model to determine the capacity of remanufacturing facilities based on the maximization of the saving from the investment required. Vlachos *et al.*, (2007) propose a complex mathematical model to determine capacity assuming a closed loop supply system but once again, aside from the complexity of the calculations, assumptions are made that the conditions for remanufacture are perfect. Tang *et al.* (2007) also propose a mathematical solution for determining lead time assuming a make-to-order system.

This work is extended by Bao *et al.* (2008) who establish minimum economic batch sizing for production.

All of this research has remanufacturing as its centre but the type and complexity of the models make them less likely to be used in industry. Scheduling systems that are actually used often tend to be local variants of manufacturing systems that have either been adjusted to suit remanufacturing or a totally individual system.

Planning is a difficult subject as the remanufacturing process is, by its nature, an unstable environment. The majority of planning models – whether for capacity or production – have difficulty dealing with this inherent uncertainty and as a consequence the proposed solutions are complex and require a level of understanding that is uncommon in remanufacturing facilities.

4.2.2.2 Inventory Management

There are two models for inventory management that are the subject of most research: deterministic and stochastic.

Deterministic models assume that both the amount of core being returned and the demand for remanufactured products are known. As a consequence of this, deterministic models attempt to balance the costs of holding inventory with demand.

Fleischmann *et al.* (1997) uses economic order quantity (EOQ) to balance inventory with production set-up costs. Richter (1997) determines the optimal number of remanufacturing and production batches for different values of return rate based on EOQ. Richter and Dobos (1999) and Dobos and Richter (2000) develop non-linear models for the analysis of EOQ repair and waste disposal problem with integer setup numbers. They argue that either total repair or total waste disposal is the optimal solution. However in practice, most manufacturers inject new material only where they are unable to use recovered product. El Saadany and Jaber (2008) consider the costs associated with switching between production and recovery runs in a system that produces both new and remanufactured products. This builds upon Koh et al. (2002) who develop an EOQ and Economic Production Quantity (EPQ) model where demand is satisfied using either remanufactured or purchased items. Tang and Teunter (2006) also develop an inventory holding policy based around a combined remanufacturing and manufacturing system in which manufacturing and remanufacturing operations for multiple product types are performed on the same production line. Rubio and Corominas (2008) develop a model to continuously adjust the capacities of manufacturing and remanufacturing in a combined production facility according to demand so that excessive inventory levels can be prevented. All of this research is relevant to combined manufacturing and remanufacturing facilities cannot be applied to pure remanufacturing operations as the demand for and availability of new parts is greatly increased by new production.

Teunter (2001) develops EOQ formulae by using different holding cost rates for manufactured and recovered items and goes on (2004) to develop simple expressions for the determination of optimal lot sizes for both production and procurement of new items and for the recovery of returned items. However, understanding the optimal return rate for core often does not guarantee that it can be met.

Chung *et al.* (2008) develop an optimal production and replenishment policy for a multi echelon inventory system with remanufacturing by simultaneously considering the concerns of the supplier, the manufacturer, the retailer and the third party recycler. This is a complex process and the ability to satisfy the concerns of all parties rely on a considerable amount of knowledge of demand, rate of core receipts and the condition of the returned core.

Yan (2012) develops a model to optimise control based on sales of new and returns of core however, this model assumes an equality of quality of returns that cannot be guaranteed.

Stochastic models are by definition non-deterministic and acknowledge the randomness of core returns and the lack of clarity of demand. As a consequence of this, continuous and periodic review policies are often used to inform stochastic models. Unfortunately they often use minimal fixed or zero lead times for procurement which are not often seen in reality.

Van der Laan *et al.* (1999a) consider the use of either a pull or a push system to control serviceable and recoverable components. They use historic demand and recovery rates, periodically reviewed, to inform their inventory decisions. Van der Laan *et al.* (1999b) extend van der Laan *et al.* (1999a) by considering stochastic lead times for joint manufacturing and remanufacturing operations. Zanoni *et al.* (2006) extend traditional manufacturing inventory control policies for use in a combined manufacturing and remanufacturing system where demand, return rate, and lead times are stochastic. Their comparisons are based upon total inventory cost.

Inderfurth *et al*. (2001) develop an approximation algorithm to determine optimal inventory policy parameters of a stochastic remanufacturing system with multiple reuse options. Vlachos and Dekker (2003) and Mostard and Teunter (2006) extend the classical newsboy problem to incorporate core returns. Vlachos and Dekker (2003) assume that a constant proportion of the new products are returned and that these can be resold only once. Mostard and Teunter (2006) extend Vlachos and Dekker (2003) by analyzing a newsboy problem in which sold products are returned with a certain probability and resold provided they are not damaged. Tang *et al.* (2007) and Bao *et al.* (2008) provide very comprehensive models for establishing component lead-times and optimal inventory levels. However the skill level and time required to both understand and use the methods outlined above are not always available in industry and consequently this makes them much less likely to be adopted.

Fleischmann *et al.* (2003) consider the use of disassembly as a source of spare parts via a basic analytic inventory model and a simulation model from a case study at IBM. Ilgin and Gupta (2008) present a simulation-optimization study to determine the optimum reorder and order quantity levels for the spare Printed Circuit Boards (PCBs) by simultaneously considering two spare parts acquisition alternatives: the recovered PCBs from end-of-life TVs and newly purchased PCBs. The use of additional cores for spare and replacement parts accords with the researcher's industrial experience.

Minner (2001) provides a system to determine the size and use of inventory buffers in a supply chain with internal and external product returns and reuse. These models more closely resemble the various inventory policies used in industry however, they all use computer-aided modelling systems that are uncommon in the remanufacturing industry.

Ferrer (2003) and Ferrer and Ketzenberg (2004) develop decision models to help to balance limited information about remanufacturing yields and potentially long supplier lead times. They state that identification of product yield early in the disassembly process is significantly more valuable than placing purchase orders with a short lead-time. These various findings are reinforced by recent research by Robotis *et al.* (2012) which found that inspection capability and processes are essential to cost-effective remanufacture. This reinforces the requirement for a robust core inspection process.

4.2.2.3 Reverse Logistics

Reverse logistics has been defined as *"…a supply chain redesigned to manage the flow of products or parts destined for remanufacturing, recycling, or disposal and to use resources effectively."* (Dowlatshahi, 2000)

Existing research concerning logistics often uses complex mathematical models that are not necessarily widely known and understood in industry.

Georgiadis and Vlachos (2004) describe a mathematical model for evaluating the long-term environmental impact of the return of core; however this is geared towards policy-making and experimental simulation. This may be of benefit to an OEM setting up a remanufacturing scheme but is not generally applicable to existing operations.

Çorbacioğlu and van der Laan (2007) consider a model for a joint new manufacturing and remanufacturing operation. They assess the need for inventory of new parts required for both strands and also the holding costs of remanufactured items. They conclude that the value of remanufactured components in such a model, particularly where the disposal option is available, has a profound effect on profitability. This is because the simplistic value of a remanufactured component is often the "added value" from the act of remanufacture, whereas the initial quality of the returned core is such that the added value can often not be applied equally. Their model works well for OEM remanufacturers but is not applicable to either contract or independent operations. Schultmann *et al.* (2006) use case studies within the automotive industry to model reverse logistic systems but again the model assumes that core receipts can be controlled and are known.

Konstantaras and Papachristos (2007) build on the Koh *et al.* (2002) research and simplify it to a two-stage calculation. Both works aim to identify the optimal inventory level for remanufactured components alongside the best ordering policy for new parts and to optimize the number of good core returns. The methods vary although the Konstantaras and Papachristos (2007) work confirms the work of Koh *et al.* (2002), however both methods assume that recovered core is perfect and equal to its new counterpart. They also assume that the level of core receipts is known and controllable. This is rarely if ever the case in practice and as a consequence both methods have an inherent flaw.

Mukhopadhyay and Ma (2009) address this known variance in returned cores in their work. They develop a model to predict the yield from a given quantity of returned cores to establish the best quantity to source alongside the required number of new parts to obtain to support a remanufacturing process. However they acknowledge that their work only considers remanufacturing of a single item and not an assembly of parts where the recovery rate of different components is variable. This makes their work useful for individual component remanufacture but not in other cases.

Richter and Dobos (1999) argue that the optimal recovery process is one of total loss – no remanufacture or one of total recovery – 100% remanufacture. This is clearly not the case in practice and subsequent work, Dobos and Richter (2006), extend the proposition to include variable core quality. This work raises interesting questions concerning whether the customer views prime manufactured products as interchangeable with the equivalent remanufactured products. They contend that this is not the case and that the customer requires a price incentive to buy remanufactured items. They also contend that sales are lost when a prime manufactured component is unavailable and the remanufactured equivalent is not seen as its equivalent. Their work does not take into account the use of remanufactured items as warranty replacements by OEMs.

Karakayali *et al.* (2007) discuss the effect of the cost of core units on the price of remanufactured products. They make interesting conclusions concerning the role of the OEM in the optimising the return of cores and this directly concerns contract remanufacturers who are able to utilise the OEM core process. However, some OEMs use the remanufacturer as the core handler and all core units are returned through dealer networks and a levy charged for incomplete units. This scenario is not considered in this work. The work also has implications for independent remanufacturers who might find it more costly and problematic to obtain core units if the OEMs are involved.

Tagaras and Zikopoulos (2008) consider the effects of sorting core at multiple collection sites prior to returning it for remanufacture. They conclude that this is desirable but many remanufacturers do not have sight of the core at this stage of the process and this is often the case for contract remanufacturers who are obliged to receive and remanufacture what is sent to them. Teunter and Flapper (2010) consider a similar theme but build in the uncertainty of core acquisition. This work is largely aimed at developing a cost-effective strategy for remanufacturers.

Langella (2007) develops a multi-period heuristic considering holding costs and external procurement of items. Kim *et al.* (2006) develop a computer-aided processing model in order to determine the quantity of products or parts processed in the remanufacturing facilities and the amount of parts purchased from the external suppliers based on the maximization of the total remanufacturing cost saving. Lu *et al.* (2007) develop a short-term bulk recycling planning model to determine what products to accept, process, and reprocess. DePuy *et al.* (2007) present a production planning method which estimates the expected number of remanufactured units to be completed in each future period together with the number of components needed to be purchased to avoid any projected shortages. Li *et al.* (2009) integrate a hybrid cell model to optimise the production planning and control policies for dedicated remanufacturing. Xanthopoulos and Iakovou (2009) propose an MILP-based aggregate production planning model which can determine how many end-of-life products and components should be collected, non-destructively or destructively disassembled, recycled, remanufactured, stored, backordered and disposed in each period. Once more these models all rely on knowledge and technology not often available to remanufacturers.

Pokharel and Mutha (2009) consider current research into reverse logistics with particular regard to the development of pricing models for remanufactured items based on the cost of core receipts. This follows on from work by Liang et al. (2007) who also attempt to link pricing of remanufactured items with the price of cores. These models are applicable to independent and possibly OEM remanufacturers but do not apply to contract remanufacturers.

4.2.2.4 Remanufacturing Process

The vast majority of research into remanufacturing processes is focused on the disassembly activity. An understanding of the amount of disassembly required and what tools need to be used are agreed to be critical to a successful remanufacturing operation. Tang *et al.* (2007), as part of wider research conclude that whilst careful disassembly is required to ensure effective remanufacture, once the processes have been defined and operators properly trained there is little or no benefit in using skilled labour. This is concurs with the researcher’s industrial experience at Caterpillar Remanufacturing.

Navin-Chandra (2003) formulates an analysis tool called ReStar, which considers the economical and environmental benefits of remanufacturing or recycling a product and then produces a plan for disassembly to suit the most efficient solution. Li *et al.* (2006) propose a different mathematical tool that also generates a disassembly plan based around the cost of disassembly. This model concentrates on the cost of disassembly around specific joining methods and the optimal sequence for that joint. The cost of either reclaiming the generated parts or disposing of them is also factored in and the method could easily also be associated with recycling rather than remanufacturing. More recent work by Lee *et al.* (2010) discusses the benefits of considering remanufacturing, reuse, recycling or disposal options for an individual component or group of components based on the economic advantage but their decisions at component level are made purely on what is economical to remanufacture, recycle or reuse.

Low *et al.* (1996) compares the costs of resale, remanufacture, upgrade, and recycling as fractions of manufacturing cost to select the best end-of-life options for telephones. This work is further refined in 1997 (Low *et al.*) to separate manufacturing, disposal and transportation costs. Assumptions that remanufacturing costs are proportional to the original assembly costs were also made. This may not be the case as research has since shown (Mähl and Östlin, 2007). The work of Low *et al.* (1997) is based entirely upon telephones that were removed after contracts were completed, with handsets in relatively good working order. The European Waste

Electronic and Electric Equipment (WEEE) Directive has identified this type of product as a priority waste stream owing to the huge proliferation of this type of technology and the relatively brief time interval between introduction and obsolescence fuelled by consumer appetite.

Ferrer (2001) demonstrates a method to determine the processes required for economic disassembly, reuse and /or recycling. However Ferrer's calculations are dependent on lifecycle data and consequently require either significant input from the OEM or a large amount of historical data. Lambert and Gupta (2002) present a tree network method aimed at balancing a line disassembly system where there is commonality of products or components whereas Kongar and Gupta (2006) extend their earlier work with the introduction of fuzzy Goal Programming to model the fuzzy aspirations of several goals. Seliger *et al.* (2002) propose a modular disassembly process where an integrated disassembly cell is created with the adaptive, partly robotic tooling all controlled by an accompanying information system specific to the product being disassembled. This work is aimed at electrical and electronic devices, particularly where a fast throughput is required and includes a range of non-destructive, partly destructive and destructive disassembly operations. The level of investment required to provide sufficient disassembly stations for remanufacturers of larger, mechanical or electro-mechanical make it less likely to impact more general remanufacturing operations, particularly when unskilled and semi-skilled labour is plentiful and cost-effective.

Torres *et al.* (2004) present a similar type of disassembly cell for computers, also incorporating a computerised information system to assist with the recognition and placement of component within the product and to model the necessary disassembly sequence and movements. Variations on computer-controlled, automated disassembly cells and lines are also considered by Weigl-Seitz *et al.* (2006), Kopacek and Kopacek (2006), Duta and Filip (2008) and Kim *et al.* (2009).

Consideration of the quantity of core units required for disassembly to provide components for remanufacturing is considered by Gupta and Veerakamolmal (2001) and they present an algorithm based on integer programming to satisfy demand over various different time periods. Jayaraman (2006) also presents a mathematical model part of which determines the quantity of core to be disassembled. The model is called Remanufacturing Aggregate Production Planning or RAPP. It is based on research concerning the remanufacture of mobile telephones. The model provides a comprehensive approach where the typical quality of the returned core can be easily assessed against existing criteria. This approach seems very well suited to the remanufacture of consumer electronic where fashion dictates a high turnover of product following a relatively short life in a generally protected environment, but has limitations when applied to larger, less complex and less well protected assemblies such as vehicle engines. Gonzalez and Adenso-Diaz (2006) describe a decision-making method for disassembly, based on the product bill of materials, which includes the amount of disassembly that is economically viable and establishes the optimum end-of-life strategy for each disassembled component/sub-assembly. The main barrier to use of these and similar methods in the remanufacturing industry is the short lead-times common in the industry.

Errington (2009) describes four high-level remanufacturing strategies for assessing core units received by independent remanufacturers. He argues that different strategies are used for remanufacturing items with different characteristics even within the same company based around the reason for the return of the core (failure/obsolescence in service or worn out) and the value or rarity of the core. Errington (2009) goes on to describe these strategies using IDEF0. The research does not consider in-depth inspection of individual core units.

4.3 Key Gaps Identified from Literature

It can be seen from the previous section that there are areas noted from literature where gaps in knowledge exist. These include the need for the integration of remanufacturing concepts at the product design stage, the requirement for innovation in the reverse logistics field to promote the default return of cores for remanufacture and the need to expand recent research into the idea of integrating the concept of remanufacturing into product service systems. The area of remanufacturing operations also highlighted several gaps; this was because generally only one remanufacturing activity was considered in isolation, particularly disassembly.

Despite the range of areas available for research, the decision to focus on cores was taken for several reasons including the researcher's industrial experience and her understanding of problems being faced by remanufacturers. Remanufacture cannot be undertaken without cores and the literature suggests that benefits can accrue from optimising this particular aspect of the process, nevertheless no real quantitative research into this aspect of remanufacture exists. What is available in this area highlighted additional gaps, including:

- The examination of cores returned for remanufacturing is investigated at a strategic level only not on an individual basis;
- There is general agreement that inspection of cores promotes cost-effective remanufacture (e.g. Robotis *et al.*, 2012), no quantitative evidence supporting this exists;
- Lead time to market and component inspection are critical to remanufacturers (Ijomah, 2002) but quantitative data that validates what inspection is beneficial does not seem to exist; and
- Successful production planning relies heavily on good information concerning the availability of new replacement components (Tang *et al.*, 2007, Bao *et al.*, 2008 etc.) but the connection between inspection of cores and the ability to plan and bring in new parts (particularly those with longer lead times) has not been investigated.

The decision to investigate the need for assessment of cores, and in particular the four areas noted above, was taken because this activity offers several benefits both to academia and industry. These include understanding the impact on profitability of inspection prior to processing, the ability to create new tools with the knowledge gained and opportunity to better understand the costs involved with remanufacturing. The employment of the researcher as a production manager in a remanufacturing facility ensured that access to a substantial amount of returned cores and the pro-processing inspection activity was readily available.

4.4 Research Objectives

The research described in this thesis addresses the four key areas noted above. It is concerned with both production planning as the inspection of core units informs the planning activity and also inventory control because more information early in the overall processes enables informed inventory decisions.

The research objectives are:

- To determine what factors are relevant to the core inspection decision - understanding whether recovery is affected by inspection (or not) will enable a clear understanding of what impact inspection has on the overall remanufacturing process.
- To establish to what extent inspection of cores makes a material difference to the efficiency of the overall remanufacturing process at component level - this will enable components to be grouped according to common characteristics that are impacted by inspection.

- To use the new knowledge to, of and about the factors affecting inspection to develop a robust component level inspection methodology.
- To extend the new knowledge to develop a more accurate cost assessment tool for remanufacturers.

4.5 Significance, Novelty and Timeliness of the Research

Remanufacturing, as has been described in this and previous chapters, is an important part of a strategy of sustainability. It provides economic, environmental and societal benefits.

The previous sections of this chapter identified gaps in the extant literature concerning remanufacture and particularly with regard to the treatment of cores returned for remanufacture. Indeed there has been a general assumption that the most benefit can be accrued from high-level, strategic decisions. The author does not contend that there is a benefit to such appraisals nevertheless there is little reason other than conventional belief to rule out additional investigations into individual cores upon receipt.

4.5.1 Significance of the Research

This research is significant because it adds to the body of knowledge concerning remanufacture. It determines the factors affecting pre-processing core inspection at a single unit level and also quantifies the benefits of this inspection. The research is embodied in a tool for remanufacturers to utilise this new knowledge to their benefit.

It has been demonstrated that remanufacturing is of benefit in terms of economics, ecology and to society. The literature review identified gaps in knowledge and developed aims for this research to answer some of these.

The result of increasing legislative pressure and the drive towards corporate responsibility have made remanufacturing a more interesting prospect for many manufacturers. Component inspection is, as noted in the preceding section, of critical importance to remanufacturers and new knowledge concerning the factors affecting this may add to the current efforts to enable more efficient and effective remanufacture.

More effective remanufacture will reduce the energy consumption of the process and consequently the emissions whilst improving profitability for remanufacturers.

4.5.2 Novelty of the Research

The new knowledge that this thesis reports, explains the relationship between component complexity and pre-processing inspection of cores. It quantifies any benefits arising from pre-processing inspection and determines what factors are relevant to that inspection. These have not been previously researched and are important because they can aid profitability. The validity of the research described in this thesis is based on unprecedented access to over two thousand engine cores and their subsequent remanufacture.

4.5.3 Timeliness of the Research

This research is timely because the increasing pressure on natural resources is generating increasing legislation aimed at controlling and reducing waste. This affects businesses and other organisations. Remanufacturers, who provide a beneficial and waste-efficient end-of-life solution for many products, rate inspection as a critical aspect of their business (Ijomah, 2002), but there is a lack of quantitative information as to what aspects of inspection are of benefit and what factors are relevant.

4.6 Summary

This chapter has reviewed the existing literature concerning remanufacture. It has identified key gaps in the current knowledge and developed research objectives to address some of these omissions.

The following chapter describes the research design.

Chapter 5 Research Design

5.1 Introduction

This chapter explains the research design and the methodology used.

"Being busy does not always mean real work. The object of all work is production or accomplishment and to either of these ends there must be forethought, system, planning, intelligence, and honest purpose, as well as perspiration. Seeming to do is not doing."

Edison (c.1912) ed. Runes (1964)

The following section describes the available choices of paradigm and the philosophical arguments that underpin them. It also describes the choice of paradigm for this research.

5.2 Quantitative and Qualitative Paradigms

Research design frames the work from beginning to end. Easterby-Smith *et al.*, (2004) argues that an understanding by the researcher of the available choices of research design and their philosophical paradigms may aid the research by:

- Understanding what the enabling paradigms are;
- Enabling the development of a research design to suit the activities; and
- Developing a research methodology to fulfill the research design.

The fundamental choice for research is between the philosophical paradigms of qualitative and quantitative research (Easterby-Smith *et al.*, 2004 and Cresswell, 1998). The paradigm selected is dependent on the nature of the phenomena being researched.

Quantitative research is based on a positivist theory that assumes that there are facts that are independent from prevailing views or beliefs and that phenomena can be objectively measured from these facts. The researcher remains independent of the phenomena being researched. This paradigm requires that numerical or "hard" data is collected (Gummesson, 1999).

Qualitative research in contrast, is centred on a phenomenological paradigm that considers the meanings that specific events have for the persons being studied, that they create their own reality (Patton, 1980). Moustakas (1994) argues that the researcher must be involved with the subject during qualitative research in order that the research is put in proper context, its significance to the subject suitably understood and so that the researcher is able to access information that might otherwise have been concealed from someone outside the social group. It is used where the object of the research is to understand personal beliefs, outlooks, feeling and opinions concerning the subject of the research.

There is an established view that quantitative and qualitative research methods are incompatible (Cresswell, 1998) because of the assumption that the paradigms from which they originate are disparate. Knox (2004) and Brannen (2005) argue that it is not only acceptable but also desirable to use a combination of quantitative and qualitative paradigms to provide a complete picture of the research subject. Brannen (2005) theorises that the phase of the research dictates the particular paradigm being used and it is that consideration that is crucial to the design of the research rather than which overall paradigm is selected.

The overall aim of this research was to understand whether pre-processing inspection improves the efficiency of the remanufacturing process. This is important because greater efficiency improves profitability thus creating a more sustainable remanufacturing industry and, in turn reduces the costs of initial manufacture through the reuse of components reducing both raw material and energy use. Measuring improvements in efficiency requires that numerical data from experimentation is gathered and consequently the research used a predominantly quantitative paradigm. However, in order to more completely understand the factors that affect inspection, the opinions of operators about pre-processing inspection were gathered both before and after the research period. This qualitative data also informed the research findings.

Regardless of the paradigm selected, there are dimensions that all researchers must consider. Gummeson (1993) argues that there are five core concepts that apply to both positivism and phenomenology. These are ontology, epistemology, axiology, rhetoric and methodology and they must be considered during research design.

5.2.1 Ontology

Ontology is the science of being, often referred to as a person's "Weltanschauung" or worldview. Wand and Weber (1993) contend that the manner in which a person interprets and articulates their reality depends upon the paradigms by which they live their life and filter experiences. Ontology therefore has a direct influence on the nature of information collected; the manner in which it is obtained, the analysis of the data and its presentation and therefore the researcher must demonstrate that the reality assumed by their research design is in actuality that consulted (Knox, 2004). The ontological basis of the research forms the underlying continuous theme uniting the research.

Quantitative research uses an objective ontological approach. It demands that objective data (i.e. independent of the researcher) is collected, classified and interpreted to provide explanations and predictions of patterns and properties. The focus is on finding facts and looking for fundamental laws to interpret them. This is most often used in scientific research because an objectivist paradigm assumes that true answers exist and can be externally validated (Cresswell, 1998).

In contrast, qualitative research requires a subjective ontology that is dependent on a potentially wide variety of perceptions of reality. It is rooted in the observable and examines the meanings of experiences from the first-person point of view. Here, meanings are considered and theories established through the understanding gained.

Cresswell (1998) argues that all standpoints have equal validity and as a consequence all must be considered as part of a rigorous qualitative methodology.

The ontological basis of this research is an objective one because objective data has been collected and interpreted. The resultant factors have been validated.

5.2.2 Epistemology

Epistemology is the philosophy of the nature of knowledge, its origins, extent and validity (Easterby-Smith *et al.*, 2004 and Cresswell, 1998). Epistemology is fundamental to how we think and concerned with how knowledge is acquired. Millar (2007) proposes that knowledge is also a function both of the manner in which it acquired and the manner in which it is communicated. The value it is given as both truth and belief directly arises from the way in which it was obtained.

Quantitative research dictates that the researcher and the research be independent and separate to ensure that the assessment of data is as objective and rational as possible, whereas qualitative research implies a much closer relationship between researcher and subject. This latter allows that an interactive relationship will enable the researcher to establish a reality based, in part, on the opinions of the research subjects.

Objective statistical analysis and validation was used in this research in keeping with the quantitative paradigm to ensure the data assessment was both dispassionate and rational. Nevertheless interaction with the various activities and operators has allowed a fuller understanding of the implication of the results on practice within the host company.

5.2.3 Axiology

Axiology is the branch of ethics that concerns human values in relation to their effect on perception, action and decision (Hartman, 1946). It seeks to define what is good and how good it is from the perspective of the researcher. Hartman (1946) argued that there are three basic tenants to defining the value of all things:

- Intrinsic value – a value based on any number of criteria personal to the individual person;
- Extrinsic value – a practical, functional or situational value, and
- Systemic value – the value within the system to which it belongs, conformity or fit.

Axiology, given this construct, assumes that quantitative data, collected and analysed without reference to the researcher's personal views or values, has an objective reality outside of human perception and therefore has both an extrinsic and systemic value ("worth" or "good"). Qualitative research acknowledges the effect of human values, both those of the researcher and those being researched, on the research findings and is consequently more rooted in intrinsic values.

This research has extrinsic value since it the data collected will be numerical and is intended to aid remanufacturing practice. The qualitative data collected is intrinsic, in that it describes the reaction of the interviewee to the impact the finding have on their activities but this is complementary to the quantitative data.

5.2.4 Rhetoric

Rhetoric refers to the language of effective communication, the art of persuasion. It is based upon the artistic proofs described in Aristotle's *Rhetoric* (trans. Jebb, 1909): logos – order and knowledge; pathos – emotional appeal and ethos – guiding ideals or beliefs. In the context of research it is often used to define the type of language used.

Cresswell (1998) proposes that as quantitative research uses objective, often mathematically expressed data, the language used should be formal, precise and impersonal whereas qualitative research is subjective and personal with a more informal and descriptive style. O'Neill (1998) argues that suspicion of rhetoric in scientific explanation seems to stem from the concern that it can be used to mislead the audience through clever or emotive language; that it does not remain constant regardless of time or context and that metaphor and other inexact language is used. O'Neill (1998) and Soskice (1985) both consider that metaphor and analogy are both central components of good communication and are essential to the progression of scientific knowledge.

The effect of the consideration of rhetoric on this research is that, whilst it does not alter the findings in any way, it does affect the manner in which they are communicated.

5.2.5 Methodology

Methodology is the template for the research, the way in which the research design will be executed. The choice of methodology needs to align with the philosophical assumptions that underpin the research and the consequent paradigm (Cresswell, 1998).

A qualitative paradigm is essentially a subjective process involving inductive reasoning from priori constructs or from hypotheses formed from the emerging research. It is often used to describe an observed but informal phenomenon. Hussey and Hussey (1997) propose that a qualitative paradigm is ideal for understanding human activities and social phenomena.

In contrast, a quantitative paradigm is one that constructs an initial set of hypotheses, often as an extension or enhancement of existing knowledge and tests these using deductive reasoning, mathematical methods and experimentation. Quantitative methods are often used to study natural phenomena.

This research uses a mixed mode but predominantly quantitative paradigm. The essential assumption that there is a cause and effect link between remanufacturing processing time and the level of pre-processing inspection dictates that the “worldview” is that of a positivist ontology. Further, the objectivism extends to the epistemology, in that objective data was collected, and also to the axiology, having both extrinsic and systemic value. The qualitative data collected is in acknowledgement that remanufacturing is a human activity system (HAS) and that the research findings impact upon that system and those involved. The paradigm alignment therefore, as advocated by Cresswell (1998), is fulfilled.

5.3 Research Methodology

The research methodology is essentially the planning referred to by Edison. It maps the research process from beginning to end, providing both a work plan and sequence. The type of methodology should align with the chosen paradigm and the underpinning philosophical assumptions.

This research had a quantitative paradigm and the research methodology was developed to complement this choice. Parahoo (1997) describes three basic types of quantitative research: descriptive, correlational and causal. These are briefly described in turn.

5.3.1 Descriptive Research

Descriptive research seeks to identify and list the characteristics of those being researched, whether individual, group or situation (Jack and Clarke, 1998). Its overall aim is to describe the existing situation, the frequency of occurrences and to classify the data to confirm theory and discover new knowledge. This type of research is often the first stage of a more complex investigation and is particularly relevant to human interactions and situations. This research studied engines and so this methodology was inappropriate and was discounted.

5.3.2 Correlational Research

Correlational research is undertaken where the researcher is looking for relationships or links between those being researched where an intervention or treatment has not been made by the researcher. In general two or more quantitative variables are studied and data collected (Burns and Grove, 1999). The research then tries to prove either a positive correlation; for example a larger number of hours spent in revision equate to a higher examination result; or a negative correlation, e.g. the number of pets in a household has no bearing on the size of seats in the family car. This type of research involves no intervention from the researcher; it is an examination of the status quo. Correlational research can also be used to form hypotheses prior to causal research (Parahoo, 1997). This research seeks to understand the relationship between pre-processing inspection and remanufacturing time and so this methodology was also discounted.

5.3.3 Causal Research

A causal research approach is used where the researcher is looking to test hypotheses about the cause and effect nature of treatments or interventions where the researcher acts as a change agent in the process (Polit *et al.*, 2001). It is used when the researcher believes that by manipulating an independent variable, for example by increasing the maintenance frequency to a machine, a dependent variable, in this case the mean time between unscheduled breakdowns, will also be altered. The success of this type of approach is dependent on the researcher's ability to ensure that all other variables remain constant. This is known as validity and is discussed later in this chapter. Causal research is also known as experimental research and where research subjects can be randomised into groups, including a control group, and treatments administered without the group members being aware of their specific regime, it is seen as true experimental research (Polit and Hungler, 1999).

This research, which considers engines and the effect that inspection has upon their subsequent remanufacture collected numerical data, is ideally suited to an experimental research approach and consequently was selected. Its application to this research is discussed in the following section.

5.4 Experimental Research

Experimental research, in essence, tests a hypothesis by manipulating the independent variable and observing the effect in the dependent variable. It is often not possible to completely prove a hypothesis but it is possible to disprove the null hypothesis (the general or default position). Consider for example, the hypothesis that, even if a coin is balanced, flipping it will not result in it landing on heads or on tails an equal number of times. The null hypothesis is then that a balanced coin will land equally on heads and tails when flipped. If the coin is then flipped 100 times and it lands 51 times on heads and 49 times on tails, then the null hypothesis is rejected. However, without infinite coin flips the original hypothesis cannot be definitively proved.

A large body of research concerning experimental research design exists and generally concerned with social, educational and medical experimentation on human subjects. Nevertheless much of the theory applies to industrial research.

Experimental research is described by literature as the ideal research design for reliable data about the effect of an intervention (Mulhall, 1994, Donnan 2000, Richardson 2000 and Polit *et al.*, 2001). It relies on a sufficiently large sample size and control of extraneous variables; that is those independent variables not subject to wilful manipulation by the researcher, together with the use of a control group to deliver results that are reliable, valid and able to be generalised to the population. The types of experimental research design and consideration of research validity are addressed below.

5.4.1 True Experimentation and Quasi-Experimentation

There are two types of experimentation (Campbell and Stanley, 1963, Patton 1980, Yount 2006, etc.). True experimentation where subjects are randomly assigned to purposely created groups that have common measured outcomes, and quasi-experimentation where it is not feasible to randomly assign subjects and so they are generally pre-tested and then assigned based on the results of this test. Quasi-experimentation is generally applicable to education and medical research.

This research was carried out using true experimentation because engines can be effectively randomised into treatment groups and, in order to understand the factors that affect the inspection decision, the same factors were measured for each group.

There are three types of true experimentation. They are briefly described below. In all cases, R represents Randomisation of the group, X represents a treatment (X_1, X_2 etc.) and O represents a group (O_1, O_2 etc.).

5.4.1.1 Pre-Test/Post-Test Control Group

The pre-test/post-test control group approach is particularly suitable for simple activities. Both groups are tested before treatment is administered, one group only is varied and they are both measured post-test:

R	O_1	X	O_2
R	O_3		O_4

This approach can be challenged on the basis of internal validity because of the potential contamination of the subjects by pre-testing; for example, two groups both try to solve the same puzzle (the pre-test). Only one group is then given a set of additional clues (the treatment) but the researcher cannot be certain that when repeating the puzzle-solving either group will not have learnt from the previous effort. Therefore they cannot be sure that the treatment is the only factor affecting the findings. This approach is not suitable for this research as pre-testing is not achievable because the engine would require dismantling for the pre-test and could not be tested again once all of the activities were completed.

5.4.1.2 Post-Test Only Control Group

The post-test only control group is as it is titled. Experimental subjects are randomly assigned to two groups, treatment is administered to one group and the groups are then measured post-test:

R	X	O_1
R		O_2

This type of experimentation addresses the internal validity concerns of the pre-test/post-test approach but is unwieldy for more than one treatment type. The measurable outcomes are too many as this research used four treatments (the pre-processing inspection protocols) and more than twelve variables were measured for each engine studied. However, a variation of this approach, adjusted to account for the number of treatments and measured outcomes, was used in this research.

5.4.1.3 Solomon Four-Group

This research approach is a combination of the two previous ones devised by Solomon (1949). Subjects are randomly assigned into four groups. Pre-tests applied to two groups, one of which is subjected to the treatment and again only one of the groups not pre-tested is subjected to the treatment. All groups are measured post-test:

R	O_1	X	O_2
R	O_3		O_4
R		X	O_5
R			R_6

This research approach addresses all internal validity concerns as it considers all the variables and utilises two control groups. Pre-testing is generally used for human subjects and cannot be used in this research as described previously. However the model of using the four groups with a control and measuring all variables informed method used.

5.4.2 Internal Validity

The internal validity of experimental research can be described as the extent to which the researcher can be confident that the observed effects are a direct result of independent variables (i.e. those controlled by the researcher) and not influenced by other factors.

Campbell and Stanley (1963) postulate that there are nine extraneous variables that weaken the internal validity of any experimental design: history, maturation, testing, statistical regression, differential selection, experimental mortality, selection-maturation interaction of subjects, the John Henry effect and treatment diffusion. These variables are considered from the viewpoint of social research but nevertheless they are worth considering in the context of industrial research and each is addressed separately below.

5.4.2.1 History of the Experiment.

History refers to occurrences within the period of the experiment that may affect results of the experiment but are not caused by researcher intervention. The effects of history on the validity of the experiment can be mitigated by the use of a control group. The experiments described in this work utilise a control group.

5.4.2.2 Maturation of the Experimental Subjects

Maturation in concerned with the changes in experimental subjects as a result of time and other experiences over the course of the experimental period. This is particularly relevant to research concerning human subjects rather than engines but could be considered to apply to any engineering changes implemented during the period of the experiment. An example of an engineering change is an OEM changing a single thickness fibrous gasket to a multi-layer metal gasket. The intention at the beginning of the research was to note any engineering changes during the experimental period for analysis later. However, because the service age of each of the engines studied is relatively old (in current production for at least the last three years), no engineering changes were implemented during the data collection period.

5.4.2.3 The Effects of Pre-Testing

Testing is once again specifically relevant to the effects of pre-testing on human subjects in terms of the familiarity of the test to the subjects. Campbell and Stanley (1963) recommend a control group to ensure that any differences noted are entirely due to the effects of the experimentation rather than the test familiarity. This research studies the effects of different inspection protocols on the subsequent remanufacturing activities of engines. Engines are inanimate objects incapable of learning. The potential effect of operators being familiar with the individual remanufacturing activities was not considered to represent a risk as individual operators were unaware of the actual treatment used on any specific component. Nevertheless, a control group was utilised to ensure that the data collected was entirely attributable to the inspection protocol used.

5.4.2 4 Statistical Regression

Statistical regression is the tendency of extreme values to regress towards the mean on second testing. It was first noted by Sir Francis Galton (1883) who noticed that extremes of size in parents were rarely passed completely on to their children. His subsequent investigations and the mathematical expression of regression formed the basis for statistical regression as a model concerned with the disappearance of sampling bias on repetition, increased sample size and new samples. Inspection protocols were randomly assigned during this research in order that any effects of the protocols could be objectively determined.

5.4.2 5 Differential Selection

Differential selection, as indicated by the name, is concerned with inequality in subject groups caused when different selection criteria are applied to different groups. As explained elsewhere, this research randomly assigned each engine core to a protocol upon receipt.

5.4.2.6 Experimental Mortality or Attrition

Experimental mortality refers to subjects dropping out of the groups during the course of the experiment. This is specifically relevant to human subjects and not to inanimate objects, however components being scrapped during the remanufacturing activities could be considered as attrition and consequently the scrap rate and the point of scrap was monitored in the following components (where applicable):

cylinder blocks, cylinder heads, crankshafts, camshafts, connecting rods, starter motors, alternators, exhaust gas recirculation valves, compressors and flywheels. Scrap transactions for these components were routinely carried out either at disassembly, machining or engine assembly (engines A and B) or engine kitting (engines C and D). In practice, the engine assembly scrap transactions would include test failures owing to damaged components as these would be repaired at engine assembly.

5.4.2.7 Selection-Maturation Interaction of Subjects

Selection-Maturation Interaction of Subjects refers to subject groups being drawn from different populations and their ability to influence each other leading to uncertainty as to what has caused any observed behaviour. This is unlikely to happen with engines although as the cores are drawn randomly from across Europe variation is inevitable. Nevertheless, randomly assigning an inspection protocol will ensure this variation is unlikely to influence the experimental results.

5.4.2.8 The John Henry Effect

John Henry is an American working-class hero of folklore. His story varies but essentially he was reputed to be a freed black slave of immense physical prowess who worked on the newly emerging railroads manually driving in the steel supports. The legend tells that the owner of the railway bought a steam-powered hammer to do the work and, in a bid to save the jobs of his fellow workers, John Henry raced the steam-hammer and won but in his victory collapsed and died, exhausted (Garst 2002). In the context of experimental research, this refers to subjects in differing groups working harder or altering natural behaviour believing they are “in competition” with subjects in other groups and thus artificially skewing the results.

Whilst this might not initially seem to be a concern with engines, there is a risk that operators processing cores might react in a similar way to John Henry. This risk was mitigated by ensuring that, for each engine type, the same operator and the same machines were used for each operation regardless of the inspection protocol used. In practice this was easily accomplished for each engine type although such continuity was not practical between engines owing to the particular sizes and complexities of each engine requiring the use of different machinery and hence, in many cases, different operators for those machines.

5.4.2.9 Treatment Diffusion

Treatment diffusion refers to the effect of different groups of subjects in close proximity “sharing” the perceived best treatment and diffusing the effect of the different treatments. This is particular to human subjects and, as the same operator was processing similar components from the same engine type, regardless of inspection protocol, the risk of treatment diffusion can be ignored.

5.4.3 External Validity

External validity is the extent to which experimental research findings can be generalised across a wider population. This is important because results that are specific to a group with closely defined criteria are of limited use to the wider academic and practitioner communities. Generalised findings can be utilised to change or refine practice. External validity can be confirmed by appropriate testing within the academic or industrial communities.

Yu and Ohlund (2010) describe four factors that reduce external validity. These are: the reactive or interaction effect of testing, interaction effects of selection bias and experimental variables, reactive effects of experimental arrangements and multiple treatment interference. These can apply to industrial research and so each is considered.

5.4.3.1 Reactive or Interaction Effect of Testing

The reactive or interaction effect of testing refers to effect of pre-treatment testing on the subject. It can be discounted for this research as there will be no pre-testing, only random assignment of engines to treatment groups.

5.4.3.2 Interaction Effect of Selection Bias and Experimental Variables

The interaction effect of selection bias is the extent to which the observed post-treatment behaviour can be attributed to the effects of the treatment and not to the cumulative effects of the treatment and any selection bias. This is important for generalisation. This risk is mitigated by the random assignment of subjects to a group as in this research.

5.4.3.3 Reactive Effects of Experimental Variables

The reactive effect of experimental variables refers to the potential bias of results caused by experimental conditions that are in some way out of the ordinary. This could be as simple as removing subjects from their everyday environment because the effect of this on the subject might cause them to react to the treatment in a very different way to that in their normal conditions.

Once again, although this does not apply to the engines, it could potentially affect the operators performing the remanufacturing activities. This risk was effectively eliminated by ensuring that the experiments were part of normal production. Every engine of each type studied was required for a sale and as such, was processed in the same way as any other with the same process controls and constraints. All that differed was the pre-processing inspection protocol.

5.4.3.4 Multiple Treatment Interference

Multiple treatment interference considers the mixing effects of more than one treatment administered to a subject group. This effect can make it very difficult for conclusions to be generalised as it can be difficult to ascribe specific outcomes to individual treatments. This research is not subject to this threat as only one treatment was administered to each group of engines and a control group receiving no treatment was present.

The next section also considers a different type of validity, that of the researcher involvement in the research subject.

5.5 Researcher Involvement

The researcher was employed by the host company as a production manager both before and during this research, Caterpillar Remanufacturing Services, in the United Kingdom. This provided an excellent basis for access to information and data to inform the research but nevertheless could have been in conflict with the positivist paradigm. Quantitative data should be independent of the researcher and consequently safeguards needed to be put into place to ensure objectivity. These are fully discussed later in this chapter but briefly, usual working practices were utilised to ensure no research bias, standard work documents detailing the exact requirements of the work required for each inspection protocol were issued to the pre-processing inspection staff, all of whom were then taken through each element to ensure understanding. This is the usual method of communicating work instructions within the facility and so familiarity meant that, once understood, no intervention was required from the researcher. Experimental results were also collected as part of usual working practices and only audited by the researcher.

5.6 Practitioner Needs

Research that is useful is the ultimate goal of research, regardless of whether the practitioner in question is an academic or based in industry. As a consequence, the needs of the practitioner should be considered. Practitioners are defined by Thomas and Tymon (1982) as “Any line manager, staff specialist, consultant or any organisational actor”. Thomas and Tymon (1982) then go on to propose that in order to assess the practical usefulness any research must fulfil five needs of the practitioner. These are: descriptive relevance, goal relevance, operational validity, non-obviousness and timeliness. Each is discussed in terms of this research below.

5.6.1 Descriptive Relevance

Descriptive relevance is defined by Thomas and Tymon (1982) as the extent to which the research findings accurately describe the phenomena being researched. They argue that research into phenomena encountered in the workplace should be studied in the workplace and that an overly positivist paradigm may miss the significance of other influences such as bi-directional relationships and feedback loops. This is supported by Lundberg (1976) and Cummings (1978).

This research was carried out using a positivist paradigm but, in order to ensure descriptive relevance was maintained, interviews to determine attitudes to pre-processing inspection were carried out with the operators, managers and other people in the facility both before the data collection and after the data analysis.

5.6.2 Goal Relevance

Goal relevance is the extent to which the phenomena investigated addresses real practitioner issues. This is influenced by the independent variables selected by the researcher and their relevance to the issue. If the goal relevance is high, the new knowledge will address practitioner concerns and help to resolve problems.

Goal relevance can be determined by validation with practitioners or by actual use in the workplace.

5.6.3 Operational Validity

Operational validity refers to the practitioner's ability to easily and conveniently use the research findings. This research directly altered pre-processing inspection within an industrial setting. The protocols from the experiment can be easily replicated so that the same benefits can be gained. In addition, the findings of this research have been used to develop both a decision-making methodology and a cost assessment tool which can be directly used by remanufacturers.

5.6.4 Non-obviousness

Non-obviousness is the extent to which the research meets or exceeds the common sense theory and practice available to the practitioner. Non-obvious research is significant and would not have been thought of without the researcher's intervention.

This research describes the quantitative study of over two thousand engines and the unprecedented access allowed enabled the pertinent factors concerning the inspection of cores prior to processing to be clearly defined.

5.6.5 Timeliness

Timeliness describes the need for the research to be available to the practitioner at the point at which it is useful to them to solve problems. Remanufacturers describe component inspection as a critical issue and the uncertainty of the remanufacturing process as a highly significant issue (Ijomah, 2002). In addition, Zikopoulos and Tagaras, (2007) and Errington, (2009) have commented on the benefits to remanufacturers of the inspection of cores.

Remanufacturing, as discussed elsewhere in this work, has economic, ecological and societal benefits and is defined under "reclamation" and "reuse", the top two preferred waste management options identified in the European Union's (EU) Fifth Environmental Action Programme (EU, 1993). These considerations and that of the increasing legislative pressures being placed on industry to control the end-of-life options of products, mean that research into remanufacturing is timely.

5.7 Chosen Research Methodology

The previous sections have described the choice of paradigm and the true experimental approach selected. This section described the methodology developed to ensure that the research design is fulfilled.

The validity of experimental research can be questioned consequently developing an appropriate methodology mitigates this risk. Van Dalen (1979) describes seven essential steps in experimental research. Many of these are valid for all types of research and also chime with the recommendations of both Eisenhardt (1989) and Yin (1994) for case study research. The steps recommended by Van Dalen (1979) are:

1. Survey the literature relevant to the problem;
2. Identify and define the problem;
3. Formulate a problem hypothesis, deducing the consequences, and defining basic terms and variables;
4. Construct an experimental plan comprising;

a. Identify all non-experimental variables that might contaminate the experiment, and determine how to control them;

b. Select an experimental approach;

c. Select a sample of subjects to represent a given population; assign subjects to groups, and assign experimental treatments to groups;

d. Construct and validate instruments to measure the outcome of the experiment;

e. Outline procedures for collecting the data, and possibly conduct a pilot or "trial run" test to perfect the instruments or design; and

f. State the statistical or null hypothesis;

5. Conduct the experiments.
6. Reduce the raw data in a manner that will produce the best appraisal of the effect which is presumed to exist; and
7. Apply an appropriate test of significance to determine the confidence one can place in the results of the study.

Each of the seven steps is considered in the following paragraphs.

5.7.1 Literature

A systematic, critical literature review was carried out and is described in Chapter 4. However, in brief, the review noted that whilst there was research into the inspection of cores, it was at product level, often prior to receipt at the remanufacturer and was more focused towards strategic sorting of cores for predominantly independent remanufacturers (for example, Zikopoulos and Tagaras, 2007 and Errington, 2009).

Less consideration was given to contract and OEM remanufacturers. In addition, any research around component inspection was generally concerned with the later stages of remanufacture (Rugrungruang, 2008). A clear gap in component level inspection, early in the remanufacturing process was found despite the usefulness of inspection of cores being of benefit to remanufacturers (Tang *et al.*, 2007, Bao *et al.*, 2008, Robotis *et al*, 2012 etc).

5.7.2 Defining the Problem

The literature review clearly identified a gap in knowledge concerning pre-processing inspection. Initial interviews were conducted with practitioners within Caterpillar Remanufacturing to understand their attitude towards pre-processing inspection. They had largely convergent and predominantly negative views of inspecting cores, only one being aware of any research findings into remanufacturing and none were aware of using any research to solve problems in their day-to-day work. These interviews are discussed in Chapter 8.

Inspection is a fundamental part of any remanufacturing process (Ijomah, 2002, Georgiadis and Vlachos, 2004, Östlin *et al.*, 2008, Mukhopadhyay and Ma, 2008 etc.). It takes place throughout the remanufacturing process but, other than at a strategic level, has not been fully addressed at the "Receive Core" (Ijomah, 2002) stage of the remanufacturing process.

The initial stage of remanufacturing is the most cost effective time to detect potential defects with the cores as little or no processing work has been carried out and consequently little resource has been added to the cores. This is illustrated below:

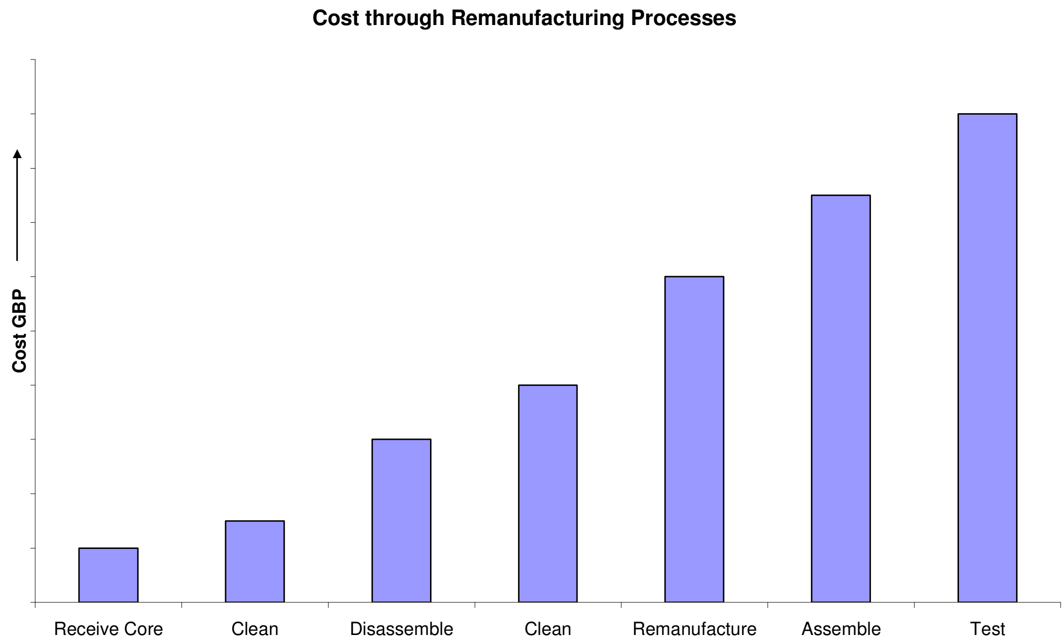


Figure 5.1 Typical Remanufacturing Costs based upon the Rushden Facility

Literature suggests that there is a high level benefit in sorting cores (Errington, 2009) and Mähl and Östlin (2007) recommend grading cores for quality to improve the disassembly activity. Teunter and Flapper (2010) go further and propose four grades of cores as part of their acquisition policy. They all suggest that remanufacturers benefit when they are able to process high quality cores.

This enables the initial research questions to be framed:

"Can the efficiency of the overall remanufacturing process of complex mechanical assemblies be increased with a more in-depth inspection of cores?"

and,

"To what extent does the inspection of cores improve the efficiency of the overall remanufacturing process?"

5.7.3 Formulating the Hypotheses

Consideration of the extant research and the preceding section gives rise to the basic hypothesis that:

If the efficiency of a remanufacturing process is related to the inspection of cores, then an overall decrease in processing time should be observed as the level of pre-processing inspection is increased.

This hypothesis can be tested by measuring the processing time of a series of engines (the dependent variable) whilst altering the level of pre-processing inspection of cores (the independent variable).

Careful examination of the basic hypothesis highlights the need to also consider the nature of the research subjects. Engines are complex mechanical assemblies. Their constituent components are a mix of material types, functions (some mechanical, some electrical) and quantity of constituent parts. It follows therefore, that it may not be the case that inspection of cores will benefit the later stages of remanufacturing. As a consequence of this, the following questions will also need to be answered:

"What factors are relevant to pre-processing inspection of cores?"

and,

"What, if any, is their relationship to each other?"

This inevitably leads to a revision of the original hypothesis. Thus it becomes:

If the efficiency of a remanufacturing process is related to the inspection of cores, then an overall decrease in the processing time for each component should be observed as the level of pre-processing inspection is increased.

The null hypothesis is then:

"*The efficiency of the remanufacturing process is unrelated to inspection of cores and consequently all inspection protocols will have the same (no) effect on processing times.*

5.7.4 Selecting Subjects

The decision to study engines is discussed in Chapter 3. It was driven both by the need to improve facility performance and by problems noted during the course of the researcher's employment with an engine remanufacturer. The need for research in this area was reinforced by literature and the researcher's employment mean that access to data was assured. However, almost 100 distinct engine variants (in terms of physical size, capacity, number and type of components) are remanufactured at the Rushden facility for a total of 9 different customers and it was necessary to limit the amount of engines to ensure a thorough analysis could be made within the time available.

When deciding which of the engines to study, the ability to generalise the findings as much as possible was the key deciding factor. This was because generalised results would enable validation of the findings for use on other remanufactured products.

The nine customers represented high, medium and low volume users of remanufactured engines and so two high volume customers (to enable a large sample to be used), one medium volume customer and one low volume customer was selected. This presented a total of 34 engines to select from. Once again, considering the ability to generalise the findings, two simpler engines (in terms of component complexity) and two more complex engines were chosen. One of the simpler engines was a physically smaller, 4 cylinder engine, with a capacity of less than 2 litres; the other a physically larger, 6 cylinder engine, with a capacity slightly greater than 2 litres and, in the same way, one of the more complex engines was a smaller 4 cylinder engine, with a capacity greater than 2 litres and the other a larger 6 cylinder engine, with a capacity greater than 2 litres. The applications for these engines varied from automotive to heavy-duty industrial.

Consequently the selected subjects were:

Engine A: High volume customer	Simpler, smaller engine	4 cylinder
Engine B: Low volume customer	Simpler, larger engine	6 cylinder
Engine C: High volume customer	Complex, smaller engine	4 cylinder
Engine D: Medium volume customer	Complex, larger engine	6 cylinder

Three of the engines were remanufactured with the facility acting as a contract remanufacturer, two of which were OEM customers, although contact was only with the aftermarket sales division of the OEM. The third was also an OEM customer but for the overall vehicle which used an engine originally purchased from another, independent manufacturer. The remaining engine was a Caterpillar product. The only engine for which full technical data was available was the Caterpillar product. Their alphabetic place in the list is no indication of the customer. All identification was removed from the results to ensure confidentiality.

5.7.5 Selecting Variables

A well defined hypothesis essentially identifies the variables for the researcher. In the case of this research, the independent variable is the pre-processing inspection of cores and the dependent variables are the individual component activity times.

5.7.5.1 Independent Variable

The initial step was to record the normal practice. All cores at the Rushden facility are received un-inspected and only assessed prior to scheduled disassembly. This assessment is a fairly cursory visual inspection, with badly damaged cores put to one side, and the part number identified. This is, in part, due to the fact the majority of core collection is not in the facility's control, the customer controls the cores, and in part, because as a contract (or indeed as an OEM) remanufacturer, the customer cannot be charged for additional work if an individual core requires more remanufacturing or new part input.

The next logical step was to establish whether inspection of cores of any kind had an effect on subsequent remanufacturing activities and so inspection protocol 1 was no inspection of any kind. Then current practice was used as the control and this became inspection protocol 2.

Subsequent inspection protocols were based around inherent practitioner knowledge and available technology. Inspection protocol 3, based on additional inherent knowledge, included further visual and manual tests such as rotation of moving parts and smelling electrical components to check for signs of burning. Protocol 4 included all these plus the use of an endoscope to check for internal damage. Further inspection was not possible as technology such as ultrasonic testing was not easily obtainable at the Rushden facility.

All the inspection protocols were written up into standard work documents and the basic processes timed. Thus the independent variables were defined as:

Protocol 1	No Inspection
Protocol 2	Baseline, current practice, brief visual condition inspection.
Protocol 3	Protocol 2 plus manual rotation and increased inspection.
Protocol 4	Protocol 3 plus internal condition inspection of main components

These are all discussed thoroughly in Chapter 6.

5.7.5.2 Dependent Variables

The dependent variables in this experiment were the activity times for the individual engine components and, as a consequence for the entire engine. Each activity in the remanufacturing process has an allocated standard time. This is the length of time agreed between the Engineering department and the Production department as the "average" time a remanufacturing activity will take. Remanufacturing is not a stable process as the quality of cores varies considerably; consequently a standard time is used for planning factory capacity, scheduling production and assessing manpower requirements. These are regularly reviewed and so a process for auditing remanufacturing activities existed at the Rushden facility. This is important because using a normal process helped to ensure any variability from the timing activity itself was minimised (see 5.4.2 for discussion on controlling extraneous variables). It also minimised any potential disruption for the operators.

Processing times were collected in decimal hours using stopwatches from the gauge calibration system. These were regularly reviewed for accuracy by the Rushden Quality department Standards Room inspectors. Individual operators timed their activities to ensure no researcher bias was present. This activity was audited by the researcher at all workstations several times each day. Operators are used to working on trials of activities including timing work as the facility uses 6Sigma methodology for continuous improvement including OEE (overall equipment effectiveness) which requires work times to be captured. This is a part of normal work and consequently, in the eyes of the operator no difference to normal practice was perceived. In addition, as all engines were identified by a unique number, no operator downstream of the pre-processing inspection could ascertain which engine had been subjected to which inspection protocol ensuring no bias could be made. Data was collected from 2196 engines over a period of six months. The collected times were collated for analysis.

A further measure of the effectiveness of pre-processing inspection would be a change in the point at which defective components were scrapped. The experimental treatments should not in themselves affect the actual rates of scrap, in that the only effect should be the earlier detection of faults rather than any reduction in the overall rate of scrap. Every operator routinely recorded scrap on the facility material planning system; this electronic booking also recorded the point at which material was scrapped and the amount of work undertaken prior to rejection. Historic details existed for all subject engines and consequently scrap details were recorded throughout the process and compared with the average of those recorded during 2010.

A full description of the experimental phase of the research can be found in Chapter 6.

5.7.6 Actual Research Approach

This research design was constructed from the post-test only control group design using the Solomon Four group design (Solomon, 1949) as a template to ensure all variables were covered.

This design measured each of the four engine types through all activities of remanufacture. Engines of each type were randomly assigned upon receipt, sight-unseen, to one of four groups comprising of that engine type only. Consideration was given to mixing the different engine types into these groups but as the component mix, engine size (both capacity and physical size) and complexity varied considerably, different machines and operators were required to process the components: this proved infeasible. Four common pre-processing inspection protocols were then applied, one to each group, and the processing times for each activity measured.

Antony (2003) recommends that experimenters further randomise experiments by randomising the treatments in time, in this case by not assigning Protocol 1 to the first group of engines, protocol 2 to the second etc. This second randomisation will enable the researcher to minimise the effect of any systematic bias or unconsidered factor on the results. This experiment randomised both the protocols and their application and so at any one time engines of all four types subjected to any one of all four protocols were passing through the facility.

The research design assumes that inspection protocol 2, which is the existing level of pre-inspection prior to the experiments being conducted, is the equivalent of no treatment and that all groups subjected to this protocol form the control group. Essentially this is just a transfer of the control from the experimental groups and to the treatment. Thus the research design was:

R	$O1_A$	X_1	$O1_A$......$O1_{An}$
R	$O2_A$	(X_2)	$O2_A$...... $O2_{An}$
R	$O3_A$	X_3	$O3_A$...... $O3_{An}$
R	$O4_A$	X_4	$O4_A$...... $O4_{An}$
R	$O1_B$	X_1	$O1_B$......$O1_{Bn}$
R	$O2_B$	(X_2)	$O2_B$...... $O2_{Bn}$
R	$O3_B$	X_3	$O3_B$...... $O3_{Bn}$
R	$O4_B$	X_4	$O4_B$...... $O4_{Bn}$
R	$O1_C$	X_1	$O1_C$......$O1_{Cn}$
R	$O2_C$	(X_2)	$O2_C$...... $O2_{Cn}$
R	$O3_C$	X_3	$O3_C$...... $O3_{Cn}$
R	$O4_C$	X_4	$O4_C$...... $O4_{Cn}$
R	$O1_D$	X_1	$O1_D$......$O1_{Dn}$
R	$O2_D$	(X_2)	$O2_D$...... $O2_{Dn}$
R	$O3_D$	X_3	$O3_D$...... $O3_{Dn}$
R	$O4_D$	X_4	$O4_D$...... $O4_{Dn}$

This design satisfies all the concerns of validity (described previously) having a control group, involving the manipulation of one independent variable and measuring all of the dependent variables. It also satisfies the recommendations of Charness *et al* (2011) by combining between-subject and within-subject design.

Numerical data in decimal minutes was collected and collated daily into an Excel spreadsheet ready to be analysed.

5.7.7 Data Analysis

Data was analysed using the IBM SPSS package. Each set of engine data was subjected to one-way Analysis of Variance (ANOVA) as this provides a statistical test of whether or not the statistical means of several groups are equal (Iverson and Norporth, 1987). It enables t-tests to be generalised over several groups (in this case four) without the possibility of rejecting a true null hypothesis that might arise from multiple t-tests. ANOVA was first widely advocated as an important tool for researchers in Sir Ronald Fisher's 1925 seminal work "Statistical Methods for Research Workers". A fixed effect model has been used because it represents the observed effects (the dependent variables) in terms of the explanatory variables (the independent variables – inspection protocols in this case). It assumes that variances in the dependent variables are caused by the independent variables. Lipsey and Hurley (2009) advocate large sample sizes or a large effect size to ensure that sensitivity, or the ability to detect an experimental effect, is addressed by obtaining a high statistical power. The selection of experimental subjects to give a high sample size and the use of ANOVA to compare the treatment effects helps to ensure a high level of confidence in the research findings. This assumption is the basis of a true experimental design and so one-way ANOVA is an appropriate analysis tool for this research. The analysis of the results is fully discussed in Chapter 8.

5.8 Overall Research Structure

The figure below is a pictorial representation of the research design.

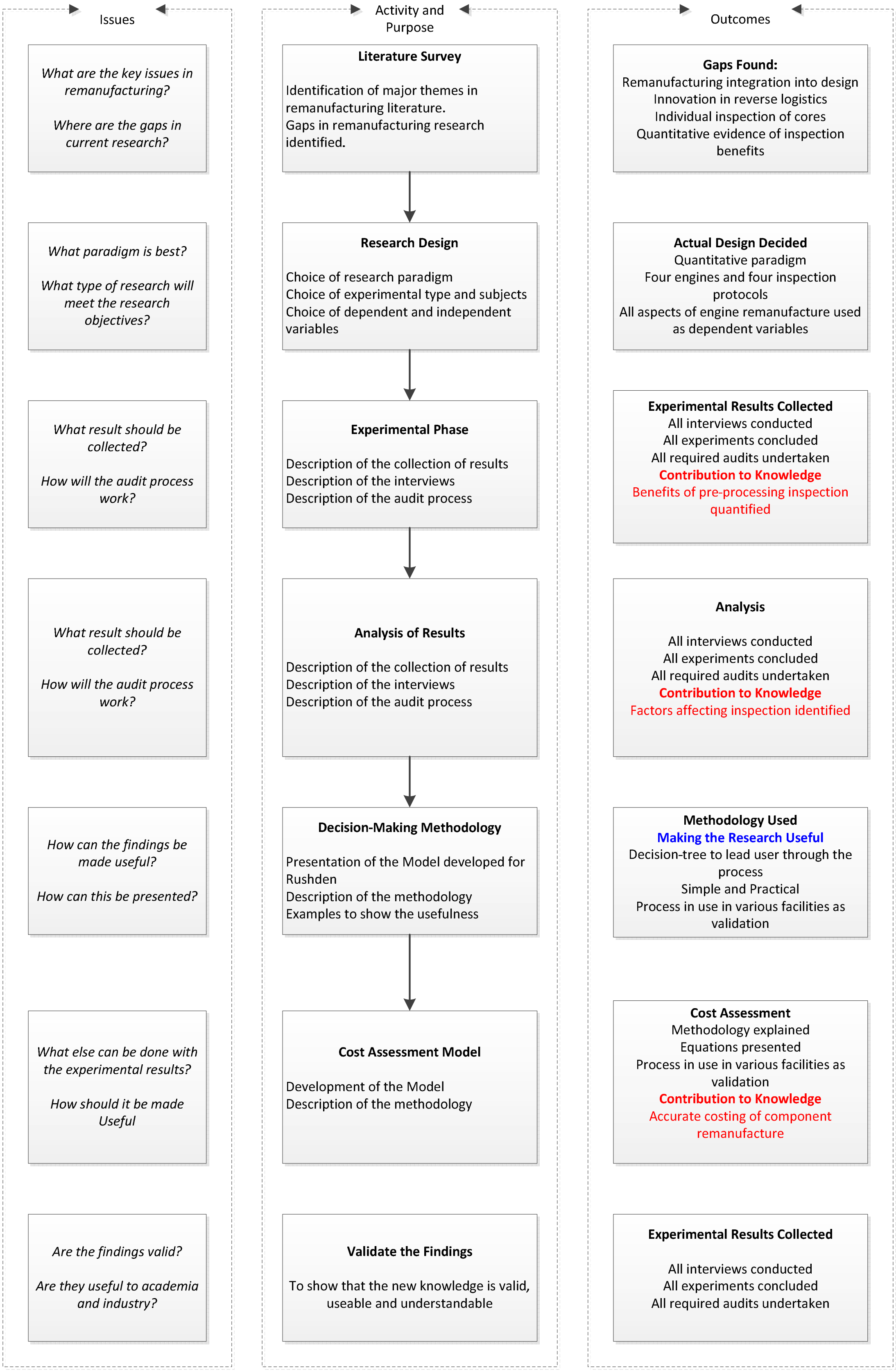


Figure 5.2 The Overall Research Structure

5.9 Presenting the Research

It has been the intention from the start of this research project to present the findings in as accessible a manner as possible. As a consequence of this, aside from the conclusions that were drawn from the experimental results (discussed later in Chapter 8); a decision-making tool was developed from the findings. This tool was intended to provide a format for assessing a new or existing product and determining the most appropriate level of pre-processing inspection for the business.

The new knowledge concerning the cost of remanufacture was also presented in as accessible a format as possible, without the need for complicated mathematics. It is possible to embed the formulae into a simple spreadsheet that would perform the necessary calculations for the practitioner.

5.9.1 Developing the Decision-Making Model

The findings of the research indicated that the inspection decision was influenced by a set of factors isolated by the analysis. These factors were constant across the engines studied and consequently could be generalised. Careful consideration of how these factors could be translated into a means of decision-making led to the conclusion that a decision tree method would be an effective means to make the research useful to others. This is because a decision tree clearly lays out all the options so that a logical path can be followed, they allow the full consequences of each part of the decision to be seen in advance and they provide a simple visual format that can be replicated anywhere.

5.9.2 Validating the Decision-Making Model

The research process was closed by validating the decision-making process. This was undertaken primarily to assess whether the research findings can be generalised to other assemblies and products and also to assess the practicality of the decision-making model.

5.10 Summary

This chapter has explained the philosophical assumptions that guided the research design and the chosen paradigm. It has justified the research methodology developed and the steps taken to ensure that both internal and external validity are assured and the needs of the practitioner considered.

The following chapter describes the experimental phase of the research.

Chapter 6 Experimental Phase

6.1 Introduction

This chapter describes the experimental phase of the research. It rationalises the involvement of the researcher in the process and the methods used to achieve data integrity.

"The strongest arguments prove nothing so long as the conclusions are not verified by experience. Experimental science is the queen of sciences and the goal of all speculation."

Roger Bacon Opus Tertium tr. Popular Science 1901

The ultimate goal of the experimental researcher is to provide incontrovertible data that justifies theory. Rigour in determining all aspects of the experimental process ensures verifiable and repeatable results.

6.2 Experimental Subjects

The term experimental subject is often used to describe human or animal participants in research, however in this work the term is used throughout to describe the engines inspected to the different protocols for the duration of the experimental period.

Examination of literature concerning remanufacture indicated that the quality and condition of the cores had a direct impact on later remanufacturing operations (for example, Tagaras and Zikopoulos, 2008). This was further confirmed by practitioners within the remanufacturing industry (e.g. Teunter and Flapper, 2010) and the experience of the researcher during her employment within the Caterpillar Remanufacturing Rushden facility.

The maturity of the automotive remanufacturing sector has led to a good deal of research being undertaken in this area and consequently the use of petrol and diesel engines as experimental subjects meant that this foundation could be used for this research.

Caterpillar's involvement as both an OEM and contract remanufacturer meant the products containing the experimental subjects were in regular, stable supply through extensive dealer networks and good volumes were achievable. The activities by which the individual sub-assemblies and components were remanufactured were also well-established and relatively stable ensuring that standard processing times were available and any notable variability in processing could be directly linked to the different inspection protocols being applied. The ability to detect an experimental effect is referred to as sensitivity.

The Rushden facility operates as both an OEM remanufacturer and a contract remanufacturer for a total of nine customers. The quantities of engines demanded by each customer were split between two high volume customers (several thousand units per annum), two medium volume customers (around one thousand units per annum) and five low volume customers (less than six hundred units per annum). The volumes quoted here may not be representative, in terms of low or high volumes, for the remanufacturing industry as a whole but are typical of the Caterpillar experience. These customers source a total of ninety-eight engine variants ranging from one litre petrol engines used in small cars including six litre petrol engines for high performance cars to six litre heavy duty diesel engines used in industrial vehicles and generator sets.

The experimental design, as explained in Chapter 5, called for four experimental subject groups to ensure that concerns surrounding validity were adequately answered. Those selected were:

Table 6.1 Experimental Subjects

Engine	Customer	Reason for Inclusion
A	High volume user	Large sample size achievable, standardised engines
B	Low volume user	High level of customization within engines
C	High volume user	Large sample size achievable, complex engines, non-OEM customer
D	Medium volume user	Wide variety of engine variants within single engine type

The intention of this research was to determine the factors that affect the pre-processing inspection of a given sub-assembly or component and therefore it was necessary to ensure as broad an array of engines as possible were included in the experiment to ensure that any conclusions were robust. The large research population helped to establish causal links. The selected engines were thus:

Table 6.2 Experimental Subject Descriptions

Engine	Physical Size	Engine Capacity	Level Supplied to Customer
A	Small	Less than two litres	Long engine
B	Large	Greater than two litres	Long engine plus oil pump and vacuum pump
C	Small	Greater than two litres	Full dress level
D	Large	Greater than two litres	Full dress level less EGR valve, starter motor and alternator

The distinction between long engine level and full dress level requires clarification as there are various interpretations in the industry. The definitions used in this research were:

- Long engine level comprises as a minimum, cylinder block, crankshaft, con-rods and pistons, camshafts, head, sump and covers;
- Full engine level consists of long engine level plus fuel injection equipment, intake and exhaust manifolds, flywheel and turbocharger where applicable.

Both long engine level and full engine level may include other sub-assemblies and components (for example starter motors, alternators) as required by the customer.

No engines supplied at full dress level and with a capacity of two litres or less were being remanufactured in the facility at the time of the experiment therefore they could not be included in the study.

Physical size, although a seemingly random selection criterion, was important because there are two machining lines at the Rushden facility, one for smaller sized components and one for large sized components. Different operators worked each line. Selecting engines because of physical size meant that approximately half the subjects were processed in each of the “small engine” and “large engine” production lines. This was important as similar findings from each production line would indicate that these results were more likely to be valid.

The selection of these engines also enabled a broad range of components to be studied and a correspondingly large quantity of data to be collected from them satisfying the need for a large sample size described in Lipsy and Hurley (2009).

Each of the selected engines was given an alphabetical reference to disguise individual part numbers, model type and customers; any of which could be used to identify the customer. Thus the experimental subjects were:

Engine A - 4 cylinder engine with a capacity of less than 2 litres. This engine was supplied to the customer at a long engine level. This comprised: cylinder block assembled with pistons, connecting-rods, crankshaft, fully assembled and timed cylinder head, sump, oil pump, timing gear and outer covers.

Engine B - 6 cylinder engine of a capacity greater than 2 litres. This engine was also supplied to the customer at a long engine level comprising: cylinder block assembled with pistons, connecting-rods, crankshaft, fully assembled and timed cylinder head, sump, oil pump, timing gear, outer covers and vacuum pump.

Engine C - 4 cylinder engine with a capacity greater than 2 litres. This engine was supplied to the customer at a fully dressed level. This comprised: cylinder block assembled with pistons, connecting-rods, crankshaft, fully assembled and timed cylinder head, sump, oil pump, timing gear, outer covers, vacuum pump, fuel lift pump, exhaust gas recirculation (EGR) valve, starter motor, alternator, flywheel, turbocharger and fuel injection equipment.

Engine D - 6 cylinder engine with a capacity greater than 2 litres. This engine was supplied to the customer at a fully dressed level. This comprised: cylinder block assembled with pistons, connecting-rods, crankshaft, fully assembled and timed cylinder head, sump, oil pump, timing gear, outer covers, vacuum pump, fuel lift pump, compressor, turbocharger and fuel injection equipment.

6.3 Dependent and Independent Variables

Experimental research is conducted by manipulating an independent variable and observing the effect of that intervention or treatment on the subject. This observation is achieved by measuring the dependent variable. The choice of dependent and independent variables is critical to the integrity of the outcome as the researcher must be satisfied that the treatment is the only factor affecting the result.

6. 3.1 Dependent Variables

The purpose of this research was to determine what factors affect pre-processing inspection and as a consequence the overriding factor in the choice of dependent variables was the ability to measure the direct effects of the experimental treatments. Examination of the overall system indicated that processing time for each activity within the overall remanufacturing cycle – from unpacking and inspection to final post-production testing – was able to be measured both at individual component/sub-assembly level and at overall engine level.

An engine is an assembly of individual components and smaller assemblies and, as a consequence, provided opportunities to establish whether the experimental treatments were equally effective on a variety of differing materials, complexities and scales. Measurement of the overall processing time would establish whether the benefits of the inspection protocols outweighed the scale of the intervention.

Examination of the details of in-process scrap during the experiment in comparison to pre-experimental scrap would also indicate whether the treatments had any effect.

The dependent variables measured therefore were the individual processing times for a wide variety of components and sub-assemblies (where applicable to individual engines) as well as the overall processing time for each engine. Each of the dependent variables (reprocessing activities) measured is discussed in the following sections.

6. 3.1.1 Decant and Inspect

This element comprised the removal of all packaging, assignation of an individual tracking number and random allocation of the experimental treatment (the inspection protocol) and the pre-processing inspection to the appropriate level, including fulfilling any feedback instructions given.

6.3.1.2 Disassembly

Disassembly included complete engine disassembly with the exception of any small assemblies that would routinely be dismantled as a complete sub-assembly from the engine and sent to the Ancillary Component department for specialist processing. This category would typically include turbochargers, starter motors, alternators etc. The disassembly content of this processing was included in the processing time for the whole component and only the time to remove from the engine included in the disassembly time.

Figure 6.1 Engine Being Dismantled

6.3.1.3 Cylinder Block

Cylinder block processing included post-wash inspection, crack detection, and any additional hand cleaning operations necessary to remove old gasket material or similar contaminants; removal and replacement of cylinder liners where applicable, metal deposition where appropriate, resurfacing, re-cutting of cylinder bores and honing operations. The process time also included all within activity inspection time and final, post-machining purge and wash.

6.3.1.4 Cylinder Head

The cylinder head processing time included post-wash inspection, crack detection, gauging, removal, replacement and re-cutting of valve guides and seats as required; removal, cleaning and replacement of pre-combustion chamber inserts (where fitted);

and machining of the fire face and the manifold faces. The process time also included all within activity inspection time and final, post-machining purge and wash.

6.3.1.5 Crankshaft

Crankshaft processing time comprised post-wash inspection and crack detection, gauging, grinding and polishing of the main and pin journals, cleaning of the oilways, re-cutting or replacing keyways and the final wash and preserving operation.

Figure 6.2 Crankshaft Crack Detection Testing

6.3.1.6 Camshaft

The processing time for camshafts included post-wash inspection, model identification, and crack detection, gauging, grinding and polishing of cam lobes; shaft polishing and the final wash and preserving operation. Where the engine variant included two camshafts – one intake, one exhaust, the overall processing time captured was per pair.

6.3.1.7 Valves

Valve processing time included protecting the stems with a sleeve, loading and unloading the cleaning machine, removing the sleeve, inspecting, regrinding and sorting into engine sets. Times captured are per complete engine set although for engines A and D only the intake valves were remanufactured whereas for engines B and C, both intake and exhaust valves were remanufactured.

Figure 6.3 Valves Pre and Post Clean, Uninspected

6.3.1.8 Connecting Rod

The processing time for connecting rods included tightening and re-torquing bolts, inspection for bend and twist, removing, replacing and finishing small-end bushes where appropriate, truncating where necessary, final inspection, weight-grading as appropriate and end-of-process cleaning. The time required for replacing bolts and assembling connecting rods to pistons and grading into engine sets was not included as this is a standard time that only applies to finish machined connecting rods and could add nothing to knowledge about the impact of pre-processing inspection.

Figure 6.4 Typical Connecting Rod being Checked for Alignment

6.3.1.9 Rocker Shafts

Rocker shaft remanufacturing time comprised initial inspection, skimming and/or polishing of the shaft, reassembly of the rocker shaft and preservation.

6.3.1.10 Compressor

The compressor processing time was made up of initial disassembly, cleaning and inspection, remanufacture of the cylinder head, housing, crankshaft and piston; reassembly and test.

6.3.1.11 Oil Pump

Processing time for oil pumps included disassembly, cleaning and inspection, rotor remanufacture, minor repairs, reassembly and test.

Figure 6.5 Cleaned, Reprocessed Oil Pump Shaft

6.3.1.12 Fuel Lift Pump

Processing time for fuel lift pumps included disassembly and inspection, minor repairs, reassembly and test.

6.3.1.13 Exhaust Gas Recirculation (EGR) Valve

The EGR valve processing time comprised partial disassembly, cleaning, testing and replacement of springs, testing of the diaphragm and valves, reassembly and final test.

6.3.1.14 Vacuum Pump

The vacuum pump processing time comprised disassembly, cleaning, testing of diaphragms and valves, repairs to sealing surfaces, reassembly and final test.

6.3.1.15 Starter Motor

Processing time for starter motors included disassembly, cleaning, testing of all electronic and electrical components, insulation, solenoid and plunger testing; skimming of the armature, brush gauging, minor repairs to housings, reassembly and test.

6.3.1.16 Alternator

Processing time for the alternator included disassembly, cleaning, testing of all electronic and electrical components, insulation testing, skimming of stator and rotor; brush gauging, minor repairs to housings, reassembly and test.

6.3.1.17 Flywheel

The flywheel processing time included initial inspection, re-tapping of holes as required, replacement of bushes as required and skimming, final clean and preservation.

6.3.1.18 Turbocharger

The processing time for a turbocharger included disassembly, wash, inspection, test and remanufacture of actuators, valves, the turbine wheel and the compressor; reassembly, balancing and test.

6.3.1.19 Small Parts Kit

The small parts engine kit forms the majority of components within an engine assembly. It includes the majority of bolts, nuts, screws, washers, brackets, covers, cam followers, lifting eyes; timing chains, gears and similar. The processing time for the entire kit included many activities such as inspection, gauging and testing where appropriate (e.g. valve spring testing); any additional hand-cleaning operations (e.g. removal of small amount of gasket material from covers) minor repairs and assembly into the appropriate engine kit.

Figure 6.6 Various Engine Parts during the Wash Process

6.3.1.20 Engine Kitting

Engine kitting is the amalgamation of a complete set of remanufactured and new parts into one complete set of components for assembly. It included all parts that have been remanufactured, all parts that are fitted new 100% of the time and new parts that have been injected to replace parts that were unable to be remanufactured successfully in this case. The time allocated includes any time the kit spent waiting for missing items but not any delay between the kit being completed and assembly commencing.

6.3.1.21 Assembly

The engine assembly time was the time taken to assemble one engine from receiving a kit to completion and transfer to test. The time included any time waiting for missing parts or parts to replace inadequate components but did not include any breaks taken by the individual assembler.

6.3.1.22 Post-Production Test

Every engine is subjected to a test once completed. Engines A and B underwent a cold test – the engine is essentially driven as a compressor. The time collected included initial pressurised oil fill, rigging to the appropriate test rig, the test itself (including recording the results) and de-rigging and draining, post-test. Engines C and D were subjected to a hot test: coupled to a dynamometer and run to a pre-determined load and speed routine including the tracing of power and torque curves and an emissions smoke test. The processing time here included engine rigging, pressurised oil fill, rigging to the appropriate test stand, loading into the dynamometer, the test itself (including recording the results) and de-rigging and draining, post-test.

6.2.1.23 Paint, Pack and Despatch

All engines in this study were painted before sending to the customer. The time for this activity included masking prior to paint, painting, unmasking, engraving and attaching the engine data plate, adding any final components (e.g. gasket sets, drive belts, fans, clutch plates etc.) and packing into transit boxes or frames.

6.3.2 In-Process Scrap

The treatments to extend the amount of pre-processing inspection were designed to observe faults or failed components as early as possible in the process. A secondary method of measuring this effect is in determining the point at which components are scrapped and consequently the value added before discarding. This could be quantified in terms of the cost savings. Operators, when discarding a failed component, record the details on the materials planning system. This electronic transaction recorded the time, date, operator identity, component part number, quantity being rejected, reason for rejection and the activity at which the scrap occurred.

Historic records going back to 2006 were available for all subject engines and consequently direct comparisons could be made. The average scrap for the entire year of 2010 was selected as a recent comparison. Scrap was measured as a percentage of cores processed.

6.3.3 Independent Variables

This research was concerned with understanding the effects of a pre-processing inspection regime on the overall remanufacturing process and consequently manipulating the nature of such inspection would allow the effects to be measured in the dependent variables.

It was important, when specifying the content of the inspection protocols, to ensure that all aspects of the experimental design were fulfilled so that any risks to either internal or external validity could be wholly eliminated or properly mitigated. This meant that four inspection protocols were necessary one of which should be the control.

The next section discusses the inspection protocols developed.

6.4 Inspection Protocols

The experimental design required four inspection protocols to be developed. The main limiting factor to generating the inspection processes was the technology available. Individual components, once disassembled and cleaned, could undergo a variety of inspection and testing, however as a complete dirty assembly, relatively little technology was accessible. Nevertheless, incremental inspection could be achieved.

The provision of a control was essential. Classic experimental design requires a control group amongst the experimental subjects (Campbell and Stanley, 1963). The design of this research has four groups of experimental subjects – essentially four populations and to ensure that the control group covered all the populations, one protocol had to act as the control. Further, in order to demonstrate that inspection in any form impacted the remanufacturing processing, the effect of no inspection whatsoever was required. Thus two protocols were, in essence, described. The remaining two protocols required additional input beyond the norm – the control.

The available inspection equipment, the nature of the subject assemblies and various inspection or sorting methods described in literature (e.g. Kulkani *et al*, 2007, Rugrungruang, 2008, Kernbaum *et al*, 2006 etc.), when considered together enabled the development of a further two protocols. The protocols, described in the following sections, increased the level of inspection as the number progressed from 1 to 4.

Operators within Caterpillar Remanufacturing have work instructions referred to as "standard work sheets". These are detailed explanations of the work content for an individual activity and explain safety considerations, what tools are required and in what order the work should be undertaken, along with any quality standards or inspection methods that are relevant. They also include product specifications where appropriate. The level of detail in these standard work sheets is such that they are considered proprietary information by Caterpillar Remanufacturing and cannot be included in this work.

6.4.1 Inspection Protocol 1

Inspection protocol 1 investigated the effect of no pre-processing inspection of cores on remanufacturing activity times. An engine core was simply decanted from the box or frame when required for disassembly and assigned a unique tracking number. No information was passed to any other department concerning condition. Where insufficient cores were available to fulfil production, the only message forwarded was to the effect that a particular part number could not be issued as no cores were available.

This protocol was written up into a standard work sheet and issued to production with appropriate training for operatives. Cores subjected to inspection protocol 1 were issued with a red identifying label with the unique tracking number written in.

Figure 6.7 Protocol 1 Red Identifying Label

6.4.2 Inspection Protocol 2

This protocol acted as the control for the experiment. The usual level of core inspection at Rushden prior to disassembly was a simple, brief visual inspection of external condition. Information on the condition of cores or missing parts was not routinely passed on to any other part of the business.

Any cores found to be in a particularly good condition – all parts apparently present, core clean and apparently lightly used – was offered to production for a "fast-track" solution. This typically bypassed the usual disassembly route and a skilled engine builder would be asked to investigate any failure mode. Where any failure could be detected and cost-effectively repaired, this work would be completed and the engine subjected to a normal post-production test. Incidents of near perfect cores are infrequent but do arise. This is often a reflection of a vehicle failing for reasons other than engine performance.

Any cores found to be in an especially parlous state, whether through an acute incident (e.g. fire damage) or excessive wear, or particularly severely broken cores could be put aside and used as a donor for smaller components required for other engines. A completely unusable core was a rarity and did not occur during the experimental period.

Protocol 2 described the usual treatment of cores and so no additional standard work sheets or training was required. Cores subjected to inspection protocol 1 were issued with a green identifying label with the unique tracking number written in.

Figure 6.8 Protocol 2 Green Identifying Label

6.4.3 Inspection Protocol 3

This protocol increased the level of inspection to the engine and also instituted an information feedback loop. Cores were visually inspected for missing or severely damaged parts and anything noted was marked on a feedback sheet together with the unique tracking number. Rotating parts were manually turned and where this was not possible, this was again noted on the feedback sheet. Electrical equipment was visually inspected and any smell of burning noted on the feedback sheet – a burnt odour is a good indication of severe damage to electrical sub-assemblies or components and is commonly known by practitioners as the "scratch and sniff" test. Particular note was taken of any partial disassembly/reassembly undertaken prior to delivery for remanufacture. It is important to understand if a core has been worked on prior to remanufacture as it can be an indicator that internal parts are missing or, as they may not been properly reassembled, further damage could possibly be inflicted on loose parts during handling and transport.

Completed feedback sheets were given daily to the production manager responsible for reclaim (comprising disassembly, wash and machining). The items noted as damaged or missing were checked against any stocked excess remanufactured parts and gaps were reported through the materials planning system in the same way as would be used following any activity where inspection had taken place. The information was then passed to the purchasing department who, because they received this information much earlier than was previously the case, were able to obtain the required material in good time.

This protocol was written up into a standard work sheet and issued to production with appropriate training for operatives. Cores subjected to inspection protocol 3 were issued with a yellow identifying label with the unique tracking number written in.

Figure 6.3 Protocol 3 Yellow Identifying Label

6.4.4 Inspection Protocol 4

Inspection protocol 4 added another layer of inspection to protocol 3. Thus, in addition to the provisions of inspection protocol 3, an endoscope was used to investigate the internal condition of the cylinder bores, cylinder head, covers, turbocharger, manifolds and starter motors (where fitted).

The feedback sheet was extended to include any notes from the endoscopic inspection. Operatives were instructed to note any internal damage, corrosion or wear on the feedback sheets. They were also given guidance on whom to ask when they were unsure of what they were seeing. The production manager responsible for reclaim was nominated for this task but was seldom asked to give a second opinion because the operators understood the requirements very well.

Completed feedback sheets were again submitted daily. The items noted as damaged or missing were checked against any stocked excess remanufactured parts and gaps were reported through the materials planning system in the same way as would be used following any activity where inspection had taken place. The information was then passed to the purchasing department who, because they received this information much earlier than was previously the case, were able to obtain the required material in good time.

This protocol was written up into a standard work sheet and issued to production with appropriate training for operatives. Cores subjected to inspection protocol 4 were issued with a blue identifying label with the unique tracking number written in.

Figure 6.4 Protocol 4 Blue Identifying Label

6.4.5 Training for the Inspection Protocols

The operatives responsible for handling the cores were experienced in their roles and familiar with the product in question. They were willing to assist with the experiment and once it was explained that they could access help and information whenever they felt it necessary, they eagerly participated.

Training was conducted with all four members of the team present and using the standard work sheets written for the protocols. The training was undertaken on cores that had already been received but not processed to simulate the experimental conditions – prior to the experiment beginning. The colour coding was explained, the feedback sheet introduced and, as a team, they worked through the day's cores, randomly assigning inspection protocols and inspecting to that level, completing the feedback sheet as necessary. Once a good level of confidence was established, the standard work sheets were amended with any of their relevant comments and suggestions ready to launch the experiment. These are proprietary information and cannot be included here.

6.5 Randomisation of Subjects

Randomisation of the experimental subjects was an essential part of the experiment so that the internal validity was maintained. This also had the effect of assisting in maintaining the external validity because of the large group size used.

The cores typically arrived at the Rushden remanufacturing facility from core collection sites after consolidation. The tracking methods in place for the cores varied from customer to customer. Typically, the cores remain the property of the OEM under contract remanufacturing and only transfer to the remanufacturer once they have been disassembled – i.e. resource has been added. The production scheduler was able to obtain information about the number and type of cores declared as being in transit for remanufacture destined for Rushden and planned production accordingly; however, deliveries were often not in accordance with that expected. No information was available in any of the tracking systems as to the condition or quality of the cores, nor was there any indication of origin or use history.

Cores are often shipped under generic part numbers that encompass a range of similar engines rather than by individual part number, a consequence of the earlier consolidation activity. This means that the cores arriving at Rushden were a random mix both of specific part number and of condition.

It could be argued that the existing level of randomisation, present upon receipt, was sufficient to guarantee internal validity, however to comply with Antony's (2003) recommendation to randomise treatment in time to avoid the potential effects of any systematic bias or unconsidered factors, further randomization was required.

Operatives were issued with four sets of tags in opaque bags marked with an appropriate letter, one for each engine, A to D inclusive. Each set included an equal number of each of the four colours of tags. Every tag had a unique tracking number written on it: Engine A tags were labelled A_1, A_2, A_3…An; Engine B tags, B_1, B_2, B_3…B_n; Engine C tags, C_1, C_2, C_3…C_n and Engine D tags, D_1, D_2, D_3…D_n. The operator removed one tag at random from the appropriate bag for each piece of core that arrived and attached it to the core. No inspection took place at this time. The cores were then stored as normal until required by production. Inspection to the assigned protocol took place at this time, prior to preparing the core for disassembly. The engine then progressed with the engine letter and number only e.g. A32, C125 etc.

The decision to assign a protocol at receipt but not to inspect until a core was required for production was driven by two factors: the need to disrupt normal working practices as little as possible, and the need to minimise the cost impact of the experiment. Disruption of normal working practices more than was necessary to administer the treatments was undesirable because it might introduce unforeseen variables that could contaminate the results.

The allocation of a unique tracking number also meant that once the engine was passed to disassembly none of the up-stream operatives were able to determine which inspection protocol had been applied to which engines or components. This further anonymity aided internal validity as operatives could not alter their behaviour based on any assumptions about the parts they were processing.

6.6 Data Collection

The nature of the experiment and the large sample involved meant that a considerable amount of data could be collected. It would be impossible for one person to collect all of the results, particularly as many of the operations were undertaken simultaneously. The primary concern therefore became the ability to ensure data integrity if the collection of processing times was dispersed amongst operators. Processing times were captured in decimal hours and collated in a spreadsheet for analysis. The following sections discuss the collection of data and its integrity, the nature of the data that was collected and the audit process that was followed.

6.6.1 Data Collection and Integrity

Operators at the Rushden facility were used to collecting processing times and other data as part of the Caterpillar Production System (CPS). This lean manufacturing system, a fundamental of all Caterpillar manufacturing and remanufacturing facilities, uses lean tools and techniques to promote the elimination of waste. One strand of CPS calculates both overall equipment effectiveness (OEE) and overall process effectiveness (OPE) as part of this continuous improvement process. OEE and OPE measure the effectiveness of a piece of equipment or a human process and, over a period of time, give a valuable insight into the nature of wasted machine and human time and failings in quality. Neither OEE or OPE can be effectively calculated without reliable data.

All operatives are trained in CPS to give an understanding of the use of tools such as OEE and OPE, the benefits continuous improvement tools like these can bring to their jobs and the importance of reliable data. They are supported through the initial stages of data collection by their team leader or manager and then, when confident, take over the measurement themselves. Individual operators then either enter the data into the computerised calculator themselves or submit a handwritten version to their team leader.

The data collection required for this experiment was part of the data normally collected by operators for OEE or OPE measurement and consequently where such measurements were already being made, the only additional requirement was that the unique tracking number was recorded alongside the processing time. A slight change to the recording sheet made this a simple adjustment for operators. This OEE and OPE data was then automatically returned onto the master data collection sheet (Appendix II).

Data was not routinely collected for either OEE or OPE in the initial decant and inspect activity or in the disassembly activity. Nevertheless the operators were routinely using other CPS tools and had undergone similar training to their colleagues. Consequently a method similar to that in the majority of the facility was implemented with very little disruption. The decant and inspect operators preferred to write their times down and these were collected daily by the researcher and added to the master spreadsheet; whereas the disassembly operators, already using the computer to record material deficiencies and other information, recorded their processing times on a centrally held spreadsheet. All the operators involved noted the times against the unique tracking numbers. This spreadsheet also automatically returned the entered data to the master data collection spreadsheet.

6.6.2 Collected Data

The nature of the remanufacturing operation at the Rushden facility assisted in the ability to collect data. Lean manufacturing tools such as OEE and OPE, embedded in the culture mean that normal activities could be used to record processing times, this increased confidence in the collected data. Additionally, as the facility was relatively small – employing around 110 people – one operator was responsible for one entire remanufacturing process thus reducing the risk of corrupted data from operator changeovers or misunderstandings.

The majority of the data collection was undertaken by the operator completing the task as a part of his or her daily activity. This was a normal part of their routine for the majority of operators, as explained earlier. Nevertheless, specific instructions were given to all operators including how to collect the data, what data to collect and how to record the data. These instructions to operators were written up into a standard work sheet and training, using similar product flowing through the remanufacturing process, was given prior to the start of any data collection.

Processing times for all stages of the remanufacturing process were recorded in decimal minutes. Digital stopwatches, recording to two decimal places (hundredths of a second) were provided to operators. These stopwatches had a start/stop function that enabled the operator to pause the timing if they needed to step away from the job

– for instance to answer the phone or take a scheduled break. Operators were instructed to record the time displayed on the stopwatch at the end of the activity exactly as displayed and not to round up or down.

Processing times included all operations that a sub-assembly or component was subjected to where the operator was involved. Therefore, cycle times in machines such as wash machines where there was no operator involvement were not recorded as part of the processing time but if the operator was required to be present the entire time, for instance during the post-production test, this period was included in the processing time.

Disassembly time included removing sub-assemblies and components and disassembling them completely where this operation was routinely carried out in the disassembly area. Where items such as turbochargers, fuel pumps or starter motors were removed as complete sub-assemblies and passed to a specialist area for processing, the only time recorded at disassembly was the time to decouple them from the core. Any disassembly time in the specialist area was included in the processing time captured in that area for the individual component.

Wash times were collected in a similar manner, in that parts not usually passed directly from disassembly to wash (for example, turbochargers that are processed in specialist areas) had their processing times collected in the areas where they were washed and allocated to their overall processing time rather than it being subsumed in the general wash time.

Electronic recording of all in-process scrap on the materials planning system was a routine operation at the Rushden facility and this continued without any intervention. The system was then interrogated to obtain data on each of the subject engines for the experimental period and for a variety of equivalent time periods. The data was then compared to establish whether any difference could be noted between periods.

6.6.3 Audit Procedure

An audit procedure was already in place at the Rushden facility and a more frequent version of this system was used. Employing a current and understood method ensured that operatives experienced working conditions that were as near as possible to normal. This was important to ensure that operators did not alter their behaviour because of changes to routine or usual methods and in some way influence the data collected.

6.6.3.1 Existing Audit Procedure

Standard procedure, as part of the Caterpillar Production System (CPS), requires regular auditing of activities against the agreed standard time. This enables easy identification of activities that require improvement. It also ensures that the information against which remanufacturing costs are calculated is accurate. The consequence of this discipline is that an audit procedure is in place and that operators are familiar with the experience.

The practice of auditing can be an issue for operators where there is a perception that its sole purpose is to obtain greater, unrewarded effort from employees. Embedding the audit procedure into usual practice and clearly demonstrating its purpose as a continuous improvement tool diffuses hostility to the process.

Process audits, as part of the CPS routine, were carried out on the highest 80% of activities ranked by length of work content every year. Each activity was measured a minimum of three times by the auditor, preferably within one working week where the quantity of appropriate cores and the production schedule allowed. The activity times noted by the auditor were compared with both that noted by the operator and that entered into either the OEE or OPE system by the operator. This allowed an audit of the activity and the recording to be undertaken simultaneously. A discrepancy of more than 5% constituted a failed audit and was noted for further improvement work and a further audit within twelve weeks. Data incorrectly entered into the production system was corrected.

6.6.3.2 The Experimental Audit Process

The purpose of the routine audits was to verify activities and look for opportunities for continuous improvement. The purpose of the within-experiment audits was ensuring data reliability. Consequently the frequency of the audits and thus sample size was important. IBM's SPSS software package was used to calculate sample size based on the predicted data population of around 30,000 entries. Sample size is dependent on population, statistical power, the level of probability that the null hypothesis will be falsely rejected (α), and the confidence that the null hypothesis will be properly rejected. This latter is β and is calculated as (1 – α). The large amount of data being collected – effectively the entire population – meant that there was high confidence that any statistical significance would be directly attributable to treatments and consequently setting the α value at 0.05 and thus the confidence at 95% could be justified (Lipsey and Hurley, 2009). The calculation of sample size based on those parameters required a 7.14% sample size or 2427.6 parts. This equated to one component in every fifteen.

The existing audit scheme was modified to satisfy the requirements of the research design whilst remaining intrinsically the same in order to reassure the process operators. The modified approach was thus:

- Every activity was audited every fifteen components;
- One complete activity only was audited on each occasion because of the high sample size;

- Auditor data was compared with both operator data and that recorded on either the centrally held spreadsheet or the paper version;
- Variances of more than 5% between auditor and operator in either case were recorded as failures and any erroneous entry, corrected;
- Failed audits would result in re-training in the data collection and recording for the operator and a further audit of the next component; and
- The overall remanufacturing process time was not audited as this was simply the sum of all the remanufacturing activity times.

All audits during the experimental phase were carried out by the researcher.

6.7 Researcher Involvement

Quantitative research, as noted previously in Chapter 5, assumes that there are facts that are independent from prevailing views or beliefs and that these can be objectively measured. It demands that the researcher should remain independent of the research subject throughout the duration of the research. This was not entirely possible as the researcher was employed throughout the duration of the project by Caterpillar Remanufacturing as a production manager at the Rushden facility. Nevertheless by confining all interventions to established routines and using standard working procedures, the effect of the researcher could be minimized. The large volume of collected data and the regular audits also assisted in maintaining data integrity.

6.8 Summary

This chapter has described the experimental data phase, the selection of experimental subjects and the development of treatment protocols. It has discussed the nature of the dependent and independent variables, the data collection and audit procedure and it has commented upon the effect of researcher involvement.

Chapter 7 Experimental Results

7.1 Introduction

This chapter presents the results of the experimental phase and the outcome of the experimental audits. The interviews with remanufacturing personnel both pre-experiment and post-experiment are also reported.

7.2 Experimental Results

The experimental phase generated multiple results for each sub-assembly and component and each activity that constitutes the overall remanufacturing process. All results were recorded in decimal minutes. Fully tabulated results can be found in Appendix II.

Engine cores were allocated at random but in almost equal quantities across the four inspection protocols. The largest variation in allocation was two cores. The population size of each engine was:

Engine A: 1053 cores

Engine B: 411 cores

Engine C: 420 cores

Engine D: 312 cores

The mean results are tabulated below, engine by engine. In each case the table records in percentages, the mean change in activity time between each protocol and the control. The control is protocol 2 which was the usual pre-experimental inspection at the Rushden facility. Where components were not fitted to the engine in question, results have been greyed out. The activities have not been removed to facilitate comparison by making each table similar.

Table 7.1 % Change of Mean Activity Times from the Control – Engine A

Engine A - Activity	% Change between Protocol and Control		
	Protocol 1	Protocol 3	Protocol 4
Decant and Inspect	-29.96	40.49	163.91
Disassembly	5.29	-2.49	-2.15
Cylinder Block Remanufacture	0.51	-0.21	-0.17
Cylinder Head Remanufacture	1.18	0.39	0.23
Crankshaft Remanufacture	1.71	-0.20	-0.29
Camshaft Remanufacture	1.03	1.09	1.05
Valve Remanufacture	-0.12	-0.38	0.00
Connecting Rods	0.12	0.20	0.02
Rocker Shaft Remanufacture			
Compressor Remanufacture			
Oil Pump Remanufacture			
Fuel Lift Pump Remanufacture			
EGR Valve Remanufacture			
Vacuum Pump Remanufacture			
Starter Motor Remanufacture			
Alternator Remanufacture			
Flywheel Remanufacture			
Turbocharger Remanufacture			
Small Parts Remanufacture	0.04	0.00	-0.03
Engine Kitting			
Engine Assembly	-0.37	-0.35	-0.38
Post-Production Test	-0.19	0.00	0.15
Paint, Pack and Despatch	0.09	0.23	0.11
Overall Remanufacture	0.43	0.31	1.86

This table shows that for Engine A, there was very little overall change in the time taken for the overall remanufacturing process regardless of which inspection protocol was used. Individual activities showed some variation, notably “Decant and Inspect” which changed as expected with the variation in inspection content and "Disassembly" which increased without any inspection and decreased slightly as the inspection content increased. However the increase in "Decant and Inspect" time in the latter two cases outweighed any benefit from "Disassembly". Other operations showed minimal change either positive or negative.

Table 7.2 % Change of Mean Activity Times from the Control – Engine B

Engine B - Activity	% Change between Protocol and Control		
	Protocol 1	**Protocol 3**	**Protocol 4**
Decant and Inspect	-24.37	46.87	176.96
Disassembly	1.60	-4.09	-4.29
Cylinder Block Remanufacture	1.16	-1.94	-2.06
Cylinder Head Remanufacture	0.78	-2.21	-2.08
Crankshaft Remanufacture	0.00	0.00	0.00
Camshaft Remanufacture	-0.03	0.10	0.04
Valve Remanufacture	0.12	-0.08	0.06
Connecting Rods	0.13	0.12	0.09
Rocker Shaft Remanufacture			
Compressor Remanufacture			
Oil Pump Remanufacture	-0.26	0.00	-0.21
Fuel Lift Pump Remanufacture			
EGR Valve Remanufacture			
Vacuum Pump Remanufacture	0.26	-0.12	0.00
Starter Motor Remanufacture			
Alternator Remanufacture			
Flywheel Remanufacture			
Turbocharger Remanufacture			
Small Parts Remanufacture	1.20	-1.81	-0.03
Engine Kitting			
Engine Assembly	-0.20	-0.03	-0.03
Post-Production Test	-0.08	-0.03	0.20
Paint, Pack and Despatch	-0.02	-0.04	-0.03
Overall Remanufacture	0.27	-0.71	0.38

The results for engine B are broadly similar to those for engine A although in the case of engine B, inspecting to protocol 3 gave a small benefit. Once again the "Decant and Inspect" activity time changed as expected with the variation in inspection content and “Disassembly” which increased without any inspection and decreased as the inspection content increased. However the increase in “Decant and Inspect” time for protocol 4 outweighed any benefit from “Disassembly”. Other operations showed little change either positive or negative.

Table 7.3 % Change of Mean Activity Times from the Control – Engine C

Engine C - Activity	% Change between Protocol and Control		
	Protocol 1	Protocol 3	Protocol 4
Decant and Inspect	-21.61	23.66	85.85
Disassembly	10.35	-20.06	-20.06
Cylinder Block Remanufacture	3.12	0.63	-0.83
Cylinder Head Remanufacture	-0.39	-3.88	-3.10
Crankshaft Remanufacture	0.03	-1.23	-1.20
Camshaft Remanufacture	-0.17	0.04	-0.06
Valve Remanufacture	0.38	0.13	0.17
Connecting Rods	-0.01	-0.02	0.20
Rocker Shaft Remanufacture	-0.08	-0.05	-0.10
Compressor Remanufacture			
Oil Pump Remanufacture	-0.01	0.06	-0.04
Fuel Lift Pump Remanufacture	3.96	-1.33	-0.53
EGR Valve Remanufacture	1.14	-3.78	-3.83
Vacuum Pump Remanufacture	0.20	-0.08	-0.88
Starter Motor Remanufacture	7.26	-17.58	-19.54
Alternator Remanufacture	7.83	-6.68	-9.42
Flywheel Remanufacture	1.06	-1.46	-3.10
Turbocharger Remanufacture	4.15	-16.70	-18.61
Small Parts Remanufacture	5.85	-13.52	-13.31
Engine Kitting	9.31	-4.07	-3.64
Engine Assembly	-0.21	-0.30	-0.32
Post-Production Test	0.19	0.04	0.02
Paint, Pack and Despatch	-0.02	-0.04	-0.03
Overall Remanufacture	2.74	-5.36	-5.27

The results for engine C show a different pattern to those for engines A and B. The “Decant and Inspect” activity time changed as expected with the variation in inspection content and “Disassembly” which increased without any inspection and decreased as the inspection content increased. However a great number of other operations mirrored this pattern. The most notable decreases in mean processing time from the control occurred in the “Cylinder Block”, “Cylinder Head”, EGR Valve”, “Starter Motor”, “Alternator”, “Flywheel”, “Turbocharger”, “Small Parts” and “Engine Kitting” remanufacturing activities. There was little change for the other activities.

Table 7.4 % Change of Mean Activity Times from the Control – Engine D

Engine D - Activity	% Change between Protocol and Control		
	Protocol 1	**Protocol 3**	**Protocol 4**
Decant and Inspect	-23.23	80.63	214.96
Disassembly	3.34	-18.00	-17.99
Cylinder Block Remanufacture	5.08	-2.10	-2.84
Cylinder Head Remanufacture	0.96	0.67	-0.86
Crankshaft Remanufacture	0.08	-2.75	-2.46
Camshaft Remanufacture	0.30	0.04	0.14
Valve Remanufacture	0.15	-0.02	0.03
Connecting Rods	0.03	-0.12	-0.04
Rocker Shaft Remanufacture	-0.17	-0.14	-0.15
Compressor Remanufacture	-0.10	-17.96	-19.23
Oil Pump Remanufacture	0.03	0.06	0.08
Fuel Lift Pump Remanufacture	0.85	-4.49	-3.70
EGR Valve Remanufacture			
Vacuum Pump Remanufacture	0.10	0.12	0.07
Starter Motor Remanufacture			
Alternator Remanufacture			
Flywheel Remanufacture			
Turbocharger Remanufacture	-0.44	-26.67	-28.60
Small Parts Remanufacture	2.59	-5.07	-5.30
Engine Kitting	0.61	-9.55	-9.51
Engine Assembly	0.10	-0.09	-0.09
Post-Production Test	0.13	0.09	0.09
Paint, Pack and Despatch	0.13	0.00	0.06
Overall Remanufacture	0.76	-6.50	-6.22

The results for engine D are similar to those for engine C. The “Decant and Inspect” activity time changed as expected with the variation in inspection content and “Disassembly” which increased without any inspection and decreased as the inspection content increased. However a great number of other operations mirrored the “Disassembly” pattern. The most notable decreases in mean processing time from the control occurred in the “Cylinder Block”, “Crankshaft”, “Compressor”, “Turbocharger”, “Small Parts” and “Engine Kitting” remanufacturing activities. There was little change for the other activities.

7.3 Experimental Audits

Audits were carried out throughout the research period on all of the remanufacturing activities. These were carried out as per the process previously detailed in section 6.5.3.

A total of 2243 audits were completed during the experimental period. Five failures were noted, of these two were caused by incorrect reading of the stopwatch by the operator and the remaining three, by the operator incorrectly recording the process time on the spreadsheet. Three failed audits were noted for engine A, none for engine B and one each for engines C and D. A second audit was carried out on the next similar component following a failed audit, all these audits were passed. This represents less than 0.23% of the total audits and less than 0.02% of the total data recorded and so the reliability of the results is confirmed.

Table 7.5 below shows the breakdown of the audits and results by remanufacturing activity.

Table 7.5 Audits by Remanufacturing Activity, All Engines

Activity	Total No. Data Entries	Total No. Audits	No. Audits Failed	% Audits Failed	No. Audits As Operator	% Audits As Operator	No. Audits Variance <0.5%	% Audits Variance <0.5%
Decant and Inspect	2196	144	0	0.00%	61	42.36%	0	0.00%
Disassemble	2196	145	0	0.00%	53	36.55%	0	0.00%
Cylinder Block Remanufacture	2196	146	1	0.68%	54	36.99%	1	0.68%
Cylinder Head Remanufacture	2196	145	0	0.00%	71	48.97%	0	0.00%
Crankshaft Remanufacture	2196	145	0	0.00%	85	58.62%	0	0.00%
Camshaft Remanufacture	2196	145	0	0.00%	78	53.79%	0	0.00%
Valve Remanufacture	2196	145	0	0.00%	94	64.83%	0	0.00%
Connecting Rods	2196	145	0	0.00%	92	63.45%	0	0.00%
Rocker Shaft Remanufacture	732	51	0	0.00%	30	58.82%	0	0.00%
Compressor Remanufacture	312	23	0	0.00%	9	39.13%	0	0.00%
Oil Pump Remanufacture	1143	79	0	0.00%	48	60.76%	0	0.00%
Fuel Lift Pump Remanufacture	732	51	0	0.00%	32	62.75%	0	0.00%
EGR Valve Remanufacture	420	30	0	0.00%	22	73.33%	0	0.00%
Vacuum Pump Remanufacture	1132	77	0	0.00%	54	70.13%	0	0.00%
Starter Motor Remanufacture	420	29	0	0.00%	18	62.07%	0	0.00%
Alternator Remanufacture	420	28	0	0.00%	17	60.71%	0	0.00%
Flywheel Remanufacture	420	28	0	0.00%	20	71.43%	0	0.00%
Turbocharger Remanufacture	732	51	1	1.96%	31	60.78%	1	1.96%
Small Parts Remanufacture	2196	145	0	0.00%	98	67.59%	0	0.00%
Engine Kitting	732	53	0	0.00%	34	64.15%	0	0.00%
Engine Assembly	2196	146	1	0.68%	103	70.55%	1	0.68%
Post-Production Test	2196	147	2	1.36%	92	62.59%	2	1.36%
Paint, Pack and Despatch	2196	145	0	0.00%	95	65.52%	0	0.00%

7.4 In-Process Scrap

Records of in-process scrap for selected (generally higher value) components were collected as part of the usual remanufacturing process at the Rushden remanufacturing facility. Data was routinely collected on these components for a variety of reasons one of which is that a sudden variation in scrap rates on complex machining processes can indicate wear on machine tools. This is because worn tooling on machining operations with very tight tolerances, for example, valve seat profile cutting; very quickly produces parts that are out of specification as the profile cannot be maintained with the required accuracy. Most modern CNC machining centres have a predicted tool life set but even so tooling can deteriorate more quickly than expected and a spike in scrapped might indicated that condition. Alternatively increased levels of scrap for a repeated reason may indicate a component specific issue that needed reporting to the design engineers, as indeed might a high incidence of failure on a safety critical component.

Historic records were examined for the experimental subjects and averaged for the year 2010. These were then compared with scrap records generated during the experimental phase. Table 7.3 below shows the average scrap rates at disassembly, machining and engine assembly for various components of the engines. Scrap figures are calculated as a percentage of the number of cores processed in all cases.

Table 7.6 % Components Scrapped of the Total Cores Processed.

	Cylinder Block		Cylinder Head		Crankshaft		Camshaft		Connecting Rods	
Engine / Activity	Average 2010 (%)	Experimental Average (%)	Average 2010 (%)	Experimental Average (%)	Average 2010 (%)	Experimental Average (%)	Average 2010 (%)	Experimental Average (%)	Average 2010 (%)	Experimental Average (%)
A / Disassembly	9.63	10.82	6.71	7.43	7.19	12.81	4.66	4.89	8.57	10.15
B / Disassembly	4.06	5.58	14.17	17.33	2.76	2.55	11.11	11.64	2.93	2.51
C / Disassembly	6.47	7.24	9.86	10.39	16.71	18.96	4.69	6.13	3.52	3.05
D / Disassembly	3.84	5.99	6.39	7.92	2.35	2.18	1.17	1.82	2.51	2.94
A / Machining	11.08	10.47	16.94	16.22	14.36	10.09	6.27	5.98	12.31	10.13
B / Machining	9.64	7.81	15.43	13.29	4.86	4.61	12.42	12.03	0.00	0.00
C / Machining	8.53	7.18	12.67	10.82	17.47	14.38	6.28	4.52	5.69	4.18
D / Machining	6.22	4.17	8.73	6.41	4.61	3.88	3.67	2.48	3.56	2.14
C / Kitting	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D / Kitting	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.00
A / Assembly	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B / Assembly	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C / Assembly	0.03	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
D / Assembly	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00

The general trend for each component of every engine showed an increase disassembly and a small decrease at the machining stage. The rates at engine kitting and engine build were extremely low and remained so. This is because all components and sub-assemblies that arrive at this part of the process will either be new or will have completed their reprocessing activities.

7.5 Pre-Experimental Interviews

Managers and operatives working at the remanufacturing facility, as well as one from another European Caterpillar Remanufacturing facility, were interviewed before the experimental phase to gauge attitudes to pre-processing inspection. The interviews were all carried out face-to-face at the place of work of all of those questioned and the responses transcribed in full by the researcher.

Interviews were conducted with a total of six people: one member of the senior management team, one production manager, one logistics manager, two operatives (one in disassembly and one in assembly) and a member of the senior management team from another European facility.

Three questions were posed to each person:

1. Are you aware of what pre-processing inspection of core is currently happening at this facility? Please describe your knowledge.
2. Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
3. If pre-processing inspection was carried out on core, what information would be useful for your job? Please comment on why this is.

7.5.1 Responses

The responses to each question are summarised below. Full transcripts can be found in Appendix III. Individuals were asked to consider their responses carefully and give as full a reply as possible. These answers were used to assign a category to each response.

Table 7.7 Responses to the Pre-Experimental Questions

	Senior Manager (Rushden)	Production Manager	Logistics Manager	Operator - Disassembly	Operator – Assembly	Senior Manager (Other facility)
Are you aware of what pre-processing inspection happens at your facility?	A little knowledge	Full knowledge	Full knowledge	Some knowledge	No knowledge	Full knowledge
Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker?	Both quicker and easier	Neither	Both quicker and easier	Quicker	Don't know	Quicker
If pre-processing inspection was carried out on core, what information would be useful for your job?	Part number	Part number	Part number, missing or damaged components.	Part number	Missing or damaged components	Part number, missing or damaged components.

All of those who had an understanding of the pre-experimental inspection regime were of the opinion that the most important outcome of the activity was determining the actual part number of the core. The disassembly operator commented that core could be graded for quality and assigned for disassembly on that basis, making his job quicker. The production manager was of the opinion that as virtually all cores were disassembled and processed at some point, very little benefit accrued from any form of core inspection. He stated that inspection at disassembly was sufficient in his opinion. However both the logistics manager and the senior manager from another facility felt that understanding what components were broken or missing at an earlier stage would benefit their part of the overall process. The assembly operator also felt that early knowledge of missing or broken parts might prevent incomplete engine kits being delivered to him, slowing his job down.

7.6 Post-Experimental Interviews

The same managers and operatives working at the remanufacturing facility who were interviewed pre-experiment, as well as the senior manager from the other European Caterpillar Remanufacturing facility, were presented with an overview of the experimental findings. This included the tables in section 7 as well as the ANOVA tables for the overall remanufacture of each engine (presentation slides can be found in Appendix IV). They were then re-interviewed to gauge whether their attitude to pre-processing inspection had changed in light of the presentation. The interviews were all carried out face-to-face at the place of work of all of those questioned and the responses transcribed in full by the researcher.

Four questions were posed to each person:

1. Has seeing the experimental results changed your attitude to pre-processing inspection? Please explain your response.
2. Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
3. Did you notice any benefit to your job during the experimental phase? Please comment on how this was.
4. Do you believe that your facility should inspect core prior to processing? Please comment on why and to what level.

It can be seen that these questions are different from those originally asked. This is because the presentation described the experiments and findings in detail, consequently making the initial questions somewhat redundant. In addition, the purpose of the questions was to understand whether and how opinions had changed.

7.6.1 Responses

The responses to each question are summarised below. Full transcripts can be found in Appendix V.

Table 7.8 Responses to the Post-Experimental Questions

	Senior Manager (Rushden)	Production Manager	Logistics Manager	Operator - Disassembly	Operator – Assembly	Senior Manager (Other facility)
Has seeing the experimental results changed your attitude to pre-processing inspection?	Improved	Improved	Improved	Improved	No change	Improved
Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker?	Both quicker and easier	Both quicker and easier	Both quicker and easier	Quicker	Quicker	Both quicker and easier
Did you notice any benefit to your job during the experimental phase?	Some benefit	Large benefit	Large benefit	Some benefit	Some benefit	No benefit
Do you believe that your facility should inspect core prior to processing?	Three	Four	Four	Three	Three	Four

Virtually all respondents agreed that their opinion of pre-processing inspection had improved following the presentation of the experimental findings. The logistics manager was particularly impressed as he had noted an increase in performance from his team during the experimental period. He had evidence that material shortages had decreased despite overall stock also decreasing. He attributed this directly to the information collected which gave sufficient time to negate the effects of some of the component lead times from suppliers, thus reducing the need for additional stock to be maintained.

The production manager also agreed that parts shortages had been reduced during the experimental period. They both agreed that was for one of two reasons: more information earlier in the process or replacement/remanufactured parts available at the right time.

The two operators did not believe that the level of inspection made their job easier in any way but thought that it was quicker. The disassembly operative knew he had the correct part to disassemble and had to do less inspection and the assembly operative had all the parts he needed available. Those who did agree that their job was made easier attributed this to the level of information they had. The production manager, for example, stated that planning work through a section was made easier when he knew that a particular sub-assembly required work beyond the scope of the normal remanufacturing activity. He was able to easily make the required decisions concerning replacing with a new assembly, sub-contracting the work or batching easily remanufactured assemblies with the more difficult one.

The respondents to the last question were equally split between protocols 3 and 4. They all agreed that a greater level of inspection was beneficial but not to what level. The logistics and production managers were keen for as much information as possible and the senior manager from Europe was equally eager to implement similar protocols in his remanufacturing facility. The remaining respondents were cautious about extending the level of inspection, neither of the operatives could see a benefit to themselves and the senior manager from Rushden was concerned about adding too much resource to a core that might yet be scrapped.

There was general agreement that the most important factor was the quality and speed of the information generated by the inspection. The provision of this feedback loop to those buying parts, additional core and scheduling remanufacturing activities (both internally and via a sub-contract route) enabled speedier decisions and reactions to be made.

Tables 7.4 and 7.5 clearly show that although when questioned pre-experiment some people thought there might be a benefit, all were surprised at the actual benefits when re-questioned post interview. All respondents from the facility where the experiments took place saw a benefit that directly stemmed from the increase in pre-processing inspection. This demonstrates the non-obviousness of the research.

7.7 Summary

This chapter has presented the summarised experimental results together with the results from the audit process. It has also detailed the finding of the pre and post experimental questionnaires. The next chapter will analyse the experimental findings.

Chapter 8 Analysis of Findings

8.1 Introduction

This chapter comments upon the choice of analysis method, presents a summary of the analysis for each engine and remanufacturing activity.

The primary analysis was within-engine as this clearly demonstrated whether the treatment applied had any effect. This was followed by a cross-engine analysis was conducted to establish similarities between engine sub-assemblies and components to enable the specific characteristics that they had in common with each other that made the pre-processing inspection effective.

8.2 Method of Analysis

The experimental phase of the research resulted in a great deal of data requiring analysis. The data was all numeric and in a decimal format and consequently ideal for various forms of statistical analysis. The goal of the analysis was to understand, with appropriate confidence, whether increasing the content of the pre-processing inspection reduced the processing time during the remanufacturing activity.

The data was gathered from the independent variables – the four inspection protocols, and a large number of dependent variables – the processing times, all previously discussed in Chapter 7. The analysis needed to establish, for each engine type, whether there was a causal link between pre-inspection content and individual remanufacturing activity times. The similarities and differences between different engines also needed to be established.

The default analysis for measuring the effect of manipulation of variables is a t-test, developed in 1908 by chemist William Sealy Gosset. This test is used when it can be assumed that the population sizes are equal, two distributions have the same variance and the distribution can be assumed to be normal. The analysis establishes the likelihood of the rejection of the null hypothesis. It is particularly effective for simple tests with only two treatment groups. These experiments have four treatment groups (the inspection protocols) and consequently analysis using multiple t-tests would be required. This is possible but is extremely difficult and cumbersome and also inflates the risk of Type I error. A Type I error is essentially a false positive, where a causal link is established by chance. Where confidence is set at 95% there is a one in twenty possibility of a Type I error, multiple related t-tests increase this error (Barlow, 1989). This makes t-tests unsuitable for this research.

Experimental results can also be analysed using regression. However regression analysis is most useful when a correlational rather than a causal link is being explored (Bird, 2010), for instance, whether the amount of fire damage to a house is related to the number of firemen who attend the scene. This research is looking for causal links and so this form of analysis would not give the best results.

An extension of the t-test, suitable for considering multiple groups of test subjects is Analysis of Variation or ANOVA. It is an analysis of the variation in an experiment. It tests whether the differences noted in results is due only to natural variation or measurement error or whether it has been caused by the treatments administered in the experiments. ANOVA measures confidence in the likelihood that the effects noted are solely due to the treatment and not random error (Kempthorne, 1973). Cox (2006) notes that the use of ANOVA also limits the possibility of Type II errors; these errors are false negatives, leading to the possibility that a causal link is not discovered and thus limiting the increase of knowledge and scientific discovery.

Confidence that the null hypothesis is rejected (i.e. any variation is due to the treatment administered) equals:

$$\frac{\text{variation due to experimental treatment}}{\text{variation due to experimental error}}$$

This is called the f-ratio (after Fisher, see section 5.7.7) and is the significance of the ANOVA results. If the null hypothesis is confirmed then this the f-ratio equals 1, the level of confidence that it is rejected is expressed numerically, thus 95% confidence that the null hypothesis can be rejected would be a result of 0.05. Results with a numerical value lower than 0.05 show an even higher confidence that the findings are caused by the experimental treatments. This means that the probability that the variation in results is caused by factors other than the experimental treatment is less than 0.05.

ANOVA was chosen as the appropriate method to interpret the experimental data for three reasons: firstly there were four experimental groups; next, this form of analysis would quantify confidence in a causal link between the changes in activity times and the increasing levels of pre-processing inspection (the experimental treatments) and finally using ANOVA ensures that the probability of either Type I or Type II errors were minimised.

The ANOVA analysis was undertaken using the IBM SPSS (Statistical Product and Service Solutions). SPSS accepted the spreadsheet-based results and enabled graphs showing the spread and value of results for each component to be generated and computed the ANOVA confidence value for each set. All of outputs of these analyses can be found in Appendix VI.

8.3 Within-Engine Analysis

The initial analysis carried out was a within-engine analysis. This enabled any effect of each treatment on each similar sub-assembly or component to be clearly identified. The set of results for each engine was individually (engine-by-engine) plotted to understand both the spread and the mean for each protocol. In addition, the change in mean processing time from the control (inspection protocol 2) has been tabulated for every sub-assembly or component studied, each individual activity time for every protocol and engine plotted graphically to establish the spread and range of values, and ANOVA carried out. The summary tables of these analyses are included here together with a commentary. Full results are included in Appendix VI.

The figures below show the mean trend for each engine protocol by protocol. This analysis shows the effect due to the differing content of the pre-processing inspection protocols.

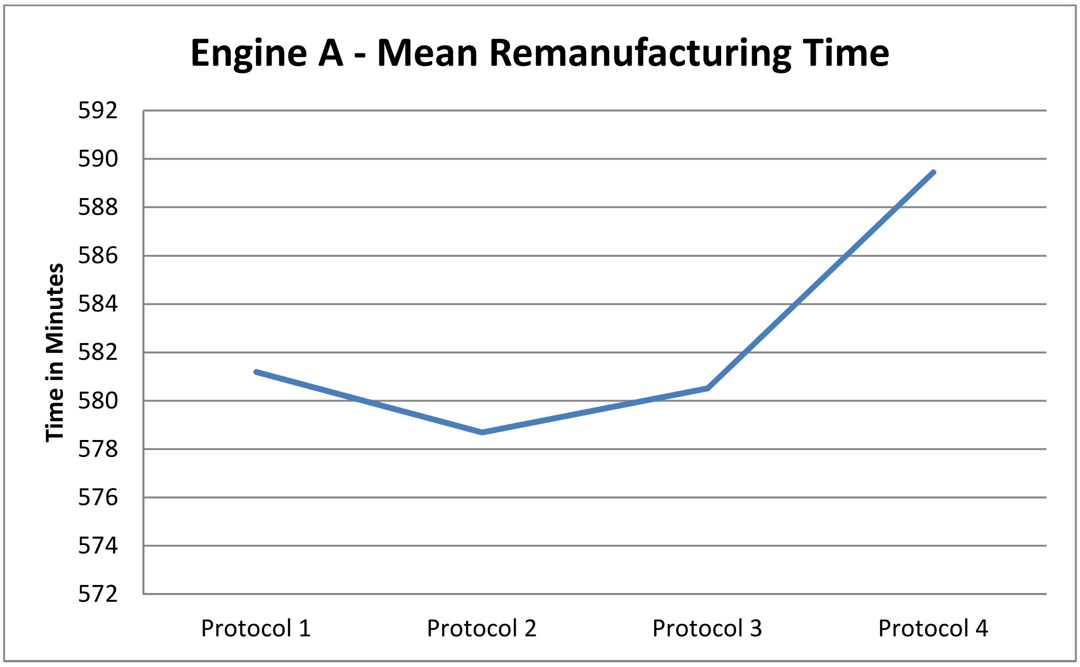


Figure 8.1 Engine A, Mean Remanufacturing Time - Effect of Differing Inspection Protocols

It can be seen that for engine A that whilst overall processing time increased when no inspection was completed, the effect of additional inspection content above the control, was greater than the benefits experienced.

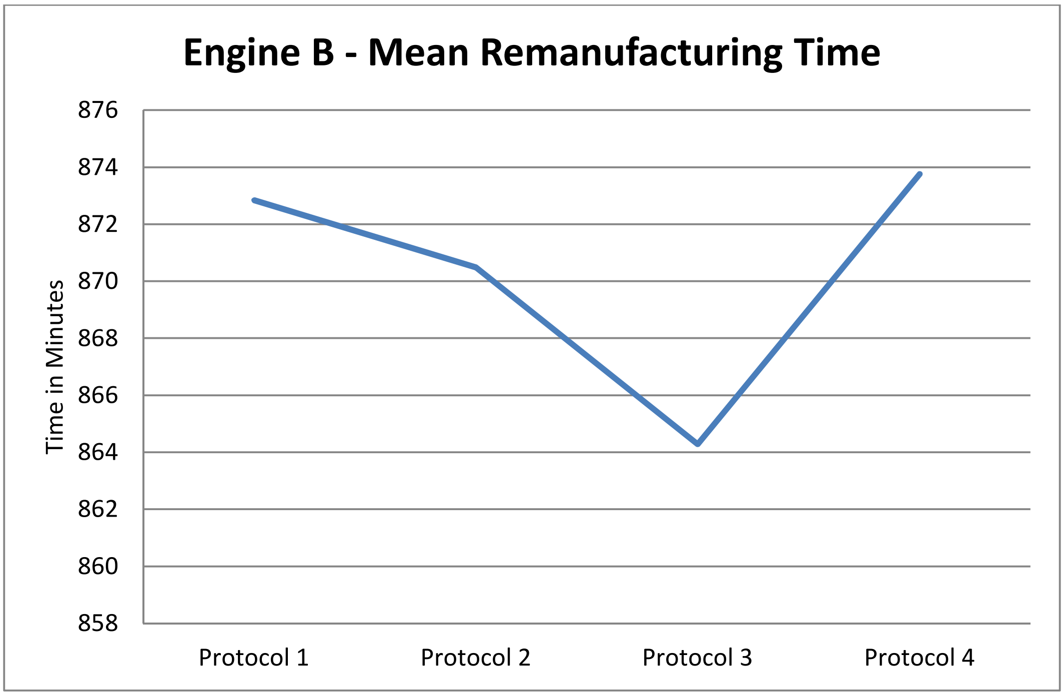


Figure 8.2 Engine B, Mean Remanufacturing Time - Effect of Differing Inspection Protocols

Engine B also experienced an increase in overall processing time when no inspection was carried out before processing, however unlike engine A, the overall time decreased again when inspection protocol 3 was implemented. However when the increased content of protocol 4 was used, the time taken to inspect was greater than any saved.

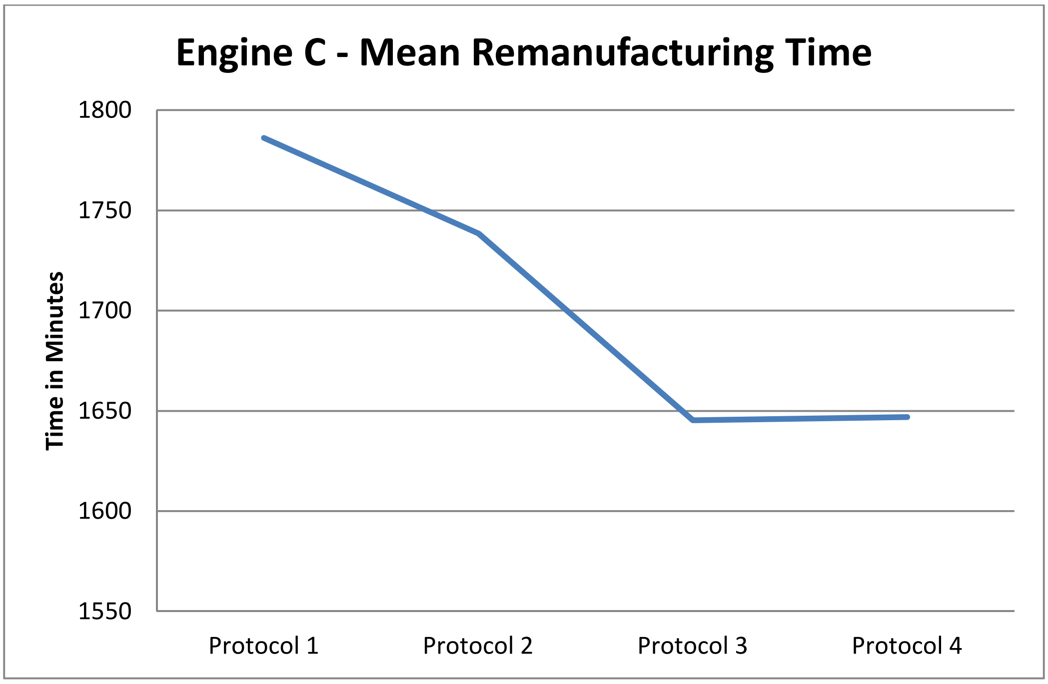


Figure 8.3 Engine C, Mean Remanufacturing Time - Effect of Differing Inspection Protocols

Engine C shows a similar but greater effect to that of engine B. This is because engine C has a greater number of complex components such as a starter motor and turbocharger, all of which saw the largest benefits from the increase in pre-processing inspection content. Once again though, inspecting to protocol 4 increased the overall time slightly indicating that any further information gathered by protocol 4 did not make a significant difference.

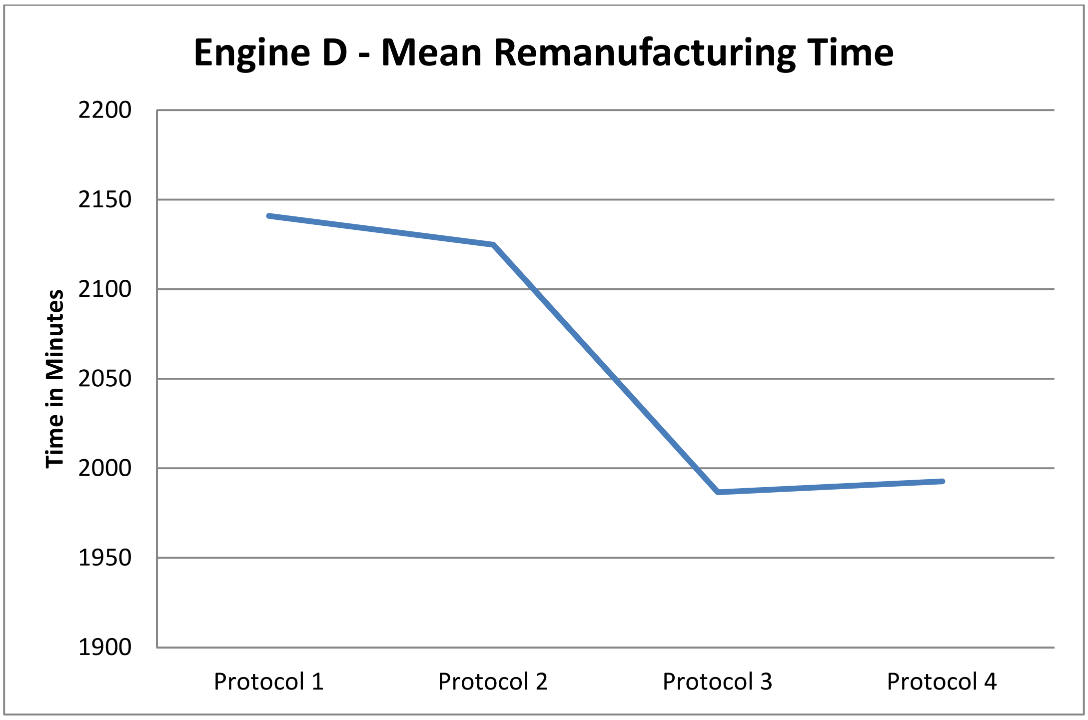


Figure 8.4 Engine D, Mean Remanufacturing Time - Effect of Differing Inspection Protocols

Engine D shows a similar but greater effect to that of engines B and C. This is because engine D also has complex components. Once again though, inspecting to protocol 4 increased the overall time slightly indicating that the benefits of any further information gathered by protocol 4 did not outweigh cost of the time taken to gather it. Engine D is a very large complex engine as are its component parts and the benefits of pre-processing inspection were more marked in this case.

8.3.1 ANOVA Significance

The individual results for each engine were analysed, activity by activity and the resulting ANOVA significance calculated. The table below gives a summary of these significance figures and indicates whether these results concur with previous findings as to the effect of the content of pre-processing inspection. The ANOVA significance, as previously discussed shows where the effect on the overall time is due to the treatment (the pre-processing inspection regime) these are marked “Yes” in the effect column. Activities marked “No” were unaffected by the change is pre-processing inspection. Individual results can be found between pages 357 and 434

Table 8.1 ANOVA Significance, All Engines

Activity	Significance							
	Engine A		Engine B		Engine C		Engine D	
	ANOVA	Effect	ANOVA	Effect	ANOVA	Effect	ANOVA	Effect
Decant and Inspect	0.000	Yes	0.000	Yes	0.000	Yes	0.000	Yes
Disassembly	0.000	Yes	0.000	Yes	0.000	Yes	0.000	Yes
Cylinder Block Remanufacture	0.008	Yes	0.000	Yes	0.000	Yes	0.000	Yes
Cylinder Head Remanufacture	0.008	Yes	0.000	Yes	0.000	Yes	0.000	Yes
Crankshaft Remanufacture	0.000	Yes	0.914	No	0.000	Yes	0.000	Yes
Camshaft Remanufacture	0.169	No	0.850	No	0.972	No	0.897	No
Valve Remanufacture	0.454	No	0.301	No	0.472	No	0.956	No
Connecting Rods	0.852	No	0.649	No	0.879	No	0.998	No
Rocker Shaft Remanufacture					0.996	No	0.958	No
Compressor Remanufacture							0.000	Yes
Oil Pump Remanufacture			0.656	No	0.995	No	0.997	No
Fuel Lift Pump Remanufacture					0.000	Yes	0.000	Yes
EGR Valve Remanufacture					0.000	Yes		
Vacuum Pump Remanufacture			0.500	No	0.509	No	0.997	No
Starter Motor Remanufacture					0.000	Yes		
Alternator Remanufacture					0.000	Yes		
Flywheel Remanufacture					0.000	Yes		
Turbocharger Remanufacture					0.000	Yes	0.000	Yes
Small Parts Remanufacture	0.943	No	0.000	Yes	0.000	Yes	0.000	Yes
Engine Kitting					0.000	Yes	0.000	Yes
Engine Assembly	0.007	No	0.406	No	0.061	No	0.215	No
Post-Production Test	0.355	No	0.421	No	0.114	No	0.803	No
Paint, Pack and Despatch	0.662	No	0.918	No	0.217	No	0.937	No
Overall Remanufacture	0.000	Yes	0.000	Yes	0.000	Yes	0.000	Yes

*Boxes coloured in grey denote engine components not fitted to the specific engine.

Table 8.1 shows that the ANOVA confirmed the findings of the initial analysis of the means. The individual results for the components and activities with an ANOVA significance of less than 0.05 show that there is a greater than 95% confidence that the benefits seen were due to the differing level of inspection. In fact, in all cases the confidence is greater than 99% (0.01).

The "Decant and Inspect" activity result can be effectively discounted because this was the independent variable and the time for this activity was deliberately lengthened by increasing the content of the pre-processing inspection. Consequently it is can be incontrovertibly stated that this variation was due to deliberate intervention.

8. 4 Across Engine Analysis

The individual activity processing times for the different engine types could not be directly compared even for the same operation. This is because the variation in the size and composition of each engine meant that the activity times were significantly different. However it was possible to consider each remanufacturing activity in turn and compare the significance of the differing protocols. Examination of the significance would enable general themes to be identified, for example whether the content of the pre-processing inspection affected the processing time for a particular activity.

The identification of a benefit noted in a particular remanufacturing activity across the majority of experimental subjects, meant, in the opinion of the author, that it was reasonable to assume that all similar components would experience a similar effect.

The results, described previously, were then collated by operation to understand whether the extent of pre-processing inspection produced similar effects in all the engines studied. These are presented in the table below.

Table 8.2 Comparison of Significance across Engines

Activity	Significant Effect				Effect replicated in similar components
	Engine A	Engine B	Engine C	Engine D	
Decant and Inspect	Yes	Yes	Yes	Yes	Yes
Disassembly	Yes	Yes	Yes	Yes	Yes
Cylinder Block Remanufacture	Yes	Yes	Yes	Yes	Yes
Cylinder Head Remanufacture	Yes	Yes	Yes	Yes	Yes
Crankshaft Remanufacture	Yes	No	Yes	Yes	Yes
Camshaft Remanufacture	No	No	No	No	No
Valve Remanufacture	No	No	No	No	No
Connecting Rods	No	No	No	No	No
Rocker Shaft Remanufacture			No	No	No
Compressor Remanufacture				Yes	Possibly
Oil Pump Remanufacture		No	No	No	No
Fuel Lift Pump Remanufacture			Yes	Yes	Yes
EGR Valve Remanufacture			Yes		Possibly
Vacuum Pump Remanufacture		No	No	No	No
Starter Motor Remanufacture			Yes		Possibly
Alternator Remanufacture			Yes		Possibly
Flywheel Remanufacture			Yes		Possibly
Turbocharger Remanufacture			Yes	Yes	Yes
Small Parts Remanufacture	No	Yes	Yes	Yes	Yes
Engine Kitting			Yes	Yes	Yes
Engine Assembly	No	No	No	No	No
Post-Production Test	No	No	No	No	No
Paint, Pack and Despatch	No	No	No	No	No
Overall Remanufacture	Yes	Yes	Yes	Yes	Yes

It can be seen that significant benefits from pre-processing inspection can be gained for the disassembly operation, cylinder block, cylinder head, crankshaft, fuel lift pump and turbocharger remanufacture for all engines where these components are fitted.

In addition, the evidence strongly suggests that the compressor, EGR valve, starter motor, alternator and flywheel remanufacturing activities can also benefit from the addition of further pre-processing inspection.

Each of the dependent variables is now considered in turn.

8.4.1 Decant and Inspect

The decant and inspect operation can be discounted from this analysis as each different protocol deliberately raised the content of the activity. A significant change was expected. The only sense in which this variable is important is when the additional processing time outweighed the benefits. This was the case for engine A.

8.4.2 Disassembly

The disassembly operation for all engines was shortened as the level of pre-processing inspection was increased. This was largely a result of the increased ability to schedule according to specific part number and core condition. This, in turn, enabled additional cores being disassembled for spare parts or to fulfil an order for which no core was available, to be allocated the appropriate additional resources without affecting scheduled disassembly. It also enabled cores to be batched according to condition, scheduling disassembly of those with the required components, for example apparently viable starter motors or a specific type of camshaft covers, to be disassembled ahead of other cores.

8.4.3 Cylinder Block

The cylinder block remanufacturing activity showed a significant reduction in overall processing time as the level of pre-processing inspection increased. This was primarily because information concerning any bore damage, the condition of the head gasket face, the oil and water passages and other similar faces was used to inform the scheduling activity and to ensure new parts or additional core were called up as required. A good understanding of the condition of the block enabled batching of components requiring similar recovery processes.

8.4.4 Cylinder Head

The cylinder head remanufacturing activity showed a significant reduction in overall processing time as the level of pre-processing inspection increased. This was primarily because information concerning any flame face damage, the condition of the valve ports, the oil and water passages and other similar faces was used to inform the scheduling activity and to ensure new parts or additional core were called up as required. A good understanding of the condition of the head enabled batching of components requiring similar recovery processes.

8.4.5 Crankshaft

The crankshaft remanufacturing activity showed a general benefit with the increase in pre-processing inspection content; however this was not the case for engine B. Close examination of all the results indicates a relatively small benefit in terms of actual time, less than one minute for engine A, just over one minute for engine C and almost 2 minutes for engine D. These times were statistically significant in terms of the overall processing times although they do not account for a particularly large material benefit. This is probably because a crankshaft is a simple component without much complexity in terms of the lack of internal surfaces and varying material content. The benefits that were noted were obtained from being able to schedule additional salvage operations for crankshaft showing signs of additional or excess wear.

8.4.6 Camshaft

The camshaft remanufacturing activity did not benefit significantly from increased levels of pre-processing inspection. This is because the camshaft is a simple component in terms of the lack of internal surfaces or varying material content.

8.4.7 Valves

The valve remanufacturing activity did not benefit significantly from increased levels of pre-processing inspection. This is because the valve is a simple component without internal surfaces or varying material content. It is also because the processing time is very short and there is little scope for improving the process.

8.4.8 Connecting Rods

The connecting rod remanufacturing activity did not benefit significantly from increased levels of pre-processing inspection. This is because the connecting rod is a simple component without internal surfaces or varying material content. It is also because the processing time is very short and there is little scope for improving the process.

8.4.9 Rocker Shafts

Engine C and D were the only two of the experimental subjects that included a rocker shaft in their sub-components. Nevertheless, it is still possible to draw some conclusions for the collected data as the results across each core of engines C and D were so consistent.

The rocker shaft remanufacturing activity did not benefit significantly from increased levels of pre-processing inspection. This is because the rocker shaft comprises simple sub-components without many internal surfaces or varying material content. It is also because the processing time is very short and there is little scope for improving the process.

8.4.10 Compressor

The only engine including a compressor was engine D and consequently generic conclusions are difficult to make. Nevertheless, it can be stated that each compressor studied in this research showed a significant decrease in processing time as the level of pre-processing inspection increased.

This was primarily because information concerning any damage or conditions requiring any less usual salvage operations was used to inform the scheduling activity and to ensure new parts or additional core were called up as required. A good understanding of the condition of the compressor cores enabled batching of components requiring similar recovery processes.

8.4.11 Oil Pump

Engine A was the only engine supplied without an oil pump and so the collected data may be used to draw general conclusions.

The oil pump remanufacturing activity did not benefit significantly from increased levels of pre-processing inspection. This is because the oil pump is essentially a simple assembly. The internal surfaces were easily accessible and there is little variation in material content. It is also because the processing time is very short and there is little scope for improving the process.

8.4.12 Fuel Lift Pump

Engine C and D were the only two of the experimental subjects that included a fuel lift pump as one of their sub-components. Nevertheless, it is still possible to draw some conclusions for the collected data as the engines were substantially different, a large number were studied and the results across each core of engines C and D were so consistent.

Close examination of all the results indicates a relatively small benefit in terms of actual time, less than half of one minute for engine C and less than one minute for engine D. These times were statistically significant in terms of the overall very short processing times although they do not account for a particularly large material benefit. This is probably because a fuel lift pump is a simple assembly without much complexity with an easily accessible interior. The main activities for remanufacturing these is to clean, inspect and test for both operation and timing. The latter activity uses a bespoke test rig and so the entire activity time is minimal. The benefits that were noted were obtained from being able to schedule replacement parts for those showing signs of excess wear.

8.4.13 Exhaust Gas Recirculation (EGR) Valve

The only engine including an EGR valve was engine C and consequently generic conclusions are difficult to make. It can be stated that each EGR valve studied in this research showed a significant decrease in processing time as the level of pre-processing inspection increased.

This was primarily because information concerning any damage or excess wear was used to inform the scheduling activity and ensure new parts or additional core were called up as required.

8.4.14 Vacuum Pump

Engine A was the only engine supplied without a vacuum pump and so the collected data may be used to draw general conclusions.

The vacuum pump remanufacturing activity did not benefit significantly from increased levels of pre-processing inspection. This is because the vacuum pump is essentially a simple assembly. The internal surfaces were easily accessible and there is little variation in material content. It is also because the processing time is very short and there is little scope for improving the process.

8.4.15 Starter Motor

The only engine including a starter motor was engine C and consequently generic conclusions are difficult to make. It can be stated that each starter motor studied in this research showed a significant decrease in processing time as the level of pre-processing inspection increased.

Starter motors are very complex in terms of the number and nature of their sub-components and there were two main reasons why the activity processing time reduced, firstly because information concerning any damage or excess wear was used to inform the scheduling activity and ensure new parts or additional core were called up as required and secondly salvage operations beyond those usually required, for example, adding metal to the shaft to restore the finish could be either scheduled in advance or components grouped to minimise set-up times and make best use of machinery.

8.4.16 Alternator

The only engine including an alternator was engine C and consequently generic conclusions are difficult to make. It can be stated that each alternator studied in this research showed a significant decrease in processing time as the level of pre-processing inspection increased.

Alternators are fairly complex in terms of the number and nature of their sub-components and there were two main reasons why the activity processing time reduced, firstly because information concerning any damage or excess wear was used to inform the scheduling activity and ensure new parts or additional core were called up as required and secondly salvage operations beyond those usually required, for example skimming metal from the rotor to restore the finish, could be either scheduled in advance or components grouped to minimise set-up times and make best use of machinery.

8.4.17 Flywheel

Engine C was the only one of the experimental subjects that included a flywheel as one of its sub-components. Nevertheless, it is still possible to draw some conclusions for the collected data the results across each core of engine C were so consistent.

Close examination of all the results indicates a relatively small benefit in terms of actual time, less than one minute for engine C. These times were statistically significant in terms of the overall very short processing times although they do not account for a particularly large material benefit. This is probably because a flywheel is a simple assembly without much complexity. The main activities for remanufacturing these is to clean, inspect and repair threads. Balance for operation and timing occurs at post-production test and is included in the test time. The benefits that were noted were obtained from being able schedule replacement parts for those showing signs of excess wear.

8.4.18 Turbocharger

Engine C and D were the only two of the experimental subjects that included a turbocharger as one of their sub-components. Nevertheless, it is still possible to draw some conclusions for the collected data as the engines were substantially different, a large number were studied and the results across each core of engines C and D were so consistent.

Turbochargers are fairly complex in terms of the number and nature of their sub-components and there were two main reasons why the activity processing time reduced, firstly because information concerning any damage or excess wear was used to inform the scheduling activity and ensure new parts or additional core were called up as required and secondly salvage operations beyond those usually required, for example repairing turbocharger wheels, could be either scheduled in advance or components grouped to minimise set-up times and make best use of machinery.

8.4.19 Small Parts Kit

The activity to remanufacture the small parts kits (comprising brackets, bolts, nuts, studs, plates etc.) showed a significant reduction in overall processing time as the level of pre-processing inspection increased for all engines except for Engine A.

This was primarily because information concerning damaged and/or missing parts was used to inform the scheduling activity and to ensure new parts or additional core were called up as required.

Engine A did not show a similar benefit because this engine is very simple and the small parts kit is made up of very few items all of which are easily seen and consequently this lack of complexity demonstrated very little benefit from additional inspection.

8.4.20 Engine Kitting

Engine C and D were the only two of the experimental subjects where the engine parts were brought together in a complete kit prior to assembly. Engines A and B were not fully kitted before assembly. This was for two reasons: firstly both of these engines were sold as short engines (block, crankshaft, connecting rods, pistons, sump and top cover), cylinder head assemblies and other small components and secondly the volumes were high enough to warrant a team of people feeding the requisite parts to the assemblers at the appropriate point. It is worth noting that some remanufacturers provide complete kits for every assembly they produce whether simple or complex although others do not.

It is possible to draw conclusions for the collected data as the engines were substantially different, a large number were studied and the results across each core of engines C and D were so consistent.

The benefits of the pre-processing inspection to the engine kitting process are essentially the culmination of the benefits to the previous remanufacturing activities for the engine sub-assemblies and components. The ability to schedule required new parts or additional remanufactured parts earlier in the process and the increased velocity for other remanufactured parts through the process enabled the smoother, quicker formation of the required engine kits.

8.4.21 Assembly

The time for the assembly activity was not affected by the amount or content of the pre-processing inspection. This was expected because all parts reaching assembly should have already been returned to as-good-as-new condition.

8.4.22 Test

The activity time for the post-production test was not affected by the amount or content of the pre-processing inspection. This was expected because the assembled engines should all have reached the required standard prior to reaching test.

8.4.23 Paint, Pack and Despatch

The processing time for the paint, pack and despatch activity was not affected by the amount or content of the pre-processing inspection. This was expected because the assembled engines should all have reached the required standard once test has been completed.

8.4.24 Overall Remanufacturing Process

The overall remanufacturing process times were inevitably altered in all cases because some of the individual sub-assembly and component remanufacturing activity times were affected and each overall time is an amalgam of these individual times.

8.5 In-Process Scrap

The in-process scrap rates showed a similar pattern for each of the engines. The introduction of the additional pre-processing inspection increased the rate of scrap at the disassembly stage but decreased the rate at the machining stage. The later stages remained largely unchanged. None of the overall scrap rates altered noticeably but the point at which components were scrapped did shift somewhat to earlier in the process. This is a good important to remanufacturers as the sooner a damaged or worn component is scrapped the less cost, in terms of work, is added to it.

8.6 General Characteristics of Components Benefitting from Increased Pre-Processing Inspection

One of the aims of this research was to identify the characteristics of components that experienced a reduction in activity time arising from increased pre-processing inspection.

The majority of the components showing this benefit had one or more of the three following traits:

- Complex geometry including internal ports;
- Large number of sub-components; or
- Constructed from or comprising of multiple materials.

Nevertheless there are components showing a statistically significant benefit in activity time reduction that do not fall into any of these categories, These are the crankshaft, the fuel lift pump and the flywheel. These three components have very short activity times in common and, although the activity times were shortened during the experiment, in real terms, the actual time reduction was less than a minute in most instances.

It can then be said that whilst the majority of the benefits of increased pre-processing inspection are seen in complex components, smaller benefits can accrue, largely from the increased accuracy of scheduling activities, in more simple components.

8.7 Attitudes to Pre-Processing Inspection

The interviews reported in Chapter 7 are evidence that by demonstrating the material benefits in terms of decreased remanufacturing activity time and scheduling benefits of the information gained the attitudes of the remanufacturing practitioners towards pre-processing inspection were improved, thus indicating the novelty and non-obviousness of the research.

8.8 Summary

This chapter has discussed the experimental results. It has explained the analysis method used for both the within-engine and across-engine analysis and has concluded that components that either have complex geometry, a large number of constituent parts or are made from multiple materials, experience the greatest reduction in remanufacturing activity time. The next chapter introduces the decision-making methodology based on these findings.

Chapter 9 Decision-Making Methodology

9.1 Introduction

This chapter describes the tool developed from the experimental findings to make them useful to remanufacturers. It introduces the overall concept, as developed for the Caterpillar Remanufacturing facility in Rushden as an example and breaks down each typical component of the whole to a generic form to facilitate replication for other assemblies or remanufacturing facilities.

9.2 Developed Process Model at Rushden

Understanding the factors that affected the amount of pre-processing inspection that produced a benefit to the overall remanufacturing process enabled decisions to be made about what level of inspection was appropriate for which component or assembly within the engine core. This led to the process model illustrated in Figure 9.1 below. Information flows are noted in red, material flows in blue for ease of understanding.

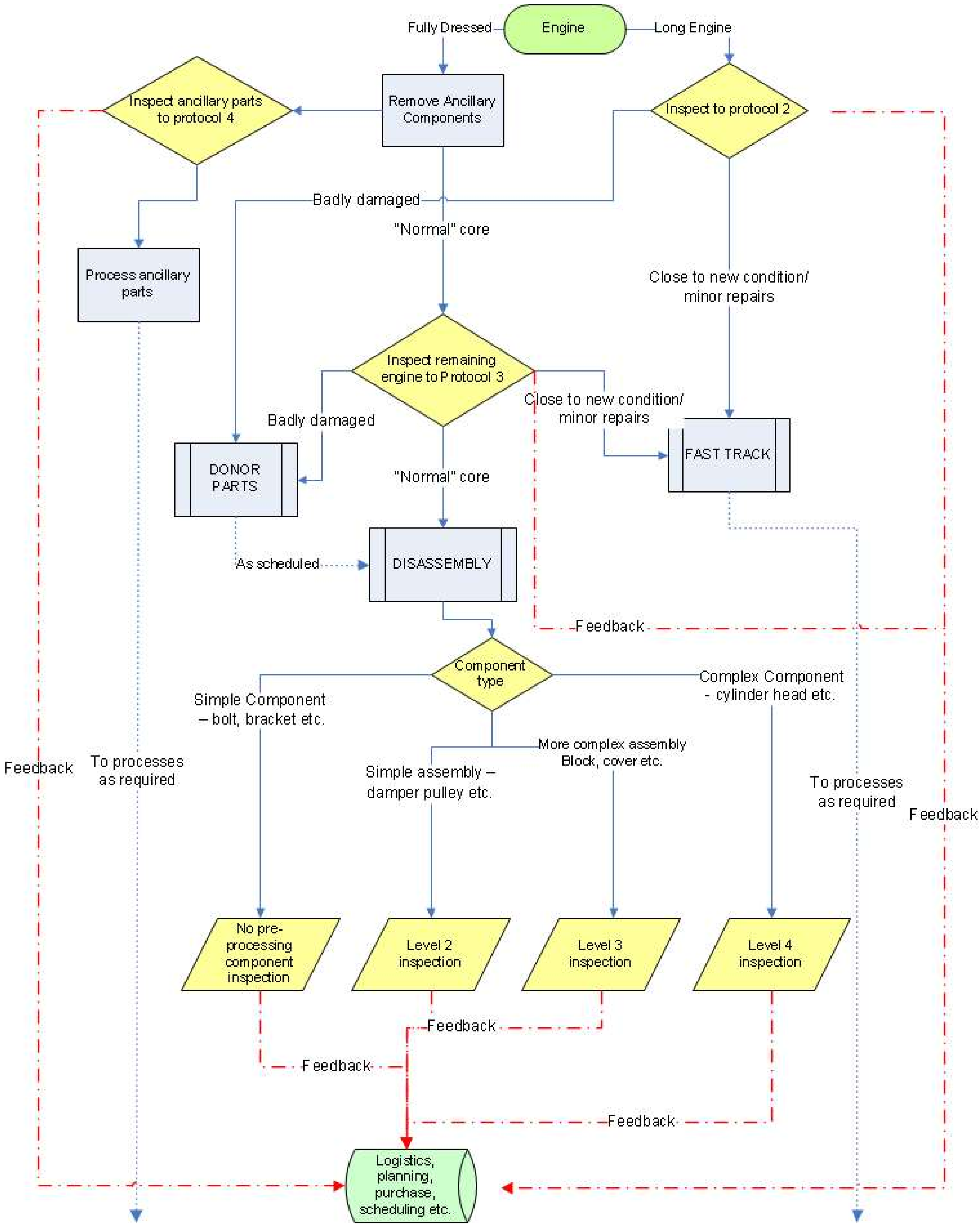


Figure 9.1 Overall Decision Making Process at the Rushden Remanufacturing Facility

This diagram was used to route all cores towards the appropriate inspection level. Ancillary items were routinely removed and separated for inspection upon receipt at the remanufacturing facility. Any resulting openings were plugged against the ingress of water or other contaminants. This also enabled the ancillary components to be better protected prior to remanufacture, helping to reduce the activity time as less cleaning and other decontamination work was necessary.

The most important aspect was the feedback loop. This is because it does not matter how much pre-processing inspection is undertaken if nothing is done with the information collected Here, the information gathered during the inspection process was sent to the Scheduling Manager, the Logistics Manager and the Production Manager. This enabled informed decisions to be made to minimise delays, shortages and to maintain flow throughout the factory.

9.3 Simple Components

The experimental results demonstrated that the effects of pre-processing inspection were minimal for simple components. Consequently a detailed inspection regime would be inappropriate. Nevertheless the feedback loop remains the most important ensuring that the information collected is sent to where it can be used properly.

It should be noted, both in this section and the ones following, that the actual content of the inspection depends on the remanufactured product involved and the technology appropriate to the process. For example, engine C only had a starter motor fitted and so was inspected for burnt-out components, whereas engine D did not but had a compressor which no other engine had and the inspection here was different again. Information flows are noted in red, material flows in blue for ease of understanding.

The process for simple components is illustrated in Figure 9.2 below.

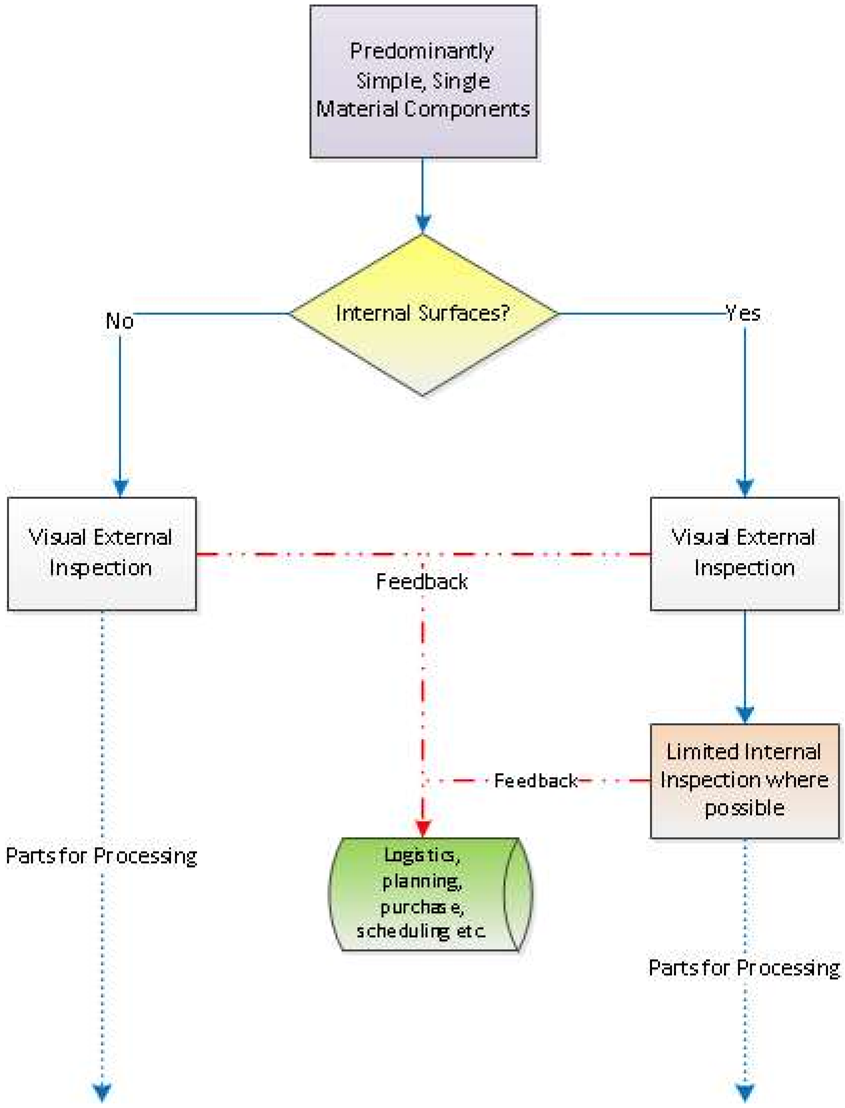


Figure 9.2 Single Material, Simple Components

9.4 Multiple Material Components

The benefits of pre-processing inspection are seen, in the experimental findings, to increase as the complexity of the component increases and consequently a more complex component may benefit from some incremental additional inspection above that of simple components. This is illustrated in figure 9.3 below. Information flows are noted in red, material flows in blue for ease of understanding.

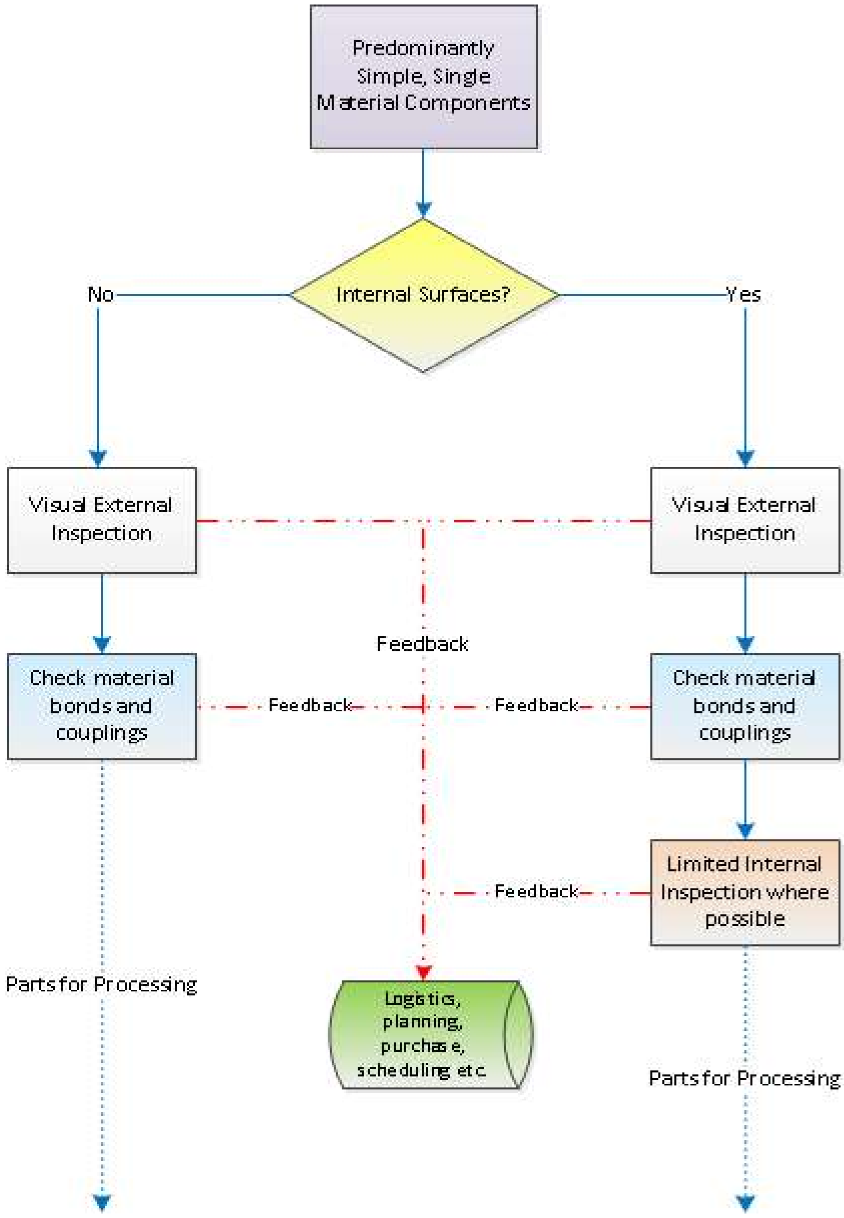


Figure 9.3 Multiple Material Components

9.5 Simple Assemblies

The experimental results show that simple assemblies also benefit from increased pre-processing inspection. The figure below demonstrates the decision-making process for these types of components.

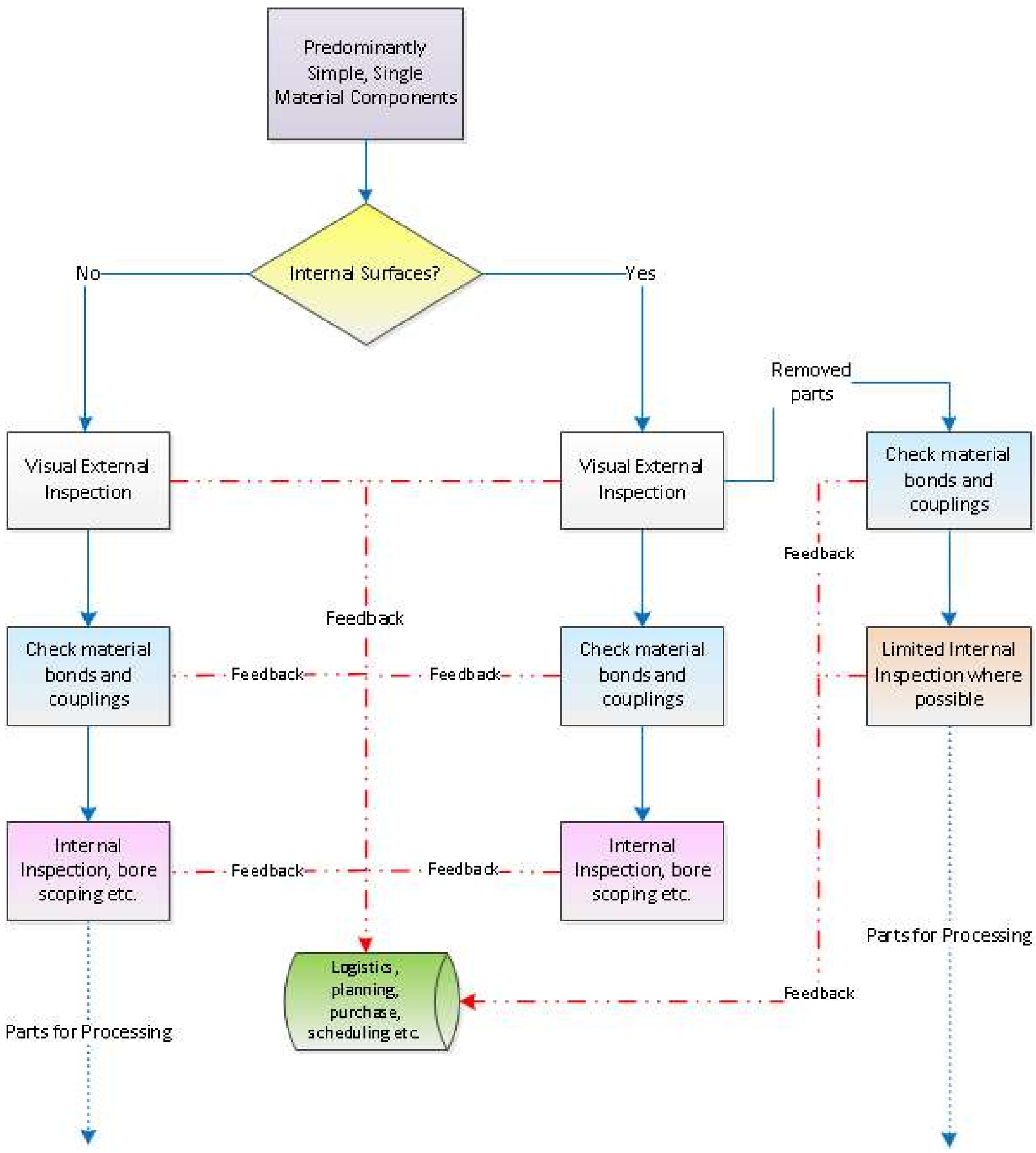


Figure 9.4 Simple Assemblies

The process, in this case is a little more complex than previous examples, nevertheless the same principles apply and inspection is only considered where a benefit can be demonstrated.

The feedback loop is the critical factor as without this, collecting the information would be a worthless activity.

9.6 Complex Assemblies

Complex assemblies benefit from increased levels of pre-processing inspection. This is confirmed by the research findings. Consequently increasing the level of inspection is appropriate but must still only be undertaken when the benefit is demonstrable.

Figure 9.5 below shows the decision-making process for the level of type of component in the assembly. Information flows are noted in red, material flows in blue for ease of understanding.

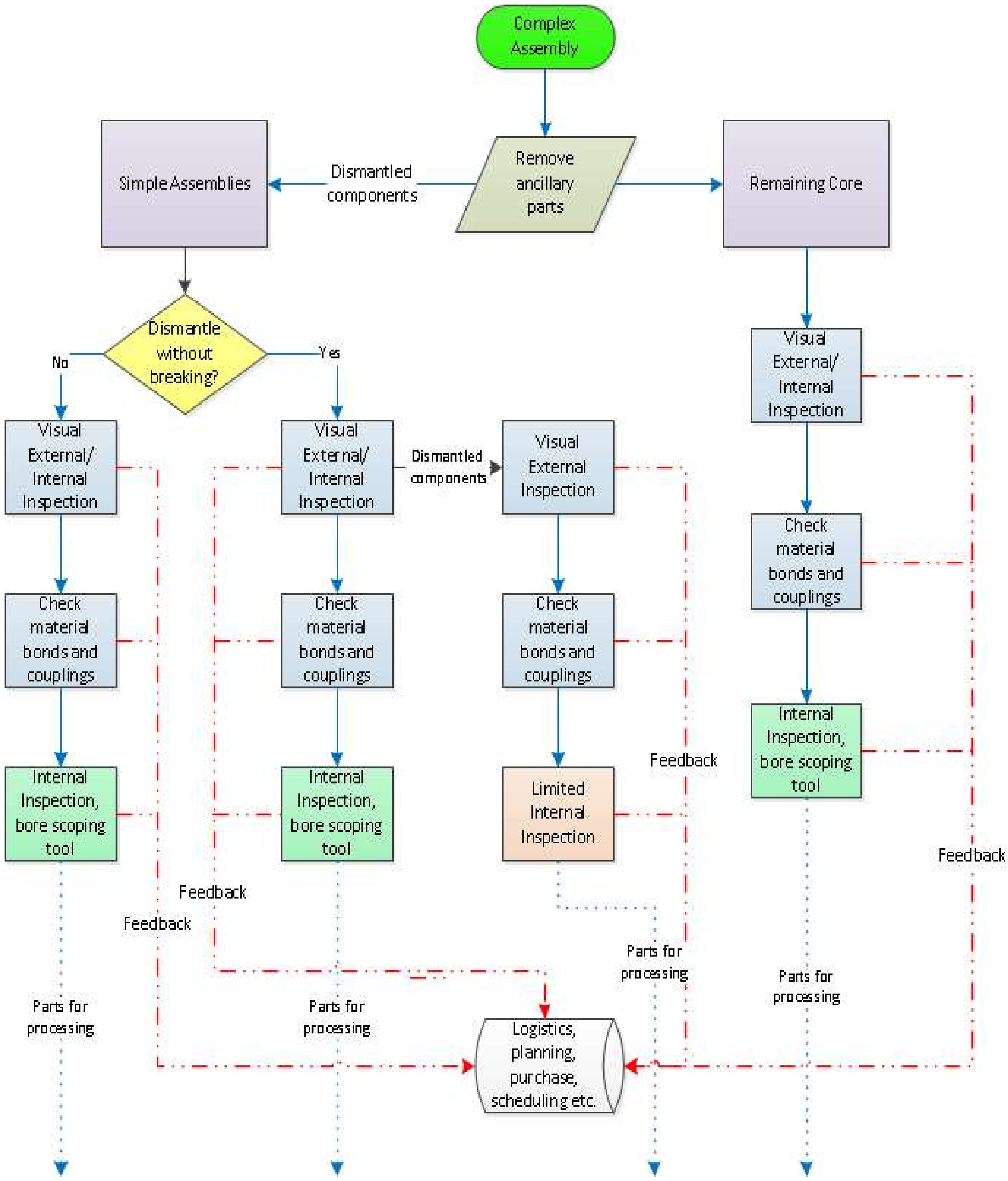


Figure 9.5 Complex Assemblies

9.7 Use of the Methodology

The diagrams above illustrate the decision-making methodology. It is possible therefore to use this with a bill of materials and construct a process map for pre-processing inspection based on them. This is explained in the sections below.

9.7.1 Consideration of the Bill of Materials

A typical, slightly simplified, automotive cylinder head bill of materials is illustrated in Figure 9.6. It has been annotated to show which components will be remanufactured and which will be replaced with new 100% of the time. Specific part numbers have been removed to preserve customer confidentiality.

Table 9.1 Annotated Bill of Materials

LEVEL	DESCRIPTION	QTY PER	REMAN	REPLACE
PARENT	REMAN CYLINDER HEAD ASSY	1	N/A	N/A
1	CYLINDER HEAD ASSY	1	N/A	N/A
2	SPRING - VALVE	16	YES	
2	SEAL VALVE STEM INTAKE	8		YES
2	SEAL VALVE STEM EXHAUST	8		YES
2	RETAINER - VALVE SPRING	16	YES	
2	BOLT & WASHER M7	12	YES	
2	BOLT & STUD WASHER ASSY	4	YES	
2	PLUG - MAIN OIL GALLERY	1	YES	
2	BOLT & WASHER M7	4	YES	
2	CYL HEAD CORE PLUG	2	YES	
2	VALVE - EXHAUST - 3 GROOVE	8		YES
2	VALVE - INTAKE - 3 GROOVE	8	YES	
2	COLLET -VALVE - 3 GROOVE	32		YES
2	CYLINDER HEAD MACHINED CASTING	1	YES	

The bill of materials can then be manipulated to decide what type of components make the whole, in terms of the categories of the decision-making diagrams.

9.7.2 Manipulated Bill of Materials

The components that are always new are removed from the bill of materials and then a category assigned to each of the remaining components. This is shown in Table 9.2.

Table 9.2 Manipulated Bill of Materials

LEVEL	DESCRIPTION	QTY PER	REMAN	CATEGORY
2	SPRING - VALVE	16	YES	Simple Component
2	RETAINER - VALVE SPRING	16	YES	Simple Component
2	BOLT & WASHER M7	12	YES	Simple Component
2	BOLT & STUD WASHER ASSY	4	YES	Simple Component
2	PLUG - MAIN OIL GALLERY	1	YES	Simple Component
2	BOLT & WASHER M7	4	YES	Simple Component
2	CYL HEAD CORE PLUG	2	YES	Simple Component
2	VALVE - INTAKE - 3 GROOVE	8	YES	Simple Component
2	CYLINDER HEAD MACHINED CASTING	1	YES	Multiple Material

This then allows the overall diagram to be constructed as in Figure 9.8

It shows the route for inspection for each of the components of the cylinder head. This is a reasonably simple example but demonstrates the ease of use of the methodology. Information flows are noted in red, material flows in blue for ease of understanding.

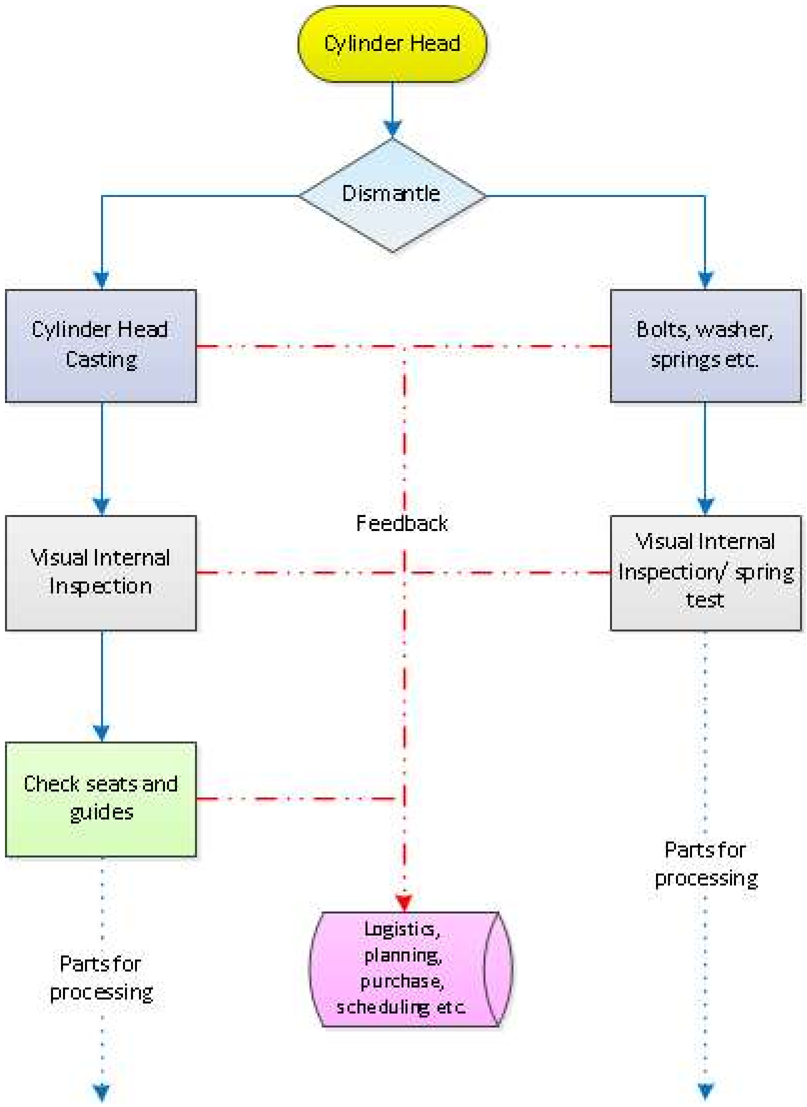


Figure 9.6 Completed Inspection Diagram for the Cylinder Head

The next example is more complex.

9.8 Complete Engine

The example below is a simplified complete engine. The bill of materials has been considerably shortened, removing small components, sub-assemblies and peripherals such as transit frames and engine mountings for this example. An excerpt is shown in Table 9.3.

Table 9.3 Excerpt from Bill of Materials – Complete Engine

LEVEL	DESCRIPTION	QTY PER	REMAN	REPLACE
PARENT	ENGINE		N/A	N/A
1	COMPLETE ENGINE	1	N/A	N/A
2	ENGINE MANAGEMENT FILE	1	N/A	N/A
2	CORE UNIT	1	YES	
2	KEY	1	YES	
2	JET	6	YES	
2	SCREW	6	YES	
2	SCREW	3	YES	
2	O RING	1		YES
2	O RING	1		YES
2	SEAL	1		YES
2	SEAL	12		YES
2	SEAL	12		YES
2	PLUG	1	YES	
2	CIRCLIP	12		YES
2	BEARING	6		YES
2	BEARING	6		YES
2	BEARING	7		YES
2	BEARING	7		YES
2	WASHER	2	YES	
2	GEAR	1	YES	
2	CRANKSHAFT	1	YES	
2	VALVE	12	YES	
2	TAPPET	12	YES	

This bill of materials, stripped down to remove the very simple components (nuts, bolts etc.) and very much reduced for this illustration, is then assigned categories as before. This can be seen in Table 9.4

Table 9.4 Bill of Materials with Categories Assigned

LEVEL	DESCRIPTION	QTY PER	REMAN	CATEGORY
2	KEY	1	YES	Simple Component
2	JET	6	YES	Simple Component
2	SCREW	6	YES	Simple Component
2	SCREW	3	YES	Simple Component
2	PLUG	1	YES	Simple Component
2	WASHER	2	YES	Simple Component
2	GEAR	1	YES	Simple Component
2	CRANKSHAFT	1	YES	Complex Component
2	VALVE	12	YES	Simple Component
2	TAPPET	12	YES	Simple Component
2	PUSH ROD	12	YES	Simple Assembly
2	CONN ROD	6	YES	Simple Component
2	CAMSHAFT	1	YES	Simple Component
2	ROCKER SHAFT	1	YES	Simple Assembly
2	CYLINDER BLOCK	1	YES	Multiple Material
2	CYLINDER HEAD	1	YES	Multiple Material
2	FUEL PUMP	1	YES	Simple Assembly
2	SEAL AND HOUSING	1	YES	Simple Assembly
2	FLYWHEEL	1	YES	Simple Component
2	STARTER MOTOR	1	YES	Complex Assembly
2	FRONT COVER	1	YES	Multiple Material
2	COOLANT PUMP	1	YES	Complex Assembly
2	WATER PUMP	1	YES	Complex Assembly
2	POWER STEER PUMP	1	YES	Simple Assembly
2	TURBOCHARGER	1	YES	Complex Assembly
2	INTAKE MANIFOLD	1	YES	Complex Component
2	COMPRESSOR	1	YES	Complex Assembly

The resultant diagram showing the level of inspection appropriate to each part of the assembly can then be constructed. This is shown in Figure 9.11 below. Information flows are noted in red, material flows in blue for ease of understanding.

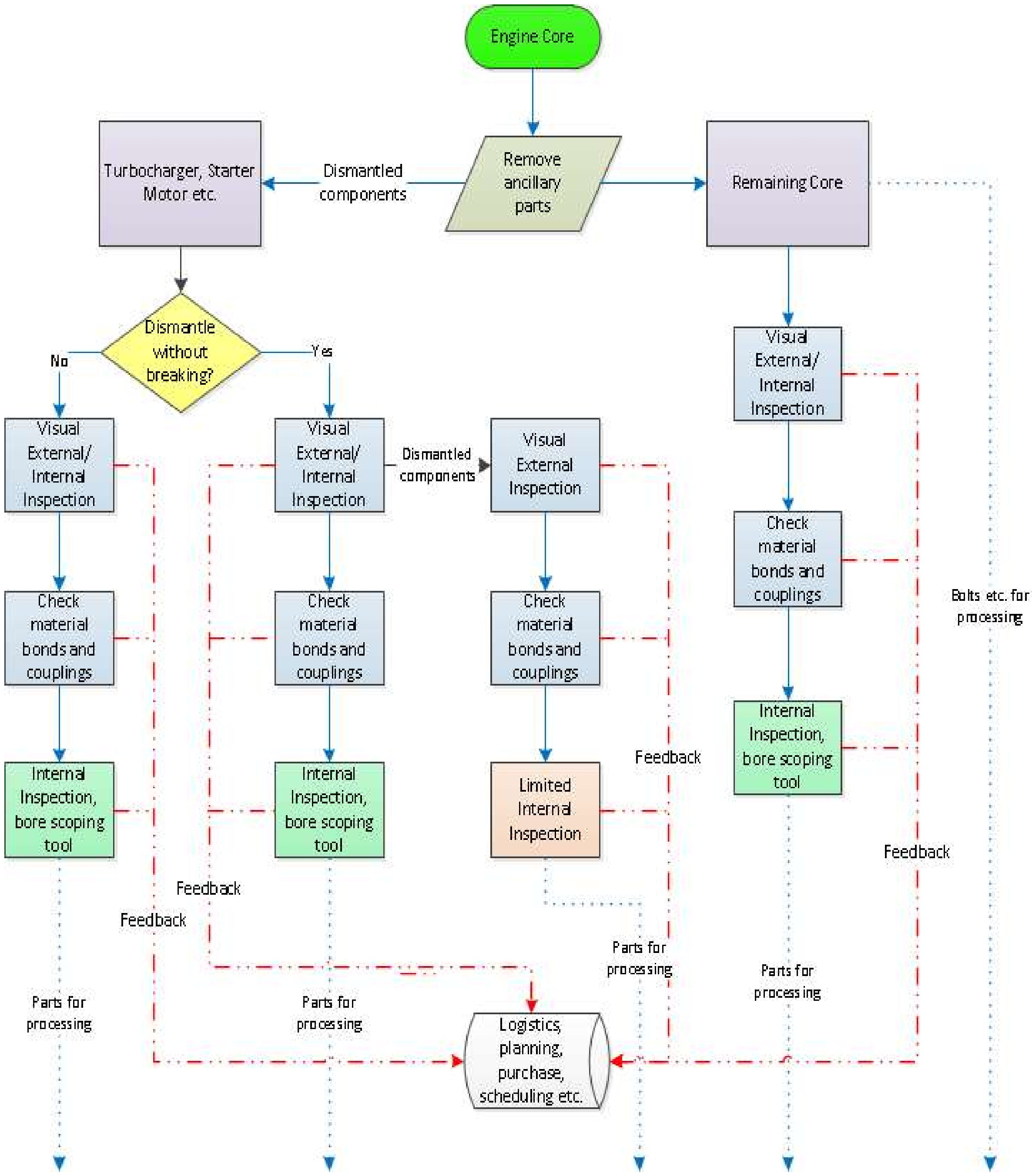


Figure 9.7 Completed Inspection Diagram for the Simplified Engine

9.9 Summary

This chapter has presented the methodology that makes the research findings useful to industry. It has displayed the inspection diagram developed for the Rushden facility as an example. The method of construction has been demonstrated via examples both simple and more complex.

Chapter 10 Cost Assessment Methodology

10.1 Introduction

This chapter presents the cost assessment methodology developed from the experimental findings. It offers a more accurate method of determining remanufacturing costs than the ones currently used. The model proposed and validated in this research is an extension of the commonly used industrial method that does not directly extend existing theoretical research. Its novelty is that rather than consider the remanufacturing process in its entirety, it breaks the process into individual activities and takes understands the individual costs associated with each one. The method can be easily applied by practitioners using information they already hold and routinely collect.

10.2 Cost Assessment Methodology

Traditionally remanufacturers aim to price their products at round two-thirds of the equivalent new price. As a consequence there is a need to minimise their costs to achieve this. Various researchers (Ferrer, 2001, Aras *et al*., 2004, Liang *et al*., 2007, Ferguson *et al*., 2009 etc.) have offered models for pricing remanufactured products which include assessing costs, many of them trying to address the uncertainty surrounding the availability and quality of cores. The researcher's employment and experience in the remanufacturing sector has led to the conclusion that these models are seldom understood or in widespread use in practice.

It became clear, as the research progressed, that the understanding of the remanufacturing activities gained during the experimental phase also influenced the costs to the remanufacturer and consequently the impact of this was also considered.

Remanufacturers, particularly independent and contract ones, usually estimate their costs using a combination of a cost per minute for the amount of work required and the time the remanufacture will take plus the cost of new parts. The cost per minute usually includes an averaged labour cost and an allowance for overheads such as rent, energy etc. whilst the cost of new parts often includes any additional cores that might be required. The amount of new parts and additional cores is usually based upon experience and, although it might be reviewed once the product is in production, is a "best guess". These factors taken together allow an expected cost per product to be calculated and this forms the basis of pricing decisions.

The experimental period highlighted the variation in the activities and skill levels present in the remanufacturing process. The variation in skill level was reflected in the labour rates paid at the Rushden facility but only an aggregated cost was used. In addition, no allowance was made for a licenced technology that was in use for one specific remanufacturing activity and consequently the cost method was not reflective of the actuality. The point at which material was scrapped, and consequently the cost of work to that point, as well as the injection of new material or additional cores needs to also be considered.

Consideration of the remanufacturing operation in such detail enabled several factors to be identified that directly affect remanufacturing costs. They are:

- The time taken for the remanufacturing activities;
- The various labour rates applicable to the activities;
- The various scrap rates and points of scrap applicable to the activities;
- Any licenced technologies used in the remanufacturing activities;
- An amount per period of time for overhead costs; and
- The cost of new parts (including additional cores).

It is necessary to allocate notation to these factors:

- Time (in minutes) = t;
- Labour rates (in GBP per minute) = $r_1, r_2, r_3 \ldots r_n$;
- Scrap rates = $s_1, s_2, s_3 \ldots s_n$;
- Licenced technology = l;
- Overheads (in GBP per minute) = o; and
- Cost of new materials = m.

The equation that describes the current cost assessment can then be written:

$$\text{Cost} = m + (t \text{ x } (r + o))$$

However, in order that all factors are considered, it is necessary to allocate the overall time to each of the differing labour rates and so:

$$t = t_1 + t_2 + t_3 \ldots + t_n$$

Consequently the original equation can be re-written as:

$$\text{Cost} = m + ((t_1 + t_2 + t_3 \ldots + t_n) \text{ x } (r + o))$$

Or

$$\text{Cost} = m + ((t_1 \; x \; (r+o)) + (t_2 \; x \; (r+o)) + (t_3 \; x \; (r+o)) \ldots + (t_n \; x \; (r+o)))$$

Adding in the varying labour rates:

$$\text{Cost} = m + ((t_1 \; x \; (r_1+o)) + (t_2 \; x \; (r_2+o)) + (t_3 \; x \; (r_3+o)) \ldots + (t_n \; x \; (r_n+o)))$$

Where a component is scrapped, the full cost of the remanufacturing activity will not apply to the entirety. Consequently the cost of the scrap will need to be removed from the equation. For the sake of clarity, scrap has been shown at each point where the labour rate changes. This may not be the case in reality and the sum can be adjusted to suit specific conditions.

$$\text{Cost} = m + (((t_1 \; x \; (1-s_1) \text{ x } (r_1+o)) + ((t_2 \; x \; (1-s_2) \text{ x } (r_2+o)) + ((t_3 \; x \; (1-s_3) \; (r_3+o)) \ldots + ((t_n \; x \; (1-s_n) \; (r_n+o)))$$

The final factor that needs to be considered is any licenced technology in use for a part of the remanufacturing activity. This can be added as a lump sum or as a percentage of the overall cost applicable to the time involved. The latter, more complicated, assumption has been made here as this was used in Rushden. The licenced technology is assumed, in the case of this example, to be at the point of t_2. The equation can then be finally written as:

$$\text{Cost} = m + (((t_1 \, x \, (1-s_1) \text{ x } (r_1+o)) + (((t_2 \, x \, (1-s_2) \text{ x } (r_2+o)) + ((t_2 \div t) \text{ x } l)) + ((t_3 \, x \, (1-s_3) \, (r_3+o)) \ldots$$

$$+ ((t_n \, x \, (1-s_n) \, (r_n+o)))$$

This equation takes all the appropriate factors into account in order that an accurate cost assessment can be made for a remanufactured product. The most accurate assessment for a complex assembly can be made by breaking down the bill of materials and summing the cost of each part of the assembly once calculated separately.

10.3 Validation

The method described above has been validated by comparison with both the existing method at the Rushden facility and the actual costs experienced at the Rushden facility. Attempts to compare it with a method from literature proved very difficult as the methods found assumed a predictable and normally distributed quantity and quality of cores; however the method proposed by Ferguson *et al.*

(2009) was used because the required could be obtained This method also relies less on assumptions than some of the others. Use of this method required some alteration because it, along with the others, was intended to be used to price remanufactured product. However, in order to do this, the cost of remanufacture needed to be calculated. Ferguson *et al.* (2009) state that the expected unit cost C_{it} for a given time period is:

$$C_{it} = \frac{\int_{qi}^{qi+1} c(q)ft(q)dq}{Ft(qi+1)-Ft(qi)}$$

Where q_i is an interval of quality between completely scrap and best quality, and $F_t(q)$ is representative of the cumulative quality distribution at time t.

For the purposes of the cost estimation, the time period was accounted to be the duration of the experimental period and the feedback from pre-processing inspection used to obtain the quality distribution.

Actual figures cannot be included as this is commercially sensitive information. The results of the validation are tabulated below. Minus figure indicate underestimation of the costs, plus figures overestimation.

Table 10.1 Comparison of the % Variance from Actual Cost of Various Cost Assessment Methods

Case	% Variance from Actual – Traditional Method	% Variance From Ferguson *et al.* Method	% Variance from Actual – New Method
A	-7.61%	-16.41%	-2.18%
B	-3.36%	21.32%	-2.09%
C	-4.12%	19.17%	1.44%

It can be seen from these results that the new method developed from this research gives the closest result to the actual cost. Actual cost varies because whilst costs are based on a mean activity time, actual time varies; also there are other potential added costs, such as remedial work and a second post-production test.

The Ferguson et al. (2009) method was seen to be the least accurate; however the method was not developed specifically to understand remanufacturing costs and some of the required information had to be estimated for the purposes of comparison.

10.4 Summary

This chapter has presented a novel cost assessment methodology developed from the research findings as a more accurate method of establishing the true cost of a remanufacturing activity.

The next chapter discusses the experimental results and analyses

Chapter 11 Discussion

11.1 Introduction

This chapter discusses the experimental findings, their novelty and the ways in which the findings can be used. It also considers whether the needs of the practitioner, as identified by Thomas and Tymon (1982), have been fulfilled. The validation of the decision-making methodology and the cost analysis tool are also described and commented upon.

11.2 Experimental Findings

The experimental findings clearly identified three common features of components whose remanufacturing activities benefitted from increased pre-processing inspection. These are:

- Complex geometry including internal ports;
- Large number of sub-components; or
- Constructed from or comprising of multiple materials.

These characteristics clearly indicate complex components make the most gains from the increase in pre-processing inspection content. Nevertheless, the results also identified smaller gains for simpler components.

These characteristics make pre-processing inspection worthwhile because they all introduce additional variables to the remanufacturing activity. Components with complex geometry are more likely to be affected by a build up of contaminants or to experience wear or corrosion on changing surface forms. This is particularly noticeable on turbochargers where the complex blade profile experiences more corrosion than the smoother, simpler sides of the chamber despite being exposed to the same operating conditions. Likewise components that have either a large number of sub-components or are constructed from multiple metals can be subject to corrosion aggravated by contact between differing materials or the inconsistent wear and fatigue created by the repetitive hot and cold cycling of an engine. Water and coolant pumps often exhibit these types of wear patterns particularly around the turbine and shaft joints where the differing metals increase the corrosion at the joint.

The benefits accrue from the knowledge obtained at the point of inspection. This information was used to inform the scheduling and procurement operations. Ijomah (2002) reported that remanufacturers rate component inspection to establish condition as a critical activity and demand forecasting as significant. This research addresses these concerns directly. It also partly mitigates the effects of uncertainty (noted by the same remanufacturers as a very significant issue) because early knowledge of part number, condition and type of received cores enables additional cores of a suitable type to be sourced in time to meet demand.

The information gathered by increasing the content of the pre-processing inspection activity allows remanufacturers to schedule disassembly and subsequent operations more effectively and also knowing more about the presence and condition of components allows demand for new components to be effective planned ahead of need.

A smaller benefit is the ability to scrap excessively worn or damaged components sooner in the remanufacturing process. This reduces the amount of cost unnecessarily added to components that cannot be salvaged, thus reducing waste.

This new knowledge is derived from examination of all the remanufacturing activity for 2196 engines of four different types. This is the largest quantitative study that has ever been undertaken into inspection of cores returned for remanufacturing. This large sample size gives confidence in the validity of the risk.

11.3 Application of the Research

The research findings are of use to both academia and industry. Chapter 9 explained the tool that makes the research accessible to remanufacturers both for making decisions about the level of inspection that will give the maximum benefit for the available return.

This work was directly concerned with engines and the tool is therefore designed around this, nevertheless the commonality of the key characteristics across a wide range of components, means that it is the belief of the author that the research findings can be generalised to components not necessarily directly linked to engines.

The novel cost assessment methodology explained in Chapter 10 arose from observation of the remanufacturing process and is applicable to any remanufacturing process. It is important to properly assess costs ahead of undertaking any work and traditionally the “two-thirds” benchmark has been used to consider whether a product is viable. This refers to the established practice of selling a remanufactured item into the market at approximately two-thirds of the price of the equivalent new.

The need to reduce costs to facilitate this level of sales price drives the remanufacturers’ decisions. However many remanufacturers estimate their costs using overall figures and do not break their costs per component down based on the types of remanufacturing operations required. The cost assessment tool presented is intended to enable remanufacturers to have more accurate knowledge of their actual costs rather than to challenge the historical pricing model.

These two tools, whilst offering a practical benefit to remanufacturers, also assist academia in that as well as providing new knowledge concerning the factors that materially affect inspection of cores they also provide quantified evidence of where future research into remanufacturing operations might bring the most benefit.

11.4 Validation

The value of the research findings lies in their ability to be useful. The satisfaction of the needs of the practitioner (Thomas and Tymon, 1982) is discussed in the following section. Nevertheless, ensuring that the tools presented were useful and that the factors upon which they were based were accurate for other engines (to those studied) and different types of remanufactured product was important.

The research findings were presented to those interviewed before the experimental phase was undertaken (as described in Chapter 7). The two facilities where these people worked were then presented with the decision-making methodology. The relevant people at each facility were given training in its use and, having made the appropriate decisions for each product (engines, short motors, cylinder head assemblies, turbochargers, water pumps, oil pumps, gear boxes and transmissions) the new inspection regimes were put in place. The training for the inspection process was that given to operatives for the experimental phase.

Each facility reported a reduction the overall processing time for each product. These varied between as little as 0.78% to a maximum of 19.53%. Confidentiality prevents actual figures being given for this phase however each facility reported an overall saving in time, 4.91% in one case and 5.12% in the other. The facilities also expressed satisfaction with the information gained and their increased ability to schedule both new components and additional salvage operations. This latter was particularly beneficial in the case of using expensive equipment or processes such as metal deposition.

The cost assessment methodology was separately presented to the financial teams in the facilities (slides are in Appendix VII) and this was used, alongside the traditional method for assessing costs. An accurate assessment of its validity for new products will become evident after some time, longer than is available for the completion of this work. It was important though to be able to give an assessment of accuracy and so experimentation by assessing the cost of remanufacture of existing products and comparing these both with the initial assessment made prior to commencement of remanufacture and the actual known costs of the remanufacture was made for three product lines – all engines. The actual remanufacturing costs used were those for the most recent full month available. This demonstrated that the new methodology presented here was a more accurate assessment. Those figures are reported in Table 10.1.

In all cases the new method presented in this work gave a more accurate assessment of costs. This is important for financial planning as well as for assessing the viability of remanufacture of a new product.

The facilities taking part in the trial of this tool are tracking the accuracy of the assessment in the new products prior to a full integration.

11.5 Satisfaction of Practitioner Needs

Thomas and Tymon (1982) propose that in order to profess practical usefulness any research must fulfil five needs of the practitioner. These are: descriptive relevance, goal relevance, operational validity, non-obviousness and timeliness. Each is discussed in terms of this research below.

11.5.1 Descriptive Relevance

Descriptive relevance refers to the extent to which the research accurately describes the phenomena being researched. This research delivers quantitative experimental results directly taken from the remanufacturing activities for the engines studied. The engines were studied as part of the normal remanufacturing process in the workplace in large quantities and consequently can be said to accurately describe the phenomena.

11.5.2 Goal Relevance

Thomas and Tymon (1982) define goal relevance as the extent to which the phenomena investigated addresses real practitioner issues. Various researchers (Ijomah, 2002, Tang *et al.*, 2007, Bao *et al.*, 2008, Robotis *et al*, 2012 etc.) agree that inspection of both cores and components is of critical important to remanufacturers as is the need for accurate information to mitigate the effects of uncertainty upon scheduling. The research described in this work directly addresses these issues and so has the appropriate goal relevance.

11.5.3 Operational Validity

Operational validity is the extent to which the practitioner is easily and conveniently able to use the research findings. The tools presented in previous chapters are designed to make this research both readily available and usable to both industry and academia. This has been demonstrated by their use in several remanufacturing facilities in the U.K. and Europe.

11.5.4 Non-Obviousness

Non-obviousness is defined as the extent to which the research meets or exceeds the common sense theory and practice available to the practitioner. This can be a more difficult criterion to satisfy. Several authors have discussed the benefits to practitioners of sorting cores (e.g. Zikopoulos and Tagaras, 2007 and Errington, 2009); despite this none have quantified what benefits can be achieved either in terms of the overall remanufacturing process or individual components thereof.

The general lack of detailed inspection of cores undertaken by remanufacturers, unless to price a remanufacturing process for a specific core and customer; coupled with the general attitudes to inspection evidenced by the interviews described in Chapter 7, all attest to the non-obviousness of this research. The Production Manager at Rushden, when first interviewed, could see no benefit at all. When re-interviewed post-experiment, he stated "…implementing more inspection has increased my throughput significantly and we are getting at least 5% more from each line we have it in place. I didn't believe it would work."

11.5.5 Timeliness

It is necessary for research findings to be available to the practitioner at the point at which they are useful in solving actual problems that the practitioner has.

Remanufacturing is an activity that has economic, ecological and societal benefits as well as being a highly useful end-of-life solution. It can also be a profitable business employing many skilled and unskilled people. The findings of this research can be used to improve the efficiency of the remanufacturing process. They can also assist future researchers in identifying additional areas of beneficial research.

11.6 Summary

This chapter has discussed the research findings and their application in remanufacturing practice. It has also considered their validity and value to remanufacturers. It has concluded that the results of this research are significant and of value to industry and that they have fulfilled the needs of the practitioner as argued by Thomas and Tymon (1982).

Chapter 12 Conclusion

12.1 Introduction

This final chapter brings this work to its conclusion. It reiterates the key problems for remanufacturers identified in the literature review and outlines the significance of the research in this context. The novelty and contribution of the research are considered as are the beneficiaries of the findings. The chapter concludes with a reflection on the ability of the chosen research design to meet the research objectives, the limitations of the research and potential areas for future study.

12.2 Key Remanufacturing Problems

Remanufacturing is the process of returning a used product to an "as-new" condition with a warranty that is at least equal to new (Ijomah, 2002). Remanufacturers collect used products referred to as "cores", dismantle, clean and repair the individual components before adding some new parts, re-assembling and testing.

The existing literature concerning remanufacture highlighted several issues, including the need for integrating remanufacturing concepts at the product design stage, the promotion of remanufacturing such that the return of cores becomes a default and the need to integrate remanufacturing into product service systems. The area of remanufacturing operations also highlighted several gaps; this was because generally only one remanufacturing activity was considered in isolation, particularly disassembly. Inspection of cores was also considered in the existing literature and this highlighted additional gaps, including the paucity of knowledge concerning the examination of individual cores returned for remanufacturing, the lack of quantitative evidence supporting the theory that inspection of cores promotes cost-effective remanufacture (Robotis *et al.*, 2012 etc), quantitative data that validates what inspection is beneficial does not seem to exist and any connection between inspection of cores and the ability to plan and bring in new parts has not been investigated.

The decision to investigate the need for assessment of cores was taken because this area offers several benefits both to academia and industry and the employment of the researcher as a production manager in a remanufacturing facility ensured that access to the activity was forthcoming.

12.3 Significance of the Research

This research is significant because it has added to the body of knowledge concerning remanufacture. This new knowledge will enable further research to be developed and also assist remanufacturers to better understand their own processes.

It has determined the factors affecting pre-processing core inspection at a single unit level. Component inspection is of critical importance to remanufacturers and this new knowledge concerning the factors affecting this may result in more efficient and effective remanufacture. More effective remanufacture will reduce the energy consumption of the process and consequently the emissions whilst improving profitability for remanufacturers.

12.4 Contribution to Knowledge and Novelty of the Research

The contribution to knowledge and the novelty of this research as described in this thesis is centred on the large amount of data collected from a large variety of engine components and their subsequent remanufacture.

Sorting or selecting cores at a strategic level has been considered in other work (Zikopoulos and Tagaras, 2007, Errington, 2009, Robotis *et al.*, 2012) but this has not been studied either at individual core level or in terms of the impact on subsequent remanufacturing operations. The new knowledge that this thesis reports quantifies the savings in remanufacturing processing time, activity by activity, as a result of inspecting cores at receipt and also determines which component characteristics are relevant to pre-processing inspection.

The collected data also enabled a novel cost assessment method to be developed to more accurately reflect the remanufacturing process. This is important because most remanufacturers, particularly the small ones, do not have the resources available to use the often complex mathematical methods described in extant literature and also many of these methods rely on assumptions concerning the quality and quantity of available core that do not necessarily reflect reality. The novelty of the method described here is that it considers all the variables for each component or sub-assembly from data already known or collected at most remanufacturers. It can easily be automated and is readily accessible.

These objectives have been met and their fulfilment described in the previous chapters. The tools for dissemination of the research are in current use in remanufacturing facilities in both the U.K. and Europe.

12.5 Beneficiaries

The beneficiaries of this research are both academia and industry.

Academia benefits because this is the first large quantitative study into pre-processing inspection and it increases the amount of new knowledge about remanufacture. There is very little knowledge about remanufacturing, particularly when compared to conventional manufacturing and this is hampering the ability of industry to meet the challenges it faces. This is for several reasons: for instance, altering a manufacturing process to accommodate the variation seen in remanufacturing can often make it less efficient. This is the case with regrinding crankshafts as they often have hardened surfaces, this makes tool life much lower than it would otherwise be, grinding hardened material also runs the risk of introducing cracks and many crankshafts then require a further hardening process which can introduce an unacceptable level of distortion. The characteristics identified will enable further research to be targeted towards effective inspection tools and methods. This is particularly important as it will enable researchers to concentrate on areas that will produce the greatest impact and create the largest savings of new materials and energy and thus produce the greatest improvement to profitable remanufacture as well as prime manufacture. Understanding the manner in which the information garnered at the inspection phase informed and improved subsequent planning and logistics functions may also assist researchers developing integrated systems.

The benefits, arising from the deliverables mentioned above, to industry are twofold. Firstly the additional in-depth knowledge of processes will help remanufactures to understand their business; and secondly, the tools developed to disseminate the research findings will provide readily accessible methods of controlling processes. Identification of the factors affecting inspection and the resulting decision-making tool will enable remanufacturers to concentrate their efforts on components that produce the greatest savings. Efficiency savings promote profitability.

The cost estimation tool will help remanufacturers to gain a better understanding of their costs and the profitability of particular products. This, in turn, will assist effective decision-making in terms of where to concentrate improvement efforts.

Industry will also benefit as the new knowledge will inform their decisions concerning inspection and will also allow greater control over scheduling and planning activities. Understanding the level of inspection that produces a benefit will enable remanufacturers to allocate resource in a more informed way, the increased information available earlier in the process will enable labour and machine resources to be allocated in the most productive manner and allow purchasers to make more informed decisions about the timing and quantity of procurement of new parts or additional cores.

12.6 Research Design

This research was undertaken using a mainly positivist paradigm. The quantitative research was carried out using a true experimental design to establish a causal link between the increase in pre-processing inspection of cores and the reduction in the overall remanufacturing processing time. The data was collected from 2196 engines giving a very large experimental population. This has ensured that the data and findings are robust.

The objectives of the research have been met using this framework and valid, robust data has been obtained and analysed. The inclusion of interviews of the main personnel involved in the remanufacturing process, providing the qualitative element of the mixed mode approach was justified as it enabled the results to be both properly considered by the people involved and also facilitated the propagation of the resultant methodologies. The evidential nature of quantitative results meant that practitioners quickly gave credence to the tools, this might have been lacking without the "hard data" to back it up.

It is the opinion of the author that the chosen research design was appropriate to the research and, if the research were to be repeated, she would not seek an alternative.

12.7 Limitations of the Research

The research described in this thesis used engines and their components as experimental subjects. No other remanufactured products were considered. This was primarily because of the unprecedented access to engines. The author has been able to generalise the findings, primarily because of the large number of similar results. Nevertheless, despite validation that has included other assemblies (essentially gearboxes and transmissions), it could be argued that the findings can only be directly attributed to automotive components.

The experiments were undertaken at a Caterpillar Remanufacturing UK facility and whilst this might be considered a limitation, the author contends that sufficient evidence of the typical nature of most remanufacturing operations exists in literature (Ijomah, 2002, Mähl and Östlin, 2007, Kim *et al.,* 2009 etc.) that the results are able to be generalised. In addition, the results were gathered from four different engines, developed by four different customers and the findings are in use in several facilities cross Europe, all of whom report similar benefits. However, it is acknowledged as a potential weakness.

The extent of additional pre-processing inspection of cores was limited by the available tools and technology for non-destructive testing. Additional benefits, or the limits of such benefits, might have been found were more technology available. Examples of technologies that might prove beneficial include ultrasound testing for metal fatigue and magnetic flux crack detection.

12.8 Areas of Further Research

The literature review identified various gaps in remanufacturing research however in addition to these this research identified several further areas requiring research. These are discussed individually below.

12.8.1 Further Experimentation

The results of this research could be extended and improved in two ways. Firstly by repeating the experiments using a greater variety of remanufactured products in order to further generalise the findings. Secondly, as the extent of additional pre-processing inspection of cores was limited by the tools and technology available to the researcher, the experiments could be repeated using more sophisticated non-destructive testing tools (for example ultrasound testing of metals). These results could be used to extend the methodology and further generalise the findings.

12.8.2 Tools and Techniques

There is still a paucity of remanufacturing-specific additional tools and techniques for non-destructive testing prior to disassembly, the majority being undertaken using either experienced labour or manufacturing inspection tools adjusted in-house to make them more effective for this non-standard activity. Tools specifically tailored to remanufacturers would mitigate the uncertainty and risk inherent in the inspection process. These new tools, coupled with the possibility of automation, might give additional efficiency benefits although work would also be required to determine their cost-effectiveness for the average remanufacturer.

12.8.3 Propagation of the Methodologies Developed

The results of this experiment have shown a reduction in processing time for some remanufactured components as the amount of pre-processing inspection is increased. This information can be of use to remanufacturers. The resulting methodologies are currently in use in several remanufacturing facilities; however monitored large-scale use would confirm the benefits to a wider range of remanufacturers and across a wider range of remanufactured components. This would enable additions or alterations to the methodologies as well as providing academia with a large body of information on remanufacturing processes.

12.8.4 Modularised Design

The single largest difficulty in the pre-processing inspection of cores experienced during the course of these experiments was the complexity of the engine assembly. The sheer quantity of components fitted into a relatively space physical space made any form of inspection beyond the superficial difficult. The dilemma for remanufacturers is always how much work (essentially added cost) to put into a core before the decision about whether the remanufacture is viable is made. Modular designs, although not the subject of this research, would facilitate limited disassembly and a greater ability to inspect. An additional benefit could be realised if sensors were incorporated into many designs to give an indication of the previous life of the components and potentially the remaining life.

12.9 Summary

This chapter has brought this research to its conclusion. It has summarised the research objectives and how they have been met, reflected on the significance and novelty of the work and commented upon the effectiveness of the research design. Lastly the limitations of the work have been acknowledged and further areas for work have been identified.

The aim of this research was to uncover new knowledge that affected the inspection of returned cores. It has been determined that gathering data prior to processing for components with complex geometry, including internal ports, a large number of sub-components or a multiple material construction produces a quantifiable reduction in overall processing time. This new knowledge has been successfully presented to make it useful to all those in the remanufacturing industry. In addition, a new cost-assessment methodology has been developed which will enable remanufacturers to accurately estimate costs.

APPENDIX I

Feedback Sheet

Reference No:	Date:	Name:
Engine Type:	Part Number:	
Major Damage or Missing Parts:		
Evidence of Burning or Overheating:		
Bore Condition:		
Other Components broken or missing: Return this form to the Production Office once completed. CRSW2011/02005		

APPENDIX II

Experimental Results

Engine A – All values recorded are in decimal minutes.

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A1	4.76	46.53	78.24	95.28	55.32	21.23	18.62	35.29	51.09	109.67	29.24	29.43	574.70	A	1
A2	4.64	49.57	77.77	99.02	54.62	23.11	18.06	34.99	50.29	108.38	29.38	30.02	579.85	A	1
A3	4.88	49.51	80.61	95.84	52.65	22.97	18.72	33.78	50.72	110.51	30.54	30.42	581.15	A	1
A4	4.95	48.80	80.59	99.93	53.27	23.31	18.39	34.48	51.47	109.05	29.90	30.21	584.35	A	1
A5	5.74	46.68	78.96	96.21	55.05	23.00	19.45	36.46	51.66	111.07	30.05	31.19	585.52	A	1
A6	5.50	49.31	81.97	99.75	52.02	20.81	19.70	33.82	50.80	110.17	29.73	29.73	583.31	A	1
A7	5.07	45.62	79.76	99.36	52.47	22.97	18.99	35.96	51.70	110.18	30.20	30.49	582.77	A	1
A8	5.04	50.48	78.28	94.46	55.88	21.19	17.89	34.92	51.61	110.93	30.08	30.56	581.32	A	1
A9	5.19	49.61	79.73	96.13	53.92	22.96	18.79	35.43	52.09	107.28	31.23	30.99	583.35	A	1
A10	5.54	48.78	78.63	96.58	52.11	20.12	19.07	35.35	52.08	107.10	31.35	29.96	576.67	A	1
A11	5.38	45.01	80.75	99.12	54.13	20.67	19.34	33.43	50.23	108.89	29.90	30.51	577.36	A	1
A12	5.19	47.28	77.50	97.11	53.49	23.80	18.49	34.07	50.90	109.06	30.06	29.59	576.54	A	1
A13	4.89	46.64	80.03	98.86	55.07	23.57	18.51	33.42	51.94	107.48	30.07	30.90	581.38	A	1
A14	5.71	49.86	79.36	95.88	54.44	21.77	17.91	33.45	51.72	109.15	29.40	30.04	578.69	A	1
A15	4.62	45.67	81.69	96.94	53.40	19.90	17.88	36.42	52.25	110.38	30.98	31.19	581.32	A	1
A16	4.89	46.76	78.32	95.54	55.20	20.32	18.19	35.08	52.05	110.17	30.28	29.60	576.40	A	1
A17	5.32	47.20	81.95	97.75	54.97	22.45	19.34	34.14	51.82	110.57	29.32	30.66	585.49	A	1
A18	5.65	49.95	79.68	96.72	52.78	22.15	17.88	35.89	50.70	111.50	29.24	30.33	582.47	A	1
A19	5.74	67.48	78.68	93.99	54.16	20.98	19.61	33.19	51.37	108.32	30.79	29.42	593.73	A	1
A20	5.20	45.27	78.70	98.20	55.80	23.77	18.78	33.29	52.18	118.78	29.86	29.83	589.66	A	1
A21	4.70	50.47	82.52	95.76	52.66	20.74	19.27	35.80	52.13	109.05	29.62	29.81	582.53	A	1
A22	4.77	46.28	81.21	97.29	52.19	21.70	18.54	34.21	50.76	106.40	30.54	31.19	575.08	A	1
A23	4.81	49.38	82.09	97.33	55.93	20.67	19.36	34.13	51.10	109.07	30.46	30.93	585.26	A	1
A24	5.20	50.42	80.62	94.42	53.10	22.20	18.62	34.69	50.35	109.26	29.93	30.53	579.34	A	1
A25	4.61	47.13	79.23	97.07	54.30	21.20	18.08	34.92	50.72	108.61	31.40	30.99	578.26	A	1
A26	5.11	45.52	82.60	97.00	55.87	23.46	18.65	34.08	50.35	109.69	30.20	31.10	583.63	A	1
A27	4.71	47.68	82.00	98.35	55.69	20.18	17.89	34.61	51.03	109.19	31.29	30.42	583.04	A	1
A28	4.83	50.40	77.16	94.32	52.23	21.16	19.03	35.48	51.07	107.77	30.33	29.84	573.62	A	1
A29	5.37	46.54	77.78	95.25	55.96	21.54	18.63	33.77	52.40	109.73	30.86	30.85	578.68	A	1
A30	4.99	49.98	80.17	98.88	55.64	22.84	19.81	33.65	52.41	110.64	29.84	30.56	589.41	A	1
A31	4.89	50.41	77.56	97.89	52.69	22.20	18.72	34.61	50.28	109.71	30.15	31.46	580.57	A	1
A32	5.73	48.00	80.03	95.84	54.53	20.80	19.32	33.60	51.56	109.47	30.45	31.47	580.80	A	1
A33	4.83	48.09	81.99	98.91	54.07	20.82	19.81	34.49	51.01	111.90	30.76	30.62	587.30	A	1
A34	4.70	46.10	77.03	97.87	55.40	19.98	18.00	34.22	52.25	107.56	31.27	30.41	574.79	A	1
A35	5.33	49.89	78.73	99.30	52.51	20.99	19.62	36.43	50.70	111.55	29.58	29.34	583.97	A	1
A36	5.03	45.97	81.83	97.87	55.61	22.55	18.42	36.01	52.10	112.40	31.36	29.31	588.46	A	1
A37	5.30	45.58	81.20	94.89	52.79	23.40	18.03	34.58	52.11	108.55	29.87	29.30	575.60	A	1
A38	5.08	47.64	76.92	95.11	54.72	23.22	19.06	33.98	52.41	110.51	30.12	30.07	578.84	A	1
A39	4.66	47.14	77.05	96.61	52.92	23.61	18.80	35.44	50.86	109.69	30.16	30.73	577.67	A	1
A40	5.70	49.48	82.50	97.34	54.30	20.07	19.37	34.07	52.23	110.19	29.34	29.99	584.58	A	1
A41	5.74	46.86	81.74	94.36	55.50	23.70	17.95	34.12	52.39	108.61	30.43	30.02	581.42	A	1
A42	5.57	49.55	81.34	96.70	54.76	23.50	18.87	35.20	51.08	117.95	29.70	30.61	594.83	A	1
A43	5.28	49.72	79.42	94.38	55.61	21.22	19.68	36.26	50.24	110.97	29.29	29.69	581.76	A	1
A44	4.89	47.19	78.56	98.94	52.56	22.93	18.13	34.07	50.40	107.74	30.52	30.98	576.91	A	1
A45	5.39	46.34	77.50	98.20	53.41	21.18	17.89	33.79	52.10	109.45	30.79	29.39	575.43	A	1
A46	5.37	49.81	77.96	99.16	54.26	23.67	18.31	34.77	50.73	106.44	29.45	29.24	579.17	A	1
A47	4.78	49.76	78.74	97.90	54.14	21.45	19.30	33.59	51.38	109.64	29.82	29.59	580.09	A	1
A48	4.53	46.25	80.94	99.52	51.92	21.47	19.66	33.55	51.02	108.26	29.96	30.52	577.60	A	1
A49	5.20	49.06	77.98	97.85	54.27	21.65	19.70	35.74	52.42	108.84	30.32	31.38	584.41	A	1
A50	5.31	49.17	81.61	94.19	53.48	23.26	18.76	34.39	50.86	110.94	29.71	31.06	582.74	A	1
A51	4.52	46.73	81.82	96.67	54.95	23.66	19.18	35.50	51.21	106.91	31.02	30.14	582.31	A	1
A52	5.58	45.44	77.02	96.58	54.70	22.25	19.28	36.48	51.78	111.32	30.87	31.23	582.53	A	1
A53	5.27	45.76	80.06	94.10	54.13	21.92	18.91	35.33	51.61	111.60	30.02	29.42	578.13	A	1
A54	4.54	49.12	76.97	99.20	52.19	23.18	18.19	36.15	50.88	110.60	31.24	29.49	581.75	A	1
A55	4.58	50.34	77.92	95.64	54.20	22.08	19.00	35.91	51.14	107.33	30.65	30.21	579.00	A	1
A56	5.29	48.35	76.88	95.75	52.95	20.45	18.82	33.12	51.38	107.11	30.39	30.19	570.68	A	1
A57	5.32	47.42	79.36	98.91	54.45	20.38	19.37	36.10	50.32	110.02	30.86	30.02	582.53	A	1
A58	5.47	47.40	77.61	97.57	55.87	22.17	18.44	34.52	50.83	111.20	30.15	30.99	582.22	A	1
A59	5.47	50.31	77.81	98.09	52.03	21.99	19.30	34.14	51.86	110.59	30.76	30.57	582.92	A	1
A60	5.28	50.15	82.16	93.81	52.42	22.65	18.24	35.81	52.23	109.55	30.41	31.47	584.18	A	1
A61	4.54	46.61	76.98	96.50	54.22	23.82	18.95	35.51	50.77	111.18	31.21	30.24	580.53	A	1
A62	5.53	48.86	80.81	94.44	53.67	21.40	18.17	34.84	52.46	109.71	30.67	31.19	581.75	A	1
A63	5.02	50.07	82.63	94.13	52.82	21.07	19.70	35.83	51.74	107.11	30.18	30.52	580.82	A	1
A64	4.76	46.91	77.93	97.30	52.70	22.36	18.23	34.90	51.16	106.69	31.37	29.28	573.59	A	1
A65	5.25	48.97	78.00	97.19	51.97	22.18	19.05	34.68	52.30	106.69	30.13	31.04	577.45	A	1
A66	5.25	45.12	81.18	95.43	53.39	22.51	17.83	33.40	50.26	107.27	30.09	30.95	572.68	A	1
A67	5.51	46.48	76.78	98.40	55.02	23.75	18.08	34.37	50.36	107.19	29.84	31.07	576.85	A	1
A68	5.19	47.18	82.79	98.42	52.70	23.61	19.71	35.33	52.46	109.54	31.06	30.08	588.07	A	1
A69	4.61	48.10	80.28	94.57	54.41	22.56	18.28	34.72	52.18	111.32	30.44	29.88	581.35	A	1
A70	5.33	45.61	78.21	94.33	52.46	20.17	19.44	33.43	52.29	111.37	31.21	30.69	574.54	A	1
A71	5.29	45.46	79.44	99.03	55.39	23.20	18.51	35.31	50.74	109.18	30.12	30.46	582.13	A	1
A72	4.69	47.25	82.77	95.26	55.43	20.60	17.90	35.88	50.37	110.86	29.49	31.02	581.52	A	1
A73	4.96	58.30	80.69	94.13	54.15	22.21	18.18	35.00	50.70	109.70	30.90	29.82	588.74	A	1
A74	4.50	47.56	81.72	99.93	55.32	20.20	19.08	36.19	50.73	111.38	29.59	30.26	586.46	A	1
A75	4.86	49.59	82.30	98.77	54.97	23.22	19.58	33.62	50.39	111.09	29.25	30.83	588.47	A	1
A76	4.80	48.21	82.64	95.10	53.02	20.72	19.32	35.42	52.27	108.11	29.23	29.57	578.41	A	1
A77	4.94	47.06	79.11	97.62	52.62	23.32	18.66	35.72	52.12	109.84	31.36	29.72	582.09	A	1
A78	4.91	49.50	77.86	98.00	53.56	21.97	17.98	33.50	52.14	106.93	29.81	29.67	575.83	A	1
A79	5.26	45.85	78.10	96.23	55.66	20.75	17.82	33.12	51.89	106.40	30.77	30.31	572.16	A	1
A80	4.74	47.20	81.02	98.73	53.56	21.98	19.01	35.48	51.97	112.14	30.63	29.69	586.15	A	1
A81	4.61	46.11	76.73	97.06	54.16	23.38	19.43	35.52	51.82	109.16	31.35	29.66	578.99	A	1
A82	4.54	50.40	78.58	95.67	54.55	19.96	17.83	35.85	51.06	112.38	30.27	29.68	580.77	A	1
A83	4.66	47.38	81.15	97.88	55.11	20.43	18.61	33.76	52.49	108.97	31.36	30.14	581.94	A	1

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A84	4.84	48.17	78.97	95.95	56.11	23.39	18.37	33.90	50.39	111.47	31.23	30.45	583.24	A	1
A85	4.89	46.82	77.33	96.02	54.75	23.06	19.59	33.31	51.20	112.05	29.97	31.44	580.43	A	1
A86	4.54	47.90	79.07	98.66	51.93	21.16	18.06	33.65	51.15	112.04	30.84	31.33	580.33	A	1
A87	5.00	48.23	77.63	96.30	54.61	22.51	18.47	35.87	51.43	111.39	30.95	30.72	583.11	A	1
A88	5.38	47.08	79.17	94.03	54.82	23.14	18.58	36.24	51.35	110.36	30.42	30.82	581.39	A	1
A89	5.44	49.59	77.00	97.61	52.45	20.70	19.15	36.00	50.39	111.69	30.48	29.85	580.35	A	1
A90	5.17	48.68	77.18	98.93	55.76	20.06	19.26	33.19	51.23	108.10	29.52	30.16	577.24	A	1
A91	4.95	49.50	77.66	98.38	55.85	22.75	19.11	33.20	51.07	107.75	30.27	31.47	581.96	A	1
A92	4.62	46.96	82.42	95.78	55.13	23.30	19.71	36.20	52.23	111.54	30.48	30.28	588.65	A	1
A93	5.08	47.07	76.98	97.76	55.84	20.06	19.72	36.20	50.58	112.22	30.19	29.23	580.93	A	1
A94	5.29	50.28	80.99	96.09	53.25	22.39	18.28	36.44	51.54	109.43	31.47	30.64	586.09	A	1
A95	5.15	46.26	79.01	94.55	52.75	22.63	19.71	34.04	51.54	106.85	30.24	31.32	574.05	A	1
A96	4.97	48.70	78.06	93.96	52.56	20.54	19.48	35.71	51.39	110.05	30.36	29.32	575.10	A	1
A97	5.35	47.65	81.48	94.16	53.41	21.43	17.85	34.20	50.99	107.23	30.44	29.73	573.92	A	1
A98	5.65	49.69	80.64	96.12	55.39	21.15	19.57	36.03	51.34	110.31	31.40	31.49	588.78	A	1
A99	5.50	49.53	81.37	98.00	53.80	21.36	18.85	35.48	51.80	110.98	29.68	31.39	587.74	A	1
A100	5.61	45.39	80.98	94.11	55.17	21.92	19.41	33.38	50.86	106.70	30.90	31.14	575.57	A	1
A101	5.60	48.66	76.74	94.51	55.61	20.38	19.08	35.54	50.81	109.49	30.52	30.15	577.09	A	1
A102	5.45	46.32	81.95	98.75	54.24	20.72	18.28	35.36	51.31	111.77	31.36	31.43	586.94	A	1
A103	4.70	48.35	82.06	97.89	52.91	21.10	19.75	36.45	50.54	112.20	31.00	29.88	586.83	A	1
A104	5.38	48.43	79.65	94.31	54.75	21.41	19.62	33.87	51.37	111.59	30.53	29.26	580.17	A	1
A105	5.06	50.12	76.99	99.15	51.80	22.78	19.52	36.43	51.05	109.86	29.72	30.99	583.47	A	1
A106	5.32	47.15	77.79	95.80	55.85	21.10	19.00	34.50	50.55	106.82	29.82	30.18	573.88	A	1
A107	5.03	50.42	78.52	97.96	53.68	20.47	18.13	34.12	52.25	109.90	31.25	31.16	582.89	A	1
A108	4.96	45.58	80.93	97.70	55.21	21.58	19.65	36.39	51.70	110.43	30.23	30.43	584.79	A	1
A109	5.34	48.72	82.08	99.88	53.70	19.96	19.01	34.65	50.50	112.45	29.26	29.28	584.83	A	1
A110	4.89	46.89	77.79	94.46	54.63	22.74	18.29	34.74	50.89	109.09	30.14	29.75	574.30	A	1
A111	5.01	46.68	77.54	95.71	55.92	22.36	18.32	33.74	51.68	111.34	30.70	30.14	579.14	A	1
A112	5.49	50.37	79.46	93.87	53.08	23.61	19.22	35.11	52.32	111.89	30.59	31.15	586.16	A	1
A113	4.92	47.07	78.69	94.24	56.10	21.07	19.54	35.85	51.10	110.00	29.60	29.36	577.54	A	1
A114	5.18	48.04	81.70	97.74	55.67	21.30	18.15	33.07	52.15	109.75	30.22	31.26	584.23	A	1
A115	4.84	48.02	77.79	95.25	53.17	20.34	17.86	34.75	51.51	109.01	30.94	29.53	573.01	A	1
A116	4.96	49.80	82.08	95.02	55.48	22.90	19.81	36.16	51.74	109.06	30.51	30.97	588.49	A	1
A117	4.58	49.32	82.21	99.42	54.02	22.54	18.79	35.88	52.36	109.79	29.69	31.06	589.66	A	1
A118	5.44	45.80	78.38	96.03	55.92	22.77	17.93	35.45	52.09	110.32	30.32	29.40	579.85	A	1
A119	5.46	46.22	82.55	97.70	55.10	21.84	19.30	35.34	51.69	106.76	31.01	30.98	583.95	A	1
A120	5.49	45.97	81.83	97.46	55.62	20.42	18.51	34.98	51.46	109.15	29.51	31.16	581.56	A	1
A121	5.62	49.10	82.41	97.49	52.67	20.20	18.42	35.93	50.91	110.19	31.21	29.71	583.86	A	1
A122	4.76	47.63	79.66	96.00	55.23	22.26	17.82	35.25	50.84	111.79	30.63	30.81	582.68	A	1
A123	4.57	50.11	79.81	97.53	55.27	22.39	19.42	35.83	51.25	109.22	29.74	29.95	584.59	A	1
A124	5.12	45.00	80.73	98.25	55.20	21.59	18.81	33.22	51.69	112.51	29.75	30.88	582.75	A	1
A125	4.63	48.51	80.95	93.87	55.83	21.87	19.41	34.67	52.10	109.34	29.78	29.25	580.21	A	1
A126	5.14	45.60	76.53	97.81	55.67	23.16	19.53	36.22	51.46	109.55	30.05	29.43	580.15	A	1
A127	4.78	48.13	79.33	96.46	53.28	20.67	19.34	35.76	51.25	110.40	30.17	30.63	580.20	A	1
A128	4.93	50.35	80.99	97.10	52.05	22.50	17.92	35.42	51.13	107.23	30.19	29.23	579.04	A	1
A129	4.60	49.33	80.07	94.31	54.26	22.29	17.80	34.49	50.33	107.38	29.48	30.48	574.82	A	1
A130	4.57	47.25	80.88	98.94	51.90	20.40	18.29	35.50	52.09	112.26	29.71	30.70	582.49	A	1
A131	4.69	47.90	82.86	96.58	52.08	23.01	18.22	34.43	52.14	110.76	30.44	31.01	584.12	A	1
A132	4.85	47.79	79.03	97.93	55.33	21.91	19.14	34.36	50.70	112.43	30.30	31.17	584.94	A	1
A133	5.46	45.28	82.45	99.23	55.73	21.95	18.95	34.68	52.16	111.70	29.48	30.98	588.05	A	1
A134	5.58	49.55	81.14	95.62	52.81	21.08	19.09	35.89	51.59	107.77	30.48	30.93	581.53	A	1
A135	5.69	47.36	78.14	95.49	52.14	20.57	18.79	34.15	52.47	112.00	29.33	30.56	576.69	A	1
A136	5.30	50.38	78.12	94.73	52.94	23.28	18.64	35.32	52.10	111.01	30.90	29.68	582.40	A	1
A137	5.19	45.77	78.98	97.49	55.41	20.46	19.52	34.50	51.16	109.51	30.03	30.89	578.91	A	1
A138	5.69	45.90	80.82	98.79	55.45	20.21	18.42	34.48	50.49	110.40	30.27	29.56	580.48	A	1
A139	5.49	47.96	79.49	99.90	55.22	20.84	18.83	36.08	51.59	109.18	29.63	30.69	584.90	A	1
A140	5.59	49.40	78.01	93.84	53.85	21.10	18.37	34.45	52.29	112.13	30.90	29.35	579.28	A	1
A141	4.59	48.34	82.27	97.56	55.91	20.84	17.92	34.06	50.27	110.05	30.56	30.89	583.26	A	1
A142	4.87	46.28	81.06	97.90	52.92	20.19	18.57	34.34	51.64	109.30	30.63	30.94	578.64	A	1
A143	4.57	46.27	79.65	98.30	53.74	22.07	17.83	34.32	52.04	106.92	29.97	30.55	576.23	A	1
A144	5.65	49.34	81.88	94.94	51.89	22.61	19.31	35.36	52.47	109.60	30.79	29.61	583.45	A	1
A145	4.93	47.26	80.98	94.31	52.07	20.91	18.58	35.80	50.94	109.15	31.49	29.66	576.08	A	1
A146	4.64	45.65	78.16	97.57	53.32	20.51	18.68	34.38	51.50	112.75	31.27	30.38	578.81	A	1
A147	5.21	45.00	77.69	97.94	52.43	21.07	19.69	33.89	50.72	108.31	29.77	29.44	571.16	A	1
A148	5.15	45.50	82.83	95.60	54.33	19.97	17.97	33.98	50.26	110.68	30.98	31.11	578.36	A	1
A149	5.35	50.41	82.70	98.88	54.49	23.26	19.28	33.46	50.45	106.72	30.58	30.66	586.24	A	1
A150	4.52	46.51	81.25	95.38	54.00	23.73	19.59	33.58	50.30	107.55	30.67	30.56	577.64	A	1
A151	5.36	49.14	77.84	96.59	53.38	21.79	17.99	33.34	52.15	109.84	30.01	30.84	578.27	A	1
A152	4.82	48.46	77.41	98.20	52.08	23.14	18.18	35.40	52.01	109.64	30.75	29.64	579.73	A	1
A153	4.85	45.96	78.14	95.78	55.27	22.47	18.08	34.61	50.90	112.47	31.47	30.83	580.83	A	1
A154	4.77	49.23	79.94	98.13	53.86	23.43	18.42	36.03	51.74	112.21	30.09	30.06	587.91	A	1
A155	5.04	48.89	82.98	95.80	51.85	20.82	18.97	36.14	51.23	110.82	30.98	29.68	583.20	A	1
A156	5.00	46.50	76.77	99.06	55.24	20.35	17.99	35.98	51.11	112.10	30.60	31.43	582.13	A	1
A157	5.53	49.34	76.58	97.41	55.00	23.30	19.04	34.44	51.37	108.41	29.35	31.39	581.16	A	1
A158	5.05	47.21	79.47	97.61	52.30	23.22	19.12	34.40	50.62	109.14	31.38	29.51	579.03	A	1
A159	5.55	49.41	81.45	97.78	55.26	20.49	19.27	34.20	52.01	110.61	29.54	30.90	586.47	A	1
A160	5.12	45.70	80.77	94.10	55.89	21.36	19.11	36.12	51.20	109.78	31.06	29.96	580.17	A	1
A161	5.55	49.89	78.01	98.70	53.82	20.60	18.55	33.24	52.40	109.77	30.60	31.46	582.59	A	1
A162	5.13	45.35	78.96	97.46	52.91	19.93	19.46	33.97	52.29	111.56	29.95	29.76	576.73	A	1
A163	4.85	48.15	82.70	94.54	52.86	20.73	19.66	35.10	51.77	110.84	30.35	29.75	581.30	A	1
A164	4.77	46.53	76.59	96.97	51.99	22.55	17.93	33.02	51.92	109.77	30.79	29.27	572.10	A	1
A165	5.44	50.49	77.81	97.37	53.47	23.68	18.80	35.81	50.38	108.60	30.75	29.43	582.03	A	1
A166	5.17	49.07	77.82	95.71	53.11	20.13	18.51	33.39	51.47	110.95	30.50	30.36	576.19	A	1

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A167	5.12	45.61	77.85	97.87	53.95	20.91	18.30	35.96	52.38	110.32	29.74	30.97	578.98	A	1
A168	5.69	46.92	80.49	96.32	52.63	21.24	18.89	35.14	51.99	108.40	31.11	30.41	579.23	A	1
A169	5.45	50.36	78.32	98.75	53.44	20.91	18.57	35.68	51.40	108.33	31.09	30.27	582.57	A	1
A170	5.15	48.42	81.84	96.50	52.98	21.28	18.96	34.53	50.68	112.59	30.00	30.39	583.32	A	1
A171	4.80	46.14	82.33	95.57	52.67	21.99	19.64	33.99	52.00	110.78	29.51	31.00	580.37	A	1
A172	5.65	49.03	82.32	95.23	54.72	21.91	18.04	36.06	51.47	112.15	30.68	29.86	587.12	A	1
A173	5.13	49.56	80.67	96.19	52.01	21.96	18.91	35.72	51.98	109.56	29.46	31.10	582.25	A	1
A174	4.93	45.55	79.83	93.83	54.93	22.02	19.49	36.22	51.37	111.02	31.24	30.25	580.68	A	1
A175	4.60	45.75	79.39	97.53	53.70	20.86	18.43	33.46	52.26	108.96	30.24	30.26	575.44	A	1
A176	5.35	47.93	77.10	97.37	53.87	21.33	19.41	35.44	51.35	110.59	31.06	29.53	580.33	A	1
A177	4.89	50.00	82.51	94.43	54.39	23.71	19.62	35.13	51.90	109.86	31.09	31.28	588.81	A	1
A178	5.19	47.58	78.02	96.81	54.27	20.13	19.07	35.27	51.00	112.13	30.06	29.82	579.35	A	1
A179	5.52	49.58	82.60	96.87	52.98	21.84	18.89	33.40	51.39	109.97	29.98	29.31	582.33	A	1
A180	5.01	48.34	78.18	97.35	53.94	21.54	18.09	35.28	50.65	111.84	29.90	30.43	580.55	A	1
A181	4.73	49.65	79.61	96.41	54.49	23.07	17.87	34.95	51.04	109.70	30.46	31.47	583.45	A	1
A182	4.73	49.33	81.99	97.81	52.81	22.48	18.73	33.94	51.20	109.01	30.26	31.37	583.66	A	1
A183	4.61	46.26	76.82	98.24	53.53	21.57	18.72	35.61	51.76	109.31	31.06	31.12	578.61	A	1
A184	4.86	48.40	80.21	97.64	56.12	21.57	18.42	34.09	52.44	108.06	30.81	29.40	582.02	A	1
A185	5.40	47.26	80.71	95.62	54.94	22.28	18.35	36.41	52.40	108.13	30.13	31.20	582.83	A	1
A186	5.60	48.41	79.18	99.65	53.35	20.88	19.42	34.67	51.10	111.96	29.67	29.92	583.81	A	1
A187	4.59	47.77	79.77	99.88	52.67	23.03	19.82	34.99	51.70	109.89	31.34	29.55	585.00	A	1
A188	5.69	47.16	81.29	98.19	54.53	20.58	19.16	36.13	51.77	110.97	30.57	29.84	585.88	A	1
A189	5.39	47.38	82.65	96.65	52.53	21.31	18.41	34.82	51.45	111.14	30.77	29.70	582.20	A	1
A190	4.76	46.03	76.55	96.29	55.21	21.89	17.89	33.98	50.24	108.80	29.36	29.55	570.55	A	1
A191	4.61	48.68	78.28	97.42	54.41	21.22	18.61	33.91	50.48	111.63	29.66	31.18	580.09	A	1
A192	4.85	50.34	81.97	98.08	55.34	21.64	19.25	33.56	51.41	108.11	30.40	30.41	585.36	A	1
A193	4.88	46.00	79.24	98.97	52.75	21.42	18.86	35.26	52.18	112.02	29.49	30.69	581.76	A	1
A194	4.53	46.43	78.46	95.63	52.54	21.18	19.40	35.11	52.08	109.92	31.02	30.50	576.80	A	1
A195	5.42	49.33	78.23	95.54	54.94	22.83	19.78	33.97	52.36	110.75	29.55	29.44	582.14	A	1
A196	5.00	48.22	81.59	98.12	55.63	22.31	18.48	35.40	52.43	109.57	29.51	29.65	585.91	A	1
A197	4.80	45.52	80.10	98.24	53.06	20.91	18.49	36.35	50.54	112.18	29.52	30.97	580.68	A	1
A198	5.08	49.81	79.75	97.82	55.32	22.99	19.17	36.23	50.47	106.39	29.28	30.34	582.65	A	1
A199	5.61	49.11	80.87	94.49	53.51	23.62	19.71	33.90	51.05	109.65	31.44	29.34	582.30	A	1
A200	5.28	47.30	77.92	94.27	55.94	23.72	19.02	34.55	50.31	112.00	30.92	29.98	581.21	A	1
A201	5.56	48.06	81.17	98.56	52.46	23.32	19.21	35.26	50.33	112.27	30.76	31.21	588.17	A	1
A202	5.16	47.04	77.81	94.69	54.34	23.23	18.70	35.76	52.35	109.56	30.32	31.11	580.07	A	1
A203	4.67	45.30	82.18	97.89	54.86	20.18	19.61	33.48	51.87	107.52	29.83	29.27	576.66	A	1
A204	5.74	50.07	80.96	98.90	52.53	21.73	19.49	34.22	52.41	111.75	29.30	29.98	587.08	A	1
A205	4.76	47.71	82.94	98.89	54.17	20.06	19.58	33.54	51.88	108.83	31.28	29.42	583.06	A	1
A206	4.90	49.82	77.95	93.96	55.47	21.64	19.40	34.14	51.69	111.31	31.48	29.95	581.71	A	1
A207	4.68	45.77	79.50	94.85	53.59	20.26	18.96	35.19	50.64	110.47	30.76	30.01	574.68	A	1
A208	5.36	46.97	80.12	98.68	53.74	21.25	18.93	34.52	52.02	109.31	30.55	29.43	580.88	A	1
A209	5.33	47.73	80.15	94.44	52.19	22.39	18.10	33.48	50.81	109.62	29.28	31.21	574.73	A	1
A210	5.38	50.40	76.50	95.14	54.80	20.90	18.53	34.94	52.22	108.61	30.59	30.55	578.56	A	1
A211	5.17	49.85	76.52	99.33	55.27	23.36	19.07	34.25	52.17	111.62	30.69	30.38	587.68	A	1
A212	5.65	50.32	80.19	98.25	53.32	22.99	18.32	33.37	50.48	110.73	29.61	30.09	583.32	A	1
A213	5.12	48.54	82.08	99.89	52.44	21.81	18.73	36.11	52.25	112.43	30.87	30.25	590.52	A	1
A214	5.66	48.10	80.97	97.69	52.04	22.36	18.17	33.88	50.31	110.63	30.31	30.70	580.82	A	1
A215	5.26	46.27	80.07	99.39	54.17	20.09	18.37	36.26	51.12	112.42	29.68	29.42	582.52	A	1
A216	4.98	49.18	77.13	99.29	55.62	22.24	18.55	33.94	52.13	110.68	30.18	29.93	583.85	A	1
A217	4.50	45.49	79.06	99.62	54.55	22.13	19.47	35.32	51.76	109.13	30.27	30.16	581.46	A	1
A218	5.16	45.47	82.29	99.59	53.18	20.89	19.60	35.92	51.32	109.60	29.67	30.90	583.59	A	1
A219	4.81	50.21	81.29	94.31	56.10	22.79	19.33	34.33	51.80	110.50	29.48	31.41	586.36	A	1
A220	4.73	46.99	81.94	94.52	53.21	21.16	18.31	35.06	50.30	110.65	30.17	29.71	576.75	A	1
A221	5.05	45.34	81.68	93.81	55.12	23.55	18.38	36.31	51.70	109.54	31.28	30.78	582.54	A	1
A222	5.50	47.71	79.68	94.48	54.67	21.42	18.49	33.26	51.25	109.46	29.90	29.60	575.42	A	1
A223	5.11	46.16	78.92	96.32	52.07	23.62	18.67	34.89	52.28	110.12	31.06	29.41	578.63	A	1
A224	5.40	48.02	82.87	95.00	54.42	23.57	19.23	36.28	52.49	111.98	30.95	31.28	591.49	A	1
A225	5.07	45.85	77.77	98.65	52.66	22.21	19.32	35.95	51.28	108.93	31.21	31.15	580.05	A	1
A226	5.38	45.93	81.27	95.40	55.10	23.70	19.56	34.98	52.19	111.53	30.16	30.63	585.83	A	1
A227	5.46	50.07	78.97	96.40	55.44	21.79	19.46	33.11	51.59	111.00	29.98	30.74	584.01	A	1
A228	5.37	45.96	79.74	98.44	53.82	22.86	19.32	33.17	50.59	109.75	30.46	31.14	580.62	A	1
A229	5.67	45.26	80.74	99.66	51.84	22.43	18.89	33.07	50.55	111.74	31.28	29.93	581.06	A	1
A230	5.15	49.75	78.80	96.91	53.07	21.44	19.81	35.15	51.56	111.53	31.15	31.00	585.32	A	1
A231	5.17	47.38	79.63	97.19	53.28	22.99	19.62	36.31	51.79	109.31	29.87	29.99	582.53	A	1
A232	4.79	50.36	78.10	96.85	53.11	22.13	18.63	35.39	52.12	112.20	30.93	29.70	584.31	A	1
A233	4.71	49.04	82.22	96.13	55.09	20.11	18.48	33.03	52.42	109.24	29.50	29.98	579.95	A	1
A234	4.69	49.21	76.86	97.36	53.78	22.30	19.46	33.00	51.72	109.18	31.04	31.31	579.91	A	1
A235	4.88	46.24	77.05	94.50	55.97	22.57	19.54	33.96	51.72	109.03	30.09	31.04	576.59	A	1
A236	4.50	47.69	79.65	96.97	54.50	21.10	17.82	35.89	51.30	111.31	29.63	30.93	581.29	A	1
A237	5.56	46.14	79.24	98.80	52.19	20.16	19.77	34.40	50.90	109.81	29.90	29.89	576.76	A	1
A238	5.51	45.11	79.44	93.84	53.66	23.05	18.78	36.15	50.57	110.71	29.75	30.11	576.68	A	1
A239	5.05	46.75	81.83	94.26	52.99	21.69	19.35	34.94	51.39	111.80	29.28	29.60	578.93	A	1
A240	4.94	45.78	79.00	98.43	53.08	21.07	18.62	35.67	52.42	112.18	30.40	29.91	581.50	A	1
A241	5.07	48.19	78.21	95.11	55.33	22.29	18.92	35.40	51.27	111.20	29.39	30.92	581.30	A	1
A242	5.43	48.08	78.95	98.62	55.92	22.03	18.68	35.41	50.54	109.22	31.16	31.44	585.48	A	1
A243	4.66	48.71	78.00	98.74	54.09	20.02	18.10	35.60	50.85	108.82	29.95	31.45	578.99	A	1
A244	4.50	50.41	78.57	98.61	52.44	20.18	19.72	33.06	50.41	109.30	30.25	29.52	576.97	A	1
A245	5.54	49.95	81.42	99.08	53.26	20.55	19.38	34.96	52.33	110.72	30.41	29.97	587.57	A	1
A246	5.46	49.10	77.90	95.57	52.67	21.55	18.77	33.97	50.43	112.39	29.93	29.35	577.09	A	1
A247	4.93	46.68	79.92	97.46	52.08	22.82	18.00	35.11	50.56	110.65	29.81	30.50	578.52	A	1
A248	5.36	46.77	77.38	94.51	54.99	22.32	19.75	36.45	50.98	110.08	29.91	29.45	577.95	A	1
A249	4.78	50.44	79.35	96.50	52.51	22.12	18.19	35.51	52.03	111.70	31.48	29.76	584.37	A	1

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A250	4.94	48.41	76.74	98.54	54.15	21.73	18.86	35.91	51.22	110.41	29.98	31.25	582.14	A	1
A251	4.96	46.01	77.23	95.80	54.27	21.78	18.06	33.30	51.59	109.76	30.35	29.90	573.01	A	1
A252	5.74	48.78	79.43	96.77	54.75	21.76	19.17	35.88	52.14	112.12	30.19	30.73	587.46	A	1
A253	4.54	45.96	79.11	93.97	55.04	22.37	18.29	34.19	52.20	109.95	29.52	30.10	575.24	A	1
A254	5.45	45.93	79.58	97.95	54.94	22.41	18.22	34.37	51.27	112.09	31.39	29.91	583.51	A	1
A255	4.67	49.32	77.81	95.70	53.45	22.82	19.35	33.52	50.51	112.46	30.12	30.10	579.83	A	1
A256	4.96	50.24	81.46	99.32	55.22	23.65	19.77	34.41	50.71	109.51	29.85	31.45	590.55	A	1
A257	5.67	48.69	77.14	96.59	52.99	20.06	18.51	34.81	50.27	111.44	29.82	31.47	577.46	A	1
A258	5.24	46.02	81.41	96.19	53.38	20.26	17.84	33.56	51.14	112.01	29.46	30.20	576.71	A	1
A259	5.30	45.23	76.74	97.85	54.74	22.87	19.14	33.26	50.99	109.13	29.72	29.71	574.68	A	1
A260	5.56	46.43	77.27	94.20	52.52	19.89	19.34	33.88	50.51	110.39	29.35	29.31	568.65	A	1
A261	4.88	47.26	81.42	98.62	55.15	23.41	19.47	35.59	51.78	109.70	29.31	30.49	587.08	A	1
A262	4.97	47.35	77.98	98.54	53.21	21.85	18.11	35.70	51.35	112.71	29.57	29.43	580.77	A	1
A263	5.21	47.23	76.81	98.83	53.05	23.49	18.81	36.29	50.49	111.22	31.31	30.68	583.42	A	1
A264	7.82	43.41	78.69	96.45	51.29	22.56	19.59	34.78	51.19	107.44	31.00	29.44	573.66	A	2
A265	7.79	47.18	79.39	96.78	55.01	19.90	18.83	33.80	51.84	107.34	31.19	31.32	580.37	A	2
A266	6.60	44.31	76.73	96.40	51.23	21.52	19.54	34.95	51.70	109.22	30.96	30.36	573.52	A	2
A267	7.00	44.56	82.99	94.05	53.62	22.11	19.22	34.67	51.49	110.55	31.48	30.01	581.75	A	2
A268	7.81	47.69	78.57	94.39	54.16	23.72	19.07	34.28	52.07	113.16	30.25	30.65	585.82	A	2
A269	7.80	45.90	82.39	96.74	52.65	22.19	19.63	33.25	50.70	111.01	31.05	30.20	583.51	A	2
A270	7.05	46.48	81.23	93.50	54.48	22.58	19.05	36.31	50.26	113.38	29.83	29.69	583.84	A	2
A271	6.67	46.67	76.48	94.35	53.89	23.26	19.04	36.49	51.73	111.65	31.36	29.75	581.34	A	2
A272	7.11	44.53	75.71	92.92	53.49	21.20	18.41	35.60	52.32	107.43	30.71	29.82	569.25	A	2
A273	7.11	47.92	77.85	98.69	51.19	20.26	18.03	34.38	50.96	109.94	30.46	29.46	576.25	A	2
A274	7.83	45.16	80.44	97.03	53.33	20.85	19.72	33.75	51.71	107.87	30.58	30.30	578.57	A	2
A275	7.06	47.16	76.36	94.15	52.84	21.61	19.29	35.45	51.68	112.18	29.76	30.32	577.86	A	2
A276	7.65	43.46	81.44	94.37	51.01	20.73	18.31	35.81	51.75	111.11	30.08	30.52	576.24	A	2
A277	7.45	43.43	81.11	94.22	54.31	21.71	19.35	35.94	51.68	109.40	29.41	30.71	578.72	A	2
A278	7.71	44.80	80.09	96.91	52.93	20.22	18.79	33.82	51.20	112.02	31.03	31.22	580.74	A	2
A279	7.67	47.37	82.00	94.02	50.90	20.38	18.16	34.51	51.02	110.12	29.77	30.31	576.23	A	2
A280	7.58	43.42	80.39	93.94	54.95	21.08	19.01	35.70	51.15	110.12	31.29	29.87	578.50	A	2
A281	7.48	46.54	82.89	93.21	53.47	21.46	19.12	35.61	51.12	109.33	31.14	31.08	582.45	A	2
A282	6.99	47.56	81.16	94.54	51.16	20.36	18.88	33.04	52.47	111.03	30.51	29.26	576.96	A	2
A283	6.75	45.60	80.01	96.25	52.31	22.05	18.44	35.64	52.23	107.24	30.15	31.16	577.83	A	2
A284	7.28	46.22	81.47	95.62	53.57	23.52	19.59	35.77	51.87	110.35	29.53	29.32	584.11	A	2
A285	6.82	46.38	77.96	93.50	52.59	22.76	19.31	34.94	51.37	108.63	31.01	30.91	576.18	A	2
A286	7.03	43.61	79.44	97.79	55.00	20.89	19.50	36.43	52.14	112.48	29.46	30.12	583.89	A	2
A287	7.75	47.87	80.96	99.08	54.89	22.73	19.11	35.22	52.34	109.96	31.30	31.29	592.50	A	2
A288	7.56	47.52	81.62	93.67	53.27	21.46	18.39	35.62	52.43	112.62	29.83	29.73	583.72	A	2
A289	6.57	46.52	81.68	96.87	53.77	23.58	18.27	35.88	52.06	109.36	29.44	30.42	584.42	A	2
A290	7.20	46.90	76.55	98.78	52.48	21.65	19.78	34.79	52.21	112.27	29.59	30.20	582.40	A	2
A291	7.88	43.89	75.51	96.68	54.29	23.67	18.08	33.77	50.52	110.52	31.21	29.89	575.91	A	2
A292	7.31	47.27	78.60	94.84	51.03	22.82	18.34	34.87	50.59	113.27	31.38	30.69	581.01	A	2
A293	7.03	47.39	79.93	97.08	52.97	20.84	18.33	36.19	50.77	109.47	30.06	30.19	580.25	A	2
A294	7.53	46.78	81.42	94.33	54.43	20.62	18.77	34.40	51.74	113.06	29.23	30.23	582.54	A	2
A295	7.91	45.33	79.87	96.48	53.67	21.46	19.34	33.47	51.38	108.79	30.20	29.73	577.63	A	2
A296	7.73	45.85	80.25	98.10	53.33	21.16	18.57	33.07	52.28	111.23	31.20	30.71	583.48	A	2
A297	6.57	44.87	82.88	93.24	52.58	21.56	19.49	36.26	50.53	109.51	30.36	30.82	578.67	A	2
A298	6.59	46.84	78.03	93.87	52.56	21.50	18.21	35.88	52.12	107.59	29.54	30.46	573.19	A	2
A299	7.98	44.12	82.32	93.59	54.04	21.20	18.31	33.04	50.85	108.53	29.87	29.26	573.11	A	2
A300	7.37	46.20	78.72	96.95	51.33	20.10	18.75	34.79	51.14	111.39	31.08	30.06	577.88	A	2
A301	6.65	43.44	79.48	95.20	52.74	20.53	17.96	36.11	51.15	111.18	29.71	30.12	574.27	A	2
A302	7.80	45.84	76.74	92.93	53.69	21.56	19.53	35.53	50.82	108.84	31.12	31.00	575.40	A	2
A303	7.66	47.91	77.83	94.41	54.40	22.01	19.69	35.69	52.43	111.60	30.52	29.91	584.06	A	2
A304	7.28	43.85	76.17	93.48	54.16	21.14	18.81	35.23	51.18	108.27	29.66	29.94	569.17	A	2
A305	7.72	43.72	82.07	95.92	52.83	23.15	18.24	36.12	50.72	110.06	29.98	29.73	580.26	A	2
A306	7.64	47.07	79.06	97.18	52.00	23.43	19.44	33.19	52.47	109.09	29.65	30.94	581.16	A	2
A307	7.19	45.35	76.94	93.99	55.07	21.04	18.75	34.04	50.97	113.10	29.76	29.50	575.70	A	2
A308	7.10	46.58	79.44	97.62	51.51	20.21	19.01	34.71	50.85	108.72	30.55	29.70	576.00	A	2
A309	7.11	47.63	81.57	97.91	51.11	22.39	18.78	33.47	51.94	109.05	29.54	29.86	580.36	A	2
A310	7.36	45.97	76.79	94.39	53.38	22.18	18.82	33.21	50.67	113.07	30.53	30.23	576.60	A	2
A311	7.17	45.33	76.07	97.07	52.75	21.46	19.02	36.45	50.72	109.78	31.21	30.54	577.57	A	2
A312	7.13	47.29	82.73	96.13	55.00	22.73	19.28	35.10	51.64	110.83	29.41	29.82	587.09	A	2
A313	7.56	46.28	75.87	98.14	54.52	23.53	19.70	34.06	50.71	109.54	30.74	29.69	580.34	A	2
A314	7.63	44.89	82.09	96.75	50.96	21.54	19.66	33.43	51.68	111.95	30.96	31.26	582.80	A	2
A315	6.85	45.62	76.23	99.17	52.77	19.90	18.03	35.63	51.47	111.29	30.67	30.00	577.63	A	2
A316	7.10	43.79	79.35	93.51	52.46	22.81	18.65	35.32	50.47	109.56	30.25	29.31	572.58	A	2
A317	7.38	44.09	80.52	94.66	54.66	22.25	19.01	34.94	50.47	108.52	29.70	31.07	577.27	A	2
A318	6.96	44.15	81.97	93.46	55.11	20.91	18.13	34.83	51.06	109.41	29.67	30.91	576.57	A	2
A319	7.10	45.61	76.88	96.74	52.86	20.86	19.54	34.99	50.25	110.48	30.06	30.37	575.74	A	2
A320	7.87	46.70	81.62	94.71	53.27	20.54	18.52	36.48	52.12	111.06	29.62	30.38	582.89	A	2
A321	7.10	46.71	78.71	93.50	53.45	19.94	17.91	34.41	50.65	111.10	31.36	30.19	575.03	A	2
A322	7.64	44.36	75.53	95.21	52.39	21.00	18.60	33.90	52.40	113.28	30.82	31.09	576.22	A	2
A323	6.79	45.20	80.58	96.15	51.08	21.64	19.54	34.18	50.99	112.96	30.45	30.95	580.51	A	2
A324	7.51	46.15	81.56	98.18	52.64	22.91	19.69	33.98	51.25	110.00	29.53	29.91	583.31	A	2
A325	7.04	46.49	79.66	96.13	52.53	20.65	18.27	35.76	52.18	110.33	31.35	29.58	579.97	A	2
A326	7.27	45.38	78.59	92.90	53.31	20.31	18.29	34.33	50.71	113.13	31.46	30.12	575.80	A	2
A327	7.92	46.57	82.85	94.88	53.13	23.49	19.59	35.00	51.55	109.28	29.90	30.21	584.37	A	2
A328	7.66	45.36	79.51	94.16	54.40	22.25	19.44	35.10	51.72	111.53	30.21	29.98	581.32	A	2
A329	6.78	43.25	75.53	96.18	52.09	21.42	18.42	35.97	51.77	112.70	30.76	30.26	575.13	A	2
A330	6.76	43.47	79.27	93.89	51.68	20.63	18.32	35.33	51.96	111.32	29.58	29.23	571.44	A	2
A331	6.64	46.16	79.63	94.88	52.01	23.13	18.94	35.28	50.36	112.63	30.94	30.02	580.62	A	2
A332	7.87	47.36	79.02	97.83	52.69	22.04	19.75	33.17	52.47	107.82	31.12	31.33	582.47	A	2

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A333	7.18	45.55	77.04	98.80	52.40	19.92	18.46	34.46	50.66	110.63	30.06	31.16	576.32	A	2
A334	7.51	44.72	80.66	98.27	52.77	19.87	18.27	35.31	51.07	107.73	30.82	29.40	576.40	A	2
A335	6.59	43.67	76.60	98.86	51.10	21.77	19.63	34.73	51.75	109.75	30.29	30.17	574.91	A	2
A336	6.68	43.11	78.85	97.97	54.16	20.87	19.67	36.46	52.42	109.72	29.76	30.76	580.43	A	2
A337	7.99	47.11	80.60	96.58	55.10	20.33	17.95	33.73	52.14	111.97	29.73	29.37	582.60	A	2
A338	7.74	47.57	81.89	93.81	54.56	22.80	18.77	33.59	50.55	112.86	31.49	30.34	585.97	A	2
A339	7.31	44.75	80.77	94.70	52.74	20.88	18.76	36.32	52.42	112.65	31.09	29.64	582.03	A	2
A340	7.89	43.24	75.90	95.70	53.49	20.18	18.19	33.84	50.56	110.86	31.40	30.08	571.33	A	2
A341	6.71	43.30	77.93	92.82	51.92	20.71	19.05	33.86	52.03	112.95	30.33	30.36	571.97	A	2
A342	7.98	44.36	76.53	95.07	52.17	21.84	19.33	34.13	51.63	112.52	30.89	30.91	577.36	A	2
A343	7.29	45.94	80.56	94.56	52.97	20.18	19.41	33.88	51.20	112.95	31.12	30.24	580.30	A	2
A344	7.29	43.59	75.51	93.47	50.87	22.08	18.81	35.82	51.55	111.47	31.29	30.81	572.56	A	2
A345	7.20	43.98	78.54	94.53	54.55	21.00	19.73	33.37	51.38	108.66	30.47	31.01	574.42	A	2
A346	7.94	44.40	76.24	93.86	52.41	22.51	18.07	35.52	50.37	112.11	29.33	30.70	573.46	A	2
A347	7.94	45.06	78.44	98.11	54.78	21.36	19.72	34.04	51.17	108.59	30.00	31.35	580.56	A	2
A348	7.86	46.08	79.77	98.18	53.22	22.99	19.15	34.30	51.60	107.80	31.11	29.86	581.92	A	2
A349	7.50	45.13	75.99	93.39	51.86	20.92	19.39	36.28	50.37	111.57	30.10	30.13	572.63	A	2
A350	7.09	46.64	77.38	94.02	51.47	22.40	19.27	36.27	50.94	107.59	31.33	30.06	574.46	A	2
A351	6.83	43.12	75.85	97.59	51.82	23.71	18.32	34.88	51.48	111.21	29.39	29.33	573.53	A	2
A352	7.13	46.55	82.51	98.98	51.34	22.24	18.84	36.19	51.74	107.61	29.64	31.29	584.06	A	2
A353	7.77	45.86	82.91	96.78	54.48	20.38	19.17	35.24	50.72	112.96	30.18	29.72	586.17	A	2
A354	7.90	44.01	78.41	96.95	52.31	22.45	18.44	36.34	51.93	108.03	29.75	30.62	577.14	A	2
A355	7.37	46.76	79.79	94.10	54.62	22.36	19.68	35.78	50.83	111.31	31.48	31.08	585.16	A	2
A356	7.35	47.50	78.59	98.36	54.30	20.84	19.34	34.57	50.45	108.18	30.14	31.40	581.02	A	2
A357	6.66	43.47	81.59	93.28	54.19	23.76	18.14	33.54	52.02	112.65	29.66	29.79	578.75	A	2
A358	7.21	46.18	79.87	98.62	51.85	21.90	19.26	35.19	51.76	108.55	31.43	29.99	581.81	A	2
A359	6.64	47.21	81.68	98.14	54.05	21.21	19.49	33.25	51.85	110.96	30.70	30.06	585.24	A	2
A360	7.85	43.54	79.26	93.26	54.94	22.86	18.33	35.11	50.42	112.67	29.46	30.97	578.67	A	2
A361	6.84	47.46	82.80	94.25	53.48	22.47	18.60	34.09	52.46	110.59	29.52	30.31	582.87	A	2
A362	7.82	46.04	76.72	94.57	53.22	22.34	18.49	33.00	50.40	108.05	30.42	30.61	571.68	A	2
A363	7.63	43.91	78.13	93.96	51.12	21.10	19.72	33.36	51.34	112.75	30.28	29.95	573.25	A	2
A364	7.70	46.71	81.93	95.59	51.19	20.56	19.76	35.87	52.38	110.38	30.97	31.03	584.07	A	2
A365	7.91	43.18	80.00	97.37	53.89	22.16	19.52	34.65	50.44	110.27	31.13	30.36	580.88	A	2
A366	7.42	47.55	77.21	93.43	53.16	20.39	18.57	35.69	51.95	110.26	29.46	29.64	574.73	A	2
A367	7.59	43.55	79.83	92.85	52.39	20.38	18.79	35.12	50.94	108.06	30.42	29.97	569.89	A	2
A368	7.16	46.61	81.34	94.78	50.82	20.23	18.72	35.75	51.39	110.68	29.42	29.35	576.25	A	2
A369	7.99	47.51	76.29	96.38	54.94	23.49	18.78	36.07	51.44	109.49	29.66	31.10	583.14	A	2
A370	7.21	46.05	77.66	92.88	54.57	21.22	18.08	34.34	52.00	108.55	29.59	29.91	572.06	A	2
A371	7.49	47.95	76.43	95.80	52.34	22.56	18.59	34.24	51.69	112.75	30.23	29.94	580.01	A	2
A372	6.66	47.21	78.46	96.07	53.98	20.03	19.56	36.25	51.76	110.78	30.13	31.43	582.32	A	2
A373	6.74	45.36	76.85	97.33	53.43	20.79	19.73	36.12	52.26	110.35	29.38	31.08	579.42	A	2
A374	6.71	43.97	82.77	94.54	54.93	22.20	18.04	34.09	50.31	107.59	31.12	30.59	576.86	A	2
A375	7.18	43.35	82.92	95.42	54.44	21.85	17.96	33.01	52.06	109.04	29.57	31.36	578.16	A	2
A376	6.58	46.28	77.45	97.70	51.28	23.35	19.77	35.62	50.73	108.47	30.91	29.29	577.43	A	2
A377	7.49	47.20	81.39	95.12	53.93	19.82	19.35	33.24	51.55	109.78	29.66	30.18	578.71	A	2
A378	7.73	43.41	81.70	94.17	55.10	20.70	19.46	34.89	51.79	109.42	30.42	30.73	579.52	A	2
A379	6.63	46.55	77.68	96.89	55.12	21.15	18.10	35.80	52.18	109.62	30.57	31.13	581.42	A	2
A380	7.27	47.59	78.52	95.62	54.37	22.85	19.51	33.87	52.46	111.26	29.87	30.84	584.03	A	2
A381	6.95	44.88	79.15	94.66	54.28	21.00	18.52	34.45	50.95	109.97	31.25	30.88	576.94	A	2
A382	7.68	45.28	81.59	94.91	50.81	22.92	18.18	35.18	52.04	108.32	30.09	29.71	576.71	A	2
A383	7.15	44.60	82.78	94.98	54.66	22.22	19.79	34.09	50.98	109.81	31.46	30.88	583.40	A	2
A384	7.85	44.25	81.49	97.10	51.09	22.98	18.12	33.54	51.82	113.25	30.93	30.06	582.48	A	2
A385	7.96	46.23	82.39	94.53	53.33	21.57	18.39	34.01	52.11	111.05	29.54	30.90	582.01	A	2
A386	6.56	46.14	82.60	93.91	53.72	20.32	19.47	34.75	52.46	109.74	31.06	30.85	581.58	A	2
A387	7.97	46.65	80.01	96.31	53.00	21.24	18.25	35.60	51.35	108.77	30.61	29.84	579.60	A	2
A388	7.22	44.86	81.41	93.50	54.07	20.37	19.01	36.22	50.86	108.83	29.44	30.52	576.31	A	2
A389	7.66	45.66	77.83	92.99	54.22	22.50	19.03	36.41	52.15	108.29	30.77	29.85	577.36	A	2
A390	7.78	44.09	76.24	97.71	54.53	21.13	19.44	35.79	51.04	111.78	30.91	30.99	581.43	A	2
A391	7.99	47.41	79.51	96.07	51.51	20.88	18.04	33.95	51.24	112.96	30.88	29.24	579.68	A	2
A392	7.55	44.53	79.23	97.67	53.32	23.64	19.60	34.40	50.83	108.29	30.31	31.15	580.52	A	2
A393	7.92	45.39	77.56	97.84	54.66	20.49	18.46	34.69	50.56	113.43	30.64	29.29	580.93	A	2
A394	7.97	46.02	79.86	95.06	53.71	21.09	19.22	35.69	50.79	108.92	31.23	31.39	580.95	A	2
A395	7.67	43.50	78.18	96.86	52.42	20.19	18.65	34.59	51.63	108.29	30.90	29.64	572.52	A	2
A396	6.73	47.58	75.70	98.83	54.59	20.35	18.59	34.28	50.24	108.44	30.16	29.90	575.39	A	2
A397	7.98	43.15	80.54	96.94	53.20	19.90	18.92	34.54	51.44	110.42	31.26	29.85	578.14	A	2
A398	7.29	46.52	80.37	96.56	53.88	20.48	17.85	35.92	51.81	108.12	30.90	30.91	580.61	A	2
A399	7.16	43.07	79.53	95.79	52.95	22.11	17.81	33.39	51.11	108.20	30.95	29.30	571.37	A	2
A400	7.90	44.28	79.20	94.39	55.12	23.67	18.97	34.00	50.87	112.66	31.42	29.88	582.36	A	2
A401	7.53	46.50	81.82	95.26	51.42	23.34	19.26	35.99	50.80	108.89	29.47	29.86	580.14	A	2
A402	7.60	47.14	81.11	93.97	53.83	21.91	18.17	34.78	51.92	107.69	30.13	30.73	578.98	A	2
A403	7.77	47.41	80.78	96.29	54.38	22.02	17.86	36.45	50.98	108.11	30.79	31.06	583.90	A	2
A404	7.72	46.08	77.04	95.89	54.11	21.06	18.16	35.96	50.82	112.89	30.25	29.85	579.83	A	2
A405	6.63	47.81	79.48	94.98	52.55	21.06	17.99	34.87	51.37	110.35	30.37	30.91	578.37	A	2
A406	7.62	43.74	82.25	93.68	53.75	20.95	19.34	34.53	52.32	111.76	30.96	29.74	580.64	A	2
A407	7.86	47.88	77.77	96.34	52.37	22.35	18.83	34.55	50.62	109.65	31.05	29.65	578.92	A	2
A408	6.55	45.33	77.24	95.99	53.03	20.87	18.09	35.97	50.65	108.22	29.89	29.34	571.17	A	2
A409	7.31	47.43	78.08	97.31	51.83	22.26	18.95	33.06	50.84	110.59	30.93	29.47	578.06	A	2
A410	7.95	47.14	82.38	95.07	54.43	21.09	18.34	35.89	50.24	113.01	30.95	31.01	587.50	A	2
A411	7.30	47.82	78.06	98.53	51.10	22.07	19.30	34.96	50.96	107.82	30.73	30.16	578.81	A	2
A412	6.62	47.74	76.91	98.93	54.28	20.24	19.23	33.47	51.02	112.15	30.03	29.40	580.02	A	2
A413	6.60	46.34	77.56	95.80	51.97	19.87	18.08	36.41	50.82	111.02	31.02	31.11	576.60	A	2
A414	7.20	45.58	79.17	93.77	52.96	23.33	18.91	34.34	52.18	111.03	30.21	31.38	580.06	A	2
A415	7.56	43.00	82.31	96.57	52.15	21.89	18.94	35.61	52.16	108.25	30.13	30.46	579.03	A	2

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A416	7.05	47.64	76.80	99.09	51.77	22.03	18.63	34.07	50.30	112.70	29.94	29.55	579.57	A	2
A417	6.55	46.98	76.09	93.97	54.43	20.28	17.90	34.05	50.37	111.48	31.38	29.55	573.03	A	2
A418	6.97	43.98	77.14	97.05	54.48	22.77	18.23	35.30	51.65	108.64	30.23	29.92	576.36	A	2
A419	7.26	47.49	76.71	96.31	53.02	21.99	17.88	34.70	51.97	111.04	29.96	30.42	578.75	A	2
A420	7.68	44.49	79.89	92.88	54.10	19.86	19.54	33.75	51.88	107.36	30.88	29.69	572.00	A	2
A421	7.21	47.55	81.21	95.19	53.81	21.19	18.55	33.29	51.30	107.93	31.05	31.05	579.33	A	2
A422	7.69	43.57	75.87	92.91	51.03	23.14	19.79	34.77	52.47	108.96	29.96	30.53	570.69	A	2
A423	7.06	44.81	82.27	96.04	54.00	20.74	18.18	34.05	51.53	107.57	29.40	31.40	577.05	A	2
A424	6.81	46.28	76.91	96.31	54.92	19.98	18.47	35.23	50.38	111.81	30.19	30.09	577.38	A	2
A425	6.76	45.63	76.07	94.98	51.65	20.86	18.79	35.97	51.02	109.09	30.11	29.27	570.20	A	2
A426	6.87	47.69	79.64	96.88	53.69	22.62	18.42	34.49	50.65	112.20	30.51	30.71	584.37	A	2
A427	6.78	45.63	78.62	94.95	54.34	20.76	18.77	36.30	51.34	110.91	29.37	30.57	578.34	A	2
A428	7.73	46.48	78.54	95.75	53.39	22.70	18.30	34.89	52.36	111.21	31.45	30.78	583.58	A	2
A429	7.02	45.10	75.74	99.08	53.48	20.28	18.52	35.11	50.99	108.42	29.41	31.38	574.53	A	2
A430	7.16	47.90	79.03	93.06	55.02	20.32	19.25	36.41	52.02	110.85	29.36	31.14	581.52	A	2
A431	6.99	43.97	80.64	94.28	52.70	23.34	18.49	34.83	50.37	107.54	30.42	29.32	572.89	A	2
A432	7.47	44.21	81.89	93.29	51.94	20.18	18.48	35.12	50.55	107.50	30.33	30.04	571.00	A	2
A433	7.36	45.24	77.58	96.58	52.64	21.24	18.07	35.07	51.95	108.77	31.46	30.99	576.95	A	2
A434	7.84	43.34	80.84	96.72	52.20	22.07	18.45	33.29	50.25	113.26	30.87	30.28	579.41	A	2
A435	7.14	44.31	77.99	98.25	52.65	22.91	18.41	36.21	50.77	112.98	30.68	30.27	582.57	A	2
A436	6.55	46.69	81.47	93.92	54.93	19.92	18.78	33.04	51.09	112.66	30.61	29.94	579.60	A	2
A437	6.74	46.57	78.97	94.96	52.88	23.69	18.54	34.58	51.23	107.24	31.32	30.94	577.66	A	2
A438	6.57	45.62	79.37	92.81	52.13	22.36	19.56	33.59	52.34	111.00	30.25	30.17	575.77	A	2
A439	6.74	44.65	77.47	98.12	54.32	19.87	18.72	34.50	50.71	111.56	30.34	30.16	577.16	A	2
A440	6.80	46.01	77.50	93.27	53.07	22.65	18.52	34.08	51.30	113.17	29.23	30.97	576.57	A	2
A441	7.88	43.00	78.73	98.07	53.90	21.43	18.54	33.99	51.85	109.00	30.78	30.31	577.48	A	2
A442	7.65	43.91	76.32	99.19	50.81	22.49	18.18	33.22	51.27	108.78	29.67	30.29	571.78	A	2
A443	7.90	46.87	77.59	97.24	53.15	22.38	18.58	35.28	50.48	109.61	29.86	30.68	579.62	A	2
A444	7.67	47.80	81.42	98.81	51.66	21.41	19.36	36.37	51.67	112.75	29.80	29.37	588.09	A	2
A445	6.83	43.72	82.15	94.81	51.18	21.19	18.39	33.15	52.32	112.33	31.47	31.29	578.83	A	2
A446	6.83	44.42	82.78	96.57	51.15	22.89	18.39	33.94	51.61	111.65	31.17	31.11	582.51	A	2
A447	7.88	47.85	75.69	96.92	51.69	22.83	19.13	33.51	51.48	108.67	29.31	30.04	575.00	A	2
A448	7.75	43.49	79.74	97.52	52.26	20.30	19.03	36.00	51.13	110.34	29.65	31.38	578.59	A	2
A449	7.53	46.44	76.85	93.70	51.68	20.47	19.56	34.80	52.16	110.40	30.50	31.29	575.38	A	2
A450	7.84	43.58	75.96	94.29	52.13	22.38	18.32	33.99	51.69	109.84	30.37	29.95	570.34	A	2
A451	6.53	47.27	76.67	93.31	51.48	22.12	19.77	35.49	51.89	110.67	31.44	29.62	576.26	A	2
A452	7.04	45.48	78.42	95.85	54.18	21.41	19.78	33.22	52.48	113.10	29.83	29.32	580.11	A	2
A453	7.83	47.34	79.15	93.34	54.20	22.75	18.45	33.18	50.62	112.15	29.53	29.98	578.52	A	2
A454	6.94	43.91	80.46	98.03	54.25	20.01	19.08	34.01	50.55	107.48	30.87	29.58	575.17	A	2
A455	7.42	47.24	78.12	96.84	52.84	21.40	19.32	33.61	50.81	113.13	29.43	29.86	580.02	A	2
A456	7.83	47.01	79.93	96.15	53.10	20.80	18.70	36.07	52.46	113.28	31.17	31.07	587.57	A	2
A457	7.03	45.61	76.77	92.93	52.19	22.53	18.06	34.43	51.31	108.05	30.11	29.57	568.59	A	2
A458	7.46	45.10	78.57	93.80	53.32	21.27	18.78	35.08	52.05	110.40	30.06	29.40	575.29	A	2
A459	6.92	45.23	80.81	95.77	53.64	21.17	19.71	35.50	50.37	111.85	29.65	30.74	581.36	A	2
A460	7.04	43.95	79.68	95.21	53.64	21.29	18.47	34.82	50.77	110.45	31.02	30.11	576.45	A	2
A461	6.78	46.19	82.35	96.46	54.56	20.21	18.95	33.43	50.76	113.49	30.43	31.28	584.89	A	2
A462	7.02	44.49	80.80	98.06	51.28	20.93	19.44	33.93	52.12	110.07	29.87	30.25	578.26	A	2
A463	6.73	43.35	80.07	95.99	51.03	21.54	17.99	35.19	51.03	109.54	31.32	30.14	573.92	A	2
A464	7.00	46.70	82.95	95.45	54.29	22.20	19.67	33.41	50.32	111.67	30.34	30.72	584.72	A	2
A465	7.58	47.04	82.65	95.23	52.49	20.87	19.50	35.70	51.11	111.98	29.85	29.41	583.41	A	2
A466	7.78	43.40	82.07	96.51	51.30	22.24	19.64	33.20	51.45	109.74	30.42	31.07	578.82	A	2
A467	7.51	46.03	78.97	97.12	54.17	19.86	17.97	35.54	51.21	111.23	30.87	30.39	580.87	A	2
A468	7.23	44.85	82.85	97.56	52.44	23.49	19.70	33.57	52.30	110.42	29.30	31.00	584.71	A	2
A469	7.70	43.03	80.58	97.06	52.48	22.35	19.20	35.18	51.69	111.35	29.37	31.05	581.04	A	2
A470	6.55	45.17	77.65	96.79	53.99	20.53	17.95	35.17	51.72	110.87	29.43	30.35	576.17	A	2
A471	6.64	47.77	76.91	94.68	54.08	23.29	17.93	36.42	52.21	111.08	29.47	30.07	580.55	A	2
A472	6.69	46.08	80.20	99.02	53.40	21.89	18.09	33.53	50.40	107.32	30.54	29.76	576.92	A	2
A473	6.56	44.11	80.03	96.73	51.87	21.92	18.75	35.54	51.66	111.31	30.88	29.28	578.64	A	2
A474	7.70	43.60	81.14	97.74	53.56	22.75	18.89	33.98	51.25	112.92	29.32	30.57	583.42	A	2
A475	7.45	46.51	79.02	96.77	50.87	20.87	19.73	34.88	50.62	112.29	30.21	29.36	578.58	A	2
A476	7.13	43.09	77.32	96.80	54.83	20.84	19.00	34.48	52.05	109.57	31.13	30.45	576.69	A	2
A477	7.33	45.18	82.69	93.92	52.09	22.93	17.93	34.39	50.67	108.79	29.36	31.32	576.60	A	2
A478	6.52	43.69	81.10	95.64	51.16	20.03	19.58	36.12	52.37	113.13	31.47	30.36	581.17	A	2
A479	7.49	47.51	79.47	98.43	51.84	20.52	19.63	33.45	50.68	108.13	29.85	30.79	577.79	A	2
A480	6.54	47.48	80.24	96.66	53.36	23.03	18.46	36.35	51.98	109.07	29.56	29.75	582.48	A	2
A481	6.88	45.29	78.25	94.20	51.56	22.26	18.58	34.60	50.64	110.84	31.36	30.77	575.23	A	2
A482	7.34	47.11	82.18	99.22	51.43	22.54	17.95	35.89	50.44	109.93	29.87	29.77	583.67	A	2
A483	6.73	47.80	77.35	96.61	52.59	21.83	18.32	33.04	50.34	111.36	30.21	30.16	576.34	A	2
A484	6.75	44.36	77.42	97.88	53.87	21.94	19.52	33.66	51.68	110.15	30.36	31.15	578.74	A	2
A485	7.86	44.92	82.70	93.22	54.76	23.81	19.54	34.31	50.67	112.68	31.01	29.45	584.93	A	2
A486	7.93	43.52	81.06	97.33	54.46	21.05	18.91	34.19	50.57	110.69	29.74	30.05	579.50	A	2
A487	7.41	44.22	76.41	93.76	53.35	23.07	19.77	33.43	51.05	109.53	31.23	29.26	572.49	A	2
A488	7.87	44.84	82.56	93.17	51.12	23.07	19.45	33.98	51.40	109.50	30.32	30.83	578.11	A	2
A489	7.06	47.19	79.20	98.62	54.83	22.28	17.93	34.38	51.63	109.82	29.94	31.02	583.90	A	2
A490	7.71	46.17	79.73	94.77	54.20	22.69	18.55	35.80	51.97	109.00	29.60	29.23	579.42	A	2
A491	6.68	47.04	82.38	94.16	53.54	20.96	17.84	34.85	51.44	112.37	30.95	29.66	581.87	A	2
A492	7.61	46.13	75.56	98.53	53.91	20.82	19.52	33.08	50.68	112.48	31.42	31.31	581.05	A	2
A493	7.76	43.47	76.34	97.93	54.48	21.15	19.67	35.64	50.80	108.03	30.30	31.09	576.66	A	2
A494	7.50	45.68	77.14	98.80	53.50	20.93	19.21	34.53	51.98	110.93	30.41	30.85	581.46	A	2
A495	6.52	43.73	80.42	95.27	53.33	22.84	19.44	33.78	51.22	111.43	29.62	29.49	577.09	A	2
A496	6.94	46.14	77.93	94.41	53.83	21.22	19.21	33.26	51.86	108.37	30.79	30.40	574.36	A	2
A497	7.55	44.06	76.57	94.51	53.67	22.84	18.37	33.09	52.48	112.13	30.21	30.07	575.55	A	2
A498	7.52	45.41	78.74	95.32	53.28	22.86	19.04	36.37	51.17	112.26	30.80	31.25	584.02	A	2

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A499	7.68	45.55	78.47	97.92	53.73	21.45	19.49	36.12	51.34	109.99	30.71	30.73	583.18	A	2
A500	6.72	44.21	77.07	96.02	55.03	21.33	18.01	35.78	50.78	110.75	29.41	31.11	576.22	A	2
A501	7.57	46.97	80.72	97.38	52.23	20.16	18.96	35.31	52.22	112.91	29.39	30.02	583.84	A	2
A502	7.57	47.95	81.71	93.06	53.32	21.82	18.52	33.21	50.96	109.45	31.05	30.99	579.61	A	2
A503	7.27	45.60	76.16	93.31	52.75	20.73	19.30	36.15	51.53	112.59	30.72	30.24	576.35	A	2
A504	7.93	47.92	81.90	93.91	50.88	23.36	19.12	34.23	50.61	109.72	29.93	30.31	579.82	A	2
A505	6.78	44.64	78.54	93.33	55.03	19.97	18.78	36.22	52.25	111.73	29.96	29.69	576.92	A	2
A506	6.79	44.79	76.38	93.99	54.88	21.86	18.61	35.50	50.71	112.10	30.21	31.32	577.14	A	2
A507	7.00	44.95	78.42	93.56	53.97	20.16	19.63	36.22	51.83	107.79	30.07	30.07	573.67	A	2
A508	7.39	46.23	81.62	93.43	51.29	20.75	17.95	33.48	51.39	112.72	30.27	30.82	577.34	A	2
A509	6.52	44.34	75.82	96.02	54.09	20.74	18.12	36.04	52.35	107.62	29.58	29.86	571.10	A	2
A510	7.25	46.04	78.20	93.09	53.92	22.76	19.00	35.01	50.94	110.89	30.78	30.06	577.94	A	2
A511	6.87	43.77	75.61	96.63	51.77	20.08	18.92	35.91	52.35	110.74	30.95	29.88	573.48	A	2
A512	6.77	44.13	75.73	98.49	53.74	21.11	19.81	35.47	50.64	112.04	29.48	30.31	577.72	A	2
A513	7.53	45.18	75.77	96.91	52.90	23.03	19.50	34.62	51.86	111.87	31.16	30.82	581.15	A	2
A514	7.69	43.42	82.22	95.58	53.19	22.88	19.29	33.00	51.44	112.99	31.21	29.67	582.58	A	2
A515	7.96	47.40	77.58	95.62	52.40	22.75	19.47	33.85	52.36	112.19	30.91	30.26	582.75	A	2
A516	6.52	46.08	76.24	97.26	52.42	20.79	18.57	33.49	51.76	107.29	30.54	30.34	571.30	A	2
A517	7.02	47.31	78.87	93.82	51.62	21.96	18.18	34.94	50.28	113.36	30.94	31.20	579.50	A	2
A518	7.30	45.77	75.91	94.02	53.53	20.71	19.53	35.33	52.13	108.59	30.62	31.18	574.62	A	2
A519	7.36	47.56	79.88	96.33	51.30	23.37	18.91	34.26	51.97	110.16	29.30	30.01	580.41	A	2
A520	6.84	44.18	81.22	97.12	54.98	23.38	18.91	34.36	50.44	113.44	30.94	31.24	587.05	A	2
A521	7.46	45.00	79.25	98.42	50.88	20.95	19.12	34.13	52.34	112.52	31.07	29.59	580.73	A	2
A522	6.66	43.77	79.38	94.98	50.90	19.81	18.34	35.32	52.42	112.63	29.50	30.88	574.59	A	2
A523	7.69	45.10	78.14	93.56	51.25	20.40	18.57	36.21	51.48	111.30	29.31	29.41	572.42	A	2
A524	6.75	44.74	80.98	94.86	54.19	22.96	18.57	33.55	50.92	111.96	30.75	29.40	579.63	A	2
A525	6.51	44.82	81.17	98.73	54.56	20.73	18.91	35.55	51.78	109.15	30.93	29.91	582.75	A	2
A526	7.12	43.90	81.63	93.92	53.01	23.82	18.99	34.21	52.37	110.39	30.35	30.02	579.73	A	2
A527	10.17	44.56	79.95	95.83	51.45	21.64	19.43	33.16	52.17	110.18	30.16	29.62	578.32	A	3
A528	10.16	44.64	75.55	94.36	53.68	22.83	18.50	34.00	50.63	108.52	30.35	31.27	574.49	A	3
A529	10.22	43.45	76.32	96.46	52.42	21.67	19.57	35.51	51.85	108.37	30.56	30.66	577.06	A	3
A530	10.50	44.73	77.61	98.71	53.22	21.80	18.02	35.81	51.25	111.07	30.32	31.20	584.24	A	3
A531	10.67	44.26	76.43	96.33	54.44	20.87	19.28	35.84	52.42	108.83	29.31	29.76	578.44	A	3
A532	9.56	43.00	79.84	97.35	50.92	20.69	19.30	34.87	51.81	109.30	31.23	29.63	577.50	A	3
A533	10.97	44.76	82.57	97.23	54.19	20.85	17.89	36.34	51.45	111.93	30.70	31.17	590.05	A	3
A534	9.96	43.98	79.08	94.82	54.34	23.03	19.37	34.90	52.40	108.80	29.64	31.41	581.73	A	3
A535	10.32	45.84	77.66	94.14	52.41	21.43	18.72	34.27	51.26	112.57	30.89	30.91	580.42	A	3
A536	10.22	45.86	77.03	93.12	51.44	21.38	19.75	33.14	52.23	108.35	29.75	30.91	573.18	A	3
A537	10.34	45.11	80.36	94.02	51.13	21.67	18.85	33.66	50.73	110.24	31.15	30.27	577.53	A	3
A538	9.50	43.29	81.44	94.34	54.76	20.82	19.26	36.33	50.28	110.82	30.40	29.90	581.14	A	3
A539	10.09	43.76	75.64	93.07	52.36	20.68	18.13	35.50	50.70	110.45	29.62	30.04	570.04	A	3
A540	10.78	43.23	80.03	96.35	52.56	21.39	18.73	35.05	52.29	110.99	29.81	31.15	582.36	A	3
A541	10.33	44.75	79.88	98.78	54.96	19.99	19.21	36.34	51.98	110.99	31.08	29.67	587.96	A	3
A542	10.58	44.57	80.40	96.16	55.06	21.08	19.41	35.16	50.64	109.85	29.77	29.88	582.56	A	3
A543	10.56	45.22	76.75	95.49	53.23	22.89	19.13	35.70	51.55	110.80	30.65	29.25	581.22	A	3
A544	9.63	44.71	82.62	95.77	54.21	21.88	19.02	33.77	51.98	109.39	30.24	30.14	583.36	A	3
A545	10.08	45.67	77.87	94.24	54.94	20.03	19.72	35.58	52.06	108.39	30.65	30.22	579.45	A	3
A546	9.75	44.91	80.74	94.58	51.77	19.86	19.00	33.24	51.85	109.28	30.14	29.98	575.10	A	3
A547	10.33	45.95	77.73	93.59	52.35	22.96	18.71	33.93	51.15	111.32	29.53	30.87	578.42	A	3
A548	10.04	44.10	76.63	96.43	54.48	20.62	19.63	34.95	51.93	108.39	31.39	30.32	578.91	A	3
A549	10.75	44.63	81.58	95.98	54.33	22.02	19.42	33.72	50.71	111.14	30.59	30.58	585.45	A	3
A550	10.07	43.52	76.81	98.12	54.75	23.53	19.68	34.79	50.55	112.37	31.18	30.03	585.40	A	3
A551	10.28	43.94	75.95	98.61	53.86	22.36	17.95	35.50	51.14	108.55	30.76	30.94	579.84	A	3
A552	9.93	43.16	80.69	94.85	50.86	20.94	19.52	33.89	51.47	112.47	31.39	31.25	580.42	A	3
A553	10.00	45.06	79.79	96.63	52.10	20.22	18.35	35.97	50.32	110.65	29.38	30.52	578.99	A	3
A554	10.29	44.18	78.20	96.87	51.80	22.76	18.03	35.55	50.86	109.63	29.81	31.12	579.10	A	3
A555	9.62	45.84	76.08	95.42	51.77	21.50	18.06	33.22	51.57	108.98	31.24	29.51	572.81	A	3
A556	9.72	43.61	82.65	97.35	53.39	23.65	19.21	35.63	52.32	112.10	30.05	30.25	589.93	A	3
A557	10.32	43.06	78.92	95.97	53.34	20.31	18.96	33.51	51.75	109.30	30.89	30.74	577.07	A	3
A558	10.15	45.90	77.10	96.50	51.35	23.36	18.87	34.12	50.46	108.88	31.12	31.37	579.18	A	3
A559	9.57	43.00	79.72	98.04	51.71	22.79	18.21	33.04	50.71	109.38	30.72	30.60	577.49	A	3
A560	9.97	45.32	76.45	98.31	54.20	22.10	18.95	35.04	51.88	110.19	31.08	29.98	583.47	A	3
A561	9.52	43.07	76.36	96.27	53.78	22.48	17.84	35.76	50.63	110.47	29.81	31.26	577.25	A	3
A562	9.54	45.83	78.11	95.79	50.98	21.51	18.16	36.04	51.40	111.46	31.15	30.61	580.58	A	3
A563	9.85	45.39	80.60	94.54	54.72	20.92	18.10	34.96	50.34	111.70	30.01	29.85	580.98	A	3
A564	9.86	44.58	77.49	98.19	54.71	20.13	19.77	36.41	50.47	108.69	31.48	30.74	582.52	A	3
A565	9.71	45.75	80.93	96.04	53.45	21.27	19.16	34.00	50.67	110.59	29.75	31.05	582.37	A	3
A566	10.31	45.78	82.79	95.44	54.23	21.33	18.33	34.09	52.08	108.54	31.39	30.64	584.95	A	3
A567	9.96	43.08	79.87	96.20	53.86	20.85	18.45	35.56	51.88	109.86	31.14	29.95	580.66	A	3
A568	9.78	45.62	80.80	98.21	51.63	23.69	18.75	33.43	50.49	107.71	30.71	31.12	581.94	A	3
A569	10.99	44.47	80.39	98.33	52.66	22.30	19.73	35.92	50.78	111.03	30.93	29.51	587.04	A	3
A570	10.62	43.38	78.09	94.65	51.31	22.76	19.12	33.26	51.70	111.44	29.69	30.21	576.23	A	3
A571	10.03	45.63	81.17	93.61	51.62	21.46	18.58	33.73	51.90	109.39	29.64	31.25	578.01	A	3
A572	10.32	44.42	78.22	92.81	53.73	21.03	17.93	35.22	51.71	108.03	30.47	29.59	573.48	A	3
A573	10.74	45.35	76.75	95.84	53.61	20.24	18.28	33.56	51.07	110.05	29.72	31.24	576.45	A	3
A574	10.61	45.03	82.81	95.74	52.51	21.91	18.85	33.36	50.40	109.01	30.96	31.27	582.46	A	3
A575	9.94	45.19	81.60	98.49	54.25	21.73	19.02	35.89	51.17	112.13	31.48	30.57	591.46	A	3
A576	10.54	44.62	75.73	96.49	51.13	23.82	19.08	36.27	50.90	111.10	29.63	30.99	580.30	A	3
A577	10.34	44.18	79.72	93.18	52.16	23.22	17.83	35.25	51.80	108.20	30.26	29.86	576.00	A	3
A578	9.94	44.35	76.09	96.87	54.02	21.70	19.18	35.02	52.30	108.14	29.51	30.98	578.10	A	3
A579	9.65	45.45	81.29	93.44	50.86	23.72	18.74	34.63	50.32	108.44	30.27	30.39	577.20	A	3
A580	10.79	43.02	76.69	93.26	54.06	20.43	19.58	35.25	52.19	109.42	29.38	30.43	574.50	A	3
A581	9.64	45.36	78.78	95.64	53.45	21.65	18.08	36.17	51.42	110.85	30.04	29.49	580.57	A	3

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A582	10.07	44.11	78.71	98.60	52.22	21.81	19.52	36.01	51.16	110.28	29.29	29.72	581.50	A	3
A583	10.04	43.38	77.37	96.06	52.97	20.91	17.99	35.16	52.06	112.09	31.22	31.35	580.60	A	3
A584	10.51	44.19	82.45	95.75	54.17	20.62	18.69	35.07	50.89	109.57	30.91	30.40	583.22	A	3
A585	9.95	45.18	82.12	94.93	53.59	20.48	19.50	33.89	51.57	111.74	31.24	30.21	584.40	A	3
A586	9.91	45.80	78.89	98.13	52.60	23.18	18.69	35.31	51.36	108.45	30.61	31.27	584.20	A	3
A587	10.49	44.23	79.24	97.46	52.85	20.03	18.04	35.95	51.36	106.94	30.41	29.46	576.46	A	3
A588	9.59	44.16	80.35	94.33	52.77	23.45	19.49	34.48	52.16	110.05	29.28	29.98	580.09	A	3
A589	10.19	43.91	78.44	95.15	52.16	22.77	18.18	33.10	51.10	109.64	30.93	30.86	576.43	A	3
A590	10.93	45.27	77.35	98.64	52.94	23.71	18.03	34.90	50.29	109.97	29.36	29.40	580.79	A	3
A591	9.55	45.09	80.28	97.71	53.25	23.21	18.04	36.06	50.76	110.35	30.70	30.58	585.58	A	3
A592	10.56	43.51	79.31	94.81	54.38	23.52	19.15	36.49	51.71	109.34	30.20	29.63	582.61	A	3
A593	10.18	43.23	80.61	94.18	52.49	20.40	19.21	34.34	50.96	108.47	29.83	29.61	573.51	A	3
A594	9.70	43.39	81.32	95.39	55.06	20.67	19.01	33.32	51.20	109.15	31.15	31.17	580.53	A	3
A595	10.99	43.97	77.10	97.31	52.80	20.91	18.97	34.33	51.11	108.50	30.31	30.75	577.05	A	3
A596	9.75	43.46	76.53	92.99	51.75	23.55	19.11	35.64	51.00	110.65	29.46	31.18	575.07	A	3
A597	10.86	44.69	81.74	96.20	52.93	20.83	18.71	36.23	51.88	111.83	29.61	29.59	585.10	A	3
A598	10.76	43.38	76.98	98.49	52.88	22.97	17.97	36.07	50.67	109.82	29.64	30.05	579.68	A	3
A599	10.87	44.04	79.09	96.56	53.87	21.18	18.01	33.60	50.61	108.72	30.03	30.69	577.27	A	3
A600	9.68	45.60	79.73	94.56	52.67	20.67	19.01	34.27	50.58	109.89	29.57	30.38	576.61	A	3
A601	10.66	45.48	75.77	93.38	54.99	23.66	18.12	35.32	50.80	109.64	29.46	30.51	577.79	A	3
A602	10.21	43.21	76.04	94.88	52.92	20.48	18.70	33.33	50.48	112.99	30.75	30.97	574.96	A	3
A603	9.55	44.36	77.65	97.30	53.27	22.95	19.52	36.07	51.04	112.43	31.17	30.58	585.89	A	3
A604	9.55	43.86	79.69	97.88	52.52	22.67	19.10	36.18	52.26	110.41	30.54	30.97	585.63	A	3
A605	9.96	44.16	78.02	96.49	51.50	20.30	18.38	33.45	50.37	108.19	31.31	30.97	573.10	A	3
A606	9.97	45.90	79.89	99.15	53.77	22.14	17.95	34.00	52.40	112.45	30.72	31.42	589.76	A	3
A607	10.22	43.52	78.61	93.81	54.25	21.40	18.22	35.28	51.92	108.75	29.41	30.58	575.97	A	3
A608	9.52	43.89	82.51	93.56	54.98	22.29	18.19	35.67	50.89	107.89	31.27	31.39	582.05	A	3
A609	10.54	44.34	75.65	96.93	51.95	21.32	19.35	36.38	51.02	112.35	31.04	30.16	581.03	A	3
A610	10.85	44.56	82.55	93.34	51.75	23.42	19.24	33.00	51.00	109.21	31.39	31.13	581.44	A	3
A611	10.53	43.15	76.36	97.34	51.11	20.44	19.43	33.22	50.74	111.62	29.48	31.23	574.65	A	3
A612	10.19	43.60	76.42	92.97	50.98	20.89	18.25	34.95	50.71	110.93	29.88	30.30	570.07	A	3
A613	10.83	44.50	82.55	96.24	54.37	22.86	18.85	34.67	50.59	110.74	30.16	29.51	585.87	A	3
A614	10.36	43.07	75.96	98.47	54.97	20.19	18.07	35.50	51.69	108.82	30.07	29.98	577.15	A	3
A615	10.13	43.55	79.23	96.82	53.78	23.09	19.51	35.46	50.68	109.19	29.45	30.96	581.85	A	3
A616	10.92	45.97	79.48	94.52	53.43	20.72	18.47	35.24	52.26	110.32	31.27	31.13	583.73	A	3
A617	9.92	43.62	82.74	93.49	53.16	21.51	19.70	35.21	51.94	111.36	29.32	29.60	581.57	A	3
A618	10.93	44.76	76.43	98.68	50.94	21.59	18.10	35.13	52.36	107.95	31.36	30.58	578.81	A	3
A619	9.53	44.57	77.45	97.69	51.06	23.32	18.58	33.64	50.90	110.00	30.08	29.77	576.59	A	3
A620	10.84	45.68	82.06	93.39	54.77	21.19	18.95	36.13	50.82	110.83	31.37	29.42	585.45	A	3
A621	9.62	45.26	77.15	96.13	53.70	21.58	19.27	35.30	50.29	109.29	29.64	31.25	578.48	A	3
A622	10.00	45.32	79.78	93.22	53.43	22.22	19.13	36.18	52.18	110.58	29.66	30.47	582.17	A	3
A623	9.93	44.40	82.35	93.09	50.97	20.41	17.91	34.57	51.80	111.34	29.34	31.00	577.11	A	3
A624	10.25	44.86	80.82	93.89	52.90	21.42	18.81	33.76	52.18	112.74	29.86	29.50	580.99	A	3
A625	10.67	43.59	80.06	93.14	53.60	23.43	18.45	35.52	51.86	111.90	30.08	29.34	581.64	A	3
A626	9.88	45.24	81.34	97.32	52.02	21.26	18.42	35.36	50.78	110.84	29.64	30.52	582.62	A	3
A627	9.89	45.90	76.75	93.89	51.20	20.05	18.90	34.54	50.75	107.74	30.25	29.75	569.61	A	3
A628	10.16	44.07	82.31	96.42	53.88	20.89	18.58	35.52	51.85	107.96	31.08	30.57	583.29	A	3
A629	10.20	45.79	77.13	98.72	51.34	22.43	19.74	34.04	51.76	110.89	31.41	29.80	583.25	A	3
A630	10.07	45.97	77.63	93.19	54.31	22.26	18.60	33.44	50.74	111.32	31.20	29.65	578.38	A	3
A631	9.98	44.34	76.23	93.81	55.02	22.82	18.49	36.20	52.48	108.22	31.48	31.26	580.33	A	3
A632	10.40	44.73	78.59	95.88	51.14	20.37	17.95	33.91	51.56	112.48	30.92	31.19	579.12	A	3
A633	10.79	43.31	81.41	98.70	53.38	22.14	18.87	34.01	51.94	108.84	31.40	30.49	585.28	A	3
A634	10.03	44.83	82.81	94.34	54.10	23.41	19.67	34.63	50.83	109.69	31.45	31.10	586.89	A	3
A635	9.74	45.03	81.19	95.26	50.87	22.54	17.80	33.71	51.88	110.03	31.18	29.55	578.78	A	3
A636	9.76	43.65	82.19	93.82	53.05	20.75	18.73	35.55	50.23	110.43	31.24	29.32	578.72	A	3
A637	10.13	44.55	81.90	94.11	53.17	22.53	18.51	36.15	50.85	112.23	30.24	31.43	585.80	A	3
A638	9.96	45.69	79.81	94.21	50.93	23.18	19.56	33.43	50.45	112.15	31.08	29.83	580.28	A	3
A639	9.92	44.81	82.76	95.35	54.31	20.65	18.01	34.97	51.50	109.26	30.41	30.79	582.74	A	3
A640	10.53	43.31	81.37	97.37	51.42	20.87	18.61	35.45	50.23	110.48	30.66	29.44	579.74	A	3
A641	10.37	43.25	80.29	95.53	54.36	20.78	18.87	35.11	50.77	110.41	30.37	30.38	580.49	A	3
A642	10.24	45.02	81.07	97.38	51.61	23.57	19.40	35.84	51.10	111.98	29.83	30.24	587.28	A	3
A643	10.76	43.37	80.97	98.74	53.34	22.61	17.95	35.10	50.76	108.91	29.30	31.01	582.82	A	3
A644	10.31	45.12	81.30	96.88	54.78	23.63	19.76	35.35	50.90	110.90	30.19	29.86	588.98	A	3
A645	10.37	43.54	79.02	95.98	52.36	21.18	19.19	35.53	51.58	110.16	29.50	30.44	578.85	A	3
A646	9.75	45.22	77.24	96.05	53.11	21.81	19.78	35.66	51.35	108.88	30.41	29.40	578.66	A	3
A647	9.81	43.70	76.52	98.17	53.28	23.45	19.72	35.82	52.43	109.72	29.53	29.65	581.80	A	3
A648	9.69	43.30	77.87	98.93	52.08	20.21	19.57	33.46	50.90	112.00	30.51	29.68	578.20	A	3
A649	10.34	43.21	79.17	97.81	55.06	22.13	19.36	36.47	51.74	109.23	31.14	30.10	585.76	A	3
A650	10.67	44.51	80.97	97.44	53.43	22.07	17.96	35.67	50.42	111.53	29.94	29.32	583.93	A	3
A651	10.62	43.84	77.37	93.36	53.32	21.25	19.55	33.73	51.46	109.10	29.92	30.29	573.81	A	3
A652	9.72	44.78	82.57	92.94	54.33	21.64	18.95	34.89	51.48	110.97	29.61	30.77	582.65	A	3
A653	9.78	43.77	76.36	94.25	50.83	20.77	17.91	35.08	52.18	111.31	30.93	30.25	573.42	A	3
A654	10.72	44.26	76.83	97.92	52.14	21.44	18.84	33.45	50.63	108.70	30.17	29.61	574.71	A	3
A655	9.59	44.42	79.94	94.88	52.68	22.18	19.38	33.81	50.91	108.10	29.72	30.45	576.06	A	3
A656	9.62	45.67	77.68	96.25	51.67	23.41	18.28	34.97	52.21	109.20	31.15	29.47	579.58	A	3
A657	10.60	44.11	81.23	98.62	53.61	22.64	18.95	34.53	52.35	109.64	30.22	30.60	587.10	A	3
A658	10.32	43.67	82.65	94.41	51.33	23.43	18.21	34.80	50.65	110.41	29.74	31.13	580.75	A	3
A659	10.51	43.33	79.94	95.41	53.19	22.86	19.06	34.95	51.72	107.73	30.48	30.99	580.17	A	3
A660	10.45	45.14	81.52	98.01	53.52	22.93	19.55	33.61	50.81	109.10	29.81	29.69	584.14	A	3
A661	10.56	43.14	75.64	95.74	53.78	21.52	19.26	33.84	51.62	110.29	31.21	30.60	577.20	A	3
A662	10.57	44.34	82.90	98.19	53.69	23.14	19.82	35.76	52.13	111.39	29.67	29.84	591.44	A	3
A663	10.39	43.19	77.75	96.19	53.46	22.53	17.92	33.62	51.49	108.56	29.23	29.96	574.29	A	3
A664	10.08	43.59	77.72	97.17	53.25	22.84	18.40	33.66	51.43	111.61	29.67	29.78	579.20	A	3

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A665	10.68	43.67	76.30	99.18	53.32	22.41	18.68	35.51	51.54	109.95	29.84	29.84	580.92	A	3
A666	10.35	45.57	75.60	95.69	52.86	21.29	18.26	36.34	51.62	112.12	30.25	31.19	581.14	A	3
A667	9.57	44.05	78.19	93.78	51.86	21.79	18.60	34.68	52.29	111.19	30.66	30.99	577.65	A	3
A668	10.42	45.06	81.69	95.97	52.24	22.54	18.60	36.41	50.92	111.48	29.26	30.75	585.34	A	3
A669	10.06	43.89	82.53	98.31	52.85	21.47	19.80	33.30	51.64	112.58	29.78	31.21	587.42	A	3
A670	9.69	43.75	79.66	98.46	51.73	20.78	18.64	33.40	51.87	110.20	30.95	30.59	579.72	A	3
A671	10.70	43.52	82.62	97.56	53.94	23.21	18.20	36.38	50.55	110.44	31.05	31.16	589.33	A	3
A672	10.06	45.86	79.37	97.48	54.44	23.42	18.67	36.39	50.36	108.08	29.62	30.40	584.15	A	3
A673	10.82	44.60	78.36	95.75	54.43	23.29	18.24	36.40	50.86	108.73	30.14	29.37	580.99	A	3
A674	9.87	43.44	76.16	95.23	51.37	21.74	18.84	33.48	50.23	109.52	29.83	29.80	569.51	A	3
A675	10.79	45.22	79.67	94.12	52.46	22.67	19.35	34.86	52.30	111.85	31.14	30.61	585.04	A	3
A676	10.37	43.52	75.74	97.79	52.08	21.14	19.58	33.63	51.78	108.24	29.79	30.90	574.56	A	3
A677	10.71	43.35	78.61	98.45	55.01	22.81	18.93	35.99	51.52	112.53	30.85	30.30	589.06	A	3
A678	9.76	43.95	81.18	99.04	53.36	23.41	18.70	36.04	52.37	110.90	31.18	29.86	589.75	A	3
A679	9.51	44.31	79.05	96.14	54.11	20.37	18.16	34.83	50.73	108.68	31.49	30.79	578.17	A	3
A680	10.60	44.67	77.09	93.73	50.97	22.44	19.19	33.27	51.79	107.20	31.15	29.70	571.80	A	3
A681	10.47	47.06	79.10	93.38	55.03	23.59	18.10	34.31	50.81	108.60	30.10	30.23	580.78	A	3
A682	10.47	43.52	77.11	97.22	53.85	23.22	19.15	34.67	51.83	109.84	29.25	30.70	580.83	A	3
A683	10.66	43.09	77.58	95.76	52.85	20.09	19.32	36.36	50.73	108.22	29.58	30.96	575.20	A	3
A684	10.16	43.39	75.81	96.90	52.86	19.93	18.59	35.22	51.02	109.56	29.87	29.25	572.56	A	3
A685	10.66	43.12	80.56	93.38	52.31	21.60	18.43	36.30	52.49	111.25	30.50	29.72	580.32	A	3
A686	10.74	43.85	77.83	97.12	55.07	20.13	18.09	36.32	51.00	111.23	31.26	31.38	584.02	A	3
A687	9.75	43.82	81.45	98.93	52.78	22.35	19.32	35.31	51.22	110.61	30.33	30.16	586.03	A	3
A688	9.80	44.23	75.51	98.81	51.33	22.16	19.63	34.58	51.12	109.23	29.49	30.00	575.89	A	3
A689	10.35	45.16	78.68	98.33	52.69	21.36	17.89	35.17	51.69	112.41	29.67	29.95	583.35	A	3
A690	10.81	44.72	77.89	97.08	51.89	19.81	18.56	34.79	51.64	110.85	30.66	31.40	580.10	A	3
A691	9.93	45.66	76.31	96.10	54.87	22.78	18.26	35.51	52.19	109.83	30.78	29.97	582.19	A	3
A692	10.40	44.67	81.28	93.01	53.49	22.25	19.19	35.10	50.67	111.48	31.14	30.51	583.19	A	3
A693	10.88	43.29	79.87	98.23	53.78	23.61	19.46	35.40	51.38	109.37	31.00	30.82	587.09	A	3
A694	10.78	45.63	79.06	96.68	54.02	20.32	19.22	34.98	51.85	109.52	31.17	31.23	584.46	A	3
A695	10.54	44.10	76.87	97.98	53.37	21.00	18.82	34.08	50.97	110.34	31.06	29.63	578.76	A	3
A696	9.93	43.81	77.55	98.32	53.73	20.68	18.23	35.21	52.22	110.12	30.58	30.63	581.01	A	3
A697	10.81	45.84	81.94	95.15	52.41	21.94	18.57	33.49	52.27	111.99	30.19	31.33	585.93	A	3
A698	10.10	43.28	82.48	95.55	51.37	21.41	17.90	36.00	50.93	109.96	30.73	30.10	579.81	A	3
A699	10.78	45.62	75.51	94.41	52.42	21.14	18.13	34.40	52.31	110.08	29.73	29.44	573.97	A	3
A700	9.93	45.00	82.41	97.08	53.54	23.44	19.22	35.73	50.27	111.05	29.71	30.15	587.53	A	3
A701	10.47	47.69	75.50	98.75	54.86	20.22	18.78	34.28	50.91	110.89	29.94	30.78	583.07	A	3
A702	9.77	45.56	76.29	93.29	52.80	21.70	18.85	34.82	51.19	112.29	30.97	29.97	577.50	A	3
A703	10.73	44.82	78.25	94.37	53.63	21.00	19.27	35.49	51.18	109.16	30.62	29.33	577.85	A	3
A704	9.58	44.92	76.68	94.74	51.43	20.51	17.88	36.25	50.69	112.15	29.82	29.52	574.17	A	3
A705	10.77	45.79	82.68	98.08	52.99	22.19	18.70	35.72	51.65	111.54	30.57	30.94	591.62	A	3
A706	9.98	43.55	79.00	94.47	53.31	20.11	18.77	35.44	51.65	111.81	30.22	30.48	578.79	A	3
A707	9.69	44.10	78.14	93.82	55.00	22.83	18.85	33.84	51.94	110.02	31.34	30.80	580.37	A	3
A708	10.00	43.71	80.82	96.81	51.18	21.81	18.89	34.24	50.85	108.10	31.15	29.91	577.47	A	3
A709	9.78	43.12	81.78	98.82	53.12	22.37	18.33	36.18	50.26	109.72	31.40	30.86	585.74	A	3
A710	10.38	45.65	81.66	94.69	54.82	22.36	18.57	33.22	52.08	110.61	29.27	31.00	584.31	A	3
A711	10.98	44.54	78.50	96.23	53.75	22.33	17.95	34.90	51.90	108.86	31.04	31.18	582.16	A	3
A712	9.65	45.01	79.81	93.06	52.72	21.93	19.69	34.27	51.01	111.91	30.64	30.87	580.57	A	3
A713	10.74	45.75	80.24	93.46	54.68	21.21	19.74	36.37	52.45	112.98	30.50	29.48	587.60	A	3
A714	10.65	43.44	78.68	95.80	53.62	21.49	18.50	35.59	52.16	112.47	30.75	30.57	583.72	A	3
A715	10.58	43.78	77.95	97.17	51.17	23.77	18.96	33.47	51.36	109.61	31.21	31.34	580.37	A	3
A716	10.05	44.08	76.83	93.19	54.15	23.28	19.01	36.47	52.15	108.57	29.86	30.31	577.95	A	3
A717	10.28	44.84	81.42	97.85	51.46	20.45	19.43	33.77	51.75	111.31	29.75	29.28	581.59	A	3
A718	10.51	43.48	80.81	98.25	53.36	22.83	18.42	34.18	50.51	111.98	31.10	29.41	584.84	A	3
A719	10.24	43.34	77.48	93.30	52.57	23.60	19.81	35.12	50.98	107.41	29.31	31.02	574.18	A	3
A720	10.48	43.37	80.15	98.96	53.27	23.61	19.08	34.34	51.61	111.05	31.41	29.48	586.81	A	3
A721	10.60	45.15	77.08	93.38	54.24	23.52	18.15	34.25	51.94	108.28	30.32	29.47	576.38	A	3
A722	10.90	44.39	79.37	94.05	54.57	21.34	19.11	34.49	51.13	110.71	29.93	29.67	579.66	A	3
A723	10.92	43.73	78.29	96.79	53.24	23.35	19.36	36.28	51.06	110.47	29.90	30.88	584.27	A	3
A724	9.55	45.06	78.36	97.68	52.28	22.59	18.47	33.84	51.50	110.35	29.96	30.55	580.19	A	3
A725	9.75	45.20	82.31	97.44	54.76	20.95	17.88	33.17	50.84	107.93	31.39	31.26	582.88	A	3
A726	10.93	43.44	82.33	97.63	54.82	20.07	18.22	34.22	51.01	108.78	29.51	29.43	580.39	A	3
A727	10.29	43.19	81.54	95.94	53.94	23.06	18.10	35.83	52.22	110.98	30.56	29.54	585.19	A	3
A728	10.13	45.48	76.99	97.17	52.19	19.91	17.94	36.27	52.29	110.01	29.61	29.50	577.49	A	3
A729	9.59	44.72	77.44	96.08	51.51	20.89	18.88	34.37	52.20	112.25	29.26	29.68	576.87	A	3
A730	10.14	43.29	78.55	94.70	51.60	22.92	18.37	35.52	51.92	109.86	30.23	29.91	577.01	A	3
A731	9.57	43.67	79.93	93.58	53.53	22.73	17.99	33.98	50.85	110.42	31.18	31.16	578.59	A	3
A732	10.30	43.22	79.84	94.49	54.76	23.12	19.25	35.48	51.86	108.27	30.57	30.49	581.65	A	3
A733	10.81	44.41	82.37	97.99	51.64	21.01	18.39	35.99	51.79	110.38	31.48	29.58	585.84	A	3
A734	9.57	43.69	78.41	98.72	54.64	23.38	17.94	34.28	51.00	110.34	31.30	30.98	584.25	A	3
A735	10.31	45.31	81.03	94.31	54.37	20.21	19.52	35.92	51.67	110.20	30.46	31.47	584.78	A	3
A736	9.81	45.80	78.77	97.96	52.51	22.29	18.98	33.78	50.71	107.70	31.39	29.52	579.22	A	3
A737	10.43	44.95	77.62	95.81	52.41	20.77	19.37	36.29	51.65	109.74	29.30	30.61	578.95	A	3
A738	9.69	44.23	76.56	97.24	52.75	21.33	19.10	35.85	50.48	112.29	30.00	30.40	579.92	A	3
A739	10.94	44.68	80.59	97.08	52.91	23.35	19.13	34.15	52.46	108.25	31.00	30.84	585.38	A	3
A740	10.86	45.46	80.82	97.05	52.49	20.42	18.17	33.25	51.24	110.24	30.31	30.34	580.65	A	3
A741	9.97	44.87	79.78	95.28	52.52	23.52	18.77	35.98	51.21	108.65	30.38	29.90	580.83	A	3
A742	10.30	43.54	77.71	93.24	51.14	23.82	18.09	33.22	51.36	109.69	30.10	30.65	572.86	A	3
A743	10.11	43.37	77.47	98.57	51.61	21.07	18.43	33.58	52.47	109.43	31.18	31.00	578.29	A	3
A744	9.87	44.33	78.39	96.96	51.02	21.41	19.10	34.67	52.38	111.98	30.56	30.18	580.85	A	3
A745	10.39	45.05	75.95	96.39	54.73	22.88	19.70	33.27	51.63	111.83	30.16	30.40	582.38	A	3
A746	10.93	43.27	80.74	98.60	53.76	21.04	17.87	33.39	51.46	109.53	30.01	29.83	580.43	A	3
A747	10.00	44.93	81.00	95.59	53.98	22.89	18.85	34.57	51.34	110.85	30.36	30.67	585.03	A	3

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A748	9.59	44.16	82.50	98.17	51.71	20.96	19.60	36.00	52.24	111.30	31.20	31.14	588.57	A	3
A749	10.13	44.12	76.54	95.17	52.81	22.34	19.69	35.44	50.65	112.41	31.45	30.13	580.88	A	3
A750	9.69	45.18	79.70	93.27	51.96	23.10	19.53	33.71	51.62	109.28	29.30	31.06	577.40	A	3
A751	10.87	43.13	82.43	95.75	54.01	21.29	19.26	33.35	51.53	111.66	30.00	30.44	583.72	A	3
A752	10.93	45.69	78.12	96.37	52.06	21.66	18.54	35.89	51.12	111.50	31.31	30.44	583.63	A	3
A753	10.70	45.81	78.72	95.14	54.72	23.45	19.15	35.05	51.08	111.99	30.60	31.48	587.89	A	3
A754	10.06	44.34	77.26	98.77	51.81	23.22	19.43	36.36	50.37	111.83	29.78	29.75	582.98	A	3
A755	9.97	45.24	80.96	96.18	53.79	20.83	19.59	36.24	52.24	112.23	31.00	30.68	588.95	A	3
A756	10.33	45.97	77.07	93.62	53.00	22.48	17.91	33.29	50.87	109.28	29.81	31.15	574.78	A	3
A757	10.03	43.88	77.15	94.99	54.71	20.65	18.64	35.83	51.90	110.16	30.71	30.23	578.88	A	3
A758	10.34	44.41	77.75	97.45	52.67	21.60	18.07	35.08	51.94	109.38	30.15	30.53	579.37	A	3
A759	10.98	45.38	81.48	96.52	51.57	20.84	19.80	36.45	52.43	111.88	29.51	30.49	587.33	A	3
A760	9.76	42.52	79.46	95.30	50.99	23.43	18.88	33.55	51.67	109.39	29.99	29.45	574.39	A	3
A761	10.53	45.00	78.06	99.03	54.93	21.72	17.89	33.56	50.52	108.40	29.51	29.63	578.78	A	3
A762	10.93	45.11	79.85	95.31	52.79	21.60	18.46	36.38	50.41	108.04	29.68	29.38	577.94	A	3
A763	10.82	45.60	75.65	98.62	53.34	19.87	19.53	34.05	52.23	111.23	29.91	29.52	580.37	A	3
A764	9.96	45.48	76.75	94.04	50.92	22.05	19.08	35.14	51.92	111.84	30.65	30.67	578.50	A	3
A765	10.92	45.46	76.08	93.45	51.53	20.73	18.40	33.76	50.27	112.28	29.43	29.25	571.56	A	3
A766	9.59	45.05	79.27	98.53	51.05	22.04	17.91	35.78	51.98	111.95	31.10	30.57	584.82	A	3
A767	10.77	45.06	82.75	94.47	51.16	20.57	19.43	35.05	50.53	109.41	31.45	29.74	580.39	A	3
A768	10.31	43.08	77.37	98.07	52.81	19.89	17.90	35.50	52.35	108.93	29.99	29.66	575.86	A	3
A769	10.99	43.51	75.88	99.12	54.98	22.02	19.39	34.48	51.54	110.20	29.35	29.41	580.87	A	3
A770	9.64	43.36	80.98	98.58	50.87	22.78	18.62	33.63	51.74	107.60	29.99	29.72	577.51	A	3
A771	9.55	44.41	78.09	92.88	53.37	20.50	18.08	33.17	51.20	112.05	30.19	31.29	574.78	A	3
A772	9.54	43.03	81.74	97.78	52.25	20.90	18.02	35.58	51.92	108.57	30.29	29.84	579.46	A	3
A773	9.81	44.51	77.55	95.99	51.25	23.56	19.28	34.79	51.98	108.03	30.76	30.96	578.47	A	3
A774	10.04	43.44	80.12	93.92	53.93	21.86	17.95	34.63	51.21	111.71	30.31	30.42	579.54	A	3
A775	10.67	44.11	77.61	98.89	51.99	20.58	18.24	36.02	51.82	112.60	29.58	30.98	583.09	A	3
A776	10.18	45.45	75.74	96.39	51.69	23.05	18.21	35.83	50.96	108.58	31.15	30.25	577.48	A	3
A777	9.56	43.28	78.94	93.53	51.33	23.76	18.05	33.31	50.34	108.72	30.27	29.99	571.08	A	3
A778	10.18	43.30	81.59	98.91	54.66	23.45	19.03	33.89	51.05	106.78	31.41	30.86	585.11	A	3
A779	10.88	45.29	76.72	99.23	52.44	20.05	18.27	33.32	50.98	109.15	30.96	30.35	577.64	A	3
A780	10.86	43.12	77.41	98.18	54.77	22.06	18.82	33.87	52.33	108.04	30.57	30.89	580.92	A	3
A781	9.80	43.36	76.09	93.52	53.76	22.76	19.79	35.59	52.09	109.92	29.44	30.90	577.02	A	3
A782	9.84	44.26	76.02	94.84	54.50	21.68	18.18	34.02	50.73	107.32	31.00	30.62	573.01	A	3
A783	10.08	43.14	78.13	96.39	51.82	19.86	17.87	34.94	52.36	108.14	29.24	31.27	573.24	A	3
A784	10.86	45.89	81.29	97.53	53.84	22.97	19.06	36.26	50.73	108.59	29.27	30.53	586.82	A	3
A785	9.80	44.32	76.91	95.39	53.03	23.57	19.42	33.18	52.16	107.32	31.30	31.42	577.82	A	3
A786	10.58	44.80	82.62	98.57	51.77	19.90	18.47	33.31	51.04	107.78	30.08	29.65	578.57	A	3
A787	10.21	44.25	76.17	94.29	53.44	23.55	19.14	33.49	51.39	110.95	30.51	30.36	577.75	A	3
A788	10.71	45.18	81.93	99.05	52.79	20.25	19.18	36.02	52.40	110.05	29.87	30.90	588.33	A	3
A789	10.70	44.51	80.94	95.51	52.69	21.78	19.34	33.66	51.76	106.46	31.43	30.39	579.17	A	3
A790	10.55	43.77	78.90	97.01	50.89	20.29	18.75	34.45	51.87	107.07	30.33	31.45	575.33	A	3
A791	18.29	43.67	75.54	94.47	54.44	23.76	18.38	33.19	50.74	108.48	30.10	30.58	581.64	A	4
A792	20.04	45.51	81.78	95.79	51.13	21.09	18.82	33.23	51.70	111.04	30.34	30.13	590.60	A	4
A793	18.04	45.68	79.46	98.09	51.38	21.52	19.82	35.07	52.29	110.64	31.41	29.52	592.92	A	4
A794	18.48	44.04	80.12	93.49	51.83	22.94	18.43	35.72	51.62	111.14	29.98	30.12	587.91	A	4
A795	20.46	43.24	82.07	96.95	53.79	22.13	19.32	33.32	52.35	109.58	30.02	30.42	593.65	A	4
A796	19.06	42.97	75.63	94.52	52.46	22.14	17.98	35.61	50.58	109.76	31.10	29.93	581.74	A	4
A797	18.25	44.92	79.20	96.12	51.22	23.10	19.74	35.67	51.68	110.49	29.79	29.33	589.51	A	4
A798	18.98	44.52	76.44	96.74	52.50	21.16	18.10	33.57	51.75	108.60	29.91	30.08	582.35	A	4
A799	18.29	45.91	76.07	93.09	52.04	20.00	18.10	34.37	50.43	109.69	30.21	29.96	578.16	A	4
A800	19.93	45.89	78.08	96.16	51.05	22.26	19.71	34.43	51.65	110.73	31.23	29.39	590.51	A	4
A801	18.73	43.09	76.72	95.38	53.03	23.32	18.53	36.08	51.65	111.96	29.50	30.49	588.48	A	4
A802	18.64	43.91	75.89	94.85	53.95	23.12	18.97	35.28	51.85	111.04	31.02	31.14	589.66	A	4
A803	19.01	43.73	77.08	94.64	53.70	20.70	19.58	34.14	51.03	109.18	30.46	30.28	583.53	A	4
A804	18.52	44.38	80.51	97.04	52.82	23.23	18.44	34.79	52.09	112.78	30.58	30.22	595.40	A	4
A805	19.97	45.58	77.55	94.46	51.36	20.60	19.59	34.89	50.88	110.37	31.06	30.16	586.47	A	4
A806	18.26	43.79	81.02	98.70	53.51	22.03	18.73	35.16	51.92	110.96	31.06	31.09	596.23	A	4
A807	18.96	44.71	77.22	98.62	52.65	21.47	18.15	33.58	51.07	108.49	31.24	30.03	586.19	A	4
A808	19.15	44.93	77.29	92.88	53.56	23.00	17.95	36.27	51.62	109.11	30.67	30.33	586.76	A	4
A809	20.47	44.22	81.94	95.98	52.18	21.44	18.97	33.87	51.45	109.56	31.30	30.43	591.81	A	4
A810	19.01	43.14	76.37	97.30	52.33	20.91	17.81	35.15	50.65	109.40	29.86	30.30	582.23	A	4
A811	18.00	45.37	78.49	98.04	52.32	21.74	19.17	35.30	51.67	111.42	30.43	29.45	591.40	A	4
A812	19.96	45.26	80.90	94.26	54.11	22.58	19.03	35.51	52.26	108.54	29.52	30.69	592.62	A	4
A813	19.18	45.84	81.54	95.75	51.71	22.40	19.48	35.29	50.69	108.47	31.28	29.92	591.55	A	4
A814	19.75	45.72	81.61	98.31	51.90	21.54	19.35	35.82	52.09	108.15	29.86	29.94	594.04	A	4
A815	19.46	43.00	82.41	97.90	54.68	21.29	18.58	35.09	52.44	109.08	31.12	30.69	595.74	A	4
A816	20.46	44.85	81.77	99.23	53.28	22.02	19.24	34.12	52.45	110.11	30.97	31.17	599.67	A	4
A817	19.46	44.10	76.32	96.33	54.12	20.60	18.89	33.95	50.69	110.06	29.92	29.83	584.27	A	4
A818	18.93	43.94	77.12	94.97	52.41	21.85	19.12	35.01	50.48	112.23	30.08	29.75	585.89	A	4
A819	19.93	45.69	75.94	95.20	54.16	22.88	18.23	36.09	52.31	111.76	29.59	30.89	592.67	A	4
A820	18.96	43.24	82.04	97.78	51.05	20.17	18.24	33.22	51.07	108.33	30.08	29.27	583.45	A	4
A821	19.22	44.12	81.65	93.70	52.09	21.68	18.87	33.67	51.90	108.49	31.09	30.37	586.85	A	4
A822	19.92	44.25	82.55	99.16	52.09	22.68	19.06	36.42	51.33	109.88	29.82	29.75	596.91	A	4
A823	20.39	43.65	79.29	95.49	54.69	23.59	19.72	34.77	51.98	110.07	30.77	30.78	595.19	A	4
A824	18.64	43.17	82.48	94.33	53.41	20.47	19.15	35.17	50.87	109.69	29.80	31.40	588.58	A	4
A825	20.21	45.99	79.67	97.22	53.03	20.06	18.19	35.39	51.95	109.33	30.07	30.23	591.34	A	4
A826	19.98	45.64	76.29	97.24	50.95	21.46	17.96	36.42	52.01	106.39	31.05	30.96	586.35	A	4
A827	20.34	45.95	76.27	97.05	51.84	22.95	19.04	35.44	50.75	110.97	30.12	29.71	590.43	A	4
A828	18.78	43.16	76.86	93.71	51.23	22.74	18.14	35.95	52.42	108.75	29.55	30.11	581.40	A	4
A829	19.46	45.91	75.51	97.04	54.40	22.93	19.61	33.54	52.11	109.63	29.36	30.11	589.61	A	4
A830	18.07	44.49	78.95	95.47	51.12	23.63	17.81	34.24	52.25	109.74	29.87	31.41	587.05	A	4

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A831	18.71	43.53	75.87	93.72	52.07	22.82	19.79	34.78	50.74	112.27	30.28	31.17	585.75	A	4
A832	19.47	44.52	80.09	96.27	54.72	22.25	18.51	33.93	51.42	111.46	29.44	29.61	591.69	A	4
A833	20.06	44.40	80.62	97.13	52.86	23.57	19.57	34.20	50.25	108.48	30.12	30.78	592.04	A	4
A834	18.21	43.74	77.53	95.11	54.70	20.63	18.57	35.98	50.92	110.73	29.65	31.39	587.16	A	4
A835	19.61	44.19	81.48	93.79	54.91	19.90	18.65	34.01	51.60	109.25	31.22	30.81	589.42	A	4
A836	19.82	45.12	81.73	94.10	53.66	21.27	19.34	33.71	50.32	109.83	30.30	29.44	588.64	A	4
A837	18.51	45.11	77.33	95.52	52.29	23.59	18.38	33.13	52.20	108.13	30.86	29.50	584.55	A	4
A838	18.88	43.47	80.98	98.50	51.46	20.02	19.50	33.12	50.36	108.85	30.98	31.46	587.58	A	4
A839	18.32	44.80	82.69	96.07	53.96	21.43	19.15	34.62	51.79	109.59	30.62	30.42	593.46	A	4
A840	19.17	44.47	79.37	94.18	53.39	20.43	18.83	36.17	50.58	106.99	30.07	30.28	583.93	A	4
A841	19.61	45.15	79.60	93.13	54.94	20.71	19.37	35.71	51.88	109.95	30.42	30.38	590.85	A	4
A842	19.89	43.60	80.63	96.36	51.14	21.38	18.00	36.23	51.89	112.36	30.50	29.47	591.45	A	4
A843	18.36	43.54	79.46	95.57	52.13	23.58	18.70	34.37	52.04	110.17	31.03	31.30	590.25	A	4
A844	20.49	44.14	81.88	92.87	53.82	21.01	18.27	35.21	51.91	106.81	31.37	30.82	588.60	A	4
A845	19.25	43.96	78.19	97.99	51.64	21.09	18.56	36.24	52.13	112.01	30.49	30.52	592.07	A	4
A846	19.81	44.23	75.95	97.71	54.67	19.89	19.32	35.16	51.94	110.20	30.80	30.47	590.15	A	4
A847	18.03	45.59	75.94	98.58	54.73	22.88	18.20	33.92	51.45	111.76	30.88	30.48	592.44	A	4
A848	19.28	43.41	82.47	95.12	53.12	23.61	19.66	33.68	50.24	110.27	29.56	29.33	589.75	A	4
A849	19.58	45.73	77.80	98.20	52.98	23.31	19.19	33.91	51.80	109.21	29.57	31.21	592.49	A	4
A850	20.41	43.36	80.09	94.93	53.50	23.08	19.12	36.39	50.47	107.92	31.10	30.62	590.99	A	4
A851	18.73	45.02	80.06	94.24	53.51	21.53	19.20	34.08	51.16	110.50	31.04	31.21	590.28	A	4
A852	19.70	45.67	77.66	94.44	54.57	23.37	19.41	35.44	52.11	112.33	31.24	30.70	596.64	A	4
A853	20.11	43.93	76.39	95.21	53.23	20.55	18.54	35.08	52.30	110.42	30.20	30.91	586.87	A	4
A854	20.29	43.27	77.93	93.96	52.63	21.32	19.57	34.67	50.35	112.43	30.11	29.98	586.51	A	4
A855	20.27	44.97	81.18	94.87	53.10	19.96	17.86	34.21	50.78	111.99	29.80	31.14	590.13	A	4
A856	19.52	45.58	77.76	93.00	51.28	19.99	18.41	34.90	50.36	110.95	31.34	30.80	583.89	A	4
A857	18.06	44.63	78.90	96.08	53.88	21.89	19.11	36.47	50.69	111.46	30.46	31.09	592.72	A	4
A858	18.65	43.35	80.01	96.67	52.42	21.86	19.30	33.35	51.83	109.21	30.03	29.62	586.30	A	4
A859	19.53	44.48	78.17	98.72	51.56	22.11	19.71	33.43	52.13	112.29	31.23	31.37	594.73	A	4
A860	18.81	44.46	77.73	95.26	52.08	20.99	18.80	34.77	50.49	108.25	29.94	29.42	581.00	A	4
A861	19.30	44.62	76.49	95.45	51.26	21.82	19.32	33.78	51.61	110.63	29.35	30.94	584.57	A	4
A862	18.92	44.22	79.94	93.99	52.75	20.06	18.16	34.99	50.70	109.89	29.85	30.31	583.78	A	4
A863	18.21	44.19	82.31	94.37	53.62	23.07	19.50	33.10	50.61	109.29	29.54	30.33	588.14	A	4
A864	19.11	45.76	79.60	96.42	51.17	22.93	18.99	35.59	51.06	109.55	30.33	29.36	589.87	A	4
A865	18.65	43.53	82.13	94.45	52.59	22.05	18.11	34.54	51.54	110.06	31.31	31.41	590.37	A	4
A866	19.75	44.49	77.22	97.47	53.65	20.34	19.32	36.21	51.07	109.46	30.30	30.27	589.55	A	4
A867	18.49	45.09	75.58	96.42	54.32	21.03	18.31	34.71	51.56	109.41	31.31	30.28	586.51	A	4
A868	19.75	43.39	80.44	98.92	54.19	20.88	17.89	33.18	50.41	108.18	31.08	30.64	588.95	A	4
A869	19.56	43.06	80.77	93.36	52.51	19.86	19.33	33.10	50.82	110.99	29.31	29.74	582.41	A	4
A870	18.68	43.27	78.96	97.15	53.86	22.21	19.15	34.38	50.84	108.15	30.45	30.07	587.17	A	4
A871	20.02	45.75	78.06	98.02	54.74	23.08	19.60	34.81	51.37	109.91	29.79	31.25	596.40	A	4
A872	19.42	43.67	78.51	96.05	54.69	20.95	19.65	35.65	52.20	112.76	29.63	30.35	593.53	A	4
A873	19.91	44.83	75.71	93.73	52.84	21.76	19.45	36.43	50.53	110.61	30.48	30.44	586.72	A	4
A874	18.25	45.14	81.83	94.63	52.44	20.73	17.98	34.99	52.43	110.65	30.02	31.45	590.54	A	4
A875	19.69	45.56	80.67	93.66	51.83	22.41	18.43	35.50	50.99	112.03	29.97	30.07	590.81	A	4
A876	18.26	44.54	81.89	98.30	54.73	21.69	19.82	36.49	50.25	110.28	30.94	31.07	598.26	A	4
A877	19.25	45.81	77.59	95.40	51.77	20.23	18.70	36.49	50.36	112.46	29.79	31.39	589.24	A	4
A878	18.36	44.09	79.92	93.72	51.76	21.40	19.22	36.48	50.55	110.20	31.47	30.38	587.55	A	4
A879	19.68	45.24	81.68	94.44	51.36	22.22	19.42	36.23	51.72	109.10	30.34	30.68	592.11	A	4
A880	18.62	44.88	78.80	97.85	51.17	22.08	18.43	33.00	50.55	106.60	31.00	30.44	583.42	A	4
A881	19.64	43.96	81.61	95.50	54.03	21.46	19.42	33.46	51.38	110.88	29.81	29.55	590.70	A	4
A882	18.04	45.15	81.65	94.37	53.74	21.91	19.19	33.67	51.90	108.73	31.14	31.01	590.50	A	4
A883	20.19	43.94	80.83	93.20	53.95	23.65	19.11	34.57	50.55	109.53	29.93	30.70	590.15	A	4
A884	19.26	45.58	77.80	95.44	51.23	23.31	18.72	35.27	51.03	110.80	31.37	29.49	589.30	A	4
A885	19.59	44.52	77.05	93.58	54.31	22.12	19.79	35.05	51.23	112.29	30.91	31.40	591.84	A	4
A886	19.35	43.68	81.32	95.44	50.82	21.20	17.94	35.12	51.90	111.59	29.67	29.76	587.79	A	4
A887	20.09	45.84	77.05	95.16	53.39	21.59	17.84	35.70	51.63	111.10	30.58	29.27	589.24	A	4
A888	18.20	44.58	81.71	96.16	51.43	20.47	19.50	33.98	50.74	107.56	30.92	29.44	584.69	A	4
A889	19.06	45.61	81.08	98.00	51.60	21.74	19.30	36.44	50.69	109.31	30.11	29.32	592.26	A	4
A890	20.15	43.98	76.89	98.88	54.93	20.40	19.54	33.67	52.33	106.91	31.39	29.38	588.45	A	4
A891	19.83	44.55	75.84	98.79	51.79	22.33	19.57	34.50	52.17	107.60	30.69	29.23	586.89	A	4
A892	18.41	44.44	75.94	97.74	52.67	20.47	18.71	35.03	51.67	112.38	31.26	30.68	589.40	A	4
A893	19.38	44.36	80.14	92.97	51.14	21.36	18.26	34.02	52.32	107.02	29.41	29.81	580.19	A	4
A894	18.45	44.89	81.54	95.09	53.94	22.45	19.64	33.40	51.59	110.85	31.26	29.32	592.42	A	4
A895	19.09	43.68	79.40	96.18	54.31	22.77	18.40	35.68	50.23	109.58	30.20	29.56	589.08	A	4
A896	20.21	44.74	80.28	98.77	54.81	20.55	19.41	35.84	52.25	112.35	31.18	30.31	600.70	A	4
A897	20.10	45.82	79.29	98.44	52.04	23.18	17.82	34.94	51.43	109.97	30.06	29.67	592.76	A	4
A898	19.30	43.84	80.48	95.25	54.87	20.19	18.94	34.22	50.77	107.22	30.47	30.04	585.59	A	4
A899	18.66	45.45	79.66	93.85	54.34	19.86	18.44	33.34	50.90	108.15	30.31	29.48	582.44	A	4
A900	19.91	45.06	75.98	99.13	51.77	20.94	18.02	34.32	51.72	112.35	31.30	30.51	591.01	A	4
A901	19.51	45.77	76.14	98.23	52.14	21.75	19.76	36.48	51.57	108.87	31.22	29.41	590.85	A	4
A902	20.06	43.93	79.19	98.46	54.95	23.36	19.59	33.60	52.37	111.14	30.02	31.16	597.83	A	4
A903	18.73	45.95	75.80	94.65	52.21	21.23	19.04	34.92	52.10	110.17	29.75	30.59	585.14	A	4
A904	19.26	44.67	81.56	93.60	53.85	22.77	18.29	33.71	50.77	111.33	30.63	30.73	591.17	A	4
A905	18.56	44.67	81.92	93.01	54.56	22.25	18.61	33.21	51.50	109.08	31.43	30.00	588.80	A	4
A906	19.29	44.23	80.61	98.51	52.30	20.83	19.16	33.25	50.45	109.77	29.84	29.49	587.73	A	4
A907	20.23	43.07	75.51	95.28	52.17	23.48	19.06	36.23	51.36	109.49	31.23	30.60	587.71	A	4
A908	19.81	44.15	81.81	97.88	53.09	23.30	18.31	36.37	50.80	111.24	30.23	30.45	597.44	A	4
A909	19.57	44.10	78.41	93.42	51.29	22.77	19.15	33.72	51.18	112.43	30.88	31.10	588.02	A	4
A910	18.85	45.12	82.82	96.06	51.09	21.81	19.73	33.39	51.75	109.24	30.54	31.23	591.63	A	4
A911	19.44	44.58	79.26	96.61	54.94	22.56	19.02	34.78	52.16	109.89	29.49	31.21	593.94	A	4
A912	20.27	45.29	81.57	97.10	51.41	21.08	18.17	33.56	52.29	109.35	30.76	30.89	591.74	A	4
A913	19.78	44.65	75.70	94.73	53.11	20.88	18.38	34.88	52.02	110.83	29.89	29.58	584.43	A	4

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A914	18.29	45.50	82.30	97.12	51.97	23.50	18.07	33.10	52.36	112.10	31.17	29.83	595.31	A	4
A915	19.99	45.54	81.40	95.76	51.99	22.70	19.82	35.16	51.84	108.00	30.75	29.23	592.18	A	4
A916	20.17	43.09	80.82	94.09	51.00	23.74	19.57	34.61	51.45	112.36	31.46	30.96	593.32	A	4
A917	20.00	44.92	75.71	94.14	53.81	21.25	18.28	35.23	51.03	111.28	30.05	30.48	586.18	A	4
A918	18.65	43.51	76.63	99.13	54.53	21.70	17.99	35.72	50.27	108.84	29.35	30.63	586.95	A	4
A919	19.11	45.58	79.04	94.81	53.44	22.95	18.02	34.20	51.12	109.90	29.56	29.28	587.01	A	4
A920	19.62	43.32	76.46	98.56	51.45	21.74	18.51	33.42	52.39	110.87	30.97	30.26	587.57	A	4
A921	20.06	44.65	80.00	96.65	52.16	21.09	19.20	34.42	51.45	112.49	30.45	30.04	592.66	A	4
A922	18.85	44.18	76.38	97.30	54.97	23.01	18.14	34.04	52.22	109.26	31.47	30.83	590.65	A	4
A923	20.19	43.47	82.89	98.77	52.49	22.15	19.52	33.94	52.34	110.43	29.79	30.77	596.75	A	4
A924	18.95	45.65	75.84	93.16	54.56	20.75	19.06	33.05	52.11	112.48	31.00	29.32	585.93	A	4
A925	19.43	44.23	82.55	95.36	50.91	21.71	18.86	35.17	50.54	108.00	30.48	31.18	588.42	A	4
A926	19.70	43.10	78.20	94.43	52.59	19.90	18.21	33.49	50.47	112.38	31.13	29.92	583.52	A	4
A927	19.25	44.06	82.37	93.44	54.64	22.87	19.78	36.19	51.80	111.36	31.24	31.25	598.25	A	4
A928	20.13	43.88	78.88	98.70	52.71	21.61	18.61	34.83	50.99	111.30	29.25	29.28	590.17	A	4
A929	19.81	44.08	81.82	93.71	51.84	19.94	18.68	34.86	52.48	109.62	30.55	30.23	587.62	A	4
A930	18.23	45.46	76.17	96.37	53.41	21.77	18.93	35.62	51.94	110.00	30.70	29.43	588.03	A	4
A931	19.09	45.76	77.68	96.41	53.28	22.64	18.14	35.48	50.63	110.93	31.29	31.19	592.52	A	4
A932	18.37	43.18	78.91	95.50	53.25	23.07	18.27	35.48	51.05	112.05	31.25	29.67	590.05	A	4
A933	19.22	43.87	79.80	94.01	54.95	21.76	19.51	34.63	50.80	111.80	29.61	30.00	589.96	A	4
A934	18.49	45.22	77.26	96.52	52.07	22.20	18.43	33.12	52.43	110.00	30.01	31.18	586.93	A	4
A935	18.01	43.27	80.17	97.38	54.11	20.20	19.78	34.03	52.27	109.76	29.87	29.50	588.35	A	4
A936	18.28	45.56	77.59	93.19	51.79	22.08	17.97	34.01	52.07	108.63	31.25	30.22	582.64	A	4
A937	20.08	45.49	82.52	97.52	53.82	20.23	18.43	34.24	51.83	109.12	31.37	31.00	595.65	A	4
A938	18.67	44.30	82.05	97.89	52.73	22.98	19.21	35.35	50.76	108.15	30.27	29.95	592.31	A	4
A939	19.19	43.14	79.74	96.54	54.59	23.00	18.41	35.20	51.69	110.64	31.36	29.61	593.11	A	4
A940	18.95	43.39	81.32	92.88	50.92	21.43	17.81	35.79	50.33	111.84	29.53	29.72	583.91	A	4
A941	19.15	44.49	81.99	97.37	53.74	23.22	19.61	35.60	52.07	112.32	30.45	29.49	599.50	A	4
A942	18.28	45.58	82.81	94.73	54.80	20.29	19.13	36.06	52.01	108.40	29.42	29.48	590.99	A	4
A943	20.40	43.60	76.52	97.69	51.10	21.44	19.40	35.21	52.19	110.78	31.07	29.72	589.12	A	4
A944	19.89	44.42	79.15	96.37	54.87	23.43	18.35	35.46	50.30	110.12	31.27	30.49	594.12	A	4
A945	20.10	44.36	82.61	96.58	53.94	23.38	17.98	34.02	52.10	111.55	29.28	29.41	595.31	A	4
A946	20.20	45.92	75.70	99.02	52.33	22.42	17.84	34.58	51.09	109.34	30.06	30.42	588.92	A	4
A947	18.16	44.13	76.04	98.93	53.91	23.01	19.54	33.53	50.96	112.00	29.78	30.73	590.72	A	4
A948	19.50	44.27	81.80	96.31	54.80	23.14	18.53	34.87	51.31	110.95	29.84	31.08	596.40	A	4
A949	19.61	45.89	77.49	93.12	52.76	20.04	19.77	33.41	51.93	111.93	30.40	29.97	586.32	A	4
A950	18.05	44.82	82.51	92.85	54.30	20.21	18.78	34.72	51.33	108.61	29.59	30.00	585.77	A	4
A951	19.81	43.98	79.35	94.09	52.35	22.57	18.32	36.39	52.05	109.63	31.30	30.55	590.39	A	4
A952	18.25	45.00	76.00	92.95	51.50	20.54	17.98	34.67	52.39	108.75	31.37	29.66	579.06	A	4
A953	18.26	45.48	77.85	99.12	52.71	21.60	18.50	35.05	51.32	108.08	29.66	29.88	587.51	A	4
A954	18.86	45.41	78.93	95.41	54.58	23.53	19.48	33.48	50.71	109.97	31.28	30.47	592.11	A	4
A955	19.30	45.76	79.58	97.45	51.81	20.93	18.08	36.28	50.47	109.39	30.00	31.27	590.32	A	4
A956	19.28	45.67	82.99	94.81	55.06	22.05	18.79	33.27	51.81	107.88	31.00	29.55	592.16	A	4
A957	19.13	45.60	76.43	95.82	52.72	22.06	19.21	34.59	50.66	108.08	29.25	30.45	584.00	A	4
A958	18.18	44.08	77.41	97.18	53.28	22.71	19.20	34.09	50.74	111.99	31.05	29.77	589.68	A	4
A959	19.14	43.97	82.06	96.41	52.23	20.64	18.33	35.89	51.15	109.32	29.53	31.24	589.91	A	4
A960	18.61	42.44	75.69	94.73	53.88	20.87	19.70	36.44	52.19	107.67	31.38	30.02	583.62	A	4
A961	18.66	45.93	76.38	95.87	54.32	20.23	17.96	35.65	52.35	109.24	29.81	31.42	587.82	A	4
A962	18.76	43.72	77.65	94.30	54.32	23.53	19.14	35.37	51.86	107.49	30.36	30.61	587.11	A	4
A963	20.38	44.17	81.10	99.12	51.89	23.06	19.11	33.87	50.93	108.64	30.96	31.08	594.31	A	4
A964	19.19	43.32	76.56	93.17	54.52	20.80	18.83	34.62	51.05	108.53	30.72	30.07	581.38	A	4
A965	19.49	45.55	77.84	95.09	52.48	23.08	18.46	34.14	52.14	108.44	30.56	31.36	588.63	A	4
A966	18.34	45.36	77.14	95.54	52.45	23.01	19.77	35.60	50.68	111.73	29.89	29.60	589.11	A	4
A967	18.43	44.61	77.41	95.38	51.16	21.06	18.99	33.89	50.58	111.47	31.02	31.28	585.28	A	4
A968	19.55	44.13	79.47	99.01	52.50	22.64	19.39	35.28	51.32	108.72	30.60	31.21	593.82	A	4
A969	19.05	44.16	75.84	98.70	53.31	21.14	19.22	34.08	50.79	109.99	30.40	29.62	586.30	A	4
A970	18.32	45.29	81.21	98.75	53.10	20.72	19.55	34.33	51.49	107.04	29.61	30.72	590.13	A	4
A971	18.48	43.63	82.79	97.47	51.37	20.62	17.97	34.41	51.44	112.48	29.83	29.99	590.48	A	4
A972	18.32	44.74	82.32	93.59	54.19	22.73	19.74	36.42	51.78	108.84	31.42	30.07	594.16	A	4
A973	18.21	43.02	78.86	98.90	55.09	23.39	17.86	33.31	51.14	109.28	29.43	30.46	588.95	A	4
A974	18.52	45.89	76.49	96.59	51.32	21.20	18.61	35.44	51.86	109.65	30.69	30.87	587.13	A	4
A975	19.23	44.84	78.37	97.59	50.88	21.43	19.01	33.92	52.42	107.61	31.40	30.65	587.35	A	4
A976	20.44	43.58	82.05	93.80	52.56	22.93	18.18	35.59	50.37	107.18	30.54	30.05	587.27	A	4
A977	19.19	45.06	77.99	95.55	54.41	23.31	18.91	34.81	51.49	110.94	31.47	29.84	592.97	A	4
A978	20.35	44.64	76.75	98.71	52.17	22.91	18.97	35.79	51.53	111.46	29.76	29.59	592.63	A	4
A979	18.79	44.92	77.22	96.16	53.49	23.55	19.40	33.28	50.34	107.21	31.18	29.54	585.08	A	4
A980	19.40	45.62	80.48	94.38	52.06	22.65	18.33	33.07	51.57	108.22	30.79	31.04	587.61	A	4
A981	19.09	45.91	79.38	94.91	54.44	19.81	18.54	34.53	50.73	107.90	30.44	30.67	586.35	A	4
A982	19.49	43.78	79.41	97.54	53.79	22.07	18.13	33.14	50.46	109.23	30.64	30.41	588.09	A	4
A983	19.53	44.10	81.14	96.63	53.73	22.08	18.88	35.57	52.11	108.25	31.21	30.92	594.15	A	4
A984	20.22	45.33	76.95	94.61	52.17	20.59	18.34	35.53	50.40	108.91	29.52	31.15	583.72	A	4
A985	19.41	45.38	81.38	94.32	52.68	23.68	19.16	35.03	51.64	108.93	30.29	31.09	592.99	A	4
A986	18.07	43.11	76.26	94.35	54.86	23.54	18.90	34.95	51.79	107.95	29.25	29.98	583.01	A	4
A987	19.72	45.13	77.67	97.34	52.52	20.77	18.05	35.74	50.86	111.54	30.37	30.45	590.16	A	4
A988	18.07	43.58	76.61	92.95	52.06	22.22	18.59	33.60	50.83	109.59	30.61	30.71	579.42	A	4
A989	18.39	45.96	79.50	97.75	51.52	19.85	17.99	33.25	51.18	111.31	30.58	31.48	588.76	A	4
A990	20.04	44.37	77.43	94.44	52.93	20.55	18.24	36.06	52.07	109.96	30.89	30.92	587.90	A	4
A991	18.25	43.21	82.96	94.73	51.74	22.59	17.96	35.63	50.54	107.22	30.78	30.78	586.39	A	4
A992	18.59	45.07	80.40	97.09	53.04	23.07	18.85	36.24	51.70	109.27	31.40	30.47	595.19	A	4
A993	18.70	45.09	79.08	97.31	52.71	23.82	17.99	33.11	51.01	112.01	30.98	30.72	592.53	A	4
A994	20.31	43.02	79.77	92.87	51.03	22.64	19.81	35.42	52.27	110.01	30.75	30.76	588.66	A	4
A995	19.75	45.80	78.34	93.87	51.81	22.88	19.46	36.09	51.45	110.63	29.80	29.27	589.15	A	4
A996	19.67	45.32	78.59	94.02	54.92	23.81	19.53	33.18	51.37	109.28	30.12	30.92	590.73	A	4

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
A997	20.04	45.93	82.54	97.24	52.91	21.24	19.76	33.12	51.86	111.79	29.28	30.74	596.45	A	4
A998	19.81	44.34	75.68	94.44	54.48	22.99	18.77	33.47	50.61	112.30	30.75	31.44	589.08	A	4
A999	18.22	45.46	77.19	95.25	54.56	21.06	18.52	36.00	50.72	109.17	31.49	30.99	588.63	A	4
A1000	18.67	43.66	75.76	93.90	53.64	22.98	17.92	34.03	52.20	108.82	30.33	30.42	582.33	A	4
A1001	19.63	43.56	80.89	95.35	50.83	19.82	17.99	34.07	50.86	108.67	30.52	29.73	581.92	A	4
A1002	19.26	43.95	75.73	93.12	52.09	20.68	18.86	35.37	52.48	109.99	29.33	31.24	582.10	A	4
A1003	20.32	44.04	77.20	97.65	55.09	23.72	19.48	35.87	52.30	110.55	29.98	30.63	596.83	A	4
A1004	19.25	43.21	82.50	92.97	51.68	22.12	18.56	35.90	51.56	111.72	30.57	30.72	590.76	A	4
A1005	20.45	44.31	76.38	93.06	50.87	20.62	18.86	36.12	51.47	106.44	31.09	31.21	580.88	A	4
A1006	19.75	44.07	82.40	97.01	54.28	23.14	17.88	36.10	50.35	108.62	30.83	29.89	594.32	A	4
A1007	19.97	45.94	79.85	93.98	51.51	21.54	19.39	34.25	50.88	112.13	29.30	30.10	588.84	A	4
A1008	19.20	45.65	78.34	95.48	54.80	20.38	18.40	35.73	51.00	111.20	30.99	30.75	591.92	A	4
A1009	18.24	44.02	78.71	97.79	51.84	20.86	19.18	35.18	50.74	110.73	30.63	30.39	588.31	A	4
A1010	18.82	43.95	76.16	96.95	53.10	21.00	18.47	33.96	50.34	111.81	30.66	30.72	585.94	A	4
A1011	18.28	45.30	77.93	95.67	53.49	20.74	19.76	36.19	51.10	112.47	29.30	29.53	589.76	A	4
A1012	18.42	47.85	80.92	95.14	54.78	22.44	18.39	33.51	50.47	109.57	30.23	29.37	591.09	A	4
A1013	18.88	43.78	78.84	95.87	51.28	22.75	18.96	36.04	50.47	111.53	29.57	29.59	587.56	A	4
A1014	18.82	43.19	77.51	97.81	53.20	21.27	19.76	34.51	50.76	108.44	29.24	29.61	584.12	A	4
A1015	18.42	45.59	80.20	96.62	53.22	20.52	19.47	36.10	51.50	112.60	30.08	31.00	595.32	A	4
A1016	19.93	44.47	75.88	92.84	52.56	20.12	19.20	36.47	50.31	111.91	30.97	30.49	585.15	A	4
A1017	19.96	45.70	77.85	95.12	52.13	23.06	19.75	35.49	52.42	109.80	31.46	29.45	592.19	A	4
A1018	18.03	43.32	77.32	98.40	52.23	23.22	19.43	35.25	51.81	111.84	29.41	29.53	589.79	A	4
A1019	18.14	45.13	80.80	93.38	52.68	23.64	19.57	35.00	51.12	109.55	30.14	31.44	590.59	A	4
A1020	18.62	43.36	78.38	97.88	54.78	21.62	19.19	34.62	51.52	108.94	31.23	29.97	590.11	A	4
A1021	19.40	43.93	79.63	94.84	50.89	22.25	18.16	33.61	51.91	109.22	29.52	30.76	584.12	A	4
A1022	18.96	44.79	82.53	98.56	52.40	22.37	19.57	33.52	50.32	111.04	29.99	29.51	593.56	A	4
A1023	19.83	44.33	76.88	96.85	53.14	19.88	19.73	34.55	50.47	111.16	29.60	30.13	586.55	A	4
A1024	18.45	45.26	77.41	97.13	54.90	21.62	19.60	36.28	51.79	109.98	31.27	30.94	594.63	A	4
A1025	20.40	45.03	80.00	97.03	51.29	20.13	18.32	33.45	50.46	106.72	29.54	29.64	582.01	A	4
A1026	19.17	44.75	82.97	94.16	51.08	21.77	19.68	33.57	51.85	112.19	29.40	29.37	589.96	A	4
A1027	18.28	43.34	81.25	97.61	53.11	21.76	18.19	34.54	51.66	111.74	30.73	30.09	592.30	A	4
A1028	18.20	45.94	77.57	94.22	51.68	20.15	19.46	34.79	51.51	111.91	31.35	30.93	587.71	A	4
A1029	20.31	44.92	78.76	97.86	54.67	22.85	19.74	34.04	52.24	109.83	30.99	30.30	596.51	A	4
A1030	19.70	43.44	80.94	95.96	52.86	21.23	18.50	36.27	50.65	108.84	29.51	30.26	588.16	A	4
A1031	19.75	45.33	79.88	98.11	55.00	20.05	18.71	34.40	50.71	108.39	30.07	30.95	591.35	A	4
A1032	20.27	43.69	76.45	99.06	51.74	22.70	17.89	33.86	51.75	108.88	30.16	30.99	587.44	A	4
A1033	18.00	47.92	77.38	95.10	53.86	22.10	19.36	34.93	52.21	110.35	29.87	29.83	590.91	A	4
A1034	20.34	45.87	77.72	94.32	52.26	20.12	18.70	34.98	51.34	107.99	31.14	29.78	584.56	A	4
A1035	19.86	43.57	82.79	95.99	52.98	22.43	18.88	34.45	50.33	111.05	30.56	31.33	594.22	A	4
A1036	19.83	45.22	78.10	97.42	51.99	22.67	18.62	34.23	50.56	112.38	30.30	30.94	592.26	A	4
A1037	19.08	45.23	79.82	95.56	52.76	19.84	19.27	34.96	51.17	110.34	29.97	31.10	589.10	A	4
A1038	19.03	43.72	77.08	97.22	52.73	21.09	19.05	36.09	50.54	110.66	29.92	29.25	586.38	A	4
A1039	18.31	43.61	76.16	93.36	53.54	22.23	18.59	36.23	50.43	112.10	31.06	29.71	585.33	A	4
A1040	19.65	44.42	80.52	96.26	53.83	22.16	18.00	33.19	50.59	111.52	31.04	30.26	591.44	A	4
A1041	19.78	45.18	80.41	95.36	52.72	22.44	18.62	35.28	50.75	112.18	30.51	30.14	593.37	A	4
A1042	19.34	43.89	82.05	97.64	52.91	22.65	19.28	34.51	51.04	112.59	29.97	30.11	595.98	A	4
A1043	18.01	45.60	76.67	97.36	51.44	21.45	18.45	34.98	52.02	111.09	31.28	29.99	588.34	A	4
A1044	20.47	45.05	77.37	98.84	54.90	23.57	18.66	34.05	51.53	109.38	29.56	30.51	593.89	A	4
A1045	20.27	45.44	82.24	98.59	54.07	21.21	19.10	35.52	51.24	109.80	30.17	30.89	598.54	A	4
A1046	19.53	45.87	76.24	95.10	52.11	20.34	19.09	36.10	52.10	110.36	30.70	30.60	588.14	A	4
A1047	18.18	43.18	77.95	93.19	52.04	23.18	19.28	34.79	51.36	111.82	30.74	30.49	586.20	A	4
A1048	18.23	43.93	82.75	98.47	54.87	20.86	18.44	33.60	52.38	111.86	31.35	31.22	597.96	A	4
A1049	20.03	45.12	80.08	99.04	54.74	21.72	18.15	34.71	52.12	112.67	29.70	29.62	597.70	A	4
A1050	20.15	45.74	81.76	94.49	53.68	22.67	18.52	36.39	50.68	108.25	29.34	30.69	592.36	A	4
A1051	19.00	43.17	82.34	96.81	52.02	23.24	19.72	35.18	52.24	109.09	30.04	30.11	592.96	A	4
A1052	18.60	44.96	82.32	98.21	51.45	23.69	18.49	35.11	52.28	110.07	30.95	30.46	596.59	A	4
A1053	18.29	44.56	75.92	93.53	50.83	20.62	19.03	36.25	50.75	108.27	29.65	30.99	578.69	A	4

Engine B – All values recorded are in decimal minutes.

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
B1	5.66	94.47	70.17	123.91	82.43	25.15	35.52	34.40	94.76	182.78	49.56	49.53	848.34	B	1
B2	5.22	96.90	69.80	124.57	81.75	25.84	36.17	34.51	93.43	181.88	49.86	49.56	849.49	B	1
B3	4.90	92.60	73.08	120.57	79.10	25.35	36.02	34.73	91.20	180.44	49.52	49.76	837.27	B	1
B4	6.12	97.93	73.97	124.36	80.35	25.85	36.14	34.12	94.46	181.08	50.27	50.27	854.92	B	1
B5	5.44	93.54	72.67	119.19	80.57	25.64	36.07	34.48	92.56	180.87	49.84	50.02	840.89	B	1
B6	5.12	88.63	73.62	119.08	79.90	25.83	35.68	34.76	94.76	180.05	50.29	49.56	837.28	B	1
B7	5.20	96.01	72.32	123.20	79.30	25.91	36.43	34.18	94.08	183.31	49.68	49.75	849.32	B	1
B8	4.93	96.46	73.45	124.21	81.94	25.10	35.91	34.31	92.23	179.36	49.64	49.67	847.21	B	1
B9	4.92	88.72	69.62	119.10	80.25	25.16	36.00	34.04	91.44	184.71	49.61	50.14	833.71	B	1
B10	6.49	94.48	73.94	122.72	82.62	25.20	36.10	34.62	94.74	180.37	49.53	49.68	850.49	B	1
B11	5.66	88.04	72.94	119.76	79.47	25.29	35.95	34.44	91.55	183.28	49.63	49.87	835.88	B	1
B12	5.13	91.63	72.81	124.66	78.78	25.90	36.48	34.63	93.35	181.71	49.78	49.95	844.81	B	1
B13	5.27	92.97	72.59	120.44	82.64	25.86	36.03	34.98	92.99	180.06	49.73	49.88	843.44	B	1
B14	5.08	95.49	71.41	119.95	81.10	25.82	36.15	34.37	91.63	181.67	50.00	50.08	842.75	B	1
B15	4.97	94.17	71.65	120.71	81.88	25.61	36.36	34.95	92.21	179.04	49.76	50.06	841.37	B	1
B16	4.99	91.71	71.69	120.48	79.70	25.49	36.45	34.91	90.60	182.24	49.97	50.20	838.43	B	1
B17	6.40	95.94	72.68	119.33	78.97	25.89	35.90	34.65	94.82	182.51	49.72	50.13	846.94	B	1
B18	5.45	94.08	72.63	122.98	82.79	25.28	35.96	34.27	89.12	179.68	50.08	49.80	842.12	B	1
B19	5.90	91.09	73.48	123.19	82.70	25.12	35.54	34.67	94.30	183.71	49.90	49.51	849.11	B	1
B20	4.93	93.97	73.28	124.34	79.91	25.39	36.03	34.50	91.32	182.04	50.06	49.85	845.62	B	1
B21	5.34	91.01	69.59	122.34	80.96	25.18	36.19	34.19	94.56	183.56	49.85	49.96	842.73	B	1
B22	5.00	94.75	73.68	120.47	81.34	25.04	36.33	34.57	94.99	181.15	49.99	49.52	846.83	B	1
B23	5.32	90.29	73.18	121.03	79.56	25.33	36.40	34.02	89.17	180.03	49.76	50.05	834.14	B	1
B24	5.05	96.85	71.21	124.30	79.84	25.85	35.93	34.95	92.75	180.78	49.83	49.91	847.25	B	1
B25	5.44	89.70	72.69	123.27	82.05	25.36	36.22	34.32	92.82	179.09	49.68	49.53	840.17	B	1
B26	5.35	90.32	73.22	122.32	80.52	25.46	36.46	34.37	93.14	179.21	50.26	49.75	840.38	B	1
B27	5.02	90.10	71.97	122.48	79.99	25.86	35.89	34.91	92.36	183.14	50.26	49.74	841.72	B	1
B28	6.39	88.98	72.38	123.34	80.85	25.03	35.93	34.94	89.38	183.81	49.50	49.50	840.03	B	1
B29	5.40	89.68	72.55	119.69	81.61	25.00	36.46	34.36	91.84	181.24	49.89	50.06	837.78	B	1
B30	5.43	93.45	72.51	123.22	82.74	25.26	35.55	34.87	93.88	183.31	49.70	50.18	850.10	B	1
B31	6.07	96.94	73.46	122.74	79.08	25.43	36.25	34.90	92.99	181.63	50.11	49.61	849.21	B	1
B32	6.02	92.76	73.62	122.86	80.07	25.39	35.98	34.24	91.27	181.65	49.66	49.89	843.41	B	1
B33	5.71	90.25	72.87	124.78	80.15	25.55	35.69	34.28	92.05	183.26	50.01	49.95	844.55	B	1
B34	5.31	90.80	73.08	124.90	82.29	25.78	36.30	34.41	89.50	180.49	49.57	50.00	842.43	B	1
B35	5.96	88.76	70.82	120.31	82.57	25.52	36.15	34.02	89.54	183.06	49.82	50.20	836.73	B	1
B36	5.66	91.76	70.25	120.49	81.61	25.39	36.18	34.92	94.08	179.19	49.50	49.66	838.69	B	1
B37	6.00	92.92	72.29	124.24	79.90	25.18	36.13	34.29	90.93	184.90	50.00	49.76	846.54	B	1
B38	5.11	92.92	72.81	123.55	79.64	25.14	35.80	34.08	91.75	182.41	49.94	50.27	843.42	B	1
B39	5.29	91.32	71.65	121.06	79.62	25.08	36.19	34.75	91.80	179.95	49.72	50.15	836.58	B	1
B40	5.98	90.44	69.95	123.74	78.46	25.15	35.98	34.62	94.83	179.64	50.23	50.29	839.31	B	1
B41	6.16	93.77	70.12	121.40	78.40	25.49	36.25	34.21	90.26	180.81	49.82	50.05	836.74	B	1
B42	4.95	93.06	70.20	120.92	79.50	25.67	36.16	34.34	94.23	182.13	50.00	50.12	841.28	B	1
B43	5.62	91.16	70.79	121.71	79.28	25.14	35.78	34.79	92.50	181.96	49.77	49.64	838.14	B	1
B44	6.46	89.15	72.40	121.49	82.26	25.86	35.92	34.48	91.69	183.09	49.73	49.93	842.46	B	1
B45	5.55	89.19	73.06	121.95	79.27	25.80	36.33	34.09	90.38	179.26	49.93	50.29	835.10	B	1
B46	5.22	96.50	73.85	120.43	80.61	25.49	35.87	34.73	93.54	179.44	49.67	49.68	845.03	B	1
B47	5.13	88.71	71.16	122.50	78.72	25.06	35.90	34.54	89.49	180.66	49.65	50.20	831.72	B	1
B48	5.60	91.27	71.31	119.66	79.58	25.46	35.92	34.33	89.14	180.73	49.63	50.29	832.92	B	1
B49	5.86	91.22	73.65	121.02	79.76	25.49	35.91	34.10	91.64	180.96	49.55	50.07	839.23	B	1
B50	6.18	90.97	69.99	123.13	78.84	25.84	35.90	34.80	92.52	179.51	49.84	49.50	837.02	B	1
B51	5.25	93.66	69.83	119.28	79.30	25.30	35.59	34.82	89.73	184.31	49.88	50.20	837.15	B	1
B52	5.09	97.32	70.28	122.00	80.10	25.47	36.02	34.46	93.45	182.65	49.91	49.70	846.45	B	1
B53	5.80	91.92	70.26	119.49	80.00	25.21	35.93	34.32	93.61	181.12	49.94	50.02	837.62	B	1
B54	5.74	90.81	71.57	120.40	79.65	25.26	36.34	34.25	90.20	183.83	49.66	49.72	837.43	B	1
B55	5.45	93.97	73.27	121.91	81.97	25.52	36.26	34.43	92.75	180.06	49.69	49.70	844.98	B	1
B56	4.91	90.99	73.48	121.62	80.45	25.92	35.82	34.33	91.93	179.36	49.84	50.04	838.69	B	1
B57	5.12	93.35	70.16	122.31	80.14	25.15	36.07	34.81	92.47	184.51	49.73	49.86	843.68	B	1
B58	5.04	91.18	71.04	121.03	80.90	25.16	35.64	34.85	90.13	181.75	50.12	49.52	836.36	B	1
B59	5.45	91.26	72.69	123.16	82.80	25.53	36.23	34.60	91.55	181.33	50.11	50.19	844.40	B	1
B60	6.04	91.23	73.75	119.90	81.48	25.89	35.75	34.35	90.30	179.01	49.51	50.09	837.30	B	1
B61	5.90	94.71	69.76	123.30	80.85	25.41	36.01	34.73	94.33	183.78	49.73	50.25	848.76	B	1
B62	5.58	95.72	71.61	122.57	82.58	25.99	36.17	34.62	91.56	181.98	49.52	50.22	848.12	B	1
B63	5.02	92.36	72.51	123.55	81.57	25.04	35.96	34.79	92.46	181.65	50.23	50.09	845.23	B	1
B64	5.05	96.95	70.17	119.40	81.04	25.40	36.34	34.85	92.41	184.38	49.50	49.54	845.03	B	1
B65	5.54	96.31	71.73	122.88	80.37	25.68	36.29	34.50	91.92	183.00	50.02	49.79	848.03	B	1
B66	5.19	91.05	73.96	123.35	82.37	25.97	35.53	34.71	94.59	183.80	49.83	50.28	850.63	B	1
B67	5.97	88.29	72.11	119.94	81.62	25.54	35.50	34.90	93.31	182.76	49.58	49.60	839.12	B	1
B68	6.43	89.33	70.87	123.03	78.72	25.17	36.26	34.62	89.43	180.48	49.66	49.61	833.61	B	1
B69	6.42	95.00	73.52	122.99	80.09	25.24	35.83	34.59	91.75	182.58	49.71	50.01	847.73	B	1
B70	5.67	88.78	70.33	123.46	81.24	25.82	35.56	34.45	93.58	182.54	49.99	50.21	841.63	B	1
B71	6.48	92.41	73.69	123.10	80.83	25.40	36.30	34.98	94.46	180.68	50.05	49.61	847.99	B	1
B72	6.03	96.51	73.56	121.82	80.67	25.61	36.46	34.01	92.51	179.61	50.05	49.56	846.40	B	1
B73	5.06	96.30	69.96	123.81	79.88	25.49	36.44	34.53	91.12	179.89	50.16	49.73	842.37	B	1
B74	5.93	96.97	69.80	122.76	81.74	25.15	35.89	34.04	89.88	182.52	50.03	49.50	844.21	B	1
B75	5.65	88.34	72.38	124.14	79.23	25.69	35.67	34.09	92.43	180.25	50.20	49.97	838.04	B	1
B76	5.63	92.89	72.57	121.55	79.38	25.25	35.93	34.77	91.56	183.23	50.00	49.95	842.71	B	1
B77	5.17	93.33	70.60	119.19	78.90	25.13	36.38	34.74	90.37	184.59	49.52	50.05	837.97	B	1
B78	5.48	92.35	71.78	120.21	81.32	25.64	36.28	34.85	93.53	181.04	49.58	49.55	841.61	B	1
B79	6.49	91.25	70.36	124.82	79.74	25.39	35.65	34.87	92.33	184.67	49.76	50.26	845.59	B	1
B80	5.64	97.98	71.35	123.43	80.60	25.45	36.03	34.36	91.04	180.89	49.76	50.29	846.82	B	1
B81	6.24	89.77	72.70	124.97	81.70	25.78	36.02	34.58	93.17	181.09	50.69	49.95	846.66	B	1
B82	5.97	92.76	69.95	120.61	79.54	25.22	35.56	34.33	94.32	182.72	49.84	49.87	840.69	B	1
B83	6.32	92.70	72.99	123.82	78.68	25.83	36.39	34.96	93.28	179.77	50.12	49.56	844.42	B	1

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
B84	6.28	92.41	70.28	123.29	80.00	25.67	35.70	34.13	90.31	181.02	50.04	49.78	838.91	B	1
B85	5.46	90.36	71.91	121.24	78.79	25.39	35.79	34.28	93.10	183.96	49.51	49.77	839.56	B	1
B86	5.02	93.71	72.88	119.80	79.97	25.12	36.09	34.05	89.29	179.24	50.19	49.54	834.90	B	1
B87	4.82	89.19	72.94	123.40	79.47	25.33	35.63	34.62	90.82	179.75	49.93	50.08	835.98	B	1
B88	5.26	91.63	73.84	121.30	82.63	25.95	36.16	34.05	91.38	183.96	49.85	49.53	845.54	B	1
B89	5.69	96.83	70.94	124.39	79.71	25.11	36.32	34.88	93.46	181.17	50.02	49.51	848.03	B	1
B90	6.44	97.93	70.61	121.75	80.47	25.22	35.52	34.65	93.12	182.04	49.65	49.72	847.12	B	1
B91	5.37	92.75	72.55	119.84	81.37	25.31	35.66	34.14	89.41	184.78	49.95	50.16	841.29	B	1
B92	5.07	94.74	70.00	124.42	79.26	25.05	36.21	34.71	92.98	182.22	50.03	49.73	844.42	B	1
B93	5.54	95.11	71.31	119.34	81.62	25.29	35.80	34.56	94.08	183.84	50.01	50.25	846.75	B	1
B94	4.87	92.32	72.48	124.10	78.76	25.42	36.28	34.82	90.83	179.27	50.05	50.12	839.32	B	1
B95	6.21	93.03	71.27	124.08	81.41	25.32	35.95	34.24	90.45	182.54	49.99	49.82	844.31	B	1
B96	6.36	89.11	73.84	119.61	81.18	25.32	36.03	34.46	94.59	180.31	50.15	49.81	840.77	B	1
B97	4.94	95.19	70.25	121.65	81.24	25.77	35.56	34.20	93.24	182.92	50.05	49.67	844.68	B	1
B98	5.87	95.11	70.92	124.29	80.97	25.56	36.36	34.99	94.93	180.04	49.55	50.17	848.76	B	1
B99	5.62	96.61	72.60	121.61	82.27	25.96	36.25	34.03	89.96	183.26	49.81	49.94	847.92	B	1
B100	4.93	90.06	73.29	124.49	79.04	25.67	35.56	34.56	91.06	182.16	50.12	49.59	840.53	B	1
B101	6.27	88.19	70.74	119.29	82.15	25.32	35.75	34.47	94.34	179.52	50.00	49.76	835.80	B	1
B102	5.49	95.47	70.66	119.83	82.50	25.69	35.76	34.19	90.41	180.26	50.14	50.22	840.62	B	1
B103	6.38	94.61	70.14	120.88	80.95	25.41	35.85	34.82	91.50	184.67	49.78	50.09	845.08	B	1
B104	7.84	92.51	70.28	122.22	78.78	25.56	36.10	34.08	92.21	184.04	50.18	50.27	844.07	B	2
B105	7.27	93.62	72.47	119.34	80.33	25.62	35.87	34.32	91.53	179.93	49.87	50.21	840.38	B	2
B106	7.63	93.82	72.79	120.42	81.89	25.95	36.23	34.28	90.50	184.00	49.62	49.94	847.07	B	2
B107	6.98	93.45	71.75	121.63	81.87	25.78	36.38	34.66	91.97	182.57	49.90	50.21	847.15	B	2
B108	6.92	88.47	69.51	120.22	79.14	25.03	35.63	34.82	91.01	180.88	49.70	49.55	830.88	B	2
B109	7.28	91.44	69.80	122.35	80.27	25.02	36.09	34.09	92.27	180.08	50.09	50.23	839.01	B	2
B110	7.62	92.99	69.99	121.91	78.97	25.58	36.14	34.19	91.74	179.13	49.57	49.88	837.71	B	2
B111	7.05	92.02	72.75	119.81	80.95	25.64	35.81	34.68	91.44	184.28	50.15	49.61	844.19	B	2
B112	6.95	93.93	70.05	120.86	81.26	25.15	36.22	34.06	89.99	184.53	50.14	49.68	842.82	B	2
B113	7.58	89.01	70.04	121.70	80.40	25.96	36.03	34.77	91.10	182.09	49.97	49.71	838.36	B	2
B114	7.85	92.63	71.15	119.38	80.26	25.44	35.69	34.50	92.45	184.08	50.07	50.00	843.50	B	2
B115	7.96	93.56	71.52	122.61	79.64	25.88	35.56	34.86	92.95	179.43	50.20	50.17	844.34	B	2
B116	6.83	88.79	69.54	122.41	82.11	25.79	35.58	34.26	91.02	183.59	49.72	49.89	839.53	B	2
B117	7.15	96.09	72.29	122.50	81.91	25.23	35.91	34.01	89.00	184.81	50.18	50.25	849.33	B	2
B118	7.12	90.60	72.54	121.60	79.42	25.95	35.78	34.81	90.42	179.99	49.85	49.95	838.03	B	2
B119	7.23	89.06	69.69	120.19	81.04	25.46	36.21	34.57	90.90	184.65	50.03	50.06	839.09	B	2
B120	7.57	88.56	69.97	120.30	82.35	25.53	35.61	34.48	91.56	181.69	49.83	49.77	837.22	B	2
B121	6.87	93.62	71.74	121.59	78.42	25.71	36.43	34.48	90.96	183.65	50.18	49.87	843.52	B	2
B122	7.88	92.16	69.51	120.25	80.62	25.65	36.00	34.66	90.10	183.70	50.02	49.60	840.15	B	2
B123	7.28	92.42	70.85	122.23	78.56	25.14	36.06	34.81	91.86	181.09	50.26	49.90	840.46	B	2
B124	7.00	89.15	70.90	119.38	80.45	25.18	36.07	34.38	90.77	180.19	49.55	49.61	832.63	B	2
B125	7.03	90.47	71.36	121.53	80.07	25.81	35.66	34.80	89.10	181.81	50.00	49.90	837.54	B	2
B126	7.25	90.54	71.08	122.38	79.70	25.06	35.86	34.17	90.07	180.38	49.53	50.02	836.04	B	2
B127	7.58	90.26	69.73	120.81	82.93	25.08	36.07	34.63	92.81	180.92	50.08	49.53	840.43	B	2
B128	7.93	92.39	71.97	121.33	80.34	25.05	35.72	34.84	92.88	179.59	50.27	49.61	841.92	B	2
B129	7.28	88.05	69.64	122.52	81.17	25.43	36.35	34.65	91.23	183.13	49.66	49.77	838.88	B	2
B130	7.45	88.78	72.32	119.23	78.68	25.94	36.01	34.76	90.08	181.61	50.26	50.25	835.37	B	2
B131	7.83	90.24	70.50	119.35	79.52	25.87	35.93	34.32	92.37	179.10	50.11	49.86	835.00	B	2
B132	7.00	90.11	71.78	119.38	78.77	25.03	35.58	34.87	92.99	180.11	50.05	49.70	835.37	B	2
B133	6.87	93.41	72.92	122.91	81.11	25.09	35.55	34.14	92.59	179.31	49.75	50.13	843.78	B	2
B134	7.59	93.88	70.40	121.76	80.02	25.28	36.23	34.21	92.91	181.54	49.72	50.00	843.54	B	2
B135	7.33	93.74	69.73	120.08	80.80	25.46	36.17	34.45	90.60	180.41	49.74	49.63	838.14	B	2
B136	7.03	92.45	70.19	120.27	82.86	25.73	36.04	34.76	91.37	181.85	49.82	49.62	841.99	B	2
B137	7.62	89.19	69.84	120.45	80.15	25.08	35.76	34.67	90.77	182.13	49.99	50.10	835.75	B	2
B138	7.06	93.53	70.42	121.52	80.29	25.03	35.86	34.48	91.35	179.48	49.63	49.97	838.62	B	2
B139	7.33	88.30	70.80	119.82	79.48	25.15	35.78	34.46	89.54	183.33	50.25	49.66	833.90	B	2
B140	6.93	88.72	72.01	121.97	80.87	25.53	36.39	34.42	91.24	183.63	49.53	49.88	841.12	B	2
B141	6.87	91.32	71.50	121.71	79.24	25.07	36.42	34.40	89.89	181.23	49.69	49.77	837.11	B	2
B142	7.31	93.27	72.22	120.32	82.47	25.50	36.21	34.31	90.86	180.99	50.22	50.18	843.86	B	2
B143	7.68	93.35	70.30	122.98	81.69	25.37	36.21	34.97	90.07	183.99	49.95	49.75	846.31	B	2
B144	7.41	88.68	69.79	119.55	80.80	25.17	36.12	34.41	90.80	181.97	50.03	49.52	834.25	B	2
B145	7.53	90.84	70.14	121.54	81.75	25.22	36.13	34.15	92.22	184.06	49.62	49.93	843.13	B	2
B146	7.93	89.43	72.22	122.04	79.89	25.02	35.71	34.01	91.06	184.45	49.84	50.28	841.88	B	2
B147	7.35	90.36	69.57	120.92	82.53	25.33	35.82	34.81	90.20	182.64	50.13	50.08	839.74	B	2
B148	7.63	92.33	71.62	122.76	79.90	25.41	36.03	34.23	90.56	182.45	49.76	49.67	842.35	B	2
B149	7.97	92.72	71.38	121.24	79.25	25.74	35.68	34.40	92.68	183.86	50.27	49.88	845.07	B	2
B150	7.37	91.05	72.24	119.39	82.62	25.37	36.38	34.61	91.15	179.24	50.11	49.63	839.16	B	2
B151	6.80	90.97	71.45	122.29	81.39	25.78	36.18	34.81	89.43	184.92	50.11	50.14	844.27	B	2
B152	7.51	89.41	72.02	120.75	81.71	25.23	35.55	34.98	92.35	184.02	50.12	49.75	843.40	B	2
B153	7.73	90.32	70.82	120.01	79.03	25.52	36.08	34.07	92.03	179.89	49.89	49.74	835.13	B	2
B154	7.99	91.64	70.03	122.73	80.37	25.57	35.79	34.28	90.76	181.46	49.78	50.06	840.46	B	2
B155	7.95	88.53	71.66	121.07	82.95	25.39	36.37	34.84	89.73	180.08	49.53	49.77	837.87	B	2
B156	7.88	92.57	69.77	121.03	79.29	25.05	36.04	34.08	92.99	184.31	49.68	49.62	842.31	B	2
B157	7.81	90.42	72.38	122.12	80.60	25.04	36.29	34.01	91.47	184.00	49.77	49.76	843.67	B	2
B158	7.00	92.56	71.12	122.76	79.21	25.49	36.32	34.40	89.64	179.08	49.84	49.59	837.01	B	2
B159	7.12	92.96	71.11	120.67	79.97	25.25	35.72	34.22	92.28	183.90	50.10	50.15	843.45	B	2
B160	7.62	88.46	71.47	119.82	81.27	25.57	36.47	34.04	91.27	181.49	49.69	49.90	837.07	B	2
B161	7.18	84.45	72.11	122.23	80.77	25.17	36.03	34.98	91.59	183.98	49.98	50.15	838.62	B	2
B162	7.53	91.96	70.39	119.98	78.61	25.31	36.25	34.75	91.89	181.92	49.71	50.03	838.33	B	2
B163	7.27	88.13	70.42	121.76	81.94	25.72	35.74	34.20	91.80	184.48	50.16	49.68	841.30	B	2
B164	7.83	90.58	70.93	119.87	81.14	25.70	36.00	34.57	92.42	179.38	50.29	50.03	838.74	B	2
B165	7.50	93.39	69.97	119.24	80.01	25.55	35.91	34.61	91.94	179.27	49.67	50.20	837.26	B	2
B166	7.41	90.59	71.55	122.54	79.71	25.72	36.49	34.29	89.96	183.60	50.27	49.87	842.00	B	2

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
B167	7.28	90.90	72.54	121.29	78.99	25.37	35.59	34.86	90.68	184.67	49.70	49.85	841.72	B	2
B168	7.41	92.64	71.40	121.11	79.63	25.87	35.73	34.53	92.28	183.37	49.69	50.23	843.89	B	2
B169	7.09	93.03	71.82	120.19	82.07	25.92	36.47	34.19	91.88	179.52	50.19	50.11	842.48	B	2
B170	7.30	89.86	70.20	121.49	79.69	25.41	35.81	34.70	90.65	180.10	49.75	50.24	835.20	B	2
B171	7.38	92.42	71.44	120.54	79.41	25.71	35.57	34.35	92.05	180.40	49.63	49.52	838.42	B	2
B172	7.17	89.18	71.32	122.94	78.57	25.99	36.18	34.70	89.80	183.37	49.88	49.97	839.07	B	2
B173	7.15	88.50	71.06	121.38	79.12	25.53	36.34	34.66	92.01	181.62	49.69	50.11	837.17	B	2
B174	7.42	93.12	72.05	119.23	79.32	25.38	35.94	34.91	89.18	181.46	50.05	50.20	838.26	B	2
B175	7.31	93.62	72.65	121.97	82.07	25.87	35.81	34.54	89.92	179.89	49.62	49.82	843.09	B	2
B176	7.04	93.48	71.73	121.34	80.25	25.05	35.97	34.52	89.14	180.66	49.74	50.25	839.17	B	2
B177	7.36	91.56	70.32	120.87	81.03	25.74	35.55	34.56	89.30	182.04	49.86	50.22	838.41	B	2
B178	7.83	93.47	72.60	120.46	79.52	25.18	36.44	34.79	89.74	181.42	49.92	50.02	841.39	B	2
B179	7.17	89.46	72.20	119.37	82.70	25.53	35.65	34.54	92.95	181.85	50.20	49.53	841.15	B	2
B180	7.62	90.91	71.44	122.25	80.32	25.96	36.36	34.05	90.72	184.42	49.51	49.91	843.47	B	2
B181	7.81	89.99	69.59	120.47	81.78	25.44	35.74	34.99	91.81	182.63	49.87	49.87	839.99	B	2
B182	7.79	90.53	69.84	120.35	79.58	25.51	36.11	34.59	92.41	179.52	49.53	49.77	835.53	B	2
B183	6.93	91.07	71.73	119.58	80.51	25.86	36.04	34.41	89.58	184.97	49.81	50.13	840.62	B	2
B184	7.31	92.21	70.17	121.57	80.54	25.11	36.05	34.39	91.45	182.72	50.13	49.81	841.46	B	2
B185	7.00	89.04	71.09	120.05	80.54	25.06	36.40	34.12	92.91	184.27	50.04	49.62	840.14	B	2
B186	7.75	88.85	70.83	120.43	80.61	25.50	35.61	34.13	90.79	181.00	49.55	49.96	835.01	B	2
B187	7.70	93.82	70.11	121.54	79.61	25.95	35.76	34.18	92.86	182.91	49.96	50.03	844.43	B	2
B188	7.04	93.17	69.51	120.32	82.42	25.05	35.63	34.53	91.64	183.24	50.00	50.09	842.64	B	2
B189	7.48	90.59	71.91	122.71	80.86	25.61	35.87	34.76	89.35	183.33	49.98	49.55	842.00	B	2
B190	7.56	93.36	69.96	122.58	80.05	25.54	35.87	34.51	90.20	181.44	49.55	50.04	840.66	B	2
B191	7.39	93.46	70.62	121.77	78.98	25.72	35.57	34.26	89.07	180.64	49.92	49.68	837.08	B	2
B192	7.79	92.56	71.83	122.68	81.17	25.80	35.59	34.32	92.02	183.05	49.69	50.03	846.53	B	2
B193	7.09	91.44	70.56	121.54	79.23	25.35	36.41	34.45	91.26	184.33	49.82	49.54	841.02	B	2
B194	6.99	89.61	70.15	120.05	80.88	25.57	36.12	34.01	90.52	180.40	50.07	50.21	834.58	B	2
B195	7.22	90.83	70.76	120.97	78.63	25.72	36.15	34.33	91.52	183.68	50.03	50.20	840.04	B	2
B196	7.91	93.11	72.23	122.98	78.92	25.62	35.83	34.26	91.45	183.82	50.12	49.81	846.06	B	2
B197	7.03	84.29	72.58	122.37	79.21	25.44	35.60	34.21	91.59	179.21	49.84	49.78	831.15	B	2
B198	6.98	92.04	70.59	120.72	79.87	25.97	35.90	34.37	90.45	181.53	49.70	50.00	838.12	B	2
B199	6.83	88.70	72.72	121.56	80.56	25.38	35.88	34.92	89.85	179.84	50.11	49.74	836.09	B	2
B200	7.38	90.07	71.14	119.65	78.51	25.52	35.55	34.77	90.47	180.43	49.73	50.05	833.27	B	2
B201	7.27	93.74	71.17	120.38	79.50	25.29	36.19	34.35	89.44	182.69	50.28	49.84	840.14	B	2
B202	6.97	95.42	70.50	121.85	81.51	25.96	35.99	34.16	90.49	182.43	49.61	49.97	844.86	B	2
B203	6.93	91.59	72.70	119.87	81.04	25.08	35.65	34.60	90.71	184.61	49.91	49.57	842.26	B	2
B204	7.04	93.30	69.50	119.03	81.61	25.34	36.41	34.41	89.41	184.82	49.90	49.68	840.45	B	2
B205	7.73	92.13	71.66	121.88	79.71	25.19	35.64	34.06	89.40	182.41	50.22	49.51	839.54	B	2
B206	7.36	90.49	72.73	122.23	79.53	25.10	35.55	34.37	92.63	179.71	49.61	50.08	839.39	B	2
B207	9.81	85.17	67.59	118.19	81.93	25.48	35.62	34.43	90.12	183.07	50.01	49.97	831.39	B	3
B208	9.92	86.33	70.68	117.54	80.56	25.68	35.50	34.86	90.90	179.33	49.66	50.01	830.97	B	3
B209	10.31	90.13	70.55	118.18	80.98	25.60	35.95	34.80	91.73	183.84	49.97	49.58	841.62	B	3
B210	10.90	88.03	67.63	119.79	82.32	25.33	36.06	34.72	88.23	181.56	49.76	50.05	834.38	B	3
B211	11.59	86.07	69.09	118.08	80.93	25.23	35.84	34.03	87.96	183.36	50.17	49.85	832.20	B	3
B212	9.94	84.23	68.66	119.53	79.44	25.03	36.30	34.53	89.01	181.62	50.16	49.93	828.38	B	3
B213	11.68	88.62	70.87	119.67	79.31	25.35	36.04	34.74	90.25	182.08	49.52	49.78	837.91	B	3
B214	11.99	86.28	71.54	118.12	80.42	25.50	35.55	34.51	87.68	184.32	49.75	49.58	835.24	B	3
B215	11.99	88.82	70.21	117.70	79.16	25.68	35.76	34.60	89.15	184.36	50.10	49.90	837.43	B	3
B216	11.11	86.12	67.86	119.33	78.53	25.44	35.97	34.31	91.96	182.63	49.60	50.21	833.07	B	3
B217	10.49	90.31	71.45	117.43	80.43	25.41	35.97	34.59	91.02	183.83	49.89	49.64	840.46	B	3
B218	11.98	89.64	71.70	117.61	79.98	25.04	36.41	34.47	88.18	182.41	50.18	49.61	837.21	B	3
B219	11.48	86.39	70.29	119.54	80.49	25.63	35.52	34.23	90.05	184.35	49.70	49.90	837.57	B	3
B220	9.96	85.64	69.90	118.00	79.32	25.23	35.53	34.16	89.89	181.03	49.56	49.84	828.06	B	3
B221	10.07	89.82	70.02	117.73	81.80	25.98	35.79	34.73	87.05	181.66	49.52	49.79	833.96	B	3
B222	10.55	87.78	69.59	117.29	79.55	25.46	36.03	34.15	87.60	181.20	50.22	49.72	829.14	B	3
B223	11.02	84.80	71.76	117.95	80.47	25.57	35.55	34.08	89.67	182.18	49.54	49.77	832.36	B	3
B224	11.92	85.36	71.12	118.35	78.77	25.47	36.01	34.03	91.44	183.38	49.94	50.07	835.86	B	3
B225	9.93	84.71	71.00	117.39	79.03	25.32	35.62	34.70	88.50	183.91	50.08	50.07	830.26	B	3
B226	10.08	87.78	70.37	118.49	81.17	25.78	35.51	34.10	91.05	184.74	50.25	50.25	839.57	B	3
B227	9.81	90.10	70.87	119.64	79.35	25.57	35.64	34.93	90.49	182.67	49.77	50.06	838.90	B	3
B228	11.61	86.65	70.21	117.90	79.01	25.31	36.39	34.40	91.71	183.35	49.77	49.78	836.09	B	3
B229	10.86	86.79	68.66	119.94	80.77	25.35	36.40	34.86	89.35	181.07	49.96	50.29	834.30	B	3
B230	10.51	88.30	67.84	117.26	79.63	25.93	36.13	34.25	90.72	182.31	50.02	50.09	832.99	B	3
B231	10.70	87.56	70.94	118.79	80.64	25.55	35.81	34.38	91.42	184.68	49.86	49.75	840.08	B	3
B232	9.80	90.45	67.95	117.17	79.53	25.91	35.99	34.82	88.42	181.70	49.84	50.11	831.69	B	3
B233	10.42	86.85	70.79	119.95	81.76	25.44	35.53	34.23	87.86	180.12	49.60	50.25	832.80	B	3
B234	11.49	88.38	67.53	118.65	80.58	25.87	35.84	34.26	88.10	179.46	49.95	50.20	830.31	B	3
B235	11.66	87.71	69.53	118.81	81.07	25.18	35.82	34.38	89.03	179.72	49.97	49.65	832.53	B	3
B236	9.94	84.14	71.16	117.75	79.89	25.68	36.27	34.39	87.58	181.57	49.64	49.64	827.65	B	3
B237	10.16	87.40	71.19	118.99	80.66	25.70	36.22	34.82	87.09	181.43	50.08	49.69	833.43	B	3
B238	11.33	87.54	70.31	117.10	79.43	25.90	35.78	34.37	89.12	179.09	50.17	50.06	830.20	B	3
B239	10.68	84.62	69.55	119.31	78.89	25.38	35.52	34.19	87.98	182.58	50.05	50.21	828.96	B	3
B240	11.11	88.83	67.65	119.29	79.46	25.11	35.97	34.48	88.54	183.38	49.84	49.54	833.20	B	3
B241	9.86	86.98	70.18	118.00	79.28	25.22	36.03	34.67	89.47	182.36	50.22	49.63	831.90	B	3
B242	11.08	84.76	69.02	118.34	78.83	25.25	35.72	34.63	90.62	184.72	50.28	49.78	833.03	B	3
B243	11.82	87.52	71.89	117.99	78.95	25.83	35.76	34.01	90.53	180.26	49.85	50.24	834.65	B	3
B244	11.58	86.42	68.38	117.72	80.47	25.45	35.87	34.28	90.94	179.58	49.90	49.51	830.10	B	3
B245	10.22	84.11	70.57	117.89	80.46	25.41	35.87	34.40	90.81	182.79	50.04	49.81	832.38	B	3
B246	10.99	87.38	69.75	118.22	82.86	25.93	36.25	34.92	90.98	184.01	50.17	50.28	841.74	B	3
B247	11.35	90.16	69.29	118.20	79.20	25.08	36.30	34.41	91.77	180.15	49.54	50.14	835.59	B	3
B248	10.96	89.78	71.81	118.10	81.75	25.43	35.59	34.30	89.04	183.52	49.97	49.92	840.17	B	3
B249	10.99	85.27	70.72	118.09	80.65	25.22	36.24	34.04	88.35	181.76	49.92	49.74	830.99	B	3

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
B250	10.95	88.13	67.52	118.89	79.28	25.28	36.14	34.78	87.76	183.09	50.10	49.55	831.47	B	3
B251	10.52	84.22	68.88	117.02	81.90	25.16	36.14	34.76	88.00	181.61	50.04	49.70	827.95	B	3
B252	10.85	88.16	70.18	117.49	79.48	25.00	35.93	34.34	87.05	182.12	50.28	49.53	830.41	B	3
B253	9.85	89.69	69.69	118.33	80.35	25.06	35.61	34.05	87.88	183.74	49.60	49.94	833.79	B	3
B254	11.04	85.54	71.57	117.51	78.72	25.00	35.61	34.93	87.22	184.90	49.89	49.86	831.79	B	3
B255	11.09	89.24	70.62	117.78	81.44	25.90	35.76	34.24	87.94	179.78	50.25	50.05	834.09	B	3
B256	10.96	89.58	68.77	118.37	80.76	25.36	35.58	34.73	90.09	181.88	49.51	50.03	835.62	B	3
B257	10.77	84.29	71.45	117.57	78.51	25.69	35.92	34.11	88.48	183.75	49.86	49.60	830.00	B	3
B258	11.28	97.93	69.65	119.81	79.56	25.22	35.97	34.31	87.76	180.09	49.90	49.84	841.32	B	3
B259	10.09	84.56	71.85	119.99	80.63	25.80	35.79	34.39	90.79	184.40	49.88	49.53	837.70	B	3
B260	11.91	86.94	70.92	117.10	79.76	25.23	36.27	34.82	88.38	180.51	49.51	49.97	831.32	B	3
B261	10.46	90.10	71.39	118.71	82.41	25.92	36.05	34.56	89.58	184.60	50.03	49.62	843.43	B	3
B262	10.59	84.49	67.80	118.47	80.87	25.66	36.03	34.03	90.73	182.26	50.01	50.27	831.21	B	3
B263	9.92	87.01	70.75	119.39	80.26	25.64	36.01	34.72	87.39	179.19	49.50	49.98	829.76	B	3
B264	10.10	88.80	70.50	117.98	81.98	25.79	35.66	34.92	91.65	180.94	49.69	49.61	837.62	B	3
B265	10.62	88.40	70.22	118.07	80.39	25.18	36.18	34.02	91.61	179.12	49.55	49.60	832.96	B	3
B266	11.66	89.84	71.57	119.98	80.42	25.14	36.16	34.83	89.91	182.37	50.02	50.05	841.95	B	3
B267	10.58	88.72	68.22	119.95	79.08	25.99	36.42	34.47	91.31	182.96	50.00	50.29	837.99	B	3
B268	10.14	85.24	69.13	117.47	80.65	25.01	35.54	34.43	88.80	184.86	49.97	50.07	831.31	B	3
B269	10.44	86.47	67.59	118.95	79.87	25.55	36.42	34.61	88.76	184.76	49.50	50.15	833.07	B	3
B270	11.04	85.66	70.63	117.03	82.06	25.92	35.65	34.91	88.12	179.13	50.14	49.78	830.07	B	3
B271	11.75	87.37	69.80	119.53	79.85	25.73	35.82	34.76	90.68	180.57	50.29	49.91	836.06	B	3
B272	10.17	89.74	70.99	119.87	79.91	25.71	35.93	34.96	87.48	181.06	49.73	49.81	835.36	B	3
B273	11.01	89.58	68.71	119.56	78.93	25.40	36.02	34.89	91.87	179.55	49.95	49.70	835.17	B	3
B274	10.38	84.32	71.12	119.99	80.31	25.13	36.03	34.96	91.47	180.79	49.76	50.25	834.51	B	3
B275	11.16	86.18	68.57	117.34	80.90	25.13	36.30	34.18	87.54	179.49	49.65	49.80	826.24	B	3
B276	10.51	89.73	67.79	119.35	80.61	25.23	35.67	34.36	91.22	179.08	49.99	49.99	833.53	B	3
B277	10.38	86.48	69.27	118.14	78.84	25.72	35.98	34.75	89.13	181.21	49.54	50.10	829.54	B	3
B278	10.73	86.35	68.96	118.36	80.55	25.75	35.75	34.03	91.71	180.14	50.04	50.13	832.50	B	3
B279	11.54	86.48	67.82	117.70	80.93	25.06	36.25	34.34	88.18	183.44	49.62	50.00	831.36	B	3
B280	10.84	86.03	70.33	118.29	81.76	25.02	36.45	34.69	90.26	181.59	50.06	49.62	834.94	B	3
B281	11.99	88.04	69.35	118.43	79.91	25.98	36.35	34.71	90.88	183.84	49.56	49.84	838.88	B	3
B282	11.82	90.38	68.28	117.08	80.65	25.88	36.35	34.55	91.09	179.55	49.82	49.87	835.32	B	3
B283	11.45	84.41	70.82	117.26	80.46	25.54	35.83	34.37	88.32	182.69	49.82	49.50	830.47	B	3
B284	11.58	85.94	69.51	119.76	81.95	25.67	35.52	34.83	91.17	184.78	49.87	50.28	840.86	B	3
B285	11.93	85.41	68.90	118.74	78.95	25.45	36.42	34.70	91.13	181.80	49.73	49.59	832.75	B	3
B286	11.58	87.86	67.61	119.98	79.74	25.99	35.93	34.37	87.08	183.48	50.20	49.80	833.62	B	3
B287	9.83	88.23	71.13	117.62	80.72	25.26	35.54	34.60	89.20	181.16	49.97	49.86	833.12	B	3
B288	10.53	84.84	69.62	118.76	80.69	25.42	36.12	34.48	89.16	183.36	49.56	50.22	832.76	B	3
B289	10.93	88.79	70.12	118.73	81.49	25.63	36.46	34.62	87.15	179.80	49.91	49.51	833.14	B	3
B290	11.22	90.11	71.19	119.77	79.98	25.96	35.93	34.55	87.99	179.13	49.70	49.86	835.39	B	3
B291	11.61	96.85	68.31	117.39	80.02	25.17	35.54	34.60	91.67	181.82	50.10	49.58	842.66	B	3
B292	9.88	86.78	68.86	117.46	79.41	25.52	35.88	34.25	91.38	179.81	50.16	49.87	829.26	B	3
B293	10.48	89.75	67.83	119.70	80.08	25.97	35.76	34.38	87.33	179.66	50.00	49.55	830.49	B	3
B294	11.51	86.10	67.87	118.14	80.39	25.48	35.94	34.73	88.56	181.30	49.66	49.55	829.23	B	3
B295	10.47	85.65	71.72	119.77	79.55	25.80	35.51	34.27	91.15	183.19	49.85	49.90	836.83	B	3
B296	10.66	84.14	68.45	117.81	80.80	25.05	36.00	34.83	91.27	183.93	50.20	50.09	833.23	B	3
B297	11.75	88.12	68.07	117.07	78.57	25.84	35.99	34.57	88.99	179.06	50.14	49.82	827.99	B	3
B298	10.56	89.04	69.67	117.46	79.62	25.05	36.20	34.43	88.76	184.39	49.89	50.04	835.11	B	3
B299	11.06	88.98	69.55	118.49	80.83	25.91	35.96	34.40	91.55	184.55	50.20	49.52	841.00	B	3
B300	10.04	89.15	69.31	117.76	79.89	25.98	36.37	34.25	90.07	180.61	50.02	49.77	833.22	B	3
B301	10.58	85.65	68.22	118.58	80.18	25.90	36.44	34.91	87.47	179.61	49.51	49.76	826.81	B	3
B302	10.64	90.31	68.35	119.63	81.53	25.42	35.52	34.02	88.16	179.21	50.07	49.98	832.84	B	3
B303	10.44	88.05	68.20	117.01	79.73	25.33	36.00	34.96	87.17	183.21	49.84	49.77	829.71	B	3
B304	9.83	84.35	71.00	118.98	80.09	25.25	36.00	34.41	90.07	184.54	50.01	49.66	834.19	B	3
B305	11.39	85.09	69.20	117.97	78.87	25.61	36.39	34.60	90.34	184.85	50.12	49.72	834.15	B	3
B306	11.02	90.23	70.17	118.81	80.99	25.43	36.32	34.97	89.75	182.40	49.80	50.14	840.03	B	3
B307	10.37	89.98	70.26	118.27	80.82	25.01	35.66	34.66	89.60	179.53	49.80	50.24	834.20	B	3
B308	10.27	87.76	69.24	119.31	79.71	25.64	35.63	34.79	88.23	184.66	49.54	49.97	834.75	B	3
B309	10.32	90.15	68.52	118.90	79.87	25.64	35.76	34.59	87.89	180.98	49.60	49.93	832.15	B	3
B310	19.81	87.31	69.10	119.98	80.43	25.85	35.86	34.62	90.08	182.10	50.23	49.88	845.25	B	4
B311	20.06	85.98	71.53	117.17	80.06	25.35	35.89	34.48	89.18	180.31	49.78	49.75	839.54	B	4
B312	20.67	85.09	68.25	119.97	79.24	25.60	36.23	34.83	91.12	181.23	50.06	49.58	841.87	B	4
B313	20.04	88.90	68.59	117.02	81.36	25.32	36.25	34.48	88.26	182.96	50.01	49.65	842.84	B	4
B314	20.60	86.58	67.72	117.26	80.59	25.08	35.86	34.66	89.64	180.83	49.71	50.12	838.65	B	4
B315	19.96	88.53	69.07	117.90	78.86	25.71	35.68	34.12	90.36	181.30	49.65	50.21	841.35	B	4
B316	20.35	88.73	70.49	118.01	81.97	25.32	35.74	34.47	89.27	183.66	49.60	49.81	847.42	B	4
B317	20.96	85.50	69.61	117.42	80.45	25.65	35.77	34.85	89.54	184.00	50.05	50.29	844.09	B	4
B318	20.65	88.10	69.90	117.49	79.25	25.63	35.62	34.03	87.64	181.29	49.88	50.13	839.61	B	4
B319	20.10	85.02	71.07	119.37	81.37	25.10	35.99	34.02	88.09	180.94	50.06	49.55	840.68	B	4
B320	20.29	85.12	71.70	117.14	80.95	25.43	35.88	34.65	90.07	182.23	50.29	49.92	843.67	B	4
B321	19.85	88.76	70.74	118.98	79.49	25.91	36.46	34.75	88.16	184.61	50.21	49.84	847.76	B	4
B322	20.15	88.34	68.12	117.92	80.85	25.76	36.26	34.73	87.73	180.73	49.64	50.25	840.48	B	4
B323	20.98	85.93	70.62	117.83	79.50	25.70	36.02	34.63	91.22	180.99	49.99	49.72	843.13	B	4
B324	20.39	88.86	70.57	118.32	80.03	25.06	36.40	34.28	87.96	183.92	49.70	50.18	845.67	B	4
B325	20.26	85.79	69.31	118.35	80.68	25.48	36.44	34.81	88.73	179.86	49.77	49.87	839.35	B	4
B326	19.98	84.50	70.75	119.65	79.98	25.11	36.48	34.57	91.83	183.04	50.18	50.20	846.27	B	4
B327	20.41	88.41	70.67	118.10	81.90	25.29	36.05	34.93	91.39	182.63	49.88	49.99	849.65	B	4
B328	20.96	99.16	67.56	119.42	80.60	25.62	35.88	34.76	88.29	180.39	49.77	49.51	851.92	B	4
B329	19.91	84.13	69.19	118.77	79.99	25.63	36.38	34.22	91.54	183.18	50.27	50.27	843.48	B	4
B330	20.14	86.62	71.04	118.86	80.05	25.69	35.93	34.08	87.66	181.91	49.55	49.90	841.43	B	4
B331	20.23	88.67	68.34	119.81	81.85	25.25	35.91	34.76	88.61	182.27	50.24	49.74	845.68	B	4
B332	19.91	86.33	71.99	117.73	80.00	25.54	35.54	34.52	87.00	181.79	50.15	49.51	840.01	B	4

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
B333	19.97	87.78	69.32	118.28	79.64	25.93	35.66	34.40	87.88	181.13	49.53	50.15	839.67	B	4
B334	20.04	89.85	68.50	118.16	80.62	25.72	35.81	34.20	89.82	180.11	50.10	50.18	843.11	B	4
B335	20.64	86.66	68.66	118.36	80.15	25.75	35.81	34.81	88.18	179.28	49.98	50.22	838.50	B	4
B336	19.96	88.56	70.95	118.88	80.98	25.42	35.98	34.75	90.54	182.05	49.64	49.83	847.54	B	4
B337	20.77	85.98	69.92	118.73	79.91	25.18	36.43	34.17	91.75	181.08	49.92	49.64	843.48	B	4
B338	20.85	84.06	68.71	119.58	80.99	25.26	36.01	34.43	91.22	184.20	50.23	49.52	845.06	B	4
B339	20.75	84.48	67.89	117.59	80.66	25.45	36.06	34.67	87.02	182.72	50.16	49.53	836.98	B	4
B340	20.98	84.08	69.22	117.67	80.15	25.10	36.05	34.54	88.05	180.32	50.18	50.21	836.55	B	4
B341	19.88	86.66	69.03	118.94	79.91	25.40	36.16	34.88	88.43	184.64	50.00	50.00	843.93	B	4
B342	19.94	85.01	70.94	119.72	79.60	25.89	35.62	34.83	90.99	184.67	50.06	49.77	847.04	B	4
B343	20.65	88.70	68.08	118.63	80.62	25.75	36.05	34.29	91.63	183.84	50.06	49.68	847.98	B	4
B344	20.44	88.00	68.89	119.44	80.24	25.75	36.02	34.00	90.98	179.42	49.77	49.58	842.53	B	4
B345	20.73	89.93	70.45	117.58	80.11	25.61	35.98	34.56	90.81	179.24	50.22	50.05	845.27	B	4
B346	20.26	95.23	71.26	118.98	79.23	25.95	36.15	34.15	91.23	182.71	49.54	50.11	854.80	B	4
B347	20.39	92.17	71.68	119.23	81.41	25.42	36.30	34.57	87.56	182.06	49.70	49.86	850.35	B	4
B348	20.56	84.59	70.34	119.46	80.93	25.07	35.67	34.23	91.70	180.79	49.51	49.57	842.42	B	4
B349	19.94	89.88	71.06	119.78	80.05	25.69	35.61	34.76	89.79	183.74	50.17	50.22	850.69	B	4
B350	20.95	85.65	68.51	117.80	79.18	25.49	35.98	34.43	91.71	181.28	49.61	50.02	840.61	B	4
B351	20.72	89.20	69.91	117.01	79.89	25.50	35.79	34.66	88.13	181.47	49.93	50.19	842.40	B	4
B352	19.86	87.55	68.32	118.96	80.73	25.22	36.08	34.09	90.05	184.70	50.10	50.29	845.95	B	4
B353	20.58	86.17	71.54	118.79	80.41	25.17	36.34	34.75	89.99	184.03	49.78	50.09	847.64	B	4
B354	20.94	89.17	71.59	117.52	80.55	25.30	35.85	34.80	87.62	180.08	49.94	49.77	843.13	B	4
B355	20.90	90.05	69.17	117.58	78.77	25.89	35.50	34.48	89.89	184.15	49.93	49.79	846.10	B	4
B356	19.97	86.12	70.54	117.88	80.64	25.09	35.99	34.62	88.41	183.16	49.80	49.73	841.95	B	4
B357	20.07	84.07	67.50	118.44	80.25	25.66	36.22	34.37	91.93	180.22	50.11	49.71	838.55	B	4
B358	20.63	87.80	68.06	119.20	81.79	25.10	35.79	34.93	87.95	179.44	49.69	50.16	840.54	B	4
B359	20.51	89.68	69.49	118.66	82.08	25.98	35.97	34.94	91.48	180.69	50.03	49.65	849.16	B	4
B360	20.89	89.51	67.78	117.09	80.25	25.77	36.28	34.65	89.74	184.93	50.21	50.06	847.16	B	4
B361	19.89	86.93	69.57	119.24	78.72	25.41	35.67	34.16	89.51	179.64	49.54	49.52	837.80	B	4
B362	20.14	87.19	68.07	119.42	79.95	25.40	36.31	34.28	89.51	182.56	49.61	49.75	842.19	B	4
B363	20.89	88.12	69.82	119.32	79.50	25.25	35.60	34.42	88.17	182.68	49.97	49.58	843.32	B	4
B364	20.00	89.99	71.46	117.46	80.76	25.02	35.83	34.22	88.12	179.74	50.08	49.87	842.55	B	4
B365	19.94	89.03	68.06	119.65	81.07	25.78	35.53	34.33	87.88	183.74	49.98	49.62	844.61	B	4
B366	20.33	88.19	71.38	118.45	79.92	25.67	35.74	34.82	88.71	184.45	49.71	50.16	847.53	B	4
B367	20.47	85.29	71.66	119.82	80.89	25.97	35.57	34.60	87.76	183.56	50.05	50.05	845.69	B	4
B368	20.27	88.12	68.39	119.36	78.66	25.24	36.33	34.77	88.28	181.14	49.87	50.13	840.56	B	4
B369	20.67	86.59	67.76	118.87	82.05	25.96	36.18	34.96	91.17	183.59	49.64	49.76	847.20	B	4
B370	20.46	85.37	67.82	117.42	79.99	25.99	36.25	34.45	88.93	179.77	49.92	49.82	836.19	B	4
B371	20.08	88.42	70.98	117.85	79.44	25.04	35.90	34.17	87.28	184.02	49.64	49.84	842.66	B	4
B372	20.88	84.71	70.43	119.93	79.60	25.52	35.73	34.21	87.70	183.10	49.86	50.19	841.86	B	4
B373	20.89	86.79	71.24	117.75	80.02	25.10	35.53	34.25	89.01	181.81	49.84	50.04	842.27	B	4
B374	20.09	85.75	71.81	117.93	80.98	25.31	36.07	34.30	91.19	183.40	49.64	49.96	846.43	B	4
B375	20.62	84.93	69.42	119.80	78.92	25.39	36.44	34.25	89.85	182.58	50.02	49.72	841.94	B	4
B376	20.03	86.58	68.10	119.67	80.04	25.32	35.75	34.92	91.29	181.09	49.72	50.01	842.52	B	4
B377	20.26	89.03	67.98	118.53	79.23	25.10	35.61	34.26	87.62	183.54	50.27	49.52	840.95	B	4
B378	20.49	84.11	67.61	118.07	79.85	25.08	35.70	34.60	89.31	183.92	49.85	50.19	838.78	B	4
B379	20.73	87.17	70.84	118.29	81.81	25.03	36.05	34.30	88.55	182.52	49.88	49.99	845.16	B	4
B380	20.90	87.43	71.12	119.90	79.46	25.70	36.19	34.82	87.31	180.63	49.66	50.08	843.20	B	4
B381	20.59	86.08	69.97	117.39	80.03	25.14	35.55	34.23	91.14	180.35	49.67	49.74	839.88	B	4
B382	20.22	90.43	68.78	119.74	79.66	25.02	36.13	34.61	90.90	182.83	50.12	50.19	848.63	B	4
B383	20.50	89.86	71.34	119.93	80.27	25.45	35.86	34.33	88.30	183.41	49.79	50.12	849.16	B	4
B384	20.45	86.94	67.85	118.72	79.62	25.58	36.43	34.85	87.74	183.35	49.97	50.22	841.72	B	4
B385	20.95	84.19	68.15	119.12	81.09	25.98	36.28	34.53	90.34	180.92	49.74	50.01	841.30	B	4
B386	20.29	88.85	71.02	118.93	80.48	25.73	36.03	34.13	88.74	181.04	49.88	49.97	845.09	B	4
B387	20.66	85.65	71.35	119.01	78.86	25.62	36.23	34.89	91.27	184.12	50.25	49.72	847.63	B	4
B388	20.23	84.59	70.85	117.71	80.76	25.13	36.50	34.26	91.17	182.78	49.81	49.62	843.41	B	4
B389	20.80	96.36	67.73	117.52	78.83	25.26	35.63	34.50	88.91	182.49	49.85	50.04	847.92	B	4
B390	20.25	84.41	68.64	119.25	80.85	25.23	36.07	34.10	87.65	182.61	49.59	49.56	838.21	B	4
B391	20.49	85.42	68.86	117.05	80.14	25.74	35.65	34.02	88.28	179.30	50.15	49.56	834.66	B	4
B392	20.16	87.47	70.22	118.98	79.00	25.51	35.75	34.44	87.24	181.10	50.25	49.66	839.78	B	4
B393	20.07	85.02	71.29	119.55	79.15	25.46	35.92	34.16	89.70	180.11	50.25	49.50	840.18	B	4
B394	20.69	87.01	67.53	119.56	78.75	25.80	36.11	34.06	90.13	182.06	49.85	50.00	841.55	B	4
B395	20.23	85.86	67.97	118.50	81.48	25.69	36.19	34.78	89.97	181.81	49.77	49.79	842.04	B	4
B396	20.73	86.32	68.12	119.05	80.38	25.05	36.48	34.34	90.84	184.74	49.94	49.94	845.93	B	4
B397	20.06	88.97	69.28	119.21	80.84	25.63	36.46	34.68	88.03	181.43	49.91	49.74	844.24	B	4
B398	20.30	85.23	67.88	119.07	80.71	25.89	35.99	34.90	89.49	183.20	50.20	49.65	842.51	B	4
B399	20.63	85.63	68.15	118.69	80.98	25.81	35.65	34.02	88.23	179.79	50.07	49.85	837.50	B	4
B400	20.78	84.25	71.88	119.24	79.76	25.57	36.19	34.96	91.74	179.04	49.98	49.98	843.37	B	4
B401	20.73	90.07	68.70	118.84	79.85	25.97	36.14	34.75	89.40	181.19	50.22	49.80	845.66	B	4
B402	20.42	90.10	70.19	117.95	81.47	25.83	35.69	34.08	89.08	179.62	50.03	50.08	844.54	B	4
B403	20.76	88.81	70.65	119.91	78.79	25.10	35.52	34.98	91.60	182.35	50.17	49.57	848.21	B	4
B404	20.62	88.62	68.31	117.39	80.64	25.17	36.38	34.29	88.96	183.63	49.98	50.28	844.27	B	4
B405	19.82	88.61	68.37	118.31	79.46	25.18	36.37	34.88	87.74	184.44	49.69	49.72	842.59	B	4
B406	20.62	85.28	68.33	117.66	81.56	25.19	36.23	34.33	88.80	180.69	49.62	49.97	838.28	B	4
B407	20.18	81.30	71.31	118.81	81.55	25.16	36.11	34.36	88.03	180.74	49.86	49.91	837.32	B	4
B408	20.85	90.33	70.39	118.56	80.26	25.90	35.60	34.82	90.96	182.28	49.63	49.56	849.14	B	4
B409	20.21	87.08	69.12	119.52	80.24	25.73	35.91	34.59	90.97	179.14	49.52	49.51	841.54	B	4
B410	20.58	85.14	71.53	117.09	81.47	25.51	36.01	34.09	87.74	184.25	50.01	50.00	843.42	B	4
B411	20.44	88.86	70.02	117.60	80.05	25.11	36.45	34.55	90.33	179.19	50.19	49.54	842.33	B	4

Engine C – All values recorded are in decimal minutes.

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
C1	9.55	148.64	119.78	90.95	45.41	21.15	33.97	15.06	11.97	15.31	6.35	11.23	12.34	79.88	48.40	14.97	164.00	134.53	126.66	388.84	167.54	123.42	1789.95	C	1
C2	9.75	151.62	119.18	90.02	45.57	20.53	33.59	15.58	11.91	15.06	7.14	11.19	12.61	80.20	54.37	15.26	165.93	136.18	125.93	390.29	166.66	121.59	1800.16	C	1
C3	10.87	144.84	121.02	97.55	45.82	19.34	34.70	14.48	12.08	15.54	5.84	11.32	13.73	79.61	51.18	16.07	165.46	135.28	127.08	388.96	166.76	120.30	1797.83	C	1
C4	10.34	143.62	121.45	96.48	46.65	20.09	33.07	14.67	11.87	15.41	5.96	12.01	11.92	81.79	49.23	15.58	168.09	133.88	123.59	389.47	167.88	124.49	1797.54	C	1
C5	9.53	153.98	121.34	95.82	45.67	19.58	32.86	14.49	11.73	15.33	5.54	11.30	12.98	81.89	49.39	14.77	164.47	128.45	116.26	390.77	167.38	118.50	1782.03	C	1
C6	9.66	149.94	119.23	95.36	44.98	20.12	34.62	15.07	11.76	15.72	5.47	11.00	12.37	81.43	49.80	15.49	169.63	136.27	108.70	386.61	165.95	119.33	1772.51	C	1
C7	9.70	146.24	122.16	93.45	45.41	20.39	32.48	15.45	11.83	14.60	7.27	10.76	13.32	80.42	48.19	15.10	165.06	127.76	110.55	390.21	168.79	118.91	1768.05	C	1
C8	10.09	144.37	121.47	90.32	46.40	19.36	33.36	14.59	12.51	14.75	6.13	10.68	14.02	82.63	52.19	16.31	166.33	123.90	117.90	389.36	167.24	124.38	1778.29	C	1
C9	10.11	139.14	119.17	96.26	45.58	19.34	32.74	14.83	12.07	15.35	7.23	11.34	14.36	79.45	52.73	16.00	164.67	139.04	112.80	389.38	167.21	120.60	1779.40	C	1
C10	10.11	143.39	122.31	89.66	46.47	19.90	34.87	14.84	11.82	15.10	5.04	11.18	14.40	81.20	48.95	14.80	166.73	129.20	112.71	390.28	167.93	119.53	1770.42	C	1
C11	10.44	144.02	119.87	96.38	46.10	21.99	32.86	15.23	12.16	15.29	5.01	12.08	12.19	80.43	52.15	16.39	167.72	127.34	121.76	390.98	167.94	124.75	1792.58	C	1
C12	10.61	141.80	120.30	96.20	45.61	20.22	33.98	15.04	12.73	14.70	6.82	11.21	12.13	81.08	49.59	16.13	166.52	131.64	113.63	388.33	167.02	124.41	1779.70	C	1
C13	10.58	143.92	122.46	93.06	45.17	21.95	34.89	14.85	11.46	14.68	5.66	10.97	14.28	81.39	52.01	15.14	168.61	125.63	111.31	387.82	166.42	118.88	1771.14	C	1
C14	10.68	142.55	122.19	96.58	44.59	20.26	33.92	14.40	12.28	14.77	5.52	12.45	12.58	81.05	52.92	16.35	168.61	135.30	119.31	388.37	167.14	123.60	1795.42	C	1
C15	10.94	142.35	121.66	96.16	45.74	19.78	33.71	14.80	12.15	14.90	5.13	12.37	12.13	80.86	52.21	15.88	167.12	138.11	128.86	388.79	165.47	118.94	1798.06	C	1
C16	10.61	151.30	120.63	89.46	44.90	19.37	33.63	14.53	11.55	15.18	5.34	12.21	12.66	80.43	50.58	15.78	165.39	134.60	126.95	389.21	165.15	122.22	1791.68	C	1
C17	10.61	138.94	119.65	92.47	45.48	20.33	34.27	14.84	11.89	15.81	5.57	12.49	13.79	80.62	49.69	15.17	168.94	132.14	118.19	386.55	167.49	119.78	1774.71	C	1
C18	9.81	140.56	121.13	90.43	46.07	19.47	33.01	15.04	12.10	14.87	5.63	12.12	12.92	80.54	49.60	15.55	167.78	133.21	129.15	390.84	167.06	120.17	1787.06	C	1
C19	10.28	150.58	118.56	92.52	44.71	22.08	32.52	14.79	11.99	15.75	7.24	11.22	13.43	81.10	51.54	15.55	167.98	134.03	123.46	390.41	168.38	119.01	1797.13	C	1
C20	9.59	153.65	119.07	90.92	46.27	19.55	34.25	15.48	12.39	14.74	7.41	11.19	12.91	81.97	48.96	15.42	168.22	130.87	122.58	391.28	167.37	120.06	1794.15	C	1
C21	10.92	144.32	119.67	95.42	46.19	22.42	33.16	15.63	12.61	14.60	6.21	12.45	13.06	82.04	49.70	16.07	167.43	128.91	126.23	389.23	167.07	120.85	1794.19	C	1
C22	10.13	147.62	122.12	96.94	44.99	22.00	34.68	14.66	11.58	15.27	5.33	11.02	11.53	82.09	52.89	14.73	164.51	133.17	123.67	389.00	167.68	119.47	1795.08	C	1
C23	10.36	145.26	122.84	95.40	44.52	21.30	34.27	14.97	12.66	14.98	5.53	11.29	12.67	80.39	49.46	15.55	168.18	130.56	125.00	390.23	168.80	124.15	1798.37	C	1
C24	9.62	143.00	120.75	89.78	46.31	20.35	33.91	15.47	12.03	15.14	5.77	12.03	12.19	80.13	48.69	14.70	169.20	131.91	119.39	391.01	166.64	121.63	1779.65	C	1
C25	10.34	153.40	122.52	95.89	45.82	22.58	32.51	15.16	11.45	15.60	6.31	10.84	12.81	82.23	48.99	14.78	169.38	125.30	124.06	390.90	168.14	120.76	1799.77	C	1
C26	9.70	151.85	120.96	90.09	46.11	20.05	32.52	14.71	11.43	14.84	7.48	11.01	12.91	82.57	54.17	14.83	165.17	137.42	119.95	388.39	167.54	121.64	1795.34	C	1
C27	10.39	149.12	121.64	95.55	44.53	20.53	33.82	14.80	11.94	14.58	7.11	12.34	11.66	82.43	54.07	15.32	165.95	126.55	109.44	390.25	167.27	119.94	1779.23	C	1
C28	9.92	139.55	119.21	91.62	46.49	21.85	34.47	15.02	11.89	14.69	6.81	11.59	13.21	80.50	52.31	15.71	165.58	127.19	123.10	389.62	168.25	120.38	1778.96	C	1
C29	9.84	144.95	122.64	92.18	44.88	21.09	33.93	14.47	11.65	15.11	6.47	10.52	12.42	79.57	53.59	15.97	167.42	139.64	122.49	388.26	167.90	118.65	1793.64	C	1
C30	9.51	148.37	122.18	93.97	46.09	19.68	32.83	15.16	12.43	14.79	5.58	11.89	12.42	81.82	49.88	16.26	163.70	131.47	119.22	388.08	166.58	122.46	1784.37	C	1
C31	10.71	142.34	120.64	90.83	45.96	21.28	32.62	14.72	12.72	15.77	6.61	11.43	11.81	80.08	47.76	16.45	164.91	129.47	128.94	386.73	165.75	121.05	1778.58	C	1
C32	10.51	147.04	118.45	95.50	44.46	21.95	34.03	15.37	12.69	15.41	5.64	11.61	13.13	82.26	59.56	15.91	169.04	132.73	117.41	388.32	167.14	124.67	1796.83	C	1
C33	9.52	139.12	120.81	97.22	44.40	19.88	32.97	14.52	12.23	14.94	6.32	12.31	14.45	80.10	51.59	15.82	165.62	126.11	122.75	387.69	168.67	123.75	1780.79	C	1
C34	10.41	159.49	119.31	90.04	46.40	21.46	32.59	15.29	11.50	15.22	7.48	12.05	13.05	80.28	53.20	15.84	169.32	124.29	121.09	390.24	167.60	119.72	1795.87	C	1
C35	10.76	148.08	121.20	96.50	45.12	21.22	32.44	15.47	11.80	14.50	7.48	11.48	11.81	79.88	53.59	16.06	168.18	138.40	117.83	388.40	167.91	119.23	1797.34	C	1
C36	10.59	150.84	118.93	97.48	44.75	19.34	34.15	14.74	11.93	15.80	5.55	11.18	14.21	81.82	52.91	15.59	165.07	135.59	119.91	390.74	167.08	122.50	1800.70	C	1
C37	10.77	150.37	119.14	97.11	45.56	21.09	34.88	15.39	11.61	15.55	5.40	10.62	12.46	82.26	48.96	16.33	165.67	131.67	124.08	388.00	168.65	124.31	1799.88	C	1
C38	9.57	142.39	120.76	89.81	45.18	20.14	32.73	14.61	11.56	15.31	7.05	12.24	13.44	80.57	53.27	15.46	164.67	135.08	123.92	386.95	166.61	119.18	1780.50	C	1
C39	10.68	141.88	121.65	97.32	46.69	21.55	33.40	15.57	12.43	15.57	6.94	10.88	13.04	80.74	49.62	15.05	165.02	129.81	118.54	388.41	168.16	119.07	1782.02	C	1
C40	10.24	145.89	118.76	91.40	45.83	21.89	33.03	15.24	11.64	15.39	6.34	11.35	12.31	80.02	51.57	14.80	168.20	126.34	112.92	388.58	166.98	122.25	1770.97	C	1
C41	10.32	141.37	122.67	89.74	44.99	22.55	34.39	14.66	12.65	14.44	6.14	11.64	13.36	81.16	47.72	15.61	167.19	128.64	116.53	386.50	168.07	119.31	1769.65	C	1
C42	10.16	149.44	122.62	89.68	44.92	19.66	33.02	14.94	12.06	14.69	5.97	12.27	12.47	81.45	49.87	14.80	166.57	131.84	120.04	391.66	168.11	120.79	1781.03	C	1
C43	9.97	148.85	121.16	93.95	44.71	20.45	33.16	15.61	12.31	14.72	6.15	10.83	14.39	81.22	47.81	16.43	163.99	128.83	127.76	389.97	168.59	120.62	1791.48	C	1
C44	10.59	144.66	119.67	97.24	45.41	21.60	33.91	15.30	11.80	15.48	7.37	10.92	14.10	82.06	50.12	15.70	163.93	127.94	119.64	389.47	166.57	121.43	1784.91	C	1
C45	10.73	153.35	122.00	89.87	46.12	20.53	33.25	14.89	11.73	14.38	6.34	10.79	14.17	80.38	53.38	16.16	165.32	138.34	112.67	390.55	166.18	121.81	1792.94	C	1
C46	10.46	154.65	122.20	92.56	45.36	19.73	33.09	15.69	12.54	15.63	6.84	11.76	12.59	82.69	51.12	15.28	165.45	139.22	111.71	387.84	167.60	118.40	1792.41	C	1
C47	9.78	149.35	121.60	96.54	46.54	22.24	33.52	15.23	12.34	15.66	6.74	10.71	11.87	81.53	48.47	15.42	163.81	133.29	109.09	386.60	167.80	122.01	1780.14	C	1
C48	9.97	146.01	120.46	90.35	46.62	19.64	33.55	14.92	12.63	14.71	6.38	11.14	12.38	80.59	54.08	16.03	167.97	134.73	114.73	390.84	165.84	121.41	1784.98	C	1
C49	10.73	153.81	118.42	89.50	44.45	20.68	34.31	15.74	11.81	14.73	7.46	11.50	12.51	82.01	49.85	15.13	164.21	127.67	119.42	389.24	167.44	123.61	1784.23	C	1
C50	9.67	153.66	119.36	93.81	45.38	19.78	33.75	15.65	12.59	15.59	6.50	12.04	14.47	81.49	52.16	15.01	168.59	125.66	120.85	387.73	166.65	120.94	1791.33	C	1
C51	10.40	139.32	120.87	94.87	45.39	21.22	33.09	14.56	11.44	14.61	5.93	11.42	14.13	79.69	52.51	16.20	169.39	137.97	114.40	387.20	168.11	123.89	1786.61	C	1
C52	10.53	146.50	118.91	91.97	46.23	21.12	33.30	14.95	11.95	15.21	6.59	12.29	13.06	81.50	48.02	15.05	165.29	126.93	110.97	387.66	167.73	119.24	1765.00	C	1
C53	10.16	141.71	120.05	90.66	45.93	19.74	34.00	15.24	11.63	15.17	7.01	11.92	12.37	81.07	50.96	16.43	166.93	139.13	126.62	387.39	165.08	123.92	1793.12	C	1
C54	10.18	142.51	121.51	95.63	46.21	21.03	32.73	15.12	12.69	15.66	6.87	12.34	12.42	79.94	52.09	14.88	166.48	129.28	121.30	390.52	167.30	122.78	1789.47	C	1
C55	10.98	149.80	122.60	95.04	45.48	20.65	34.67	15.34	11.88	14.78	5.38	11.39	11.84	80.81	50.79	16.26	164.44	130.20	123.92	387.93	167.76	123.20	1794.54	C	1
C56	9.88	153.24	121.01	94.79	46.22	20.46	32.83	15.52	11.86	14.68	5.91	11.05	12.02	81.67	52.52	15.45	169.44	135.55	129.62	390.57	168.13	118.54	1810.96	C	1
C57	10.47	142.64	122.67	93.34	44.88	21.10	34.47	14.92	11.63	15.85	6.10	11.07	12.75	79.64	53.98	15.29	169.22	127.97	115.70	386.89	167.93	120.11	1778.62	C	1
C58	10.67	140.25	121.74	95.25	45.40	21.55	34.41	15.06	12.40	15.31	6.04	12.45	13.80	81.66	51.23	15.48	167.74	132.14	119.28	389.76	167.25	123.47	1792.34	C	1
C59	10.35	154.08	120.39	94.34	46.29	21.89	34.78	15.67	12.52	15.73	6.81	11.41	13.07	82.68	51.30	14.85	164.47	128.91	124.13	390.21	167.24	122.24	1803.36	C	1
C60	9.84	140.97	120.40	94.16	45.89	20.27	34.08	14.95	11.86	14.69	6.66	11.64	11.57	81.84	49.05	14.96	168.54	128.06	119.65	390.10	167.48	121.29	1777.35	C	1

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PARTS	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
C61	10.32	164.22	118.48	96.72	45.50	20.49	34.72	15.73	11.48	14.86	6.86	10.87	12.89	80.53	53.72	14.78	169.62	129.27	122.02	390.07	168.87	119.05	1811.07	C	1
C62	10.17	152.24	121.04	92.20	46.53	19.64	32.74	15.67	11.78	15.65	6.09	10.65	13.88	80.48	51.40	16.00	165.72	134.43	125.10	387.88	166.42	122.37	1798.08	C	1
C63	10.54	151.72	118.77	94.94	44.96	21.27	32.93	15.08	11.64	15.30	5.08	12.03	13.07	79.58	49.73	16.19	167.41	132.66	110.84	387.21	168.59	121.43	1780.97	C	1
C64	10.31	150.36	119.61	90.23	45.10	19.82	32.44	14.68	11.59	14.53	5.66	12.38	11.51	79.84	50.34	14.91	167.81	127.28	110.11	388.52	166.37	122.54	1765.94	C	1
C65	10.41	144.27	122.35	94.42	46.68	21.06	34.52	14.77	12.74	15.07	5.20	11.28	12.51	82.39	53.16	15.50	166.04	134.56	124.83	389.93	167.36	120.16	1799.21	C	1
C66	9.53	151.47	119.07	94.39	46.36	20.28	33.88	14.83	11.66	15.32	5.33	11.16	12.29	82.69	48.44	14.83	167.84	137.99	119.54	390.97	166.64	120.70	1795.21	C	1
C67	9.96	145.01	121.76	91.75	45.58	22.23	32.40	15.16	11.55	14.95	7.20	11.29	13.77	81.83	48.25	16.08	168.38	138.93	127.95	388.19	168.38	121.61	1802.21	C	1
C68	9.75	148.68	120.84	93.91	44.63	21.81	32.81	14.98	11.82	14.51	7.12	12.20	11.88	80.33	48.05	16.04	164.11	124.78	114.69	386.75	168.26	124.22	1772.17	C	1
C69	10.06	143.50	122.74	96.72	44.41	22.23	34.35	14.48	11.62	15.46	5.02	12.04	12.86	79.61	53.13	15.30	168.04	124.77	129.54	391.57	167.44	121.12	1796.01	C	1
C70	9.65	147.96	119.97	96.88	45.48	19.97	33.84	15.37	11.95	15.32	6.84	10.74	14.19	81.43	49.83	15.48	167.84	128.38	111.38	390.14	168.09	119.07	1779.80	C	1
C71	10.18	142.13	118.57	95.06	44.56	20.48	34.57	15.08	11.65	14.82	6.28	12.09	12.55	79.56	50.10	16.45	163.94	136.35	114.13	390.82	168.92	121.72	1780.01	C	1
C72	10.49	140.30	119.95	91.50	45.34	20.77	34.57	14.95	12.60	15.40	5.99	10.81	13.87	81.12	49.82	15.73	166.41	134.85	117.68	388.31	168.72	121.16	1780.34	C	1
C73	9.81	144.64	120.47	93.73	45.83	20.04	34.52	15.70	12.07	15.00	6.38	11.75	14.25	81.57	49.06	14.72	167.14	136.74	114.84	388.38	167.41	118.55	1782.60	C	1
C74	10.48	142.64	122.27	93.51	45.04	20.02	32.73	14.96	12.75	14.88	6.14	10.84	13.92	79.86	51.45	15.13	164.93	134.46	120.56	390.96	168.02	119.56	1785.11	C	1
C75	10.48	144.26	118.84	96.43	45.16	19.20	34.17	15.16	11.61	14.84	6.91	11.22	13.85	80.39	51.83	16.22	164.52	127.09	116.90	386.88	168.35	118.79	1773.10	C	1
C76	10.24	139.96	120.78	96.10	45.51	19.99	34.56	14.58	11.50	15.61	6.56	11.48	13.89	82.25	49.19	15.32	165.93	133.05	112.43	389.48	167.57	123.76	1779.74	C	1
C77	10.32	139.14	120.07	93.51	46.63	19.91	32.90	15.32	12.03	15.38	5.81	11.84	11.95	81.23	53.90	16.39	165.38	132.29	111.46	390.73	165.06	118.58	1769.83	C	1
C78	9.76	146.07	122.17	94.22	46.25	20.64	33.24	15.61	12.68	15.36	5.93	10.73	12.48	82.65	51.32	16.34	169.24	127.76	125.14	389.45	166.19	123.49	1796.72	C	1
C79	9.75	142.34	121.53	90.34	45.81	20.04	32.91	14.56	11.71	15.21	5.71	12.39	11.61	81.09	49.02	15.75	163.83	128.97	109.62	388.25	167.41	121.01	1758.86	C	1
C80	10.01	150.18	121.56	93.86	46.00	19.73	32.99	14.47	12.34	14.44	6.03	10.73	13.72	82.26	50.66	16.04	166.69	129.41	121.29	389.17	166.80	119.93	1788.31	C	1
C81	10.01	141.54	119.15	89.83	45.89	20.58	34.59	15.57	11.50	15.44	6.99	11.45	12.44	81.24	48.57	15.32	168.22	132.22	126.08	388.00	168.62	124.50	1787.75	C	1
C82	10.17	145.25	119.20	93.91	46.38	20.03	34.15	14.63	12.21	15.50	5.38	11.66	12.63	81.89	52.12	15.26	165.77	124.18	114.31	387.00	166.50	120.51	1768.64	C	1
C83	9.83	149.47	119.95	93.74	44.67	19.63	33.29	15.67	11.69	14.43	7.13	11.47	12.01	82.05	49.60	16.43	168.92	135.84	125.78	389.95	165.44	119.05	1796.04	C	1
C84	10.54	142.18	120.35	96.04	45.72	19.34	34.09	14.71	12.52	14.83	6.05	10.94	13.62	79.63	49.06	15.83	167.74	136.34	126.30	387.51	166.66	119.89	1789.89	C	1
C85	9.86	142.74	121.74	90.07	45.63	21.43	33.22	15.56	12.63	15.16	5.69	11.96	12.75	81.22	52.88	15.97	167.48	124.78	127.29	389.64	168.42	124.24	1790.36	C	1
C86	10.24	151.85	120.38	89.41	45.52	19.42	32.80	15.56	12.62	15.39	5.52	12.29	12.98	79.63	54.13	16.34	166.41	131.14	108.85	390.97	167.24	124.03	1782.72	C	1
C87	10.70	143.56	122.86	95.47	45.82	19.79	32.96	15.18	12.09	15.31	6.54	12.34	13.58	80.67	53.31	15.31	164.69	127.53	123.90	387.33	166.55	121.49	1786.38	C	1
C88	10.63	151.01	122.30	93.44	44.98	20.16	32.81	14.67	11.85	14.72	7.30	10.69	12.20	79.49	54.29	15.73	168.34	126.83	109.95	390.48	164.96	120.69	1777.52	C	1
C89	10.65	144.83	119.58	94.27	46.39	20.12	34.17	15.22	11.98	14.67	6.63	11.74	12.48	80.40	53.06	15.64	166.59	127.71	116.52	389.44	168.70	119.57	1780.36	C	1
C90	10.29	146.85	122.25	97.03	44.52	19.47	33.74	14.60	12.68	14.48	5.90	11.22	13.10	81.46	51.79	15.89	167.46	137.62	126.39	387.49	166.54	123.43	1804.20	C	1
C91	10.35	140.41	122.44	92.90	45.56	21.22	34.79	15.21	11.94	15.42	5.86	11.80	11.94	82.26	52.87	15.90	165.32	136.14	121.29	390.75	167.68	123.73	1795.78	C	1
C92	9.59	146.75	120.26	96.20	44.75	19.73	33.87	14.60	11.81	14.61	6.80	11.18	11.66	80.61	52.91	15.39	168.62	130.06	129.22	387.32	168.48	122.36	1796.78	C	1
C93	9.74	150.67	122.16	95.73	46.21	20.34	34.62	14.87	11.64	14.30	5.56	12.08	12.35	80.58	52.82	14.99	164.12	125.69	126.92	389.86	167.35	121.31	1793.91	C	1
C94	10.78	149.82	122.02	89.56	45.41	19.87	34.35	14.99	12.62	14.65	6.69	11.87	12.22	80.18	50.62	15.05	167.03	138.61	108.75	386.68	167.01	119.23	1778.01	C	1
C95	10.63	147.91	119.74	90.42	45.27	20.16	33.41	14.46	11.63	15.41	6.07	12.33	13.76	80.07	51.18	15.05	164.12	131.85	113.83	389.86	168.02	121.50	1776.68	C	1
C96	10.83	132.34	122.46	93.43	45.28	20.22	32.85	14.93	11.40	15.44	7.48	11.10	12.31	81.66	50.95	15.59	165.39	127.32	127.90	387.54	168.10	120.60	1775.12	C	1
C97	9.59	151.41	121.80	91.90	45.85	19.66	34.37	15.15	12.04	14.43	7.03	12.05	14.41	81.80	53.08	16.18	165.97	129.46	124.19	390.90	166.66	121.91	1799.84	C	1
C98	10.72	142.26	120.08	95.96	46.36	20.12	33.49	15.13	12.62	14.59	5.17	10.96	14.47	82.55	50.66	15.35	165.21	126.76	120.57	387.88	164.89	123.30	1779.10	C	1
C99	9.67	153.92	122.01	90.90	45.53	19.79	33.97	15.03	11.54	15.71	6.70	11.56	12.44	82.17	49.39	15.85	168.08	129.05	128.77	387.95	166.80	124.69	1801.52	C	1
C100	10.06	140.64	120.15	93.51	46.28	20.65	34.02	15.10	12.26	15.78	5.30	11.06	12.91	82.82	49.01	15.51	165.55	126.39	128.95	390.02	167.78	124.64	1788.39	C	1
C101	9.87	141.68	120.44	93.68	46.64	20.52	32.98	14.68	12.75	15.25	5.41	11.40	12.38	80.29	50.20	15.83	168.87	137.65	113.14	388.76	167.52	121.10	1781.04	C	1
C102	10.49	147.33	121.33	92.93	44.43	19.27	34.50	15.75	12.23	14.42	6.70	12.09	11.57	80.31	48.26	16.08	165.35	132.68	108.84	390.63	166.18	123.61	1774.98	C	1
C103	10.52	138.54	121.21	96.85	45.76	20.10	32.40	14.91	12.32	15.42	6.19	10.71	12.48	81.20	53.56	14.93	167.29	137.87	125.72	388.79	166.22	121.34	1794.33	C	1
C104	10.00	151.00	121.39	91.37	45.42	19.43	33.95	15.02	12.27	15.83	5.14	11.87	14.38	81.19	53.84	15.20	168.21	137.11	127.34	390.23	165.16	121.14	1806.49	C	1
C105	13.52	131.64	116.16	89.89	45.46	19.98	33.28	14.83	11.85	15.19	6.46	11.07	11.57	74.99	47.06	14.81	158.26	127.53	106.15	390.47	167.00	119.95	1727.12	C	2
C106	13.43	130.41	117.71	96.19	45.63	20.86	33.85	15.61	11.66	14.50	6.06	10.53	13.90	77.21	46.57	16.20	157.33	126.64	108.26	390.92	167.85	121.37	1742.69	C	2
C107	13.45	131.30	118.45	89.56	45.81	20.33	33.60	14.93	12.24	14.67	6.41	11.13	11.80	77.13	47.74	15.30	160.18	119.85	113.09	389.54	167.19	119.52	1733.22	C	2
C108	13.14	132.22	116.71	95.42	45.38	19.41	33.48	15.71	12.29	14.84	5.48	11.31	13.65	74.68	47.43	15.29	160.75	121.25	111.87	390.42	166.53	119.84	1737.10	C	2
C109	12.91	130.70	117.56	95.81	44.49	20.90	32.75	14.66	11.69	14.74	5.57	11.89	13.73	76.67	47.45	16.27	162.49	127.59	113.66	390.56	167.25	119.64	1748.98	C	2
C110	12.78	131.22	116.77	90.59	44.99	21.64	32.32	14.83	11.62	15.60	5.37	10.87	12.06	76.31	46.51	14.63	158.58	126.35	109.73	387.68	167.09	120.40	1727.94	C	2
C111	13.08	131.64	118.63	94.33	44.76	21.69	34.20	14.69	12.32	15.47	5.62	12.09	13.53	76.09	46.54	14.43	161.40	124.71	106.93	388.26	168.24	121.93	1740.58	C	2
C112	12.43	134.00	117.35	97.43	44.69	21.01	33.95	14.53	11.76	14.73	5.60	11.23	11.99	76.68	47.66	16.39	159.36	124.37	106.99	393.72	167.91	120.42	1744.20	C	2
C113	12.71	134.52	117.52	94.51	44.62	20.64	33.13	15.20	11.67	14.71	6.62	11.53	13.13	73.73	47.72	14.49	161.77	125.45	110.70	390.65	167.76	121.29	1744.07	C	2
C114	12.63	133.14	117.61	92.39	45.20	19.49	34.37	15.57	12.04	14.73	5.54	12.05	14.54	75.90	47.10	15.39	155.43	123.77	108.73	387.98	165.96	121.92	1731.48	C	2
C115	13.56	132.56	117.06	97.48	46.53	21.24	33.17	15.36	11.46	15.13	5.48	10.68	13.44	75.98	48.54	15.76	163.47	124.40	112.51	392.00	167.75	121.42	1754.98	C	2
C116	12.86	132.77	116.87	95.15	46.65	19.90	32.32	15.80	12.73	15.21	5.60	10.90	14.28	75.62	47.15	14.97	156.02	127.16	113.54	387.43	168.69	121.43	1743.05	C	2
C117	13.69	129.78	118.62	96.85	45.78	20.89	32.32	15.23	11.80	14.68	6.59	10.89	13.61	73.77	48.06	15.31	158.83	128.59	113.28	387.69	165.36	121.30	1742.92	C	2
C118	12.68	134.42	115.43	91.38	45.15	21.06	32.72	15.35	12.34	14.64	6.58	11.77	13.36	75.16	47.13	15.62	160.86	122.42	110.09	386.46	166.12	119.91	1730.65	C	2
C119	12.49	130.05	117.81	97.03	44.83	21.05	32.99	14.85	11.35	14.76	5.60	11.26	14.12	73.77	48.48	15.71	158.69	123.79	107.11	390.68	164.87	119.61	1730.90	C	2
C120	12.50	132.07	116.77	91.53	45.43	19.33	34.11	14.48	11.48	15.11	5.33	11.79	12.45	76.67	47.22	15.61	164.09	128.08	112.86	389.92	165.46	119.50	1741.79	C	2

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
C121	13.31	133.10	118.21	93.25	44.67	21.71	33.33	14.64	12.43	14.85	5.89	10.60	11.85	73.91	47.51	16.22	161.10	126.97	114.56	387.76	165.40	119.96	1741.23	C	2
C122	13.37	133.75	118.25	90.44	44.97	20.71	34.20	14.96	11.35	14.50	5.77	10.47	12.69	75.92	48.21	15.54	160.95	126.85	111.11	390.25	167.83	119.64	1741.73	C	2
C123	13.65	131.55	118.22	94.33	44.57	20.17	33.10	14.91	12.33	14.79	5.35	11.29	13.72	77.15	47.72	15.00	157.80	122.79	109.42	392.90	166.19	120.76	1737.71	C	2
C124	13.31	129.45	115.95	92.88	45.45	19.59	34.33	14.77	11.65	14.70	5.30	10.88	12.55	73.78	47.88	16.47	161.59	128.60	110.20	389.79	164.48	119.92	1733.52	C	2
C125	12.83	130.28	116.49	90.17	45.48	21.56	33.34	14.83	11.54	15.52	6.74	10.65	13.38	74.90	46.57	14.46	163.99	126.95	111.58	386.49	167.84	120.81	1736.40	C	2
C126	13.61	132.53	118.13	95.60	46.01	20.68	33.74	15.52	12.44	14.88	5.41	12.11	13.43	75.05	46.88	16.05	159.59	125.00	108.95	390.63	165.43	119.57	1741.24	C	2
C127	12.41	135.05	118.11	95.63	44.89	21.14	34.41	15.32	12.31	14.86	6.12	10.81	11.87	74.85	46.51	16.01	155.72	128.13	113.77	391.02	165.39	121.63	1745.96	C	2
C128	13.44	134.57	118.29	94.34	46.23	20.29	34.72	15.78	12.68	15.55	6.39	10.80	11.79	77.53	47.90	15.13	157.88	122.78	112.95	392.78	165.03	121.78	1748.63	C	2
C129	12.81	129.41	117.10	96.63	46.51	21.29	33.66	14.66	12.07	15.15	5.87	11.67	12.44	75.02	46.55	15.30	161.00	122.49	106.16	391.59	167.35	120.40	1735.13	C	2
C130	12.50	131.19	117.03	97.68	44.62	21.02	34.47	14.30	12.49	14.97	5.43	11.72	13.41	77.05	46.76	15.52	160.23	127.69	106.47	391.82	164.45	120.63	1741.45	C	2
C131	12.82	133.96	118.55	95.58	46.13	20.09	32.33	15.68	12.01	14.50	6.41	10.97	11.66	76.24	47.27	14.42	161.32	124.89	111.58	387.86	165.89	121.55	1741.71	C	2
C132	12.76	135.34	117.00	96.61	44.51	20.33	33.60	15.47	11.74	15.01	6.67	11.60	14.36	75.18	46.89	16.20	161.76	120.59	105.97	390.62	168.14	120.63	1740.98	C	2
C133	13.50	134.95	118.61	95.01	45.79	19.78	33.60	14.76	11.51	14.42	6.45	10.53	12.98	76.12	47.51	15.16	157.53	125.71	107.91	393.73	168.44	121.86	1745.86	C	2
C134	12.85	130.77	117.34	89.96	46.25	21.34	33.36	14.58	11.83	14.88	5.45	12.55	13.47	73.87	48.29	15.79	156.27	120.43	107.59	391.36	164.69	120.28	1723.20	C	2
C135	13.30	133.03	116.26	92.40	45.54	19.51	33.89	14.69	11.66	15.96	5.86	11.43	12.89	74.50	47.57	16.11	163.77	128.40	111.86	387.37	167.43	119.95	1743.38	C	2
C136	12.64	130.61	117.61	94.68	45.50	21.66	34.49	15.16	11.81	15.69	5.86	12.18	13.39	75.24	47.29	15.42	160.83	127.29	110.36	393.44	167.62	120.73	1749.50	C	2
C137	13.16	129.68	117.94	94.15	46.56	19.62	32.50	15.07	12.66	15.30	6.43	11.16	11.41	76.71	46.83	15.70	155.61	128.01	108.57	387.51	167.12	121.51	1733.21	C	2
C138	13.51	133.52	115.49	93.19	45.22	20.31	34.41	14.36	11.87	15.61	5.56	11.41	12.05	73.83	48.35	15.13	160.15	123.82	105.71	390.18	165.23	120.40	1729.31	C	2
C139	12.87	134.15	115.86	89.44	45.34	20.25	32.75	15.24	12.05	14.40	5.81	12.03	11.99	74.95	47.28	16.24	156.17	128.08	105.50	391.71	167.77	121.01	1730.89	C	2
C140	13.24	132.04	118.68	93.07	44.95	20.36	32.71	14.98	12.36	15.95	5.77	12.17	12.36	77.27	48.42	16.01	163.90	123.27	111.84	387.69	165.68	120.58	1743.30	C	2
C141	12.71	134.16	118.34	93.12	44.48	19.49	33.33	15.08	12.26	15.15	5.40	10.84	11.77	75.68	46.68	15.11	160.09	125.04	107.00	386.47	167.37	120.43	1730.00	C	2
C142	12.70	134.11	116.82	96.51	46.02	20.87	32.97	15.70	12.72	15.12	6.10	12.49	12.86	73.76	47.20	15.87	155.93	120.17	106.34	393.75	167.90	121.61	1737.52	C	2
C143	13.51	131.17	116.83	89.66	45.52	21.14	33.12	15.52	12.07	14.61	5.61	11.07	12.05	76.66	46.96	15.92	158.98	127.69	111.09	391.50	165.43	120.00	1736.11	C	2
C144	12.89	131.08	115.48	95.62	46.50	20.88	34.80	14.59	12.30	14.43	5.38	11.60	12.00	76.15	48.55	15.15	163.65	127.68	106.25	387.17	168.21	120.81	1741.17	C	2
C145	12.75	132.50	118.48	91.21	45.37	20.05	34.38	15.17	12.14	15.33	5.97	11.83	13.09	75.18	46.47	15.54	159.85	128.37	110.27	387.05	165.49	120.10	1736.59	C	2
C146	12.56	130.34	115.92	94.57	46.20	21.57	32.53	15.10	11.67	15.44	5.54	11.61	13.13	77.35	47.15	14.63	157.11	123.13	108.50	393.09	166.28	119.61	1733.03	C	2
C147	12.41	129.53	117.00	90.49	45.80	19.52	34.36	15.01	11.90	14.95	5.60	11.35	14.42	76.05	46.43	15.56	160.72	128.26	110.16	390.55	168.43	120.14	1738.64	C	2
C148	13.16	138.74	116.27	94.21	46.27	19.89	32.62	14.64	12.71	14.82	5.72	10.79	11.87	76.65	46.40	14.76	163.62	119.92	110.01	388.98	167.60	120.46	1740.11	C	2
C149	12.53	131.66	116.56	94.37	44.96	21.64	34.70	15.49	11.76	15.36	6.63	11.17	12.08	75.83	48.36	15.72	155.80	122.97	107.42	390.68	166.25	120.50	1732.44	C	2
C150	12.69	131.95	116.66	92.52	46.21	19.52	33.17	15.76	12.04	15.91	5.39	11.92	11.56	75.37	47.05	15.81	164.05	122.30	107.41	389.36	165.43	120.74	1732.82	C	2
C151	13.05	135.03	118.45	93.86	45.00	19.69	34.60	15.26	12.50	14.47	5.80	11.18	11.96	76.89	48.50	15.13	163.44	123.49	111.12	391.48	166.15	120.88	1747.93	C	2
C152	12.52	133.28	115.60	97.44	45.64	19.78	32.42	14.80	11.76	15.96	5.68	10.93	12.95	76.90	46.87	15.80	169.42	125.71	107.74	392.23	168.26	121.77	1747.46	C	2
C153	12.77	129.46	117.95	97.54	44.95	20.48	32.53	15.47	12.53	15.03	5.73	12.15	13.63	77.46	47.12	16.03	159.57	126.39	107.03	392.16	167.43	121.16	1744.57	C	2
C154	13.20	132.91	117.95	91.42	45.38	20.00	32.73	14.52	12.71	14.48	6.12	10.52	12.96	75.81	47.06	15.01	162.16	122.12	110.11	386.65	166.69	121.94	1732.45	C	2
C155	13.10	131.06	116.97	95.20	44.89	20.04	34.34	15.31	11.53	15.33	5.90	12.54	13.52	73.44	47.20	15.00	158.46	123.71	113.79	393.47	168.59	119.99	1743.38	C	2
C156	13.59	133.28	117.47	90.56	44.66	20.13	32.96	15.03	11.39	15.10	5.60	12.05	14.17	75.60	46.49	14.41	155.52	127.38	109.03	388.25	168.18	120.38	1731.23	C	2
C157	12.60	135.67	115.91	96.21	46.17	21.03	34.46	15.12	11.65	14.55	5.90	12.44	12.18	74.32	46.66	14.44	156.38	123.74	109.25	391.04	168.00	121.20	1738.92	C	2
C158	12.46	131.86	116.44	90.69	45.56	21.44	32.56	14.39	12.62	15.95	6.27	12.07	14.19	76.86	47.96	15.11	159.47	119.49	111.72	390.73	168.12	121.60	1737.56	C	2
C159	13.51	129.76	118.52	90.79	46.06	20.29	33.34	14.95	11.99	15.36	6.72	12.46	14.54	75.17	46.93	14.81	157.74	124.46	105.73	386.79	166.60	120.61	1727.13	C	2
C160	12.55	132.15	117.42	96.35	44.88	19.58	32.39	15.12	11.82	14.64	5.38	11.66	12.57	75.14	46.94	15.76	163.02	127.77	107.53	387.76	168.57	119.80	1738.80	C	2
C161	12.42	130.31	116.88	93.41	44.62	19.79	34.79	15.53	12.47	14.92	5.87	11.20	11.48	73.94	47.70	15.45	163.47	125.27	108.09	390.23	164.51	120.37	1732.72	C	2
C162	13.14	132.41	116.40	95.80	45.37	21.40	34.38	14.33	12.29	15.30	6.68	10.51	14.33	75.23	47.79	15.72	156.39	121.29	106.88	388.26	165.86	120.34	1730.10	C	2
C163	12.59	132.83	115.81	96.99	46.08	20.59	32.42	14.94	12.56	14.70	6.15	11.14	12.14	73.79	47.01	14.58	160.89	124.11	112.25	386.86	166.11	120.31	1734.85	C	2
C164	13.36	134.43	118.28	97.01	46.69	19.50	32.51	14.82	12.60	15.11	5.30	10.68	13.95	76.02	47.11	15.23	162.79	126.53	109.32	392.95	167.16	121.22	1752.57	C	2
C165	13.02	129.62	118.14	90.22	45.96	21.36	34.14	15.69	12.51	15.73	5.35	10.44	13.60	74.81	47.50	15.93	158.44	125.30	105.62	389.96	168.46	119.50	1731.30	C	2
C166	13.51	132.48	116.15	97.19	46.45	19.79	34.34	14.45	11.53	14.43	5.91	10.62	11.91	76.94	47.24	16.05	158.75	128.10	108.61	393.48	165.10	121.85	1744.88	C	2
C167	12.51	133.82	116.56	95.79	46.43	21.48	33.22	15.14	12.58	15.96	5.63	12.40	12.80	77.32	47.24	14.44	160.71	124.28	113.43	389.59	168.23	120.16	1749.72	C	2
C168	12.71	134.01	116.43	96.80	44.66	21.74	32.65	15.48	11.92	15.27	6.62	12.37	14.07	75.19	46.85	14.86	161.24	122.70	108.93	390.24	166.98	121.68	1743.40	C	2
C169	13.36	134.39	116.03	93.97	44.56	21.62	34.29	15.56	11.64	14.73	6.07	10.65	11.42	76.48	48.01	15.04	161.01	121.09	114.72	389.42	168.71	121.66	1744.43	C	2
C170	13.65	131.02	117.09	90.48	46.10	19.91	32.32	14.65	11.62	15.36	6.67	11.67	11.72	75.95	48.04	15.93	156.52	124.84	106.97	393.54	167.86	120.86	1732.77	C	2
C171	13.30	131.54	117.19	96.29	45.11	21.30	32.49	14.38	12.49	15.18	6.54	11.95	14.46	75.17	46.60	15.32	157.74	120.81	105.55	393.07	164.60	121.16	1732.24	C	2
C172	12.68	132.72	117.39	95.56	45.24	20.54	32.70	15.52	11.68	15.32	6.29	12.35	13.22	76.81	47.70	15.47	157.03	127.03	109.14	390.98	167.82	120.76	1743.95	C	2
C173	13.46	133.26	115.83	89.55	44.52	21.78	34.27	14.56	12.32	15.45	5.72	12.14	11.70	76.48	48.04	15.49	161.28	126.50	107.67	391.35	165.97	121.35	1738.69	C	2
C174	13.23	134.27	116.49	97.60	44.66	19.80	34.52	15.00	11.98	15.60	5.49	10.98	13.30	76.32	47.68	14.47	160.89	124.47	107.88	388.43	168.56	119.52	1741.14	C	2
C175	12.77	135.17	118.20	92.71	46.54	20.43	33.76	15.66	12.10	15.14	5.48	11.39	13.26	74.62	47.33	16.26	162.48	120.97	107.01	387.80	167.27	121.60	1737.95	C	2
C176	12.60	133.76	118.57	89.68	45.75	21.00	32.43	15.71	11.73	15.37	6.13	10.92	12.01	73.45	47.40	16.09	161.23	125.91	108.35	390.23	165.47	121.05	1734.84	C	2
C177	13.63	131.28	117.55	95.47	46.61	19.42	33.57	15.31	12.36	15.36	6.67	10.80	13.78	75.33	48.10	14.66	159.09	125.32	107.97	388.32	165.74	119.59	1735.93	C	2
C178	13.69	132.32	118.01	97.56	44.49	20.55	33.44	14.71	12.49	15.53	6.42	11.18	13.01	75.45	47.98	14.43	157.57	119.71	109.75	393.33	165.42	121.14	1738.18	C	2
C179	13.18	131.98	116.96	96.19	45.15	20.93	32.51	14.94	12.41	15.55	6.30	12.11	12.20	75.38	46.82	16.52	163.30	122.47	109.44	386.42	166.03	120.55	1737.34	C	2
C180	12.71	133.92	116.68	96.07	45.75	20.73	33.20	15.33	12.59	14.62	6.65	11.05	12.48	77.08	47.53	14.48	159.47	125.33	111.18	390.64	166.08	121.26	1744.83	C	2

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
C181	12.82	133.39	116.48	92.88	45.40	21.75	34.32	14.61	12.13	14.96	6.63	10.53	13.71	77.37	47.75	14.74	162.02	124.97	106.17	392.31	168.20	119.92	1743.06	C	2
C182	12.66	135.15	115.52	94.30	45.07	21.16	34.01	15.19	12.20	14.43	6.29	10.66	13.64	76.94	48.29	15.18	162.26	120.98	108.81	387.16	167.41	121.61	1738.92	C	2
C183	13.69	134.05	115.80	95.36	46.03	19.82	32.49	14.79	12.61	15.50	6.07	11.77	12.50	76.36	47.15	16.09	159.75	122.98	114.42	387.50	166.14	121.83	1742.70	C	2
C184	13.20	133.64	118.42	93.84	46.10	20.29	33.93	15.46	11.97	14.60	5.82	10.54	12.20	74.38	48.31	14.84	158.21	121.31	109.57	388.76	166.98	120.45	1732.82	C	2
C185	12.57	140.61	118.36	92.35	46.60	20.87	32.64	14.33	12.07	14.61	5.95	10.93	13.06	75.08	47.43	16.25	162.01	122.17	106.66	390.26	164.85	120.18	1739.84	C	2
C186	13.40	133.56	117.71	92.82	45.73	21.60	34.80	15.09	11.66	15.44	5.38	10.65	11.49	77.05	46.81	15.50	157.62	126.68	105.44	388.44	166.18	121.02	1734.07	C	2
C187	13.33	129.53	117.59	92.67	44.89	20.87	33.05	14.99	12.01	15.97	6.61	10.98	12.33	75.59	47.92	15.36	158.32	120.24	112.97	390.37	168.69	119.53	1733.81	C	2
C188	13.33	133.73	117.84	92.55	44.84	21.52	34.35	15.03	12.47	14.83	6.66	10.77	11.60	76.67	46.50	16.46	157.98	127.17	112.19	388.21	165.49	120.21	1740.40	C	2
C189	13.25	132.10	116.56	89.65	46.36	20.02	34.32	15.16	11.74	15.26	6.64	10.60	14.09	75.96	47.53	15.87	162.13	127.64	106.29	391.45	165.17	120.35	1738.14	C	2
C190	13.33	131.93	117.49	91.27	46.00	19.31	33.92	14.55	11.77	14.40	6.14	11.40	13.34	77.20	47.50	15.10	158.37	124.51	113.94	388.56	166.07	120.38	1736.48	C	2
C191	12.86	130.98	117.13	90.49	45.59	21.29	34.22	14.94	12.46	15.99	6.26	11.65	14.33	73.52	48.27	16.43	164.16	120.94	112.59	390.02	165.38	121.98	1741.48	C	2
C192	13.31	134.24	118.19	94.97	44.67	19.63	32.53	14.78	12.11	15.24	5.56	11.92	13.28	75.86	46.91	15.02	162.36	123.87	108.95	390.96	168.19	121.33	1743.88	C	2
C193	13.17	129.84	116.58	90.67	46.32	20.73	34.49	14.40	11.55	14.84	6.68	10.63	12.10	74.25	46.75	14.85	157.72	120.25	112.84	386.72	165.88	121.34	1722.60	C	2
C194	12.98	129.90	118.19	93.07	46.17	19.51	33.78	15.52	12.12	15.03	5.59	10.88	11.57	77.00	46.79	14.53	157.94	123.72	110.43	387.21	166.90	120.41	1729.24	C	2
C195	12.52	134.54	115.40	97.04	46.17	20.36	34.26	15.31	11.47	15.53	5.70	11.73	11.52	75.67	46.51	16.04	162.80	121.41	110.72	389.19	164.94	119.63	1738.46	C	2
C196	13.14	131.52	117.18	95.81	46.31	20.50	32.83	14.66	11.90	14.65	6.58	12.00	12.46	74.97	48.18	15.60	162.04	122.02	111.91	390.64	166.49	120.29	1741.68	C	2
C197	12.66	131.72	117.43	92.96	45.16	21.66	34.12	15.68	11.95	15.20	5.63	10.41	13.45	74.01	46.88	15.79	163.44	122.28	110.26	389.38	164.96	121.82	1736.85	C	2
C198	13.14	131.00	117.39	96.74	46.41	20.57	32.60	15.06	11.32	14.78	6.16	11.81	14.28	75.58	47.06	16.50	156.03	128.67	114.07	392.79	166.60	119.86	1748.42	C	2
C199	13.00	135.52	116.97	96.07	46.18	21.53	33.96	15.66	12.45	15.39	6.21	10.70	12.13	75.88	47.13	15.42	157.63	121.48	107.77	386.71	166.81	121.09	1735.69	C	2
C200	12.50	130.54	118.17	90.71	46.56	20.21	32.99	15.80	11.76	15.17	6.69	12.20	13.97	73.84	48.12	15.26	161.92	121.52	114.00	389.11	166.98	121.36	1739.38	C	2
C201	13.40	130.95	117.48	92.75	45.70	20.76	34.13	15.40	11.66	15.55	5.60	12.57	13.90	73.61	47.95	16.24	156.97	127.21	107.70	389.03	164.50	121.26	1734.32	C	2
C202	13.34	134.09	116.91	97.00	45.93	19.79	33.43	14.68	11.62	15.24	6.72	11.53	11.46	75.71	47.83	16.11	162.03	127.45	110.01	389.32	167.95	119.73	1747.88	C	2
C203	13.33	135.66	116.27	90.34	46.57	20.58	34.38	14.67	12.01	14.20	6.23	11.22	13.52	75.24	46.66	15.77	160.05	120.74	112.07	391.26	167.30	121.96	1740.03	C	2
C204	12.76	133.46	115.88	97.11	44.90	20.71	34.05	15.13	11.63	14.84	6.75	10.85	13.45	76.48	47.71	14.53	159.55	121.75	107.04	391.18	168.60	119.92	1738.28	C	2
C205	13.56	132.08	116.80	96.80	46.65	20.14	32.50	14.70	12.56	15.97	6.61	12.80	13.23	77.13	46.68	14.52	161.37	128.66	110.96	388.07	166.66	120.65	1749.10	C	2
C206	13.25	130.38	116.91	94.82	44.52	19.37	32.66	14.56	12.37	15.98	6.75	11.57	11.50	74.89	46.74	15.19	159.41	119.95	108.33	393.70	165.83	120.87	1729.55	C	2
C207	12.55	132.44	116.46	92.15	46.56	20.46	34.30	15.60	12.46	14.33	5.40	11.36	13.32	74.34	47.28	16.02	160.55	119.62	114.10	386.68	166.61	119.89	1732.48	C	2
C208	12.73	133.15	115.56	92.88	46.64	19.98	34.08	14.35	11.36	15.27	6.00	11.45	14.55	75.04	48.38	14.88	160.83	120.98	107.42	387.15	166.58	120.60	1729.86	C	2
C209	13.66	129.35	115.61	96.67	45.21	20.69	33.20	15.34	12.57	15.95	6.38	11.30	12.00	72.81	46.56	15.45	160.45	120.55	112.46	390.14	165.92	119.70	1731.97	C	2
C210	16.42	106.38	118.13	90.19	44.38	20.40	33.35	14.73	12.38	15.33	6.22	11.55	12.36	63.15	45.73	14.04	131.64	109.18	102.52	388.65	164.55	120.29	1641.57	C	3
C211	15.94	114.55	116.21	89.80	45.21	20.08	33.77	14.99	12.20	14.76	5.23	10.91	12.38	60.32	42.73	14.03	133.42	103.61	104.16	389.59	166.87	120.87	1641.63	C	3
C212	16.23	107.92	118.66	89.62	44.31	19.79	33.82	15.22	12.33	14.46	6.69	11.06	12.78	63.02	45.29	15.13	132.71	104.65	109.39	389.28	166.94	120.26	1649.56	C	3
C213	16.17	106.67	108.41	89.90	45.27	20.25	33.61	15.22	12.28	14.61	5.37	11.29	12.36	63.35	43.68	13.73	130.26	107.47	100.73	388.87	165.94	120.86	1626.30	C	3
C214	15.44	103.35	116.71	90.72	44.77	20.65	33.11	14.97	11.86	14.27	5.20	11.39	13.20	61.78	44.57	13.78	134.04	110.93	107.41	389.99	165.27	121.18	1644.59	C	3
C215	15.41	105.97	117.51	90.15	45.16	20.77	33.53	15.41	12.20	14.86	6.61	10.52	12.68	62.89	44.20	14.83	133.75	106.95	100.56	390.15	165.76	120.70	1640.57	C	3
C216	15.77	107.69	116.90	90.47	44.53	21.75	34.11	15.04	11.99	14.43	5.59	10.75	12.50	60.46	45.46	14.32	133.76	106.91	102.93	389.22	165.72	120.03	1640.33	C	3
C217	15.49	106.98	118.32	89.70	44.61	21.14	33.57	15.40	11.51	14.55	5.87	10.51	12.62	62.62	45.73	15.22	132.49	108.21	103.25	389.20	164.70	120.77	1642.46	C	3
C218	15.85	107.92	118.11	90.06	44.75	20.07	33.78	15.19	12.00	15.62	5.47	10.59	12.93	64.19	44.00	15.18	130.64	106.05	101.58	388.24	168.09	120.30	1640.61	C	3
C219	15.26	106.91	117.86	91.18	44.90	20.47	34.00	15.44	11.70	14.74	6.42	10.23	12.62	60.95	44.09	15.26	131.36	109.79	103.54	388.39	165.61	120.49	1641.21	C	3
C220	15.81	103.51	116.54	89.93	45.44	21.01	33.25	14.82	12.23	15.57	5.65	11.48	13.65	62.22	44.59	14.51	130.64	105.89	104.26	389.63	167.52	121.28	1639.43	C	3
C221	16.17	108.73	116.57	90.62	45.30	21.21	33.09	15.04	11.54	14.47	5.69	10.27	12.42	60.70	43.52	15.27	133.94	105.09	106.51	389.30	166.76	120.69	1642.90	C	3
C222	16.08	104.15	118.23	90.16	45.01	20.54	32.77	14.86	12.43	14.88	6.09	10.63	12.83	61.34	43.95	15.91	130.84	107.98	109.24	388.56	165.97	120.70	1643.15	C	3
C223	15.50	106.79	118.10	90.68	45.56	20.84	33.61	14.68	12.16	15.72	5.81	10.73	12.95	63.19	44.41	16.57	134.37	103.96	101.08	387.53	165.78	120.69	1640.71	C	3
C224	16.03	108.50	118.11	90.45	45.68	21.39	33.48	14.94	11.92	15.16	5.64	11.42	12.68	61.77	43.87	14.57	132.20	106.42	104.40	388.35	166.90	120.46	1644.34	C	3
C225	16.56	103.14	118.31	90.42	44.69	20.10	33.82	15.41	12.17	15.40	5.58	11.70	12.81	63.92	45.19	15.46	130.62	107.93	109.45	387.75	165.32	120.37	1646.12	C	3
C226	16.72	103.38	119.63	90.73	45.03	20.58	33.45	14.85	12.42	15.20	6.61	11.37	12.51	62.40	45.11	14.62	130.22	105.47	109.32	397.47	166.66	119.36	1653.11	C	3
C227	15.85	106.17	119.69	89.88	45.13	20.25	33.77	15.18	12.12	15.46	5.64	10.67	12.23	63.51	45.21	14.83	131.56	104.48	100.46	391.71	167.21	120.77	1641.78	C	3
C228	15.59	106.89	117.53	90.41	45.35	20.87	33.49	14.60	11.98	15.44	5.44	11.43	12.64	62.45	44.76	15.23	134.12	106.03	110.93	389.06	166.77	121.74	1652.75	C	3
C229	15.49	107.09	116.51	91.21	45.49	20.82	33.76	14.76	12.45	15.27	6.43	11.34	12.22	62.13	44.16	14.83	130.92	109.06	103.09	372.48	165.43	120.23	1625.17	C	3
C230	15.34	108.51	118.96	90.04	45.29	20.80	33.44	15.37	12.39	14.62	6.21	10.77	12.43	61.43	43.86	15.65	134.23	104.90	107.77	390.93	166.49	120.88	1650.31	C	3
C231	16.80	107.28	116.20	90.54	45.35	20.66	33.96	15.34	11.60	15.01	6.66	10.92	13.07	63.58	44.46	15.48	133.75	110.54	109.03	385.70	165.24	120.55	1651.72	C	3
C232	15.57	102.71	119.21	91.25	45.02	20.31	33.43	15.26	12.44	15.35	5.45	11.73	12.66	61.30	45.76	14.98	145.26	103.67	106.32	388.55	166.24	121.26	1653.73	C	3
C233	16.42	104.89	119.37	90.65	44.67	19.87	33.25	14.72	12.02	14.95	6.29	10.25	12.62	63.71	45.36	15.80	132.12	105.07	104.77	388.56	167.23	120.78	1643.37	C	3
C234	16.99	103.52	118.86	89.91	45.50	20.86	34.02	14.82	12.25	15.51	5.31	10.23	12.70	63.70	42.34	14.79	132.59	105.56	111.45	389.29	166.84	119.65	1646.69	C	3
C235	16.99	108.63	116.87	90.30	44.89	21.37	33.87	14.84	12.37	15.20	6.05	10.44	12.23	62.86	42.69	15.12	133.05	108.17	103.41	389.96	168.87	120.96	1649.14	C	3
C236	16.22	104.73	117.54	91.27	45.04	20.68	33.46	15.28	11.97	15.11	5.35	11.05	12.66	64.07	43.38	15.13	132.50	109.69	101.52	388.71	168.00	120.66	1644.02	C	3
C237	16.45	104.68	117.02	89.44	44.41	20.04	33.36	15.11	11.80	15.09	6.45	11.57	12.46	61.57	44.69	15.64	131.94	104.51	101.50	388.97	168.80	120.07	1635.57	C	3
C238	16.82	108.18	117.44	89.89	44.50	20.15	33.26	14.63	12.07	15.21	5.31	11.69	12.88	60.49	44.78	15.28	133.82	109.89	106.52	389.69	167.54	121.10	1651.14	C	3
C239	16.46	107.08	119.37	90.11	44.70	20.55	33.76	14.96	12.27	15.48	5.69	10.85	12.82	62.58	45.20	15.46	132.76	107.69	108.25	390.00	167.19	119.87	1653.10	C	3
C240	16.75	106.50	119.51	91.21	45.49	21.24	32.66	15.09	12.15	15.74	6.01	10.22	12.99	63.45	45.36	16.07	131.00	103.97	107.96	389.04	166.21	121.51	1650.13	C	3

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
C241	16.64	107.19	118.98	89.71	44.50	20.91	33.14	15.22	11.51	15.35	5.58	10.80	12.94	60.24	43.20	14.86	131.92	104.23	104.38	389.51	166.13	119.77	1636.71	C	3
C242	15.69	108.87	117.93	90.65	45.39	20.85	33.32	14.60	12.35	15.49	6.15	10.65	12.93	64.22	44.79	15.50	133.73	107.06	108.97	387.72	166.01	121.27	1654.14	C	3
C243	16.07	104.12	119.36	90.90	45.05	20.77	33.70	15.13	11.83	15.32	5.48	11.50	12.80	61.99	43.85	14.39	136.05	106.96	102.37	388.09	165.90	121.07	1642.70	C	3
C244	16.54	102.68	117.19	90.12	44.98	20.13	33.03	15.12	12.27	15.55	5.98	11.24	12.98	60.56	45.38	14.97	130.72	108.28	103.66	389.96	166.50	120.35	1638.19	C	3
C245	16.12	105.09	118.94	90.11	45.11	20.11	33.43	14.70	12.37	14.55	6.38	10.99	12.87	61.63	42.26	15.51	130.40	106.39	101.20	389.46	167.66	120.59	1635.87	C	3
C246	15.95	109.29	117.06	90.48	45.20	20.14	33.04	15.40	11.56	14.48	6.70	11.36	13.27	60.93	45.01	15.38	136.30	108.09	108.44	389.72	167.11	120.26	1655.17	C	3
C247	15.47	104.35	118.98	89.46	44.30	19.90	33.13	15.31	11.53	15.20	5.89	10.36	12.51	63.71	42.97	15.21	134.73	105.41	109.93	388.50	166.55	121.14	1644.54	C	3
C248	16.42	107.28	118.75	89.79	45.09	19.89	33.30	15.07	12.41	15.51	6.24	10.23	12.83	63.04	44.81	15.18	132.11	109.43	111.18	388.35	166.39	120.76	1654.06	C	3
C249	15.66	108.95	116.30	90.14	45.46	20.84	34.05	14.94	12.16	15.47	5.89	11.07	12.70	62.24	44.51	15.13	133.28	108.74	112.20	387.36	166.86	120.30	1654.25	C	3
C250	16.77	107.09	118.36	91.32	45.61	20.21	33.62	14.79	11.51	15.30	6.68	11.14	12.47	60.42	42.51	15.65	135.49	105.20	106.13	388.18	165.25	121.17	1644.87	C	3
C251	15.41	106.07	117.94	90.75	45.63	19.66	33.24	14.96	12.42	15.32	6.60	10.76	12.85	63.34	44.62	15.31	131.33	110.50	100.90	387.47	167.45	120.30	1642.83	C	3
C252	15.50	104.66	119.45	89.71	45.05	20.87	33.19	14.81	12.29	15.29	6.01	11.32	13.12	60.61	44.45	15.64	134.23	104.72	101.11	387.43	167.62	120.20	1637.28	C	3
C253	15.71	104.62	118.71	90.44	44.86	19.62	33.15	15.33	12.43	14.95	5.41	11.67	12.91	60.66	42.73	14.73	132.26	106.31	112.02	387.67	165.51	120.62	1642.32	C	3
C254	16.49	105.48	116.34	89.93	45.61	19.75	33.89	15.11	12.23	15.23	6.59	11.00	13.20	62.61	44.09	14.45	132.04	106.60	107.00	389.40	168.16	120.95	1646.15	C	3
C255	15.69	102.90	116.36	89.94	45.32	20.45	33.54	15.16	11.57	15.66	6.51	11.04	13.04	60.21	44.30	15.32	135.11	109.84	109.21	388.26	167.92	120.81	1648.16	C	3
C256	16.35	104.17	118.08	91.26	45.54	21.44	33.76	14.66	11.93	14.70	5.67	11.21	11.78	60.49	43.79	15.34	133.52	110.44	101.73	388.59	166.42	120.53	1641.40	C	3
C257	16.14	105.24	116.47	91.36	44.93	20.59	33.25	15.20	12.29	15.16	5.56	10.87	12.96	63.03	43.98	15.27	131.77	106.43	106.22	388.32	167.84	120.93	1643.81	C	3
C258	16.84	106.74	118.08	90.16	44.76	21.33	33.80	15.14	12.04	15.70	5.25	11.73	12.90	62.95	43.60	15.36	136.22	108.55	101.87	389.55	166.23	119.65	1648.45	C	3
C259	16.20	107.62	118.10	90.42	45.35	20.69	33.39	14.66	12.25	14.40	6.01	11.05	13.32	60.35	42.81	14.98	135.60	106.48	102.20	389.72	166.20	121.20	1643.00	C	3
C260	15.71	108.87	117.88	90.48	44.87	19.66	33.29	15.28	11.99	15.17	5.20	10.30	13.24	61.93	45.10	14.93	133.17	107.34	104.42	389.63	165.57	121.30	1645.33	C	3
C261	16.27	108.51	117.77	89.39	44.99	21.07	33.37	15.27	12.15	14.45	6.13	11.71	13.27	62.62	45.36	15.48	131.78	109.31	103.85	388.48	165.26	120.23	1646.72	C	3
C262	15.36	104.50	117.32	90.67	45.07	21.24	33.82	14.83	12.38	15.32	5.61	11.44	13.08	63.48	44.13	15.83	135.12	105.81	104.40	389.60	166.41	119.59	1645.01	C	3
C263	16.01	104.14	119.49	89.44	44.64	20.54	33.41	14.67	11.71	14.39	5.96	11.03	12.31	61.33	42.41	15.62	130.81	105.73	109.57	389.67	166.96	120.58	1640.42	C	3
C264	16.81	102.36	118.45	90.53	44.88	20.27	33.43	15.05	12.44	15.08	5.50	11.50	13.22	62.14	43.51	14.95	133.03	109.35	101.89	387.85	167.51	120.97	1640.72	C	3
C265	16.37	106.10	117.87	90.28	44.78	21.10	33.79	15.39	12.22	14.52	6.59	10.79	12.97	61.76	45.40	15.00	134.51	107.16	109.31	387.34	165.32	121.83	1650.34	C	3
C266	16.51	102.26	117.40	91.36	44.47	20.88	33.99	14.60	12.05	14.56	6.53	10.27	13.49	61.74	43.89	15.67	130.21	105.73	103.84	387.48	166.48	121.45	1634.86	C	3
C267	16.16	109.17	119.29	89.84	44.82	19.91	33.59	15.31	11.73	15.27	5.94	10.71	12.84	61.73	44.45	15.32	134.87	107.80	101.78	388.99	167.58	120.30	1647.40	C	3
C268	15.90	108.24	119.31	89.53	45.20	21.37	33.50	14.83	11.83	15.27	6.23	10.82	12.77	63.12	44.94	15.82	134.93	111.25	106.37	388.30	165.70	121.27	1656.50	C	3
C269	16.80	105.09	116.21	90.52	44.31	20.23	33.84	14.98	12.45	15.36	5.34	11.01	12.50	62.13	42.84	14.88	134.99	107.92	103.00	388.42	169.09	120.30	1642.21	C	3
C270	16.03	108.77	116.90	89.51	44.50	20.83	33.98	15.01	12.02	15.34	6.44	10.53	12.20	61.25	44.94	15.87	133.82	109.74	109.78	387.38	165.14	119.88	1649.86	C	3
C271	15.53	105.29	118.84	89.72	44.74	20.58	33.86	15.39	11.68	15.43	6.36	11.09	13.60	61.59	43.39	14.45	135.88	107.04	103.41	388.64	168.00	120.76	1645.27	C	3
C272	16.30	106.55	116.63	89.46	45.05	20.79	33.66	14.82	11.91	15.20	5.60	11.37	11.75	61.29	42.80	14.77	134.38	108.92	104.94	388.61	168.53	120.82	1644.15	C	3
C273	15.60	109.22	116.81	89.63	45.22	21.04	33.14	15.06	11.88	14.34	6.73	11.67	12.24	61.48	44.00	15.40	139.64	109.11	103.50	386.46	165.07	121.05	1648.29	C	3
C274	16.90	106.04	116.38	90.46	44.65	20.38	34.07	15.39	11.91	15.22	5.48	10.22	13.36	62.80	42.82	15.29	132.59	110.20	110.13	388.66	169.97	120.07	1652.99	C	3
C275	16.99	109.19	118.47	89.30	45.51	20.50	33.11	14.90	11.53	14.92	5.71	10.61	13.38	63.26	43.58	15.28	135.34	110.88	106.45	389.33	167.09	120.83	1656.16	C	3
C276	16.34	102.39	119.69	90.28	44.73	20.91	33.60	15.43	12.15	15.01	6.67	10.20	13.28	62.48	44.80	15.21	131.43	104.21	106.66	388.53	165.49	120.08	1639.57	C	3
C277	16.56	103.37	116.91	89.40	45.42	20.77	33.86	15.19	11.96	15.21	5.29	11.23	13.22	62.30	45.14	15.73	133.56	106.67	110.93	388.39	169.06	120.39	1650.56	C	3
C278	16.54	104.43	118.84	90.77	45.52	20.53	34.13	15.32	12.40	15.28	5.52	10.84	12.55	64.30	42.78	16.03	132.15	109.82	102.44	388.55	168.53	120.69	1647.96	C	3
C279	15.38	103.28	117.23	90.78	45.55	21.01	34.02	15.30	12.41	14.99	5.42	10.35	13.06	61.64	45.51	15.13	132.48	109.06	101.41	389.32	168.48	120.33	1642.14	C	3
C280	15.49	106.64	119.73	91.21	45.02	20.50	33.27	14.90	12.01	14.69	6.42	11.65	12.85	63.14	44.20	14.84	135.10	109.99	106.53	390.08	169.94	120.51	1658.71	C	3
C281	15.69	113.14	117.08	90.19	45.06	20.97	33.72	15.10	12.44	14.37	5.38	11.22	12.48	63.32	44.18	15.21	134.81	106.94	104.33	388.89	168.99	120.19	1653.70	C	3
C282	15.73	105.55	118.68	89.97	45.39	20.63	33.40	15.07	12.43	15.20	6.10	10.86	12.47	62.98	44.59	15.06	134.88	108.87	111.60	388.38	166.16	120.48	1654.48	C	3
C283	16.30	104.31	117.94	90.99	45.26	20.33	33.70	15.44	12.08	15.10	6.12	10.62	13.02	64.20	43.13	15.70	132.56	106.67	104.52	389.28	166.40	119.88	1643.55	C	3
C284	15.44	106.79	119.15	91.00	45.68	20.99	33.55	15.14	12.08	14.96	5.40	10.70	12.95	64.09	43.28	14.92	133.27	110.07	111.86	387.64	166.83	120.90	1656.69	C	3
C285	15.78	105.03	118.14	90.96	45.22	20.23	33.74	15.26	12.15	15.56	5.48	11.61	12.95	62.94	45.21	14.96	130.86	110.25	107.55	388.52	166.04	120.27	1648.71	C	3
C286	16.65	104.66	118.66	91.35	44.82	20.34	33.79	15.02	12.43	14.96	6.73	11.38	12.30	62.15	43.35	15.38	135.15	109.81	100.27	388.79	166.51	120.33	1644.83	C	3
C287	15.42	107.63	118.65	91.32	44.88	21.04	34.22	14.88	11.49	14.67	6.10	11.19	12.54	63.03	43.10	15.25	132.03	110.18	110.30	389.60	167.29	120.39	1655.20	C	3
C288	16.70	104.73	116.65	90.43	45.63	21.05	34.08	14.94	11.58	15.38	6.67	11.37	13.23	60.54	45.73	15.23	134.03	106.97	101.79	388.29	165.20	120.23	1640.45	C	3
C289	16.59	102.49	118.10	89.71	44.71	19.81	33.94	15.02	11.75	15.73	6.71	10.20	12.30	62.96	44.43	15.74	134.67	105.72	103.24	389.30	166.98	120.34	1640.44	C	3
C290	15.20	108.53	119.22	90.45	44.75	20.92	32.85	14.69	12.20	15.61	5.20	11.24	12.96	61.71	43.50	14.91	132.87	108.53	103.09	389.27	166.57	121.12	1645.39	C	3
C291	15.98	105.71	117.84	90.36	45.66	21.27	33.96	15.41	11.53	15.51	6.12	11.24	13.72	63.50	45.06	15.85	133.16	110.66	103.69	389.99	166.81	121.19	1654.22	C	3
C292	15.81	103.70	119.25	89.35	44.88	20.81	33.43	14.99	11.98	15.30	5.63	11.33	13.20	60.67	45.45	15.21	131.40	110.89	104.63	388.40	167.49	121.06	1644.86	C	3
C293	16.23	103.14	119.21	91.13	44.49	20.81	34.03	14.78	11.56	15.46	5.28	10.71	13.59	62.98	43.17	15.20	132.23	107.60	105.69	389.83	166.27	119.50	1642.89	C	3
C294	16.86	105.44	118.35	90.99	45.32	20.77	33.91	15.12	11.87	15.30	5.58	10.35	13.26	61.19	45.22	15.43	131.53	103.28	106.77	388.71	166.02	120.84	1642.11	C	3
C295	16.67	107.96	118.32	90.23	44.80	20.96	33.88	15.29	11.72	15.27	6.16	10.36	14.06	60.29	42.29	15.63	132.43	110.38	106.55	387.81	165.05	120.21	1646.32	C	3
C296	15.72	105.18	118.64	89.95	44.91	20.34	33.25	15.15	11.83	14.34	5.52	11.48	12.41	63.93	43.35	15.30	134.66	103.23	107.33	387.09	167.65	120.96	1642.22	C	3
C297	15.83	108.28	116.74	90.35	45.45	20.43	33.21	15.45	12.20	15.04	6.56	10.48	13.49	61.78	42.44	14.93	133.19	110.65	101.37	387.42	166.34	121.27	1642.90	C	3
C298	15.66	104.81	117.92	91.06	44.71	20.07	33.95	14.62	12.30	15.15	5.47	10.50	11.59	63.17	44.20	15.86	131.56	110.50	100.52	388.93	167.00	120.41	1639.96	C	3
C299	16.79	106.92	116.54	91.38	45.10	20.04	32.98	15.24	12.30	14.74	5.69	10.53	13.78	63.43	45.70	15.16	134.91	104.69	102.85	388.51	165.88	119.88	1643.04	C	3
C300	16.84	102.36	116.81	89.42	44.83	20.40	33.27	15.01	12.20	15.56	5.73	11.57	12.94	63.20	45.30	15.56	134.00	107.29	105.59	388.88	166.19	120.96	1643.91	C	3

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
C301	15.48	107.50	118.12	89.50	44.66	20.40	33.62	14.82	11.43	15.36	6.36	11.14	12.91	63.56	43.90	15.13	130.86	110.68	102.98	389.43	166.71	121.18	1645.73	C	3
C302	16.42	107.93	117.84	90.62	44.71	19.73	34.01	14.91	11.97	15.42	5.44	10.77	12.47	60.75	45.18	15.07	133.01	103.56	100.98	388.74	165.12	120.38	1635.03	C	3
C303	16.33	104.51	119.32	90.33	44.98	19.80	32.58	14.62	12.38	15.02	5.95	10.67	13.56	61.63	42.51	15.48	133.59	108.71	103.95	389.94	166.43	120.30	1642.59	C	3
C304	16.65	102.97	117.31	90.56	44.64	20.22	33.12	15.06	11.78	15.58	5.88	10.41	12.33	62.91	42.31	14.96	135.54	104.48	101.10	387.74	166.80	120.35	1632.70	C	3
C305	16.53	103.34	117.20	90.20	44.34	19.70	33.27	15.13	11.47	15.44	5.68	10.54	13.64	62.95	43.45	15.61	134.70	106.17	105.07	388.73	167.66	119.87	1640.69	C	3
C306	16.74	106.53	118.64	89.94	45.69	20.55	33.61	15.08	12.40	14.59	5.73	11.53	13.28	61.12	45.10	15.15	133.83	106.90	103.49	387.90	167.51	120.92	1646.23	C	3
C307	15.84	104.50	117.23	89.67	44.75	20.27	34.28	14.78	12.12	15.55	5.32	10.67	13.92	63.34	44.78	15.62	133.58	105.46	104.10	388.85	168.22	121.27	1644.12	C	3
C308	15.28	107.92	116.66	90.50	45.26	21.27	33.33	15.27	11.94	15.73	6.36	10.63	13.41	64.08	45.38	15.41	130.94	110.85	106.64	388.12	167.41	120.96	1653.35	C	3
C309	16.06	102.69	119.68	90.87	44.43	21.06	33.84	14.79	11.94	15.23	5.46	10.78	13.91	61.99	44.92	15.78	134.18	106.91	100.73	389.65	168.87	120.39	1644.16	C	3
C310	16.93	105.58	117.00	90.84	45.03	20.52	33.16	14.83	11.87	15.27	5.95	11.72	13.22	62.31	43.28	15.20	131.61	107.15	101.25	391.14	167.37	120.22	1641.45	C	3
C311	15.75	104.45	117.52	89.33	44.84	19.61	33.66	15.32	11.97	14.58	6.31	10.77	12.84	61.29	45.14	15.15	135.58	108.10	105.96	388.53	167.45	120.80	1644.95	C	3
C312	15.66	106.29	118.32	89.50	45.00	20.65	33.71	14.83	11.77	15.00	6.21	11.14	13.01	60.39	45.35	14.83	135.89	109.15	104.92	388.06	167.28	121.23	1648.19	C	3
C313	15.36	103.73	116.53	89.32	44.88	20.28	32.98	15.26	12.39	14.65	6.43	10.68	13.10	63.59	43.52	15.13	132.76	108.97	108.87	389.86	165.35	121.28	1644.92	C	3
C314	16.86	103.64	119.37	89.72	44.32	20.12	33.29	15.40	11.79	15.17	6.16	10.23	12.84	62.80	45.24	14.93	131.42	106.12	103.33	389.65	165.16	120.14	1637.70	C	3
C315	24.53	105.64	117.46	89.71	45.67	19.85	33.98	15.53	11.40	15.44	5.39	12.28	13.13	61.36	43.61	14.48	128.95	105.94	103.18	389.03	166.65	120.87	1644.08	C	4
C316	23.47	103.69	117.45	89.74	45.07	21.31	33.32	15.60	12.36	14.50	6.56	10.85	12.31	60.75	44.49	14.66	133.07	110.21	105.55	388.83	166.92	120.34	1651.05	C	4
C317	23.39	108.40	116.52	89.74	44.84	20.90	33.41	15.39	11.67	15.14	6.18	10.93	13.53	59.19	43.70	15.19	132.54	110.71	104.57	388.40	166.38	120.87	1651.59	C	4
C318	23.87	108.87	116.47	92.25	45.05	19.85	33.15	15.61	12.14	14.79	5.82	10.64	12.57	61.00	43.34	15.35	128.31	104.70	106.42	389.33	165.56	120.77	1645.86	C	4
C319	24.71	104.30	116.29	92.65	45.64	21.59	33.39	15.02	11.81	15.11	5.61	12.11	12.95	60.83	41.72	14.71	133.77	106.65	108.07	388.23	167.72	121.43	1654.31	C	4
C320	23.92	109.24	116.15	90.24	45.51	20.48	33.96	15.00	12.40	14.92	5.10	10.80	12.97	61.93	42.67	15.01	126.34	107.11	104.53	388.05	167.94	120.17	1644.44	C	4
C321	25.18	107.55	115.28	92.07	44.56	20.46	33.59	15.16	11.60	14.50	5.01	10.61	12.50	61.55	42.65	15.54	130.37	107.58	102.57	390.33	165.17	120.85	1644.68	C	4
C322	24.74	108.53	116.51	90.99	45.20	20.95	33.34	15.50	11.61	14.72	5.15	11.27	13.33	59.16	42.07	14.79	132.21	104.21	107.61	387.00	166.96	120.87	1646.72	C	4
C323	24.74	107.20	114.78	92.50	44.49	19.95	33.58	14.99	12.18	15.47	6.31	10.59	12.64	60.46	42.49	15.49	132.78	107.23	102.71	389.66	165.20	121.63	1647.07	C	4
C324	24.82	103.55	117.93	91.29	45.22	21.23	33.32	14.64	11.51	15.20	6.23	12.02	12.95	59.53	42.46	14.76	129.12	106.71	107.06	386.59	165.05	121.69	1642.88	C	4
C325	25.05	103.79	115.30	92.14	44.72	19.63	33.98	14.77	12.18	14.92	6.08	10.55	12.98	61.16	42.47	14.38	128.71	104.59	103.57	390.01	167.25	120.76	1638.99	C	4
C326	24.63	108.97	115.11	92.67	44.42	20.97	33.75	15.02	11.97	15.20	6.09	10.35	12.74	60.00	43.11	14.24	126.43	106.18	106.43	386.77	166.85	120.86	1642.76	C	4
C327	24.52	106.85	117.14	90.47	45.69	19.48	33.11	14.86	12.09	14.84	6.51	10.69	12.64	61.84	44.54	14.90	126.23	106.89	101.93	389.35	166.80	121.65	1643.02	C	4
C328	24.62	103.36	116.35	91.75	44.97	21.04	33.41	15.66	12.24	14.77	6.42	11.46	13.45	60.32	41.38	15.10	133.39	109.77	105.94	389.57	167.12	121.13	1653.22	C	4
C329	23.44	105.66	117.38	92.24	45.28	20.37	33.83	15.15	11.57	14.79	6.47	10.85	13.24	61.24	43.05	14.46	132.87	110.43	107.80	387.26	166.50	120.23	1654.11	C	4
C330	24.73	108.82	116.13	90.15	44.50	20.49	33.83	14.76	11.65	15.52	5.62	11.06	12.46	62.09	43.33	14.48	132.45	104.39	107.40	387.07	166.97	120.80	1648.70	C	4
C331	24.35	104.55	117.54	92.22	45.42	20.45	33.12	15.19	12.44	14.83	6.41	11.73	12.71	60.41	43.82	14.94	127.44	107.79	103.03	389.07	167.90	120.80	1646.16	C	4
C332	24.67	109.26	116.69	92.42	45.08	19.67	33.40	15.12	12.36	15.45	5.40	11.96	13.24	60.80	42.09	15.01	132.40	104.73	105.48	389.75	166.54	119.83	1651.35	C	4
C333	24.24	108.77	116.26	90.02	45.32	19.44	33.54	15.25	11.49	14.97	6.40	12.44	13.47	60.82	43.46	14.58	129.17	107.97	109.71	388.69	168.06	121.50	1655.51	C	4
C334	23.94	108.84	116.14	89.77	45.13	20.93	33.46	14.78	12.04	15.62	6.21	11.20	12.24	59.18	42.61	15.16	132.03	107.70	106.48	389.44	166.98	120.50	1650.38	C	4
C335	24.69	105.44	114.86	91.16	44.83	21.22	33.90	15.17	11.75	15.06	6.73	12.52	12.89	60.91	44.43	15.48	131.34	109.10	105.41	389.49	167.52	120.36	1654.26	C	4
C336	23.24	105.38	117.72	90.15	45.12	21.32	33.41	15.22	11.78	15.10	5.67	12.49	12.98	60.79	44.19	14.54	129.32	107.81	104.61	389.00	166.93	121.70	1648.47	C	4
C337	24.27	107.73	117.58	90.12	44.51	20.55	33.35	15.41	12.03	15.63	5.53	10.90	12.45	59.81	43.48	14.30	129.19	106.79	103.92	388.62	166.28	121.11	1643.56	C	4
C338	23.27	102.91	115.52	89.78	45.19	19.94	33.18	15.01	11.67	14.60	5.97	12.38	12.42	62.02	44.04	15.08	132.65	107.45	103.52	390.00	166.35	120.79	1643.74	C	4
C339	23.22	106.08	117.04	92.42	44.87	20.19	33.55	14.68	12.29	14.97	6.21	12.02	13.73	59.90	44.20	15.14	129.66	109.74	104.23	387.80	166.72	120.97	1649.63	C	4
C340	24.53	105.66	115.04	91.89	44.62	19.80	33.52	15.33	11.85	15.07	5.31	10.90	12.70	59.31	42.13	15.43	131.04	105.19	105.51	389.56	165.29	121.62	1641.30	C	4
C341	23.76	108.27	115.48	90.80	45.65	21.33	33.49	15.57	11.56	15.06	5.67	10.88	12.30	59.72	43.74	15.68	131.31	106.40	105.31	388.71	166.05	120.61	1647.35	C	4
C342	24.19	102.62	117.78	89.69	45.64	20.46	33.26	14.72	12.19	15.61	6.49	10.66	13.06	60.57	43.92	14.25	130.34	108.40	103.56	388.95	166.00	120.72	1643.08	C	4
C343	24.16	104.92	114.85	92.12	44.91	19.91	33.45	15.75	12.54	15.20	5.29	10.20	12.44	62.13	43.90	14.75	130.78	107.96	104.41	388.49	166.57	120.09	1644.82	C	4
C344	23.66	107.97	116.04	89.40	45.32	20.00	33.28	14.60	12.29	14.94	6.50	11.96	11.92	59.55	41.82	15.82	130.33	105.19	108.19	387.23	167.83	121.69	1645.53	C	4
C345	25.03	104.09	116.58	91.79	44.64	20.94	33.25	15.34	12.24	15.07	5.82	11.48	13.54	60.16	42.05	14.55	128.35	109.01	105.41	386.96	166.86	119.78	1642.94	C	4
C346	24.32	108.32	117.18	90.76	45.57	19.59	33.46	15.34	11.99	15.05	5.87	11.68	12.61	60.92	42.51	15.08	133.56	110.76	103.47	387.30	166.63	121.31	1653.28	C	4
C347	23.47	105.20	117.37	89.93	45.48	21.40	33.19	14.90	11.69	15.34	5.22	10.93	12.37	59.65	42.55	15.34	132.68	108.11	102.42	389.46	165.69	121.57	1643.98	C	4
C348	23.29	103.81	117.37	92.15	44.46	19.98	33.22	14.97	11.78	15.20	6.68	11.98	11.62	60.29	43.77	14.30	130.50	107.73	106.07	388.27	166.62	120.70	1644.76	C	4
C349	24.91	108.04	117.62	91.53	45.06	20.97	33.98	15.30	12.34	15.36	5.90	11.56	12.22	59.15	44.06	15.04	127.98	107.95	101.81	388.85	168.11	120.93	1648.67	C	4
C350	25.16	106.90	114.95	90.06	45.26	20.22	33.90	15.26	12.27	15.12	6.65	10.62	13.38	62.20	43.10	15.67	126.62	106.12	106.83	386.72	167.96	120.42	1645.39	C	4
C351	23.34	108.08	115.45	91.83	45.54	20.96	33.71	15.14	12.33	15.38	5.17	11.92	12.78	61.40	43.31	14.78	133.61	108.03	107.97	389.78	165.65	121.08	1657.24	C	4
C352	24.86	109.15	117.88	91.12	44.51	19.76	33.49	15.30	11.60	15.10	6.16	10.86	13.47	60.81	41.26	15.81	133.06	106.33	101.74	387.52	166.32	121.71	1647.81	C	4
C353	24.49	108.71	115.98	92.05	44.99	20.32	34.05	15.23	12.30	15.35	6.12	12.26	12.34	62.45	42.97	14.93	133.12	105.91	109.46	389.86	167.23	120.59	1660.71	C	4
C354	23.66	103.83	115.10	92.59	44.85	19.98	33.62	15.23	12.35	14.60	6.20	10.45	13.53	59.91	42.39	14.49	129.37	104.61	104.40	388.29	167.69	120.21	1637.35	C	4
C355	23.53	108.94	114.32	91.62	44.37	19.57	33.35	15.39	12.21	15.22	6.37	12.03	13.18	60.26	44.02	15.26	132.01	106.93	108.66	390.32	166.68	121.42	1655.66	C	4
C356	23.69	105.02	116.44	91.69	45.25	20.63	33.95	15.74	11.73	15.04	5.73	11.31	11.95	59.64	43.20	14.33	132.21	109.82	102.89	387.48	166.00	121.49	1645.23	C	4
C357	24.59	103.84	116.66	92.04	44.37	19.52	33.16	14.92	12.26	15.64	6.10	10.39	12.37	59.99	43.69	15.18	131.60	108.75	108.67	389.55	166.72	120.44	1650.39	C	4
C358	23.28	107.77	114.56	90.31	45.48	19.85	33.74	14.98	12.25	14.99	6.27	11.23	12.84	59.17	42.79	15.37	131.58	107.36	106.86	389.03	166.00	120.73	1646.44	C	4
C359	24.90	102.62	116.65	90.82	44.40	21.32	33.81	15.56	11.79	15.04	6.51	10.46	12.56	60.41	43.12	14.39	126.86	104.92	103.21	388.52	165.42	120.95	1634.24	C	4
C360	24.92	104.60	115.35	91.10	45.24	21.09	33.30	14.58	12.55	14.61	5.52	11.14	12.28	61.14	42.56	15.10	130.30	108.10	108.99	387.79	166.02	120.11	1646.39	C	4

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
C361	24.40	108.41	118.00	89.45	44.88	20.51	34.05	15.00	11.81	15.16	6.66	10.40	12.26	60.97	43.54	14.48	128.85	106.62	106.52	389.66	166.16	120.43	1648.22	C	4
C362	25.17	105.25	116.26	89.99	44.39	21.38	33.66	15.30	11.68	14.58	6.52	11.37	12.33	62.17	41.69	14.72	133.56	108.82	104.99	389.36	167.31	121.45	1651.95	C	4
C363	24.86	109.06	117.33	91.70	44.81	19.73	33.71	15.11	11.95	14.88	6.75	10.92	12.51	59.86	41.26	15.03	127.32	110.59	107.32	390.87	165.40	120.92	1651.89	C	4
C364	23.39	103.10	115.59	91.51	45.56	21.15	33.94	15.11	11.64	15.43	6.73	11.46	13.19	59.84	44.78	14.78	130.09	109.23	106.70	388.59	166.80	120.37	1648.98	C	4
C365	25.06	105.05	117.15	90.97	45.14	20.47	33.70	14.77	12.33	15.07	5.28	10.65	12.83	62.07	42.77	14.48	130.15	106.50	107.35	388.85	166.95	120.94	1648.53	C	4
C366	23.60	103.75	117.45	90.39	44.60	19.22	34.07	15.24	11.98	15.09	5.13	11.40	12.58	62.13	42.48	14.58	127.36	105.39	108.85	389.26	167.70	121.54	1643.79	C	4
C367	23.86	104.80	115.19	90.70	44.30	19.98	33.70	15.34	11.67	15.11	6.20	11.97	13.50	60.81	43.21	14.72	130.86	109.03	105.69	389.24	166.92	120.48	1647.28	C	4
C368	23.79	106.70	116.26	92.00	44.68	19.92	33.46	14.91	12.10	15.22	6.34	11.28	11.96	59.80	43.05	15.60	130.43	107.88	104.57	388.86	166.71	120.65	1646.17	C	4
C369	23.63	106.85	115.65	91.71	44.93	21.31	33.73	15.17	12.26	15.34	5.16	12.08	12.51	59.26	41.42	14.99	127.71	110.66	107.28	387.20	168.13	121.20	1648.18	C	4
C370	23.37	106.52	117.08	89.59	44.82	20.37	33.40	15.63	12.38	14.70	5.10	12.36	12.81	62.28	43.18	15.36	131.95	109.16	109.69	390.02	167.12	121.22	1658.11	C	4
C371	23.72	106.75	114.30	90.22	44.51	20.24	33.24	15.49	11.42	15.41	6.70	12.25	12.91	59.52	41.76	14.22	128.59	108.48	101.95	389.66	166.30	121.11	1638.75	C	4
C372	24.03	106.82	116.33	92.30	44.56	21.21	33.53	14.71	12.24	14.92	6.22	11.95	12.21	61.66	43.44	14.49	129.96	108.60	104.14	388.16	166.09	121.75	1649.32	C	4
C373	24.75	104.77	117.04	90.48	45.44	20.41	33.48	14.79	12.28	15.37	5.64	12.00	12.53	61.90	44.58	14.42	129.03	110.85	107.95	388.88	167.83	119.79	1654.21	C	4
C374	23.73	118.25	116.17	90.02	44.67	20.29	33.52	15.59	11.79	15.11	5.28	10.20	12.50	60.11	43.24	15.53	132.69	109.62	102.59	390.30	165.63	121.30	1658.13	C	4
C375	24.97	107.34	115.08	90.62	45.54	20.56	33.14	15.75	12.36	14.67	5.73	11.48	12.63	59.45	44.62	15.72	131.74	109.48	107.13	387.83	167.66	119.81	1653.31	C	4
C376	23.75	105.80	114.35	89.69	45.23	20.78	33.87	15.28	12.44	15.61	6.50	10.56	13.15	60.79	43.66	14.27	130.07	106.55	104.90	389.51	167.82	120.24	1644.82	C	4
C377	23.22	104.27	117.10	91.16	44.61	20.97	33.35	15.32	12.22	14.67	5.07	10.67	12.64	59.94	41.62	14.70	127.22	104.79	102.03	386.71	167.55	121.01	1630.84	C	4
C378	24.09	106.12	114.44	92.09	45.31	20.17	33.98	15.62	12.32	15.12	6.06	10.62	12.27	60.54	43.07	15.41	132.95	107.37	106.41	388.79	166.98	120.71	1650.44	C	4
C379	23.32	103.15	115.43	91.03	44.33	21.31	33.31	15.26	12.42	14.68	5.53	12.05	12.64	61.22	43.71	14.15	129.10	106.98	108.31	389.15	166.74	120.57	1644.39	C	4
C380	24.26	105.33	115.43	91.03	45.41	20.79	33.40	14.63	11.63	14.60	6.01	11.16	12.87	60.71	42.12	15.78	127.79	108.39	108.33	388.80	166.06	119.93	1644.45	C	4
C381	24.62	104.60	115.77	90.88	44.81	21.53	33.75	15.51	11.48	15.51	5.84	11.43	12.80	60.34	42.68	15.49	130.92	109.43	107.39	387.06	166.28	120.05	1648.17	C	4
C382	24.63	104.57	114.36	89.64	44.31	19.48	33.33	15.29	12.18	15.29	6.60	10.96	13.45	59.95	42.15	15.63	131.94	109.48	107.08	389.48	167.63	120.56	1647.99	C	4
C383	25.12	107.92	115.19	89.43	45.10	21.25	33.68	15.54	12.38	15.64	5.26	11.98	12.16	59.68	42.61	14.25	126.66	108.42	108.85	388.54	166.17	120.46	1646.29	C	4
C384	24.87	104.05	117.02	89.53	44.77	19.64	33.90	15.49	12.09	15.07	6.69	11.80	13.56	61.91	43.67	14.73	131.73	106.82	101.72	389.23	165.45	119.89	1643.63	C	4
C385	24.97	105.69	115.40	90.49	45.43	20.69	33.95	14.52	12.18	15.32	5.60	10.53	13.18	60.06	42.41	14.84	130.68	105.64	105.19	388.91	166.52	121.17	1643.37	C	4
C386	24.43	102.55	116.58	92.18	45.25	21.54	34.02	15.64	12.34	14.53	6.34	11.21	12.25	59.40	41.38	14.96	131.66	106.56	107.03	388.07	165.52	120.90	1644.34	C	4
C387	23.25	104.96	114.71	92.11	44.66	21.61	33.93	15.03	12.32	15.32	5.79	10.51	12.26	61.66	42.34	15.04	132.63	108.24	107.20	387.66	167.17	121.55	1649.95	C	4
C388	23.48	102.81	115.14	91.75	44.70	19.94	33.45	15.28	11.42	15.15	5.50	10.61	13.26	60.74	42.21	14.17	131.59	110.48	103.46	387.66	166.64	119.83	1639.27	C	4
C389	23.35	104.31	115.71	89.80	45.60	19.74	33.40	14.66	11.52	15.71	6.42	10.69	12.90	62.02	41.81	14.75	126.64	108.32	103.75	387.23	166.65	121.16	1636.14	C	4
C390	24.73	102.70	117.64	91.12	45.35	21.03	34.09	15.65	12.26	15.07	6.27	11.89	13.54	61.11	41.15	15.80	130.70	106.72	105.78	389.54	166.30	120.96	1649.40	C	4
C391	24.85	108.87	115.28	92.41	45.36	19.72	33.16	15.54	12.11	15.63	6.13	10.79	13.44	59.76	41.54	15.41	131.75	106.47	105.50	389.47	166.27	119.87	1649.33	C	4
C392	23.60	106.95	115.06	90.18	45.49	21.36	32.89	15.23	12.15	15.65	6.18	12.49	13.02	62.40	42.55	14.20	132.09	109.69	104.16	386.71	166.76	119.89	1648.70	C	4
C393	25.18	104.54	117.11	89.77	45.37	21.60	33.32	15.37	11.45	15.01	5.49	11.06	12.21	60.69	41.87	14.38	131.66	108.95	105.05	387.72	166.76	119.66	1644.22	C	4
C394	23.58	104.95	115.28	90.96	44.30	20.71	33.40	14.71	12.26	15.53	6.29	11.44	12.95	61.67	42.58	14.47	126.17	108.79	105.28	389.46	168.11	120.56	1643.45	C	4
C395	25.16	106.67	116.21	92.60	45.13	20.58	33.76	15.25	12.19	15.03	5.52	11.68	13.15	62.18	41.26	14.86	127.15	105.04	103.96	389.17	166.50	121.59	1644.64	C	4
C396	24.49	105.01	115.97	91.07	45.56	19.77	33.38	15.68	11.83	15.16	5.95	11.80	12.92	59.98	42.72	15.57	131.42	110.82	103.74	390.92	167.94	121.71	1653.41	C	4
C397	24.31	107.45	114.94	91.58	44.43	20.05	33.15	15.69	11.67	15.58	5.16	10.58	12.29	62.01	41.44	15.40	130.58	108.91	104.49	388.98	166.14	120.97	1645.80	C	4
C398	23.41	103.97	115.94	91.51	45.45	20.50	33.39	15.70	12.03	15.18	6.54	11.27	12.40	60.81	43.13	15.20	128.46	104.41	107.27	388.10	166.09	119.76	1640.52	C	4
C399	23.36	103.39	117.57	92.00	44.93	20.56	33.22	15.26	12.18	15.34	6.57	10.79	12.27	59.40	42.71	14.71	132.67	108.54	108.78	388.36	165.67	121.63	1649.91	C	4
C400	25.08	102.45	115.55	89.54	45.67	19.93	33.80	15.61	12.29	14.86	5.32	11.85	12.40	62.42	41.84	15.03	133.12	110.65	106.87	388.49	165.70	121.20	1649.67	C	4
C401	25.06	103.01	116.69	91.87	44.30	21.55	33.64	14.71	12.45	15.43	6.34	12.45	12.61	59.95	43.71	14.87	129.79	110.08	101.99	388.34	167.25	119.82	1645.91	C	4
C402	24.34	105.39	115.60	89.64	45.31	21.00	33.66	15.35	11.73	15.22	6.34	10.21	12.15	60.55	41.85	15.59	129.63	108.06	108.60	393.09	167.82	120.81	1651.94	C	4
C403	23.68	105.68	114.92	91.43	45.19	21.01	33.37	15.08	12.56	15.21	5.16	12.23	13.48	62.09	43.34	14.80	127.12	110.03	102.92	389.36	167.39	120.50	1646.55	C	4
C404	23.23	102.54	114.66	89.51	45.18	20.10	34.03	15.30	12.51	15.19	5.15	12.52	13.54	61.45	44.67	14.16	126.44	105.08	106.23	387.29	166.15	121.28	1636.21	C	4
C405	23.94	103.10	115.13	90.76	44.88	21.84	34.15	15.07	12.12	15.04	5.75	10.52	11.87	60.57	42.68	15.56	127.79	105.48	109.12	388.49	166.14	121.40	1641.40	C	4
C406	24.73	105.47	117.13	91.40	45.59	19.89	34.09	15.33	11.89	14.66	6.41	12.26	11.85	62.15	44.82	15.80	132.36	108.39	107.89	386.71	166.38	121.03	1656.23	C	4
C407	24.29	109.17	117.65	91.47	44.36	19.92	33.34	15.71	12.24	15.54	5.45	10.46	12.64	59.39	42.18	14.26	131.05	108.99	102.26	388.83	166.73	121.59	1647.52	C	4
C408	24.99	103.20	115.53	92.02	45.11	20.68	33.65	15.62	11.59	15.24	6.08	10.90	12.81	62.18	43.88	15.03	132.18	109.76	106.44	387.33	167.85	121.24	1653.31	C	4
C409	23.97	106.00	115.05	91.79	44.57	20.76	33.45	15.62	11.97	14.94	5.78	11.37	13.16	60.44	41.38	15.66	129.75	108.28	106.92	387.47	167.65	120.05	1646.03	C	4
C410	23.92	106.94	116.66	92.48	44.96	21.88	33.40	15.14	11.95	14.81	5.55	11.00	12.82	60.29	43.17	15.67	131.41	106.11	102.58	389.56	166.05	120.55	1646.90	C	4
C411	23.73	105.28	117.68	91.61	44.57	20.81	33.32	15.63	12.40	15.21	6.73	12.50	13.59	59.67	44.18	15.09	129.03	110.66	108.57	387.37	166.29	120.30	1654.22	C	4
C412	23.81	106.49	115.95	91.04	45.53	20.50	34.03	14.54	11.82	14.55	6.54	10.40	13.06	62.39	41.68	14.48	132.66	109.52	109.27	388.86	166.52	120.73	1654.37	C	4
C413	24.19	103.93	116.14	91.67	45.58	19.90	33.60	15.03	12.05	15.03	6.61	11.10	13.54	59.65	44.02	15.69	127.36	108.47	102.02	388.54	165.48	121.39	1640.99	C	4
C414	23.78	106.04	117.44	91.36	45.24	19.93	33.26	15.57	12.15	15.01	6.33	11.44	12.34	61.98	41.39	14.49	128.04	106.15	103.04	388.23	167.56	120.74	1641.51	C	4
C415	24.34	104.78	116.07	91.79	44.37	20.98	33.70	15.47	12.39	15.13	6.05	12.36	13.19	61.13	43.64	14.81	127.53	105.45	108.94	389.45	166.57	120.92	1649.06	C	4
C416	24.51	105.18	116.62	89.59	45.55	21.46	33.41	14.50	12.29	14.70	5.97	11.06	13.27	61.32	43.91	14.31	127.00	105.45	106.78	387.04	168.12	121.15	1643.19	C	4
C417	23.63	109.30	117.63	89.69	44.91	19.53	33.40	14.76	12.06	14.57	6.44	11.88	12.70	60.97	43.84	15.05	128.44	107.56	103.46	389.01	166.84	121.75	1647.42	C	4
C418	25.06	106.18	115.51	89.45	45.60	20.72	33.68	14.87	11.53	14.38	5.89	10.86	12.64	59.81	43.54	14.42	130.71	108.53	107.45	388.39	167.90	120.07	1647.19	C	4
C419	25.17	108.97	115.90	90.90	45.16	21.52	33.51	15.48	12.08	15.26	6.02	11.36	13.71	61.25	41.92	15.24	127.89	110.04	108.09	387.90	167.61	121.31	1656.29	C	4
C420	24.76	105.88	117.90	90.44	45.25	20.53	33.76	15.74	12.51	14.96	5.85	10.19	11.84	61.73	42.17	15.79	132.51	109.53	105.56	388.36	167.46	119.97	1652.69	C	4

Engine D – All values recorded are in decimal minutes.

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
D1	7.71	279.12	87.74	55.30	74.82	20.56	50.49	46.54	30.61	108.61	19.69	14.14	12.27	170.00	124.96	248.35	663.01	89.48	48.90	2152.30	D	1
D2	7.41	281.90	86.77	55.20	78.48	20.96	50.87	46.15	29.34	110.82	20.08	13.24	12.25	165.35	122.69	241.83	669.23	90.53	48.96	2152.06	D	1
D3	7.59	258.04	85.85	57.21	76.96	20.19	49.50	47.00	30.63	108.62	20.40	14.19	12.24	167.34	122.52	241.96	659.18	90.72	49.09	2119.23	D	1
D4	7.54	276.87	89.68	56.41	77.44	19.92	50.61	46.54	31.23	112.68	20.48	13.01	12.36	169.73	126.53	241.92	669.44	90.82	49.26	2162.47	D	1
D5	7.68	276.72	85.31	57.17	75.21	20.01	50.79	46.22	30.51	108.11	20.31	15.57	12.26	169.90	122.35	243.60	672.05	90.99	49.53	2154.29	D	1
D6	7.43	258.22	87.89	57.52	76.81	20.01	50.11	48.03	31.55	112.41	20.50	14.07	12.49	163.47	127.18	246.11	664.63	90.70	49.53	2138.66	D	1
D7	6.25	260.40	88.94	55.40	75.41	19.81	49.65	46.72	30.37	114.77	20.75	15.85	12.05	170.20	127.10	243.74	660.11	89.75	49.85	2137.12	D	1
D8	7.81	269.16	84.74	57.42	78.40	19.57	49.13	46.74	30.53	114.03	20.62	13.84	11.74	163.72	127.02	245.78	670.13	90.96	49.29	2150.63	D	1
D9	6.77	277.19	82.23	56.21	78.96	20.77	50.57	46.45	29.00	112.49	19.44	13.94	12.45	169.48	127.86	247.02	667.36	89.35	49.42	2156.96	D	1
D10	6.72	274.16	91.25	54.66	75.35	20.05	48.18	44.96	31.22	114.30	20.75	14.16	12.23	165.02	126.61	242.07	672.79	89.50	49.66	2153.64	D	1
D11	7.47	272.74	87.59	56.83	74.24	20.2	49.88	46.74	30.87	114.19	20.39	15.68	12.01	163.66	124.99	242.45	664.91	91.44	49.62	2145.90	D	1
D12	7.19	257.63	87.07	58.52	74.47	20.13	49.80	45.29	30.14	113.18	19.46	13.86	11.93	171.50	125.57	245.51	672.38	90.74	49.69	2144.06	D	1
D13	6.25	261.93	88.48	57.91	77.92	19.7	49.45	47.94	31.23	110.29	20.00	14.26	12.31	170.19	121.23	241.75	665.39	90.06	49.51	2135.80	D	1
D14	7.71	269.75	90.86	54.70	77.86	20.09	48.68	45.14	30.17	111.53	20.50	15.16	12.27	169.13	122.11	247.30	661.44	90.31	49.67	2144.38	D	1
D15	6.83	262.79	82.32	54.67	76.33	20.58	49.57	46.14	31.51	113.67	20.11	14.24	11.87	164.83	124.32	245.31	653.30	89.29	48.92	2116.60	D	1
D16	6.49	274.38	84.13	57.27	73.54	19.08	50.96	46.87	31.86	109.38	19.69	15.02	12.43	167.20	127.60	244.12	658.84	91.43	49.67	2139.96	D	1
D17	7.24	269.50	83.9	55.99	73.75	19.05	49.86	46.44	31.56	109.99	20.51	15.65	12.52	163.45	128.37	245.22	657.94	90.90	49.50	2131.34	D	1
D18	6.27	262.61	87.35	57.08	74.27	20.14	50.54	46.14	29.21	110.65	20.89	14.23	12.24	168.79	122.12	247.69	664.23	89.91	49.35	2133.71	D	1
D19	6.54	260.25	90.09	54.40	76.88	20.04	49.41	46.61	31.93	108.88	20.55	14.73	12.21	163.59	127.51	245.90	669.78	89.42	49.81	2138.53	D	1
D20	6.48	266.56	83.91	54.54	74.44	19.74	49.63	46.92	30.23	113.52	20.62	14.05	12.32	167.71	122.36	243.54	666.91	89.87	49.71	2133.06	D	1
D21	7.66	268.74	88.99	54.84	78.11	20.16	50.69	46.85	31.50	108.52	19.41	12.91	12.28	164.66	127.10	241.26	668.12	90.17	48.87	2140.84	D	1
D22	6.50	259.70	83.71	55.07	76.14	19.01	49.67	45.84	30.08	111.99	20.23	12.80	12.40	166.76	122.50	244.17	658.85	90.85	49.37	2115.64	D	1
D23	7.03	255.96	85.96	57.23	76.27	19.62	48.48	46.35	31.80	111.75	20.98	15.36	11.99	168.74	128.06	247.69	661.98	90.41	49.37	2135.03	D	1
D24	7.36	258.62	84.44	55.71	78.19	20.31	49.40	46.17	29.24	113.08	20.73	13.33	12.69	165.79	127.65	242.59	658.38	91.04	49.74	2124.46	D	1
D25	6.88	259.30	86.6	55.31	73.60	19.21	50.12	46.18	29.18	114.13	20.74	13.13	11.50	166.57	125.98	247.93	667.73	91.35	49.56	2135.00	D	1
D26	6.54	268.65	84.04	59.04	76.85	20.48	49.25	47.08	29.58	113.65	20.45	14.80	12.04	172.35	122.26	241.69	663.85	91.14	49.30	2143.04	D	1
D27	7.57	271.48	90.34	58.92	74.73	19.04	48.58	46.21	29.55	113.91	20.40	15.51	11.86	165.49	122.66	247.02	653.24	91.11	49.23	2136.85	D	1
D28	6.47	267.68	91.35	57.82	74.77	20.21	49.67	46.80	31.33	114.53	20.97	15.06	11.80	169.09	127.45	246.50	665.45	91.25	49.33	2157.53	D	1
D29	6.30	266.04	90.41	59.28	74.63	20.36	51.25	46.10	29.64	112.86	20.49	15.06	11.51	163.60	122.23	247.89	668.63	89.53	49.76	2145.57	D	1
D30	6.74	262.06	86.96	55.09	77.84	19.62	50.87	46.47	30.48	112.66	20.60	14.87	12.20	163.45	123.40	245.66	668.01	91.09	49.87	2137.94	D	1
D31	6.68	269.39	90.9	58.40	76.19	20.87	50.48	45.57	30.88	111.25	21.02	14.82	12.34	167.00	124.64	245.63	665.28	90.21	49.49	2151.04	D	1
D32	7.56	276.52	84.54	58.02	77.28	19.42	52.00	45.45	31.24	113.98	19.22	13.21	11.83	163.85	125.19	247.06	666.39	91.46	49.03	2153.25	D	1
D33	6.33	256.01	88.04	56.85	77.94	20.14	50.64	46.07	31.20	109.48	20.35	14.69	12.42	165.26	128.04	242.25	665.65	91.39	49.04	2131.79	D	1
D34	7.52	269.41	82.59	54.05	73.96	19.56	51.47	46.58	29.96	113.79	20.62	15.29	11.91	165.90	122.94	244.61	656.36	90.71	49.43	2126.66	D	1
D35	6.58	262.61	89.49	57.67	74.04	20.74	50.90	46.64	31.50	114.62	20.63	15.71	12.26	165.40	125.55	243.26	650.33	89.88	49.37	2127.18	D	1
D36	6.75	268.22	86.32	54.51	78.84	20.77	51.27	46.14	30.05	108.92	19.33	14.28	11.59	163.61	125.70	247.32	650.22	90.69	49.66	2124.19	D	1
D37	7.02	267.75	89.12	55.21	73.07	20.32	50.97	45.06	31.79	110.17	20.57	14.25	11.95	164.57	127.52	242.73	650.74	90.71	49.75	2123.27	D	1
D38	7.35	264.07	88.65	55.15	78.56	20.21	48.60	47.00	29.15	109.13	21.45	14.65	12.25	166.56	125.95	243.81	671.21	91.23	49.01	2143.99	D	1
D39	7.02	272.03	82.66	56.95	75.09	19.51	51.30	46.63	31.55	110.57	20.73	13.33	11.54	168.01	126.94	245.42	673.75	90.00	49.14	2152.17	D	1
D40	6.43	277.97	85.23	56.10	73.40	19.89	49.16	46.46	30.97	109.18	21.65	15.36	12.13	170.76	128.28	246.27	669.92	90.48	49.24	2158.88	D	1
D41	6.50	271.12	89.09	54.07	75.87	19.93	50.70	45.92	31.02	112.51	21.50	15.45	11.99	169.77	124.70	242.34	655.16	90.84	49.28	2137.76	D	1
D42	6.86	263.69	82.67	54.04	73.48	19.95	49.06	44.85	31.22	112.98	21.15	13.80	12.19	167.86	124.53	245.41	669.15	89.90	49.51	2132.30	D	1
D43	7.83	270.14	90.38	54.01	77.43	20.1	50.19	46.34	29.36	113.20	21.77	14.53	12.42	164.61	122.72	246.84	668.17	91.47	49.60	2151.11	D	1
D44	7.00	280.12	83.38	56.73	74.23	20.54	48.37	46.13	30.17	114.64	21.81	14.25	12.41	163.63	123.30	246.15	679.37	89.33	48.91	2160.47	D	1
D45	6.33	278.21	88.75	57.89	75.47	20.81	50.61	45.08	30.65	113.44	21.69	15.41	11.67	171.98	123.17	244.20	654.37	89.43	49.37	2148.53	D	1
D46	6.53	276.37	87.12	54.72	77.80	19.37	49.41	45.91	29.67	110.35	21.14	14.71	11.64	170.91	125.60	246.77	671.21	91.46	49.87	2160.56	D	1
D47	6.99	256.12	90.08	56.89	76.75	19.1	49.00	45.15	29.43	113.62	21.00	14.63	12.45	165.58	126.36	243.56	667.31	90.51	48.86	2133.39	D	1
D48	7.37	265.09	89.32	58.64	74.60	20.82	50.00	45.77	30.55	111.26	19.56	14.41	12.06	169.65	124.78	242.83	662.86	91.09	49.92	2140.58	D	1
D49	7.47	262.92	89.36	58.74	75.48	20.93	50.35	45.97	29.35	108.81	19.85	14.95	12.16	164.11	127.05	247.60	678.57	90.58	49.48	2153.73	D	1
D50	7.66	271.19	83.31	55.37	73.39	20.93	51.27	45.68	29.43	111.12	20.49	13.26	12.32	172.04	126.91	245.00	667.01	91.45	49.69	2147.52	D	1
D51	7.46	278.66	90.36	57.08	73.09	19.68	49.48	46.37	30.47	111.38	21.38	13.95	12.28	163.69	121.68	246.64	655.97	89.43	49.75	2138.80	D	1
D52	7.51	257.13	90.6	58.00	73.27	19.91	49.05	46.79	30.56	109.84	21.67	15.28	12.43	169.83	123.07	247.78	672.20	89.57	48.99	2143.48	D	1

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESSO	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
D53	7.81	270.01	86.34	55.58	77.34	20.56	50.80	46.34	31.15	111.06	19.55	14.06	11.99	164.14	121.26	241.90	665.34	91.41	49.53	2136.17	D	1
D54	7.03	269.60	82.8	58.23	76.70	19.02	51.58	46.36	30.89	110.11	20.28	15.58	12.44	168.92	121.30	246.43	667.31	91.03	49.47	2145.08	D	1
D55	7.77	262.95	91.44	57.45	75.43	20.91	49.87	46.76	30.61	109.68	20.54	13.50	12.04	167.76	123.42	245.87	667.95	90.00	49.62	2143.57	D	1
D56	6.96	268.46	85.22	57.73	77.56	19.19	51.37	46.34	31.46	114.43	20.81	14.06	12.03	164.86	123.65	242.80	667.19	90.68	48.85	2143.65	D	1
D57	7.77	267.12	84.84	55.33	75.61	19.28	50.07	46.29	29.85	109.19	21.34	14.65	12.28	165.99	127.98	244.42	669.41	90.62	49.62	2141.66	D	1
D58	6.28	278.30	91.48	55.90	74.74	20.59	50.39	46.28	29.68	112.48	21.35	15.68	11.62	167.91	122.86	244.27	677.17	89.88	49.57	2166.43	D	1
D59	7.66	273.41	82.83	55.41	78.41	19.49	52.01	46.25	29.88	111.55	20.76	15.10	12.17	166.74	126.17	245.50	664.48	90.95	49.25	2148.02	D	1
D60	6.67	277.99	88.1	54.83	74.65	19.52	51.30	46.17	31.95	110.17	20.05	14.07	11.83	164.16	125.31	247.07	654.92	91.41	49.00	2139.17	D	1
D61	7.29	275.08	90.71	57.69	73.99	20.97	51.01	45.79	30.03	114.32	20.07	13.55	12.44	168.15	128.03	247.32	664.25	89.76	48.88	2159.33	D	1
D62	7.31	261.28	85.5	55.07	73.74	20.93	48.59	46.85	30.32	113.01	19.71	14.14	12.07	167.36	125.89	244.94	675.84	91.04	49.36	2142.95	D	1
D63	6.87	270.38	89.87	58.59	75.08	19.13	51.66	46.24	31.52	110.20	21.64	13.32	12.43	166.79	123.44	242.49	667.20	89.73	49.12	2145.70	D	1
D64	6.41	255.25	83.91	55.99	77.15	19.18	50.47	45.96	29.01	109.12	20.41	14.36	12.33	170.23	128.12	245.03	661.35	90.65	49.38	2124.31	D	1
D65	7.43	259.63	84.26	56.39	74.44	20.87	51.31	45.33	29.42	111.86	21.25	14.93	11.72	169.48	121.94	243.09	662.34	89.92	49.99	2125.60	D	1
D66	6.38	263.75	88.22	56.21	74.68	19.44	50.46	45.90	31.90	108.97	19.23	13.28	11.99	167.63	125.75	244.23	661.47	90.66	49.32	2129.47	D	1
D67	7.12	274.94	83.79	54.09	73.37	19.18	50.53	4.42	30.18	113.34	21.17	13.09	12.27	165.20	121.83	245.35	654.01	90.01	49.09	2082.98	D	1
D68	6.97	258.06	91.56	58.66	76.14	20.33	50.88	45.98	29.86	112.21	19.80	14.14	11.80	164.37	126.20	242.68	675.48	89.73	49.34	2144.19	D	1
D69	7.24	270.12	85.43	55.20	76.36	19.31	50.49	46.08	31.86	111.12	20.28	13.81	11.70	169.51	128.24	241.34	666.29	91.23	49.73	2145.34	D	1
D70	6.26	277.78	85.78	55.24	78.04	19.24	48.30	46.05	30.65	114.81	19.81	14.67	12.34	163.37	126.76	244.04	665.15	90.65	49.50	2148.44	D	1
D71	7.76	263.20	91.57	59.19	76.85	20.11	48.71	45.99	29.64	112.14	21.30	14.97	11.69	165.38	122.08	243.69	678.41	90.46	49.60	2152.74	D	1
D72	7.45	275.19	85.79	59.26	78.07	19.34	50.60	45.09	30.17	109.46	20.33	12.81	12.44	171.51	125.21	246.71	669.38	90.99	49.24	2159.04	D	1
D73	7.50	265.68	90.9	56.36	76.90	20.98	50.94	45.69	29.66	108.64	19.85	13.85	12.26	170.18	121.56	242.91	673.79	90.20	49.12	2146.97	D	1
D74	7.16	272.11	86.24	54.45	77.39	20.54	49.22	46.61	29.00	109.56	19.79	14.33	11.58	170.58	125.59	244.72	659.45	90.99	49.53	2138.84	D	1
D75	6.55	273.15	86.44	55.22	76.02	19.93	50.40	45.35	31.88	110.48	20.75	14.47	11.68	168.46	128.14	247.03	659.84	89.38	49.03	2144.20	D	1
D76	6.39	270.45	87.08	58.29	77.74	19.32	48.47	45.08	31.38	110.63	21.78	13.34	12.35	171.76	122.73	247.33	650.41	89.77	49.14	2133.44	D	1
D77	7.58	269.92	89.09	59.21	75.51	20.34	49.27	44.84	29.84	108.13	20.29	13.09	11.88	167.55	122.09	241.67	654.93	90.62	49.75	2125.60	D	1
D78	7.18	259.49	84.34	56.25	77.12	20.95	49.66	46.50	30.59	110.20	19.36	14.29	11.63	169.14	126.23	241.87	667.58	90.68	49.42	2132.48	D	1
D79	8.30	259.76	83.80	56.56	74.12	19.49	52.20	44.87	30.94	112.25	20.07	14.23	11.45	168.57	122.90	239.04	669.44	91.40	50.72	2130.11	D	2
D80	10.09	262.26	81.89	56.98	75.19	20.67	48.31	44.54	29.72	114.13	20.58	14.38	12.57	164.55	122.93	248.37	669.46	91.03	50.56	2138.21	D	2
D81	8.44	262.08	84.44	56.19	76.03	19.93	48.39	44.59	31.10	110.81	20.09	14.81	12.89	165.55	124.20	241.84	668.24	91.55	50.46	2131.63	D	2
D82	9.40	261.04	80.92	56.97	73.18	20.62	51.28	46.36	30.94	113.18	19.81	13.70	12.41	162.54	119.44	241.29	661.98	90.26	50.62	2115.94	D	2
D83	8.40	258.42	82.77	56.68	77.94	20.44	50.97	45.75	29.80	113.24	20.56	13.26	11.84	169.14	121.48	246.43	659.57	90.14	49.36	2126.19	D	2
D84	9.94	259.31	82.22	57.29	73.17	20.59	51.64	44.79	31.09	112.91	21.00	15.16	11.52	164.94	122.86	243.40	659.09	90.32	49.66	2120.90	D	2
D85	8.45	258.60	83.31	54.55	73.28	19.61	51.94	45.02	31.39	114.60	20.02	13.96	12.64	162.26	120.97	242.76	665.52	91.13	48.42	2118.43	D	2
D86	9.34	256.97	82.70	57.24	72.82	20.01	49.67	45.07	30.26	109.59	20.62	13.80	11.28	168.47	121.51	244.99	668.50	91.72	48.89	2123.45	D	2
D87	9.98	259.95	80.90	54.10	74.25	19.31	50.72	44.84	31.18	112.16	20.34	13.13	12.20	168.72	122.11	238.46	667.82	89.52	49.99	2119.68	D	2
D88	9.55	258.92	80.57	56.28	76.06	19.51	49.61	46.60	30.57	111.89	21.17	14.89	11.00	169.86	121.16	248.60	665.02	90.39	50.40	2132.05	D	2
D89	10.24	258.77	81.77	57.43	76.48	20.35	50.23	46.46	29.98	112.36	20.41	15.32	12.10	168.57	123.09	240.64	659.09	90.17	50.92	2124.38	D	2
D90	9.00	262.16	81.53	56.53	77.41	19.81	50.79	46.12	30.12	113.86	20.51	14.57	11.01	168.32	124.50	239.16	663.77	89.15	49.41	2127.73	D	2
D91	10.09	262.09	80.89	54.65	77.66	20.42	51.91	45.05	31.30	111.99	20.72	14.36	12.41	166.01	124.00	239.87	665.97	89.62	47.95	2126.96	D	2
D92	9.04	258.41	80.32	56.25	74.21	20.31	49.18	45.43	30.98	109.77	19.75	14.56	11.08	165.31	121.99	246.27	666.96	89.80	48.60	2118.22	D	2
D93	8.64	262.15	85.73	54.10	76.55	20.18	50.81	46.55	30.17	109.58	20.88	13.99	12.77	170.67	119.79	242.14	665.75	89.85	49.28	2129.58	D	2
D94	9.31	261.94	85.84	55.44	74.69	19.84	48.37	46.29	29.90	110.08	20.95	13.16	11.12	169.39	120.34	248.82	665.34	89.95	48.44	2129.21	D	2
D95	9.01	260.64	85.66	57.05	78.18	19.90	48.32	45.06	30.07	114.33	19.71	15.15	11.57	169.19	120.92	238.41	669.07	89.55	50.56	2132.35	D	2
D96	8.61	261.44	84.35	55.09	72.83	19.90	50.62	44.72	30.98	113.11	19.72	13.59	12.29	172.59	119.84	248.18	664.18	90.71	48.68	2131.43	D	2
D97	8.58	262.25	82.76	56.83	75.21	19.87	51.88	45.22	30.79	110.73	20.82	14.33	11.32	166.06	122.74	239.74	667.02	90.04	50.84	2127.03	D	2
D98	9.15	261.07	81.27	55.87	76.19	19.51	49.99	45.53	30.82	110.84	21.01	13.79	12.17	167.74	124.57	248.89	667.77	90.96	50.23	2137.37	D	2
D99	9.25	255.91	81.51	56.89	76.42	19.83	51.41	45.21	30.19	114.60	20.27	14.21	11.27	169.63	124.66	248.95	664.37	90.06	50.39	2135.03	D	2
D100	9.85	260.69	85.54	54.11	76.94	19.34	48.61	45.62	31.15	113.97	19.90	14.08	12.61	171.67	124.59	240.26	669.42	89.52	47.34	2135.21	D	2
D101	9.18	261.73	84.81	55.44	74.50	20.56	48.10	45.10	30.86	111.75	20.86	14.56	12.81	171.43	122.87	239.32	659.23	90.14	47.53	2120.78	D	2
D102	9.96	259.43	80.22	56.50	78.45	19.39	51.14	46.21	30.83	112.47	20.14	14.24	12.68	169.55	119.96	245.14	660.70	89.74	47.80	2124.55	D	2
D103	8.39	256.62	82.15	54.77	72.80	20.17	50.17	45.55	31.42	110.77	20.43	14.22	11.86	170.55	121.31	241.60	660.60	90.29	50.97	2114.64	D	2
D104	9.49	260.58	82.38	56.12	73.34	19.32	49.62	45.24	30.17	109.42	21.28	15.30	12.83	164.07	124.51	242.33	668.76	90.03	47.90	2122.69	D	2

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
D105	9.76	255.56	81.68	55.99	76.15	20.43	52.04	46.01	29.55	110.28	20.31	14.18	11.76	165.41	120.74	240.24	659.65	89.60	50.87	2110.21	D	2
D106	8.21	260.14	81.89	57.32	76.05	19.42	51.32	44.78	29.47	109.59	19.92	14.41	11.47	172.38	120.52	240.00	659.04	89.70	50.15	2115.78	D	2
D107	8.81	256.80	83.36	57.19	77.01	20.44	48.81	45.97	30.98	113.45	21.03	13.20	11.83	165.31	120.42	239.78	663.96	90.30	51.09	2119.74	D	2
D108	10.11	261.01	81.17	55.28	78.46	19.31	50.90	45.41	30.83	110.98	20.75	15.14	12.91	170.09	120.87	240.29	666.63	89.99	47.96	2128.09	D	2
D109	9.71	257.23	81.68	57.36	77.24	19.92	48.21	45.68	30.05	113.09	20.54	13.32	12.55	169.12	119.53	247.14	662.82	89.27	47.50	2121.96	D	2
D110	8.66	259.19	82.46	56.27	75.32	20.04	48.86	45.97	29.43	113.91	20.84	13.80	11.79	167.35	123.35	247.32	661.28	90.08	50.31	2126.23	D	2
D111	10.20	259.30	85.92	56.94	74.18	20.51	49.74	46.52	30.77	111.09	20.12	14.01	12.42	164.14	119.77	249.80	660.35	90.25	50.05	2126.08	D	2
D112	10.17	259.50	80.34	57.50	77.22	19.53	49.44	45.29	31.44	109.31	19.77	14.96	12.57	168.17	121.46	248.29	661.91	91.30	50.62	2128.79	D	2
D113	8.22	255.70	85.55	55.17	78.12	20.35	51.81	45.96	30.86	114.36	19.95	14.66	12.45	172.08	122.57	242.62	659.45	91.97	48.06	2129.91	D	2
D114	8.68	257.41	83.22	55.49	72.69	19.48	49.70	46.32	30.06	108.95	19.96	13.55	12.45	169.61	120.78	248.77	661.33	91.05	48.85	2118.35	D	2
D115	9.98	275.56	81.17	54.50	73.41	20.15	50.76	44.77	31.25	112.82	20.85	13.50	11.81	169.24	119.34	249.62	664.04	88.95	47.18	2138.90	D	2
D116	8.59	256.38	80.72	55.12	75.78	19.52	50.21	45.60	30.63	108.68	20.86	13.66	13.13	172.15	123.66	239.16	664.76	90.60	47.41	2116.62	D	2
D117	8.45	258.60	82.48	54.41	76.12	20.17	49.26	45.74	29.55	109.50	20.23	14.86	11.25	171.18	120.53	241.12	668.14	89.85	47.39	2118.83	D	2
D118	10.01	259.23	83.30	54.54	74.42	20.13	48.29	46.47	30.39	111.37	21.34	15.13	12.03	166.59	124.41	247.83	668.84	91.54	50.72	2136.58	D	2
D119	8.47	257.14	85.05	55.96	75.86	20.07	50.32	44.63	30.40	110.99	20.03	13.77	12.53	170.08	123.02	245.96	669.48	90.07	50.15	2133.98	D	2
D120	9.61	256.23	81.75	54.69	77.39	19.75	48.39	44.98	30.24	111.91	20.35	13.68	11.24	169.88	121.47	242.03	666.37	90.32	50.18	2120.46	D	2
D121	9.42	261.37	84.39	55.08	74.77	19.51	49.56	46.03	31.03	112.86	19.91	14.70	12.16	168.91	120.70	247.33	665.92	91.52	50.01	2135.18	D	2
D122	8.59	257.36	82.44	56.81	78.62	19.97	48.04	44.72	30.97	114.33	20.97	14.98	12.16	170.38	123.02	241.87	659.08	91.18	48.27	2123.76	D	2
D123	8.83	260.55	83.23	55.37	76.33	20.57	48.95	45.03	30.69	114.62	20.04	14.96	12.61	170.84	122.64	246.46	661.16	91.58	50.52	2134.98	D	2
D124	8.24	259.32	80.81	57.36	73.72	19.63	50.90	45.47	30.91	110.78	20.16	14.40	13.09	163.82	123.32	241.12	668.74	90.93	47.23	2119.95	D	2
D125	8.58	257.76	84.74	56.62	75.10	19.73	51.43	46.05	30.31	114.57	20.93	13.51	11.05	171.42	123.83	243.85	659.03	88.94	48.12	2125.57	D	2
D126	9.43	256.04	81.99	55.60	74.29	20.31	52.15	45.93	30.84	109.11	20.32	14.21	13.02	163.97	124.23	241.53	669.55	90.60	47.57	2120.69	D	2
D127	9.28	258.57	81.60	54.37	76.98	19.82	47.88	46.51	30.11	110.71	21.26	13.67	11.69	170.38	120.32	239.99	666.30	89.92	49.60	2118.96	D	2
D128	9.44	260.92	83.25	57.66	74.83	19.86	48.21	46.12	30.68	114.24	20.98	13.62	12.55	165.12	120.15	238.34	669.12	90.03	49.31	2124.43	D	2
D129	8.85	258.36	85.74	54.28	75.01	19.26	48.47	45.15	31.27	111.69	20.49	15.33	12.30	162.53	121.01	239.18	660.57	90.75	47.76	2108.00	D	2
D130	8.74	257.40	85.90	54.85	75.71	20.05	49.77	45.64	31.38	110.10	20.23	13.96	12.17	168.12	119.55	242.32	659.75	89.45	50.46	2115.55	D	2
D131	8.73	260.26	83.21	54.95	78.60	19.85	50.87	45.71	30.27	114.14	20.06	15.18	12.52	164.65	123.58	246.93	664.51	89.75	50.62	2134.39	D	2
D132	9.96	258.45	83.31	56.46	74.28	20.17	49.36	45.82	30.67	110.07	20.63	13.14	11.97	169.05	120.98	243.65	668.68	91.95	50.68	2129.28	D	2
D133	8.97	259.40	85.60	56.00	78.29	19.72	50.00	45.87	30.93	108.72	20.92	14.01	12.29	172.13	119.62	246.32	665.50	90.94	50.05	2135.28	D	2
D134	9.43	259.10	82.44	56.01	78.08	20.13	48.10	44.90	31.12	114.18	21.16	15.11	13.00	170.82	120.65	238.83	666.97	90.24	47.88	2128.15	D	2
D135	9.90	257.21	80.24	56.28	78.56	19.56	50.24	46.53	30.60	114.66	21.05	13.74	12.88	166.28	124.01	238.26	661.47	90.11	47.16	2118.74	D	2
D136	8.55	261.01	83.03	55.33	75.29	18.97	50.71	46.59	30.87	109.73	21.10	14.96	11.00	168.29	119.23	244.32	666.00	89.55	49.31	2123.84	D	2
D137	8.66	255.39	80.88	54.26	74.92	19.34	48.75	46.09	30.25	110.69	20.48	14.34	12.59	162.71	120.87	245.92	668.87	89.27	50.15	2114.43	D	2
D138	10.12	256.32	82.56	55.79	77.68	19.99	48.86	45.67	29.49	110.80	19.71	15.31	11.16	162.12	119.73	244.59	667.53	91.44	50.14	2119.01	D	2
D139	9.75	258.14	81.46	55.09	76.41	20.18	51.81	45.85	29.73	108.59	20.37	14.25	12.66	162.79	120.82	248.49	659.20	90.25	49.17	2115.01	D	2
D140	8.59	260.42	80.59	56.73	73.22	19.96	47.85	46.04	30.99	109.08	20.28	13.13	11.13	165.56	121.84	238.06	659.12	91.03	50.59	2104.21	D	2
D141	9.91	261.11	82.61	55.82	77.52	20.33	51.72	45.62	30.20	113.38	21.00	14.43	12.55	168.24	122.48	242.58	668.93	91.93	47.37	2137.73	D	2
D142	8.55	256.83	84.35	54.75	74.47	19.31	52.03	45.41	31.38	111.90	21.27	14.19	11.91	167.54	122.46	245.33	659.07	89.70	48.80	2119.25	D	2
D143	8.20	259.54	83.87	57.56	77.47	20.61	50.05	45.33	29.81	109.21	21.24	15.19	12.55	164.26	123.14	240.90	661.59	90.04	48.64	2119.20	D	2
D144	8.50	259.35	84.56	56.90	72.53	19.80	48.97	46.07	30.06	109.49	20.25	13.85	11.57	167.37	120.58	248.46	661.00	90.23	50.16	2119.70	D	2
D145	9.75	259.69	85.80	55.72	77.58	20.11	51.40	46.50	30.22	109.04	21.36	13.74	12.09	170.35	119.44	240.12	666.17	89.30	47.44	2125.82	D	2
D146	8.58	257.32	84.14	55.85	78.58	20.39	52.17	44.91	29.54	110.87	20.31	13.99	12.99	172.10	119.26	243.68	668.49	90.74	50.86	2134.77	D	2
D147	9.98	261.97	85.82	56.63	74.55	20.54	49.41	45.04	30.85	113.25	21.20	13.25	11.02	167.28	122.55	244.98	660.81	91.53	50.75	2131.41	D	2
D148	9.11	257.46	81.09	55.63	76.13	20.40	49.07	46.40	29.69	113.54	20.33	15.23	12.96	168.94	123.07	238.73	659.43	90.19	48.74	2116.14	D	2
D149	9.80	259.68	81.31	57.11	75.66	20.29	49.67	45.84	30.69	110.75	20.14	13.87	11.43	170.29	123.96	238.92	664.67	89.29	50.36	2123.73	D	2
D150	9.40	257.35	84.74	55.40	75.01	20.23	51.15	46.59	31.00	110.98	21.35	13.17	12.54	162.27	119.58	246.29	661.13	89.61	51.18	2118.97	D	2
D151	9.18	261.77	81.46	57.14	76.55	19.74	51.79	45.86	31.32	109.27	21.40	15.12	12.46	170.29	124.66	242.50	659.58	90.94	47.77	2128.80	D	2
D152	8.74	261.92	84.82	55.86	78.59	20.38	50.17	45.54	30.83	111.73	20.14	14.80	10.73	165.60	121.84	238.98	660.75	91.65	50.80	2123.87	D	2
D153	8.92	261.16	85.39	54.88	78.13	19.88	51.57	46.52	31.07	109.88	20.02	13.97	12.29	171.95	119.70	239.80	665.63	90.02	50.88	2131.66	D	2
D154	9.11	258.50	83.09	54.14	78.70	19.68	49.14	45.31	30.19	109.61	21.28	13.71	12.28	164.25	119.90	239.66	659.27	91.12	48.63	2107.57	D	2
D155	9.23	256.36	81.01	56.72	77.52	19.59	49.03	45.44	29.54	113.88	19.81	13.96	11.96	168.49	124.61	242.21	668.26	91.12	49.34	2128.08	D	2
D156	10.08	258.80	82.66	57.15	73.44	20.07	49.28	44.85	30.64	113.97	19.78	14.05	11.75	172.48	121.18	249.73	666.95	90.20	47.37	2134.43	D	2

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
D157	17.30	210.68	78.44	55.59	74.56	19.82	48.56	45.70	30.02	90.06	19.89	14.08	11.68	119.27	117.27	221.12	670.65	90.96	49.94	1985.59	D	3
D158	15.84	214.77	81.77	55.41	75.09	19.72	49.73	45.30	30.68	92.28	19.71	13.31	12.16	118.65	116.21	220.17	662.63	89.43	49.81	1982.67	D	3
D159	16.88	209.96	79.58	55.03	74.58	20.73	50.12	44.54	30.69	87.99	20.46	13.99	12.47	122.60	114.44	223.04	662.00	90.84	49.01	1978.95	D	3
D160	16.60	211.12	83.30	56.85	74.90	19.39	48.72	45.39	30.48	90.46	19.93	13.59	12.20	124.05	114.73	222.29	675.38	90.23	48.82	1998.43	D	3
D161	16.78	214.52	83.19	57.06	74.54	19.25	48.60	45.48	30.10	91.08	19.95	13.18	11.57	120.75	116.03	217.54	661.60	90.63	49.58	1981.43	D	3
D162	16.20	211.24	83.15	55.60	72.64	20.36	52.15	46.11	29.78	94.33	20.12	13.95	12.34	125.55	116.76	218.74	661.32	89.11	49.58	1989.03	D	3
D163	16.70	210.67	79.06	57.37	74.81	19.86	49.39	44.87	30.17	91.79	20.94	13.36	11.90	123.38	115.97	219.71	662.85	90.52	49.60	1982.92	D	3
D164	17.27	210.56	82.72	55.84	75.06	20.17	48.85	45.37	30.78	91.63	20.21	13.11	11.96	125.83	112.56	222.85	662.89	90.28	48.82	1986.76	D	3
D165	16.96	214.33	82.27	57.35	72.32	19.47	50.58	45.34	30.26	94.39	21.07	13.69	12.24	122.97	115.84	220.32	665.52	90.02	49.55	1994.49	D	3
D166	16.12	214.67	82.79	54.35	73.32	19.69	49.78	45.48	30.81	95.26	20.76	13.94	11.61	118.73	113.89	221.64	656.10	90.93	49.21	1979.08	D	3
D167	16.29	212.64	82.01	57.51	74.79	19.30	49.36	44.95	29.82	90.21	19.66	14.11	12.16	128.96	113.94	219.07	662.17	89.61	49.29	1985.85	D	3
D168	17.48	223.03	80.49	56.93	73.15	20.33	47.95	45.48	30.72	94.26	20.67	14.04	11.94	121.04	118.02	221.21	659.35	91.10	49.68	1996.87	D	3
D169	15.96	211.22	78.44	57.40	73.26	20.13	50.43	46.19	30.41	89.75	20.54	13.57	12.34	128.38	116.28	222.19	661.18	91.10	49.01	1987.78	D	3
D170	15.81	220.34	83.53	54.44	73.03	19.54	50.27	45.64	30.12	88.40	20.24	13.34	11.88	118.77	112.61	221.02	664.44	91.40	49.32	1984.14	D	3
D171	17.36	215.58	81.33	56.61	73.68	19.88	48.54	45.52	31.23	89.52	20.58	13.30	11.80	121.57	118.74	223.70	659.71	90.88	48.90	1988.43	D	3
D172	17.17	211.35	79.85	54.46	74.72	20.09	50.66	45.32	31.26	95.89	21.45	13.94	12.20	123.04	114.71	219.00	660.29	89.25	49.04	1983.69	D	3
D173	15.88	212.47	79.59	55.53	73.71	19.26	48.35	44.52	30.39	95.45	20.50	13.68	11.59	120.27	116.07	223.11	659.92	89.23	49.02	1978.54	D	3
D174	16.47	214.65	78.88	55.47	74.72	19.90	52.28	46.10	30.38	90.33	20.65	13.75	12.07	120.77	112.96	220.25	660.23	90.45	49.50	1979.81	D	3
D175	16.97	212.13	83.43	55.51	72.78	19.81	48.43	44.66	30.39	91.83	21.05	14.14	12.42	120.03	113.20	218.40	656.43	90.80	49.41	1971.82	D	3
D176	16.81	210.85	80.78	56.97	75.13	20.47	51.68	45.37	29.91	90.39	20.42	13.83	12.02	125.11	116.89	220.06	669.81	90.90	48.85	1996.25	D	3
D177	16.05	210.88	80.93	56.23	72.96	20.51	48.78	44.73	31.30	89.79	20.30	13.66	12.53	122.79	116.47	223.23	664.53	90.85	49.80	1986.32	D	3
D178	16.90	214.86	78.64	57.41	72.67	19.40	51.35	44.60	30.72	93.01	20.53	14.15	12.21	119.92	112.68	220.06	659.22	89.68	49.17	1977.18	D	3
D179	16.48	215.31	79.72	56.11	72.64	19.92	48.87	45.53	30.29	92.91	20.31	13.83	11.94	119.91	115.24	218.07	660.44	90.46	48.76	1976.74	D	3
D180	16.07	215.83	83.21	55.08	74.64	19.89	49.34	46.02	30.44	95.34	20.75	13.18	11.97	125.85	114.94	218.78	664.54	89.74	49.22	1994.83	D	3
D181	16.70	209.67	81.68	55.28	73.06	20.94	49.59	46.26	30.43	90.63	21.34	13.61	11.88	119.07	113.78	222.74	656.88	91.57	49.01	1974.12	D	3
D182	15.83	214.91	80.71	56.97	74.47	19.38	49.48	44.75	29.80	87.75	20.13	13.47	13.05	122.12	112.45	216.70	660.65	91.64	48.83	1973.09	D	3
D183	15.94	209.74	83.51	57.99	73.63	19.40	48.92	45.48	30.03	88.00	20.69	13.86	11.81	122.32	118.82	221.43	669.20	91.10	49.04	1990.91	D	3
D184	16.85	212.35	82.87	55.61	72.59	20.15	51.05	45.40	31.59	93.25	20.38	13.98	12.92	122.05	115.79	218.67	660.65	91.71	49.64	1987.50	D	3
D185	17.46	212.72	82.55	55.04	74.57	19.99	48.90	44.70	30.67	91.11	20.66	13.65	12.95	125.52	113.38	216.74	662.90	91.72	49.63	1984.86	D	3
D186	16.79	211.41	78.60	55.47	74.08	19.53	49.55	46.25	29.77	90.04	21.02	13.09	12.10	118.49	115.29	218.67	656.34	90.82	48.88	1966.19	D	3
D187	15.94	211.07	82.58	55.53	74.97	19.23	49.80	44.80	30.38	89.90	20.96	13.45	11.54	125.71	116.08	218.45	664.87	90.64	49.63	1985.53	D	3
D188	16.07	214.55	83.08	58.05	73.10	19.49	49.94	45.43	30.71	92.81	20.52	13.20	12.51	125.46	115.87	220.94	670.92	88.63	49.75	2001.03	D	3
D189	16.04	213.77	81.61	56.10	74.56	20.51	50.63	46.27	31.28	93.79	20.69	13.18	12.17	119.86	118.81	222.34	669.62	90.35	49.79	2001.37	D	3
D190	17.08	213.50	81.91	56.10	73.59	19.90	50.61	44.61	31.26	88.43	20.37	13.02	12.16	123.73	118.69	223.06	670.00	89.08	49.34	1996.44	D	3
D191	16.09	211.75	79.64	56.23	73.41	20.30	48.49	45.43	31.33	95.35	21.04	13.70	12.20	120.89	115.92	221.98	662.05	90.71	49.36	1985.87	D	3
D192	16.92	210.33	81.50	56.79	73.23	19.69	49.75	46.08	30.94	92.26	20.39	14.10	12.17	122.07	118.11	221.18	669.36	91.53	48.81	1995.21	D	3
D193	16.16	213.36	80.68	55.23	73.31	20.46	49.63	45.47	30.06	89.07	20.16	13.54	12.04	118.82	116.74	219.30	661.37	91.38	49.19	1975.97	D	3
D194	16.17	211.33	80.74	55.41	74.66	20.65	50.52	45.30	30.25	88.41	20.61	13.20	11.77	122.21	114.14	216.66	662.25	89.88	49.69	1973.85	D	3
D195	16.60	210.61	81.48	54.99	73.90	19.69	49.22	44.83	31.31	89.56	21.28	14.01	12.37	123.23	112.72	219.65	664.78	90.84	49.28	1980.35	D	3
D196	16.92	215.42	79.67	55.97	73.74	19.54	51.21	44.91	30.41	88.66	20.71	13.19	11.98	122.55	112.47	219.03	669.35	90.76	49.06	1985.55	D	3
D197	16.23	211.06	79.22	57.11	74.04	20.29	48.90	44.77	30.91	91.20	20.31	13.33	12.53	121.45	118.61	218.89	659.19	88.97	49.77	1976.78	D	3
D198	17.45	209.53	82.07	55.00	73.05	20.05	48.84	45.45	30.40	94.04	20.86	13.45	12.40	129.24	117.08	218.52	660.26	90.71	49.79	1988.19	D	3
D199	17.01	211.61	80.96	57.59	73.87	20.33	49.72	44.86	31.21	91.80	20.51	13.69	11.53	119.32	113.63	216.71	660.08	91.27	48.85	1974.55	D	3
D200	15.82	210.36	82.51	54.30	72.53	19.86	50.13	46.13	29.77	89.50	20.80	14.06	12.48	123.96	117.57	217.03	660.63	90.92	48.74	1977.10	D	3
D201	17.17	215.75	79.09	56.92	73.23	19.48	50.22	45.41	30.65	94.43	21.38	13.46	12.14	121.22	116.44	220.52	656.80	91.05	48.84	1984.20	D	3
D202	16.16	214.67	80.52	56.74	73.52	20.81	50.32	46.21	30.42	93.75	20.87	13.69	12.13	122.89	113.29	216.78	664.66	89.23	48.76	1985.42	D	3
D203	16.12	210.15	82.25	58.27	73.69	20.28	49.60	45.41	30.40	87.59	20.45	13.01	11.65	121.63	114.10	221.35	660.32	91.64	49.94	1977.85	D	3
D204	15.92	211.92	78.75	58.12	75.02	19.36	51.07	46.19	29.89	93.83	21.11	14.12	11.66	120.52	113.75	222.66	669.54	91.61	49.59	1994.63	D	3
D205	17.03	209.54	79.98	54.55	72.92	20.81	49.91	44.75	30.07	95.85	20.81	13.01	12.22	118.63	116.33	219.23	670.21	89.42	49.29	1984.56	D	3
D206	16.55	210.72	82.45	54.66	73.44	20.33	49.74	45.33	30.08	91.60	19.52	13.78	11.71	122.87	113.83	220.06	664.90	91.10	49.24	1981.91	D	3
D207	16.40	215.86	80.99	56.07	74.94	19.78	50.25	46.16	29.98	91.55	20.27	13.30	11.51	119.46	117.89	220.76	662.08	90.46	49.45	1987.16	D	3
D208	16.99	212.32	78.59	56.76	73.50	20.07	51.81	45.36	31.27	92.52	20.10	13.85	12.10	122.92	113.90	220.90	659.24	88.47	49.80	1980.47	D	3

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
D209	16.52	209.52	79.69	56.91	74.90	20.30	49.18	45.39	30.82	87.98	20.30	13.42	12.59	120.77	118.17	219.64	670.23	91.25	49.55	1987.13	D	3
D210	15.85	213.98	82.46	54.65	75.07	20.47	51.22	44.76	30.61	95.47	20.75	13.21	11.88	119.16	116.88	222.65	662.37	89.61	49.46	1990.51	D	3
D211	16.94	213.18	78.33	57.47	74.79	20.24	50.55	46.60	30.44	94.14	20.81	13.10	11.84	124.17	114.93	221.30	660.93	88.92	49.39	1988.07	D	3
D212	16.96	210.98	82.74	55.74	73.85	20.27	50.72	46.31	30.42	91.76	20.15	13.23	12.36	118.90	116.72	217.22	662.68	90.76	48.79	1980.56	D	3
D213	16.71	209.66	78.71	57.92	74.13	19.70	51.32	46.63	30.34	89.55	19.73	13.01	11.97	123.96	114.54	219.97	660.58	90.86	49.99	1979.28	D	3
D214	17.03	212.52	82.98	55.96	73.24	19.71	50.41	46.45	29.91	92.02	20.89	14.03	11.98	119.96	116.63	221.15	670.62	91.05	49.14	1995.68	D	3
D215	16.67	215.50	83.38	58.16	73.23	20.57	49.27	46.45	31.30	87.56	20.43	13.62	11.89	123.05	113.33	223.66	664.99	91.66	49.30	1994.02	D	3
D216	15.93	212.21	82.97	57.95	72.44	20.91	51.30	46.98	30.63	95.03	19.89	13.19	12.49	122.13	113.76	216.63	666.78	91.59	49.67	1992.48	D	3
D217	16.40	213.33	82.20	56.76	73.88	20.77	49.37	46.78	29.90	90.97	20.96	14.18	12.03	120.07	116.22	220.35	670.52	88.74	49.36	1992.79	D	3
D218	17.22	210.02	80.87	54.87	72.20	19.35	50.55	46.31	29.95	88.49	20.73	13.61	12.44	125.43	116.56	221.89	660.09	91.10	49.30	1980.98	D	3
D219	16.92	212.98	81.56	58.03	73.26	20.64	51.35	46.42	29.94	93.05	21.16	14.06	12.20	123.22	117.48	217.12	655.55	90.79	49.23	1984.96	D	3
D220	15.97	210.30	80.12	54.66	72.89	19.96	51.11	46.34	30.50	90.90	20.93	13.49	11.99	122.65	117.22	222.01	670.09	90.93	48.78	1990.84	D	3
D221	16.87	215.36	82.46	57.47	73.25	19.85	50.77	46.53	30.48	90.51	21.03	13.57	11.96	124.36	114.96	216.41	666.32	90.76	49.45	1992.37	D	3
D222	17.29	214.81	78.96	55.95	74.92	19.74	49.61	46.84	30.56	91.00	21.34	14.04	11.63	123.08	117.90	223.12	662.62	89.01	49.54	1991.96	D	3
D223	16.39	211.50	81.92	57.77	73.92	19.42	50.75	44.64	30.61	90.78	20.41	13.30	11.82	122.71	117.65	217.00	669.66	90.82	48.76	1989.83	D	3
D224	16.42	211.26	81.30	56.37	74.68	19.33	50.44	45.30	30.13	94.71	20.44	13.07	12.11	125.81	113.30	218.02	656.62	90.22	49.53	1979.06	D	3
D225	16.30	211.29	80.06	57.77	75.09	19.67	49.47	45.43	31.33	95.41	20.35	13.26	12.19	121.52	114.19	222.64	662.01	91.25	49.39	1988.62	D	3
D226	17.35	213.82	80.48	55.28	72.82	19.80	51.00	46.20	31.68	87.77	21.50	14.14	12.64	120.78	118.16	219.71	670.06	90.00	49.56	1992.75	D	3
D227	15.81	214.04	81.01	57.83	72.77	20.09	51.25	46.29	29.92	91.43	19.78	13.42	12.35	124.79	116.41	216.87	670.23	88.64	49.39	1992.32	D	3
D228	17.12	210.97	81.39	55.58	74.04	19.81	50.09	46.12	30.68	89.91	20.02	13.78	11.53	121.52	114.26	223.53	656.73	91.36	49.63	1978.07	D	3
D229	16.62	215.49	82.59	57.17	72.81	20.25	51.18	44.64	30.77	94.16	20.53	13.99	12.15	120.44	112.74	218.65	670.30	90.23	49.40	1994.11	D	3
D230	17.30	215.15	79.98	56.38	72.66	19.51	50.28	44.81	30.50	89.63	20.13	14.05	12.01	124.90	117.18	221.08	661.47	91.45	49.14	1987.61	D	3
D231	16.55	213.30	81.13	55.98	73.61	20.33	50.69	46.12	30.27	95.75	19.69	13.21	11.68	195.30	116.90	221.84	670.27	89.59	49.85	2072.06	D	3
D232	16.54	212.96	83.29	57.64	74.51	18.90	50.76	44.97	29.84	89.95	21.23	13.68	13.16	122.78	116.34	219.82	660.04	89.46	49.83	1985.70	D	3
D233	16.85	211.27	83.56	56.43	72.21	20.30	48.89	46.23	29.96	89.93	20.13	13.09	11.97	118.97	115.26	217.82	669.22	88.90	49.23	1980.22	D	3
D234	16.79	209.91	78.95	55.50	74.05	19.57	49.42	44.76	31.46	94.02	19.47	13.31	12.36	118.68	118.81	217.13	660.15	90.83	49.39	1974.56	D	3
D235	27.99	212.27	78.76	57.31	74.53	20.23	51.72	45.97	30.40	89.39	20.11	13.48	11.54	118.10	115.11	221.39	660.06	90.12	49.48	1987.96	D	4
D236	29.07	210.28	78.87	56.94	73.73	20.29	49.59	46.57	30.64	91.95	20.10	13.65	12.47	129.03	113.57	220.70	661.73	89.40	49.03	1997.61	D	4
D237	27.82	214.71	79.83	57.44	74.57	19.53	50.64	44.92	30.19	90.62	20.13	13.04	12.00	122.58	113.95	221.41	670.80	91.72	49.85	2005.75	D	4
D238	27.87	217.92	79.14	56.29	74.01	19.39	50.98	45.88	31.18	92.73	20.09	13.63	12.31	119.83	118.39	218.15	661.51	89.36	49.67	1998.33	D	4
D239	29.76	212.13	80.79	54.01	73.29	20.18	49.45	46.49	31.02	93.14	20.36	13.38	11.11	120.32	118.16	217.71	661.63	90.72	49.28	1992.93	D	4
D240	29.14	209.75	81.60	57.02	74.38	19.85	50.14	46.46	31.38	86.56	20.06	13.11	11.47	122.00	115.36	219.20	656.97	91.11	50.06	1985.62	D	4
D241	28.02	210.87	80.20	53.79	74.94	19.73	49.38	45.68	30.39	94.50	20.22	13.95	11.81	120.35	115.98	221.66	668.63	89.19	49.01	1998.30	D	4
D242	28.47	214.19	82.23	53.63	74.24	19.99	50.53	45.05	31.29	91.37	19.90	14.00	12.62	120.89	115.72	221.55	662.52	90.89	49.56	1998.64	D	4
D243	29.64	213.92	80.06	55.86	74.66	20.54	50.45	45.86	29.51	93.20	20.80	13.07	11.76	119.06	118.04	221.74	666.72	91.81	48.18	2004.88	D	4
D244	29.24	214.75	81.27	53.58	73.44	19.91	49.46	46.77	30.62	88.50	20.86	13.14	12.77	119.10	114.06	220.26	661.22	91.47	49.75	1990.17	D	4
D245	28.66	214.91	82.03	56.82	74.12	20.10	49.75	45.65	30.21	93.39	20.17	13.65	12.54	119.63	116.94	221.13	670.93	90.09	48.05	2008.77	D	4
D246	28.69	212.70	81.57	54.10	72.96	19.35	51.09	45.50	31.46	90.13	20.27	14.18	12.30	119.45	118.21	220.40	660.04	91.48	48.53	1992.41	D	4
D247	29.21	212.83	80.68	56.90	72.97	19.46	50.03	46.51	30.84	93.52	21.20	14.20	11.52	118.30	114.60	220.49	659.21	90.41	49.87	1992.75	D	4
D248	29.79	214.52	78.46	55.85	73.85	20.72	49.72	45.61	30.59	86.75	21.08	13.62	11.91	118.36	116.91	220.03	670.76	90.43	49.76	1998.72	D	4
D249	28.80	214.40	81.15	54.28	74.18	19.46	51.5	45.74	31.68	89.13	20.44	13.68	12.40	117.65	113.43	218.16	658.40	89.91	48.75	1983.14	D	4
D250	29.43	214.16	79.80	54.97	73.85	19.55	51.4	45.28	31.16	91.20	21.08	13.59	12.39	119.27	113.26	217.52	659.22	90.73	50.16	1988.02	D	4
D251	29.67	210.72	80.30	57.58	73.36	20.28	49.29	46.45	30.44	86.48	20.53	14.25	12.01	118.62	115.06	221.56	661.78	91.59	48.69	1988.66	D	4
D252	28.63	209.51	78.61	57.15	73.32	19.53	51.08	45.68	31.73	92.24	19.98	14.19	12.15	117.61	115.09	220.37	666.24	90.33	49.83	1993.27	D	4
D253	30.15	213.41	80.49	56.07	75.00	19.68	52.02	46.79	30.82	90.00	20.60	14.23	12.12	122.96	114.89	221.53	670.26	89.84	48.46	2009.32	D	4
D254	29.27	209.80	78.89	53.50	74.62	20.47	48.63	45.36	30.48	92.34	19.72	14.27	12.03	122.12	115.34	218.28	659.94	89.47	49.46	1983.99	D	4
D255	29.86	214.00	78.55	55.12	73.58	20.06	48.76	46.32	30.34	87.67	20.20	13.20	11.87	120.90	116.36	220.36	660.61	90.30	48.98	1987.04	D	4
D256	27.54	211.90	81.62	55.81	75.01	19.47	50.54	45.72	30.82	87.39	20.16	14.06	12.19	122.48	115.13	218.91	661.26	91.63	48.19	1989.83	D	4
D257	30.16	211.48	82.45	55.99	73.96	19.47	49.62	46.52	29.54	90.60	20.84	13.40	12.34	119.41	113.16	219.86	669.15	90.07	48.57	1996.59	D	4
D258	27.80	209.94	82.13	56.70	73.90	20.51	49.22	45.48	29.54	91.21	21.18	13.61	12.04	118.06	114.42	218.38	661.46	91.95	48.86	1986.39	D	4
D259	28.39	212.31	81.85	56.09	74.01	19.64	49.88	45.36	29.63	89.71	20.34	13.23	12.62	118.51	116.18	220.08	661.89	89.77	49.00	1988.49	D	4
D260	28.79	212.42	80.97	55.96	74.77	21.03	49.99	45.33	29.69	86.89	20.37	14.23	11.48	120.66	113.20	218.29	662.48	90.08	48.75	1985.38	D	4

ENGINE NO	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESSO	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH	TOTAL TIME	ENGINE	PROTOCOL
D261	28.13	212.11	78.53	55.67	73.18	19.40	50.34	46.46	30.42	90.42	20.95	13.46	12.50	122.69	113.12	224.04	660.18	90.66	49.97	1992.23	D	4
D262	29.35	213.02	79.58	55.90	74.88	20.25	49.9	46.46	29.76	88.74	19.90	14.08	11.89	122.51	115.23	219.91	670.62	91.57	48.98	2002.53	D	4
D263	28.98	210.91	81.13	55.39	73.33	19.79	51.86	45.29	30.68	87.83	20.17	14.08	11.60	117.52	113.34	217.57	658.33	90.32	49.57	1977.69	D	4
D264	27.62	212.76	82.50	56.30	74.66	20.55	50.64	45.26	30.04	94.57	21.17	13.17	11.79	116.87	116.87	220.69	670.37	88.82	48.17	2002.82	D	4
D265	28.75	213.50	79.92	57.02	73.98	20.33	49.61	44.93	30.47	89.11	20.98	14.20	12.70	119.83	116.95	220.31	661.95	90.24	48.26	1993.04	D	4
D266	29.12	210.53	81.20	54.13	73.58	20.38	49.32	45.35	30.67	93.59	20.47	14.36	12.19	120.29	115.15	218.84	656.16	91.61	48.50	1985.44	D	4
D267	28.05	214.68	78.55	54.23	74.33	19.70	49.5	45.13	30.28	93.87	20.46	13.67	12.70	129.36	115.85	221.20	661.58	90.05	48.26	2001.45	D	4
D268	28.28	211.70	80.66	56.67	72.92	19.79	50.01	45.47	28.97	92.85	21.05	13.09	12.06	122.04	116.73	220.20	661.04	89.23	50.20	1992.96	D	4
D269	29.06	214.42	80.99	54.59	74.41	19.93	49.66	46.48	31.00	87.44	20.65	13.61	11.51	117.20	114.80	224.11	656.79	89.40	49.77	1985.82	D	4
D270	30.49	210.32	82.08	55.59	74.05	19.27	50.87	44.74	30.17	89.93	21.13	13.89	11.72	116.63	114.83	221.57	658.66	90.31	50.02	1986.27	D	4
D271	27.34	211.59	81.56	53.52	73.92	20.00	49.88	44.63	30.54	91.39	19.79	14.33	12.55	122.67	115.52	220.22	670.30	90.72	49.58	2000.05	D	4
D272	29.09	214.57	81.58	54.30	74.48	21.07	50.85	44.60	31.77	86.60	20.28	13.95	12.42	118.12	115.75	220.08	669.28	91.00	50.01	1999.80	D	4
D273	29.04	214.64	81.91	56.91	73.18	20.07	50.07	45.19	30.78	90.79	21.02	13.15	12.62	120.12	113.33	220.52	661.29	90.22	49.21	1994.06	D	4
D274	27.45	214.55	79.33	56.44	75.02	19.92	49.03	45.45	30.18	86.80	20.55	14.32	12.01	122.56	114.70	218.36	661.13	90.02	50.08	1987.90	D	4
D275	30.23	209.67	81.88	54.41	73.67	20.45	48.73	44.58	30.00	92.66	21.15	13.13	12.08	117.03	115.59	218.56	660.41	90.24	49.88	1984.35	D	4
D276	28.99	209.81	79.51	55.85	74.93	20.06	48.77	44.65	30.60	89.38	20.67	13.53	12.23	118.64	116.56	219.36	658.38	91.12	49.91	1982.95	D	4
D277	29.52	214.30	79.77	56.14	74.52	20.00	49.16	46.45	28.96	92.27	20.31	13.50	12.28	122.25	115.26	218.92	670.82	89.76	49.83	2004.02	D	4
D278	29.68	214.05	80.83	56.53	73.66	19.60	50.79	45.68	29.94	90.80	20.69	13.10	12.20	119.23	114.87	221.55	661.26	90.86	49.84	1995.16	D	4
D279	28.96	214.31	78.95	53.78	74.81	19.96	49.13	45.69	29.76	87.42	21.19	14.32	12.53	116.80	115.08	218.96	660.26	91.85	49.43	1983.19	D	4
D280	27.40	210.21	79.23	55.82	73.11	19.17	51.1	44.91	30.87	89.37	19.94	13.49	12.17	119.34	116.37	220.26	656.86	90.30	48.51	1978.43	D	4
D281	30.12	212.06	78.50	54.43	74.50	19.27	49.63	45.82	31.18	87.54	20.05	13.09	11.75	118.33	115.87	218.23	659.34	91.62	50.06	1981.39	D	4
D282	29.95	212.36	80.84	54.12	74.50	20.50	51.02	46.01	29.68	93.25	20.90	13.77	12.09	119.00	113.56	218.98	660.32	90.48	50.20	1991.53	D	4
D283	28.13	210.11	81.29	56.68	73.73	20.22	49.36	45.36	31.16	92.23	20.83	13.82	12.25	117.82	114.66	220.65	662.20	90.41	50.24	1991.15	D	4
D284	29.13	222.44	81.40	53.70	72.91	19.39	50.83	45.19	30.64	88.48	20.05	14.36	12.45	118.78	115.07	220.28	663.28	91.19	49.49	1999.06	D	4
D285	27.58	212.25	78.64	57.09	74.44	20.16	51.49	46.00	29.52	87.31	19.94	13.51	11.35	119.96	118.09	220.16	662.16	91.29	49.58	1990.52	D	4
D286	28.92	209.90	80.91	53.47	73.45	19.03	50.73	45.51	30.96	91.73	20.33	13.96	11.27	122.40	113.40	219.17	659.31	91.90	49.41	1985.76	D	4
D287	29.76	211.05	81.79	55.54	74.29	19.45	50.4	45.90	30.23	90.81	20.77	14.27	11.96	120.97	115.12	218.56	660.78	91.16	49.81	1992.62	D	4
D288	30.64	211.03	79.26	54.11	73.40	20.19	50.13	45.62	31.33	89.86	20.19	13.79	11.62	119.21	115.16	220.54	670.59	91.13	48.76	1996.56	D	4
D289	30.29	211.57	82.48	56.11	73.45	20.07	49.17	44.57	30.16	92.47	21.18	13.30	12.06	119.76	112.87	220.79	658.77	90.42	49.62	1989.11	D	4
D290	29.42	213.90	78.91	55.90	73.64	20.75	49.68	46.34	31.12	88.30	20.58	13.99	12.13	117.53	118.13	219.61	663.36	88.83	48.15	1990.27	D	4
D291	29.20	212.50	80.96	53.76	73.76	20.80	49.36	46.36	31.05	89.74	20.06	13.27	12.07	122.54	115.02	221.61	661.16	89.23	49.29	1991.74	D	4
D292	28.21	212.07	80.46	56.86	74.66	20.88	49.1	44.83	30.83	89.12	21.02	13.40	12.51	119.96	115.48	221.87	666.85	90.33	49.62	1998.06	D	4
D293	28.06	212.73	81.66	54.01	74.13	19.15	51.55	46.01	30.77	86.88	19.89	13.81	11.84	119.47	114.50	221.70	670.52	90.43	49.57	1996.68	D	4
D294	29.45	214.83	82.29	54.31	73.50	19.86	50.46	46.08	31.41	91.86	20.63	13.54	12.21	119.32	118.04	221.67	670.70	90.12	49.94	2010.22	D	4
D295	28.91	214.60	82.29	55.96	74.32	19.33	49.48	46.46	31.08	88.04	20.78	13.33	12.28	119.04	116.43	217.49	659.46	89.70	49.24	1988.22	D	4
D296	29.32	214.88	79.80	53.76	73.47	20.94	50.39	45.72	29.74	91.39	21.02	13.10	12.52	119.36	116.43	221.87	670.91	90.84	49.65	2005.11	D	4
D297	27.44	213.07	82.08	56.32	74.04	19.87	50.39	45.51	30.73	86.92	20.90	13.50	11.54	122.96	113.26	219.04	661.57	90.34	50.19	1989.67	D	4
D298	28.69	212.09	82.39	54.70	73.07	20.39	48.95	44.52	30.84	93.56	20.75	13.39	11.65	116.69	115.92	218.54	662.65	89.85	50.15	1988.79	D	4
D299	29.44	212.22	79.10	57.28	74.04	20.02	49.47	45.20	30.70	86.70	20.36	13.88	12.65	117.99	115.45	221.46	661.03	90.27	49.81	1987.07	D	4
D300	30.31	213.57	80.34	55.18	74.92	20.27	50.75	44.63	29.54	87.91	21.10	13.38	11.66	118.86	114.97	221.35	661.76	89.66	49.97	1990.13	D	4
D301	28.49	214.46	80.13	54.96	73.91	20.47	49.86	46.03	31.13	90.68	20.39	13.25	12.42	116.55	115.11	219.26	660.15	90.96	49.21	1987.42	D	4
D302	29.58	214.42	81.13	53.52	73.11	19.01	49.19	45.47	31.00	87.72	20.62	13.43	12.59	117.97	115.73	221.37	660.73	89.70	49.43	1985.72	D	4
D303	28.87	213.90	79.37	55.88	74.78	20.32	49.36	45.47	29.99	94.53	21.20	13.59	12.43	119.07	115.05	219.45	669.73	90.02	49.55	2002.56	D	4
D304	27.83	212.82	78.61	56.26	74.59	20.62	49.87	45.99	30.46	89.49	21.13	13.64	12.40	119.80	115.65	218.14	663.11	91.70	48.84	1990.95	D	4
D305	28.25	212.69	81.03	54.71	73.22	19.18	49.7	44.96	30.09	89.09	20.34	13.69	11.91	122.04	115.21	221.89	670.82	90.52	49.64	1998.98	D	4
D306	28.61	211.95	81.25	56.23	73.35	20.19	51.02	44.91	30.35	92.93	20.27	13.17	12.51	120.44	114.91	221.13	663.42	91.21	48.68	1996.53	D	4
D307	28.68	214.32	79.28	55.21	73.26	19.25	48.56	45.88	30.86	88.32	20.70	14.33	11.87	119.67	112.91	218.54	660.58	89.12	48.06	1979.40	D	4
D308	30.26	212.03	79.39	55.67	74.76	20.40	49.58	44.97	30.01	92.42	20.89	14.06	11.97	118.53	115.63	220.56	661.31	89.86	50.10	1992.40	D	4
D309	28.27	213.40	79.21	53.61	74.26	20.48	49.19	45.27	29.79	90.44	20.47	14.13	12.39	122.69	118.04	221.47	662.17	89.96	49.30	1994.54	D	4
D310	28.58	210.27	81.42	55.08	73.19	19.83	50.19	44.67	31.15	89.69	20.08	13.84	11.61	120.03	115.74	218.00	662.95	90.93	49.55	1986.80	D	4
D311	30.03	210.03	82.28	57.46	74.85	20.25	50.62	45.51	29.97	87.84	20.14	14.23	11.44	120.54	113.20	221.32	670.07	89.63	49.61	1999.02	D	4
D312	28.63	209.87	81.91	54.45	73.29	19.59	50.27	46.38	30.33	90.29	20.83	14.25	12.67	119.33	115.17	221.24	669.80	90.36	49.91	1998.57	D	4

Engine A Audit Results – All values recorded are in decimal minutes.

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH
A1		46.52										
A2			77.78									
A3				95.85					50.70			
A4					53.27							
A5						23.00				111.07		
A6							19.71				29.72	
A7								35.95				30.48
A16		46.75										
A17			81.95									
A18				96.71					50.70			
A19					54.16							
A20						23.77				118.78		
A21							19.27				29.62	
A22								34.21				31.20
A31		50.41										
A32			80.03									
A33				98.91					51.01			
A34					55.41							
A35						21.01				111.55		
A36							18.42				311.36	
A37								34.58			29.88	29.30
A46		49.81										
A47			78.72									
A48				99.51					51.01			
A49					54.27							
A50						23.26				110.95		
A51							19.18				31.02	
A52								36.48				31.23
A61		46.62										
A62			85.82									
A63			82.63	94.13					51.74			
A64					52.71							
A65						22.18				106.71		
A66							17.83				30.09	
A67								34.36				31.08
A76		48.21										
A77			79.11									
A78				98.01					52.14			
A79					55.66							
A80						21.97				112.14		
A81							19.42				31.34	
A82								35.84				29.68
A91		49.51										
A92			82.43									
A93				97.75					50.58			
A94					53.26							
A95						22.62				106.85		
A96							19.48				30.36	
A97								34.22				29.73
A111		46.68										
A112			79.46									
A113				94.24					51.10			
A114					55.67							
A115						20.34				109.00		
A116							19.81				30.51	
A117								35.88				31.05
A126		45.61										
A127			79.32									
A128				97.10					51.13			
A129					54.26							
A130						20.41				112.26		
A131							18.23				30.44	
A132								34.36				31.18
A141		48.34										
A142			81.05									
A143				98.30					52.04			
A144					51.89							
A145						20.92				109.15		
A146							18.68				31.27	
A147								33.89				29.45
A156		46.50										
A157			76.58									
A158				97.61					50.62			
A159					55.26							
A160						21.35				109.78		
A161							18.55				30.60	
A162								33.98				29.75

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PAR	BUILD	TEST	PAINT & DESPATCH
A171		46.14										
A172			82.32									
A173				96.18					51.98			
A174					54.92							
A175						20.86				108.96		
A176							19.41				31.05	
A177								35.13				31.28
A186		48.41										
A187			79.78									
A188				98.18					51.77			
A189					52.53							
A190						21.89				108.81		
A191							18.61				29.66	
A192								33.56				30.41
A201		48.05										
A202			77.82									
A203				97.88					51.87			
A204					52.54							
A205						20.08				108.83		
A206							19.41				31.47	
A207								35.19				30.01
A221		45.33										
A222			79.68									
A223				96.32					52.28			
A224					54.41							
A225						22.22				108.93		
A226							19.56				30.15	
A227								33.11				30.74
A236		47.68										
A237			79.25									
A238				93.84					50.56			
A239					52.99							
A240						21.08				112.18		
A241							18.92				29.40	
A242								35.41				31.44
A251		46.02										
A252			79.43									
A253				93.97					52.21			
A254					54.92							
A255						22.82				112.46		
A256							19.77				29.85	
A257								34.81				31.48
A266		44.32										
A267			82.98									
A268				94.38					52.08			
A269					52.66							
A270						22.58				113.37		
A271							19.05				31.36	
A272								35.60				29.83
A281		46.54										
A282			81.15									
A283				96.26					52.22			
A284					53.58							
A285						22.78				108.63		
A286							19.49				29.46	
A287								35.22				31.29
A296		45.86										
A297			82.89									
A298				93.88					52.12			
A299					54.05							
A300						20.10				111.38		
A301							17.96				29.71	
A302								35.52				31.00
A311		45.36										
A312			82.73									
A313				98.13					50.71			
A314					50.95							
A315						19.91				111.29		
A316							18.65				30.25	
A317								34.95				31.06
A331		46.18										
A332			79.05									
A333				98.81					50.65			
A334					52.77							
A335						21.77				109.75		
A336							19.67				29.76	
A337								33.73				29.37

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH
A346		44.42										
A347			78.45									
A348				98.18					51.61			
A349					51.85							
A350						22.41				107.59		
A351							18.32				29.39	
A352								36.19				31.29
A361		47.45										
A362			76.72									
A363				93.96					51.34			
A364					51.19							
A365						22.16				110.26		
A366							18.58				29.46	
A367								35.12				29.97
A376		46.28										
A377			81.38									
A378				94.18					51.78			
A379					55.11							
A380						22.85				111.26		
A381							18.52				31.25	
A382								35.18				29.72
A391		47.41										
A392			79.23									
A393				97.84					50.56			
A394					53.71							
A395						20.18				108.29		
A396							18.60				30.15	
A397								34.53				29.85
A406		43.74										
A407			77.77									
A408				96.00					50.65			
A409					51.83							
A410						21.09				113.01		
A411							19.31				30.71	
A412								33.48				29.41
A421		47.56										
A422			75.86									
A423				96.04					51.52			
A424					54.92							
A425						20.85				109.09		
A426							18.43				30.53	
A427								36.31				30.56
A441		43.01										
A442			76.32									
A443				97.23					50.47			
A444					51.67							
A445						21.19				112.33		
A446							18.39				31.17	
A447								33.51				30.04
A456		46.99										
A457			76.77									
A458				93.82					52.06			
A459					53.64							
A460						21.29				110.45		
A461							18.95				30.43	
A462								33.93				30.25
A471		47.78										
A472			80.21									
A473				96.74					51.66			
A474					53.55							
A475						20.87				112.29		
A476							19.00				31.13	
A477								34.39				31.32
A486		43.52										
A487			76.42									
A488				93.17					51.40			
A489					54.82							
A490						22.68				109.00		
A491							17.84				30.94	
A492								33.09				31.31
A501		46.98										
A502			81.68									
A503				93.32					51.53			
A504					50.87							
A505						19.97				111.73		
A506							18.61				30.20	
A507								36.23				30.07

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH
A516		46.05										
A517			78.85									
A518				94.03					52.13			
A519					51.31							
A520						23.37				113.44		
A521							19.13				31.07	
A522								35.32				30.88
A531		44.25										
A532			79.82									
A533				97.24					51.45			
A534					54.34							
A535						21.40				112.57		
A536							19.75				29.75	
A537								33.66				30.27
A551		43.95										
A552			80.68									
A553				96.63					50.32			
A554					51.81							
A555						21.50				108.99		
A556							19.21				30.06	
A557								33.51				30.74
A566		45.78										
A567			79.87									
A568				98.22					50.49			
A569					52.66							
A570						22.76				111.44		
A571							18.59				29.63	
A572								35.22				29.59
A581		45.37										
A582			78.72									
A583				96.08					52.05			
A584					54.17							
A585						20.48				111.72		
A586							18.69				30.61	
A587								35.95				29.46
A596		43.45										
A597			81.75									
A598				98.51					50.67			
A599					53.87							
A600						20.66				109.88		
A601							18.13				29.46	
A602								33.34				30.96
A611		43.15										
A612			76.42									
A613				96.25					50.59			
A614					54.97							
A615						23.09				109.19		
A616							18.48				31.27	
A617								35.22				29.61
A626		45.23										
A627			76.75									
A628				96.42					51.85			
A629					51.34							
A630						22.26				111.32		
A631							18.49				31.48	
A632								33.91				31.19
A641		43.25										
A642			81.08									
A643				98.75					50.76			
A644					54.78							
A645						21.18				110.16		
A646							19.78				30.40	
A647								35.82				29.65
A661		43.14										
A662			82.89									
A663				96.19					51.49			
A664					53.25							
A665						22.41				109.94		
A666							18.26				30.25	
A667								34.68				30.99
A676		43.52										
A677			78.61									
A678				99.05					52.37			
A679					54.12							
A680						22.44				107.21		
A681							18.11				30.10	
A682								34.67				30.71

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH
A691		45.65										
A692			81.29									
A693				98.23					51.38			
A694					54.03							
A695						21.00				110.34		
A696							18.23				30.57	
A697								33.48				31.33
A706		43.55										
A707			78.15									
A708				96.81					50.84			
A709					53.11							
A710						22.36				101.61		
A711							17.95			108.85	31.04	
A712								34.29				30.87
A721		45.15										
A722			79.36									
A723				96.79					51.06			
A724					52.27							
A725						20.95				107.93		
A726							18.23				29.51	
A727								35.83				29.54
A736		45.80										
A737			77.62									
A738				97.24					50.48			
A739					52.93							
A740						20.42				110.23		
A741							18.77				30.38	
A742								33.22				30.65
A751		43.13										
A752			78.15									
A753				95.12					51.08			
A754					51.82							
A755						20.82				112.23		
A756							17.92				29.83	
A757								35.83				30.22
A771		44.40										
A772			81.75									
A773				95.97					51.98			
A774					53.93							
A775						20.57				112.60		
A776							18.22				31.15	
A777								33.31				29.99
A786		44.79										
A787			76.15									
A788				99.08					52.40			
A789					52.69							
A790						20.28				107.06		
A791							18.38				30.11	
A792								33.23				30.12
A801		43.08										
A802			75.88									
A803				94.64					51.04			
A804					52.82							
A805						20.61				110.36		
A806							18.73				31.06	
A807								33.58				30.01
A816		44.85										
A817			76.31									
A818				94.67					50.47			
A819					54.15							
A820						20.17				108.32		
A821							18.87				31.09	
A822								36.42				29.75
A831		43.53										
A832			80.09									
A833				97.13					50.26			
A834					54.71							
A835						19.91				109.25		
A836							19.34				30.30	
A837								33.13				29.51
A846		44.23										
A847			75.95									
A848				95.12					50.25			
A849					52.97							
A850						23.08				107.91		
A851							19.19				31.04	
A852								35.44				30.70

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PART	BUILD	TEST	PAINT & DESPATCH
A861		44.61										
A862			79.95									
A863				94.37					50.60			
A864					51.18							
A865						22.06				110.06		
A866							19.32				30.31	
A867								34.72				30.28
A881		43.95										
A882			81.64									
A883				93.20					50.55			
A884					51.25							
A885						22.12				112.29		
A886							17.94				29.67	
A887								35.71				29.27
A896		44.73										
A897			79.28									
A898				95.25					50.77			
A899					54.34							
A900						20.94				112.35		
A901							19.76				31.21	
A902								33.62				31.16
A911		44.58										
A912			81.55									
A913				94.72					52.02			
A914					51.97							
A915						22.72				108.01		
A916							19.58				31.45	
A917								35.21				30.48
A926		43.11										
A927			82.35									
A928				98.70					50.99			
A929					51.84							
A930						21.78				110.00		
A931							18.14				31.29	
A932								35.48				29.67
A941		44.46										
A942			82.80									
A943				97.70					52.19			
A944					54.88							
A945						23.38				111.55		
A946							17.84				30.05	
A947								33.53				30.73
A956		45.66										
A957			76.42									
A958				97.18					50.74			
A959					52.23							
A960						20.88				107.66		
A961							17.96				29.81	
A962								35.37				30.60
A971		43.62										
A972			82.32									
A973				98.91					51.14			
A974					51.32							
A975						21.43				107.61		
A976							18.18				30.55	
A977								34.81				29.84
A991		43.21										
A992			80.42									
A993				97.30					51.01			
A994					51.03							
A995						22.89				110.63		
A996							19.53				30.12	
A997								33.13				30.74
A1006		44.06										
A1007			79.86									
A1008				95.48					51.00			
A1009					51.84							
A1010						21.02				111.81		
A1011							19.76				29.31	
A1012								33.51				29.37
A1021		43.93										
A1022			82.52									
A1023				96.85					50.47			
A1024					54.91							
A1025						20.13				106.72		
A1026							19.69				29.40	
A1027								34.54				30.10

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	SMALL PAR	BUILD	TEST	PAINT & DESPATCH
A1036		45.22										
A1037			79.82									
A1038				97.23					50.54			
A1039					53.54							
A1040						22.16				111.51		
A1041							18.62				30.51	
A1042								34.51				30.11
A1051		43.17										
A1052			82.13									
A1053				93.53					50.75			

Engine B Audit Results – All values recorded are in decimal minutes.

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	OIL PUMP	VAC PUMP	SMALL PAR	BUILD	TEST	PAINT & DESPATCH
B1					82.43									
B2						25.84						181.88		
B3							36.02						49.54	
B4								34.13						50.28
B7									14.97					
B10										14.84				
B12	5.13													
B13		92.98												
B14			71.42											
B15				120.72							92.21			
B16					79.71									
B17						25.89						182.52		
B18							35.96						50.08	
B19								34.67						49.52
B22									15.43					
B25										15.14				
B27	5.00													
B28		88.96												
B29			72.55											
B30				123.22							93.88			
B31					79.08									
B32						25.39						181.65		
B33							35.68						50.00	
B34								34.42						49.99
B37									15.43					
B40										15.61				
B47	5.13													
B48		91.25												
B49			73.64											
B50				123.12							92.52			
B51					79.30									
B52						25.48						182.65		
B53							35.93						49.94	
B54								34.25						49.72
B57									15.22					
B60										15.26				
B62	5.58													
B63		92.35												
B64			70.15											
B65				122.88							91.91			
B66					82.37									
B67						25.52						182.76		
B68							36.26						49.66	
B69								34.59						50.01
B72									15.67					
B75										15.62				
B77	5.16													
B78		92.35												
B79			70.38											
B80				123.43							91.04			
B81					81.71									
B82						25.21						182.72		
B83							36.38						50.12	
B84								34.14						49.78
B87									15.02					
B90										15.63				
B92	5.07													
B93		95.11												
B94			72.47											
B95				124.07							90.44			
B96					81.18									
B97						25.78						182.92		
B98							36.36						49.55	
B99								34.03						49.94
B102									15.12					
B105										14.76				
B107	6.98													
B108		88.47												
B109			69.81											
B110				121.91							91.74			
B111					80.95									
B112						25.16						184.53		
B113							36.02						49.96	
B114								34.50						50.00
B117									15.61					
B120										15.57				
B122	7.87													
B123		92.42												
B124			70.91											
B125				121.53							89.09			
B126					79.71									
B127						25.09						180.92		
B128							35.73						50.27	
B129								34.65						49.77
B132									14.87					
B135										15.21				
B137	7.62													
B138		93.53												
B139			70.80											

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	OIL PUMP	VAC PUMP	SMALL PAR	BUILD	TEST	PAINT & DESPATCH
B140				121.96							91.24			
B141					79.24									
B142						25.50						180.99		
B143							36.25						49.95	
B144								34.41						49.52
B147									15.21					
B150										15.41				
B157	7.81													
B158		92.56												
B159			71.12											
B160				119.82							91.26			
B161					80.77									
B162						25.31						181.92		
B163							35.74						50.15	
B164								34.57						50.03
B167									15.46					
B170										15.55				
B172	7.16													
B173		88.53												
B174			72.06											
B175				121.97							89.82			
B176					80.26									
B177						25.74						182.05		
B178							36.44						49.92	
B179								34.54						49.53
B182									15.05					
B185										15.17				
B187	7.71													
B188		93.18												
B189			71.91											
B190				122.58							90.20			
B191					78.98									
B192						25.81						183.05		
B193							36.41						49.82	
B194								34.02						50.21
B197									15.61					
B200										15.06				
B202	6.97													
B203		91.62												
B204			69.51											
B205				121.88							89.41			
B206					79.53									
B207						25.48						183.07		
B208							35.49						49.66	
B209								34.83						49.58
B212									15.04					
B215										15.42				
B217	10.48													
B218		89.64												
B219			70.29											
B220				118.01							89.89			
B221					81.80									
B222						25.46						181.21		
B223							35.54						49.54	
B224								34.03						50.08
B227									15.19					
B230										15.58				
B232	9.81													
B233		86.86												
B234			67.52											
B235				118.81							89.03			
B236					79.89									
B237						25.69						181.43		
B238							35.76						50.17	
B239								34.19						50.21
B242									15.35					
B245										15.42				
B247	11.36													
B248		89.79												
B249			70.71											
B250				118.88							87.75			
B251					81.91									
B252						25.01						182.12		
B253							35.61						49.61	
B254								34.93						49.85
B257									15.38					
B260										15.49				
B267	10.58													
B268		85.25												
B269			67.59											
B270				117.03							88.12			
B271					79.85									
B272						25.71						181.06		
B273							36.02						49.95	
B274								34.96						50.25
B277									15.09					
B280										15.25				
B282	11.83													
B283		84.46												

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	OIL PUMP	VAC PUMP	SMALL PAR	BUILD	TEST	PAINT & DESPATCH
B284			69.52											
B285				118.74							91.13			
B286					79.74									
B287						25.26						181.17		
B288							36.11						49.55	
B289								34.62						49.51
B292									15.49					
B295										15.21				
B297	11.74													
B298		89.11												
B299			69.55											
B300				117.76							90.06			
B301					80.18									
B302						25.42						179.21		
B303							36.00						49.84	
B304								34.41						49.65
B307									14.84					
B310										15.10				
B312	20.67													
B313		88.91												
B314			67.73											
B315				117.91							90.36			
B316					81.97									
B317						25.65						184.00		
B318							35.82						49.88	
B319								34.02						49.55
B322									14.78					
B325										15.35				
B327	20.42													
B328		99.15												
B329			69.21											
B330				118.86							87.66			
B331					81.85									
B332						25.54						181.79		
B333							35.66						49.52	
B334								34.20						50.18
B337									15.32					
B340										15.47				
B342	19.94													
B343		88.71												
B344			68.88											
B345				117.58							90.81			
B346					79.23									
B347						25.41						182.05		
B348							35.67						49.52	
B349								34.75						50.23
B352									15.17					
B355										14.76				
B357	20.09													
B358		87.80												
B359			69.49											
B360				117.12							89.83			
B361					78.72									
B362						25.41						182.56		
B363							35.61						49.97	
B364								34.23						49.87
B367									15.31					
B370										15.31				
B377	20.25													
B378		84.12												
B379			70.83											
B380				119.91							87.31			
B381					80.03									
B382						25.03						182.83		
B383							35.86						49.79	
B384								34.85						50.22
B387									15.56					
B390										15.45				
B392	20.17													
B393		85.06												
B394			67.52											
B395				118.52							89.97			
B396					80.38									
B397						25.63						181.43		
B398							35.99						50.21	
B399								34.02						49.84
B402									15.54					
B405										14.88				
B407	20.17													
B408		90.32												
B409			69.15											
B410				117.10							87.74			
B411					80.05									

Engine C Audit Results – All values recorded are in decimal minutes.

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PAR	KIT	BUILD	TEST	PAINT & DESPATCH
C1						21.15														388.84		
C2							33.59														166.67	
C3								14.48														120.31
C4									11.87													
C6										15.71												
C7											7.26											
C8												10.67										
C9													14.35									
C10														81.19								
C11	10.44														52.13							
C12		141.82														16.13						
C13			122.46														168.61					
C14				96.58														135.30				
C15					45.74														128.86			
C16						19.38														389.20		
C17							34.27														167.49	
C18								15.08														120.16
C19									11.99													
C21										14.61												
C22											5.33											
C23												11.29										
C24													12.19									
C25														82.23								
C26	9.71														54.17							
C27		149.11														15.32						
C28			119.22														165.58					
C29				92.19														139.64				
C30					46.09														119.21			
C31						21.29														386.73		
C32							34.03														167.14	
C33								14.52														123.75
C34									11.51													
C36										15.81												
C37											5.39											
C38												12.24										
C39													13.04									
C40														80.02								
C41	10.31														47.72							
C42		143.44														14.81						
C43			121.16														163.98					
C44				97.24														127.94				
C45					46.12														112.69			
C46						19.73														387.84		
C47							33.52														167.82	
C48								14.92														121.41
C49									11.81													
C51										14.61												
C52											6.59											
C53												11.92										
C54													12.42									
C55														80.81								
C56	9.89														52.52							
C57		142.65														15.30						
C58			121.75														167.74					
C59				94.35														128.91				
C60					45.88														119.65			
C61						20.49														390.07		
C62							32.73														166.42	
C63								15.08														121.43

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATC	FLYWHEEL	TURBOS	SMALL PAR	KIT	BUILD	TEST	PAINT & DESPATCH
C64									11.59													
C66										15.32												
C67											7.21											
C68												12.20										
C69													12.85									
C70														81.43								
C71															50.10							
C76	10.23																					
C77		139.15														16.39						
C78			122.17														169.24					
C79				90.35														128.96				
C80					46.01														121.29			
C81						20.57														388.02		
C82							34.15														166.50	
C83								15.68														119.05
C84									12.51													
C86										15.39												
C87											6.54											
C88												10.69										
C89													12.48									
C90														81.45								
C91	10.35														52.86							
C92		146.75														15.39						
C93			122.15														164.12					
C94				89.56														138.62				
C95					45.27														113.83			
C96						20.21														387.54		
C97							34.37														166.66	
C98								15.14														123.30
C99									11.53													
C101										15.25												
C102											6.70											
C103												10.71										
C104													14.38									
C105														74.98								
C106	13.42														46.58							
C107		131.31														15.3						
C108			116.72														160.76					
C109				95.82														127.59				
C110					44.99														109.73			
C111						21.69														388.26		
C112							33.95														167.90	
C113								15.21														121.29
C114									12.04													
C116										15.21												
C117											6.59											
C118												11.77										
C119													14.12									
C120														76.67								
C121	13.31														47.51							
C122		133.76														15.54						
C123			118.23														157.82					
C124				92.88														128.61				
C125					45.47														111.58			
C126						20.67														390.63		
C127							34.41														165.39	
C128								15.78														121.78
C129									12.08													
C131										14.51												

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATC	FLYWHEEL	TURBOS	SMALL PAR'	KIT	BUILD	TEST	PAINT & DESPATCH
C132											6.67											
C133												10.53										
C134													13.47									
C135														74.50								
C136	12.65														47.29							
C137		129.68														15.70						
C138			115.49														160.15					
C139				89.45														128.07				
C140					44.95														111.84			
C141						19.49														386.47		
C142							32.97														167.90	
C143								15.52														120.00
C144									12.31													
C146										15.44												
C147											5.60											
C148												10.79										
C149													12.10									
C150														75.36								
C151	13.06														48.51							
C152		133.29														15.80						
C153			117.95														159.57					
C154				91.42														122.12				
C155					44.89														113.79			
C156						20.13														388.25		
C157							34.46														168.02	
C158								14.39														121.59
C159									11.99													
C161										14.92												
C162											6.68											
C163												11.15										
C164													13.95									
C165														74.81								
C166	13.51														47.24							
C167		133.81														14.44						
C168			116.43														161.24					
C169				93.97														121.09				
C170					46.11														106.97			
C171						21.31														393.07		
C172							32.71														167.82	
C173								14.56														121.35
C174									11.98													
C176										15.37												
C177											6.67											
C178												11.18										
C179													12.20									
C180														77.08								
C181															47.75							
C186	13.41																					
C187		129.52														15.36						
C188			117.84														157.98					
C189				89.65														127.64				
C190					45.99														113.94			
C191						21.29														390.02		
C192							32.53														168.19	
C193								14.41														121.34
C194									12.13													
C196										14.65												
C197											5.62											
C198												11.81										

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	OIL PUMP	LIFT PUMP	EGR VALVE	VAC PUMP	STARTER	ALTERNATO	FLYWHEEL	TURBOS	SMALL PART	KIT	BUILD	TEST	PAINT & DESPATCH
C199													12.13									
C200														73.84								
C201	13.42														47.95							
C202		134.08														16.11						
C203			116.27														160.04					
C204				97.12														121.75				
C205					46.64														110.86			
C206						19.36														393.70		
C207							34.30														166.61	
C208								14.35														120.61
C209									12.58													
C211										14.76												
C212											6.69											
C213												11.29										
C214													13.21									
C215														62.89								
C216	15.77														45.46							
C217		106.95														15.22						
C218			118.12														130.65					
C219				91.18														109.79				
C220					45.44														104.26			
C221						21.22														389.31		
C222							32.78														165.98	
C223								14.69														120.68
C224									11.92													
C226										15.21												
C227											5.64											
C228												11.43										
C229													12.22									
C230														61.44								
C231	16.79														44.45							
C232		102.71														14.98						
C233			119.37														132.12					
C234				89.92														105.56				
C235					44.89														103.41			
C236						20.67														388.71		
C237							33.36														168.81	
C238								14.63														121.10
C239									12.28													
C241										15.35												
C242											6.15											
C243												11.51										
C244													12.96									
C245														61.62								
C246	15.95														45.00							
C247		104.35														15.21						
C248			118.75														132.11					
C249				90.14														108.74				
C250					45.61														106.13			
C251						19.67														387.46		
C252							33.20														167.62	
C253								15.32														120.62
C254									12.23													
C256										14.71												
C257											5.56											
C258												11.73										
C259													13.32									
C260														61.93								
C261	16.28														46.36							

Engine D Audit Results – All values recorded are in decimal minutes.

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PAR	KIT	BUILD	TEST	PAINT & DESPATCH
D1	7.71																		
D2		281.91																	
D3			85.86											167.35					
D4				56.41											126.53				
D5					75.21											243.60			
D6						20.02											664.63		
D7							49.64											89.75	
D8								46.75											49.29
D9									29.01										
D10										114.31									
D11											20.39								
D12												13.85							
D14													12.27						
D16	6.48																		
D17		269.52																	
D18			87.34											168.79					
D19				54.41											127.51				
D20					74.43											243.54			
D21						20.16											668.12		
D22							49.67											90.85	
D23								46.35											49.38
D24									29.24										
D25										114.12									
D26											20.45								
D27												15.50							
D29													11.51						
D31	6.68																		
D32		276.51																	
D33			88.04											165.26					
D34				54.05											122.94				
D35					74.05											243.26			
D36						20.77											650.23		
D37							50.96											90.71	
D38								47.00											49.01
D39									31.55										
D40										109.19									
D41											21.51								
D42												13.80							
D44													12.41						
D46	6.53																		
D47		256.11																	
D48			89.32											169.95					
D49				58.74											127.04				
D50					73.39											245.00			
D51						19.68											655.97		
D52							49.06											89.57	
D53								46.34											49.53
D54									30.88										
D55										109.68									
D56											20.81								
D57												14.65							

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PAR	KIT	BUILD	TEST	PAINT & DESPATCH
D59													12.17						
D61	7.31																		
D62		261.28																	
D63			89.86											666.79					
D64				55.99										170.23	128.12				
D65					74.44											243.09			
D66						19.45											661.46		
D67							50.53											90.01	
D68								45.98											49.34
D69									31.86										
D70										114.81									
D71											21.31								
D72												12.82							
D74													11.58						
D76	6.38																		
D77		269.90																	
D78			84.36											169.14					
D79				56.56											122.91				
D80					75.15											248.38			
D81						19.92											668.24		
D82							51.28											90.25	
D83								45.75											49.36
D84									31.09										
D85										114.59									
D86											20.62								
D87												13.13							
D89													12.12						
D96	8.61																		
D97		262.25																	
D98			81.24											167.74					
D99				56.88											124.66				
D100					76.94											240.26			
D101						20.56											659.23		
D102							51.15											89.75	
D103								45.55											50.96
D104									30.17										
D105										110.28									
D106											19.92								
D107												13.21							
D109													12.55						
D111	10.21																		
D112		259.51																	
D113			85.55											172.08					
D114				55.48											120.77				
D115					73.41											249.61			
D116						19.52											664.76		
D117							49.26											89.85	
D118								46.48											50.72
D119									30.41										
D120										111.91									
D121											19.91								

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PAR	KIT	BUILD	TEST	PAINT & DESPATCH
D122												14.97							
D124													13.06						
D126	9.43																		
D127		258.58																	
D128			83.23											165.12					
D129				54.27											121.00				
D130					75.71											242.33			
D131						19.85											664.49		
D132							49.36											91.94	
D133								45.88											50.06
D134									31.12										
D135										114.66									
D136											21.10								
D137												14.34							
D139													12.66						
D141	9.91																		
D142		256.82																	
D143			83.87											164.26					
D144				56.91											120.58				
D145					77.57											240.12			
D146						20.39											668.49		
D147							49.40											91.53	
D148								46.41											48.75
D149									30.69										
D150										110.98									
D151											21.39								
D152												14.81							
D154													12.28						
D156	10.07																		
D157		210.67																	
D158			81.77											118.65					
D159				55.03											114.44				
D160					74.92											222.29			
D161						19.25											661.59		
D162							52.15											89.11	
D163								44.87											49.61
D164									30.78										
D165										94.39									
D166											20.75								
D167												14.11							
D169													12.34						
D171	17.36																		
D172		211.35																	
D173			79.60											120.27					
D174				55.47											112.96				
D175					72.78											218.41			
D176						20.47											669.81		
D177							48.78											90.85	
D178								44.61											49.17
D179									30.29										
D180										95.34									

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PAR	KIT	BUILD	TEST	PAINT & DESPATCH
D181											21.31								
D182												13.47							
D184													12.92						
D186	16.79																		
D187		211.07																	
D188			83.09											125.46					
D189				56.11											118.81				
D190					73.59											223.06			
D191						20.31											662.05		
D192							49.75											91.53	
D193								45.47											49.19
D194									30.25										
D195										89.59									
D196											20.71								
D197												13.33							
D199													11.53						
D206	16.55																		
D207		215.86																	
D208			78.59											122.92					
D209				56.91											118.18				
D210					75.07											222.65			
D211						20.24											660.93		
D212							50.75											90.76	
D213								46.63											49.99
D214									29.91										
D215										87.53									
D216											19.89								
D217												14.17							
D219													12.21						
D221	16.87																		
D222		214.79																	
D223			81.91											122.71					
D224				56.37											113.30				
D225					75.09											222.65			
D226						19.81											670.06		
D227							51.25											88.64	
D228								46.13											49.62
D229									30.78										
D230										89.61									
D231											19.69								
D232												13.68							
D234													12.36						
D236	29.08																		
D237		214.71																	
D238			79.14											119.82					
D239				54.01											118.16				
D240					74.37											219.20			
D241						19.73											668.63		
D242							50.53											90.89	
D243								45.86											48.17
D244									30.62										

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PAR	KIT	BUILD	TEST	PAINT & DESPATCH
D245										93.41									
D246											20.26								
D247												14.20							
D249													12.42						
D251	29.68																		
D252		209.51																	
D253			80.51											122.97					
D254				53.52											115.33				
D255					73.56											220.35			
D256						19.47											661.26		
D257							49.62											90.07	
D258								45.49											48.86
D259									29.63										
D260										86.86									
D261											20.96								
D262												14.08							
D264													11.79						
D266	29.11																		
D267		214.67																	
D268			80.67											122.02					
D269				54.61											114.81				
D270					74.06											221.57			
D271						20.02											670.30		
D272							50.86											91.01	
D273								45.20											49.21
D274									30.19										
D275										92.66									
D276											20.67								
D277												13.50							
D279													12.53						
D281	30.12																		
D282		212.38																	
D283			81.29											117.84					
D284				53.71											115.07				
D285					74.45											220.16			
D286						19.04											659.31		
D287							50.40											91.15	
D288								45.62											48.76
D289									30.16										
D290										88.31									
D291											20.06								
D292												13.40							
D294													12.21						
D296	29.31																		
D297		213.09																	
D298			82.39											116.68					
D299				57.28											115.45				
D300					74.92											221.35			
D301						20.48											660.14		
D302							49.20											89.71	
D303								45.48											49.55

	DECANT AND INSPECT	STRIP	BLOCK	HEAD	CRANK	CAM	VALVES	CON-RODS	ROCKERS	COMPRESS	OIL PUMP	LIFT PUMP	VAC PUMP	TURBOS	SMALL PAR	KIT	BUILD	TEST	PAINT & DESPATCH
D304									30.46										
D305										89.09									
D306											20.28								
D307												14.32							
D309													12.39						

APPENDIX III

Pre-Experimentation Interview Transcripts

Pre Research Interview:

Facility: Date:

Person:

Are you aware of what pre-processing inspection of core is currently happening at your facility? Please describe your knowledge
Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
If pre-processing inspection was carried out on core, what information would be useful for your job? Please comment on why this is.

Pre-Research Interview:

Facility: European

Date: 03/02/2011

Person: Ops Manager

Are you aware of what pre-processing inspection of core is currently happening at your facility? Please describe your knowledge

Yes. We determine part number on receipt, locate it and log it on our System. There is an automatic comparison between requirement and stock of cores, one a core is flagged for use, it is moved to disassembly and ~~[illegible]~~ inspected.

Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.

Some of our components are on very long lead times and it would be quicker to know sooner but I don't think there will be enough you can find out to make a difference.

If pre-processing inspection was carried out on core, what information would be useful for your job? Please comment on why this is.

For me the keys are
1) Part no
2) Broken things
3) missing things

all else is not relevant.

Pre-Research Interview:

Facility: Rushden

Date: 03/02/2011

Person: Disassembly operator.

Are you aware of what pre-processing inspection of core is currently happening at your facility? Please describe your knowledge I know some. The yard tell me what the part number is. I don't usually get it with holes or anything, they sort those ones out.
Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is. It makes it quicker for me. I know what I'm getting, no problem.
If pre-processing inspection was carried out on core, what information would be useful for your job? Please comment on why this is. I just need the part number.

Pre-Research Interview:

Facility: Bushden

Date: 03/02/2011

Person: Assembly Operator

Are you aware of what pre-processing inspection of core is currently happening at your facility? Please describe your knowledge
No idea – nothing to do with me.

Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
Don't know – not really worried as long as I can do my job.

If pre-processing inspection was carried out on core, what information would be useful for your job? Please comment on why this is.
If they knew what was missing or broken, I could have a full kit and not one with bits missing.

Pre-Research Interview:

Facility: Rushden

Date: 02/02/2011

Person: Logistics Manager

Are you aware of what pre-processing inspection of core is currently happening at your facility? Please describe your knowledge
Yes. The core is checked against manifest on arrival, offloaded and part number checked and located. Scheduling decide whether we can directly match demand or call similar cores in. The only check other than for part number is for obvious damage or missing parts.
Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
Yes both, If we know what we need as soon as possible we have a fighting chance of getting it without a delay to assembly.
If pre-processing inspection was carried out on core, what information would be useful for your job? Please comment on why this is.
Part number, missing or damage components This would allow us to schedule and buy in a more smart way & minimise down time.

Pre-Research Interview:

Facility: Borsholder Date: 02/02/2011

Person: Production manager

Are you aware of what pre-processing inspection of core is currently happening at your facility? Please describe your knowledge Yes. I oversee the core receipt, matching to delivery note and location. Part number by location is recorded + the scheduling team tell me what to dismantle + then this is pulled through to assembly.
Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is. Neither - we only need part number. If we ~~have~~ needed to inspect because it helped we would already be doing it. Everything gets taken apart eventually, why inspect at core and at dismantle?
If pre-processing inspection was carried out on core, what information would be useful for your job? Please comment on why this is. As I said before - part number

Pre-Research Interview:

Facility: Rushden

Date: 02/02/2011

Person: Facility Manager

Are you aware of what pre-processing inspection of core is currently happening at your facility? Please describe your knowledge
A little, I know we check the euro code - generic engine family on some - against the delivery number + the yard men find out the part number.

Do you think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
I would have thought quicker and easier - you know what you are dealing with. The part number gives us knowledge of matching actual variant with required one.

If pre-processing inspection was carried out on core, what information would be useful for your job? Please comment on why this is.
Part number for the scheduling team - for my job, it's not relevant.

APPENDIX IV

Presentation Slides

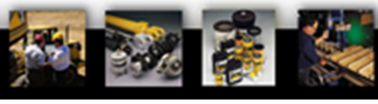
Improving the Efficiency of the Remanufacture of Complex Mechanical Assemblies with Robust Inspection of Core Units

Experimental Feedback

Sara Ridley

Section Manager, Rushden

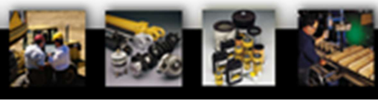
CAT Reman Services Caterpillar Remanufacturing Services



Content

- Overview of Research
- Experimental Results
- Analysis of Results
- Conclusions from the Analysis
- Process Flow for Rushden
- Questions

CAT Reman Services Caterpillar Remanufacturing Services

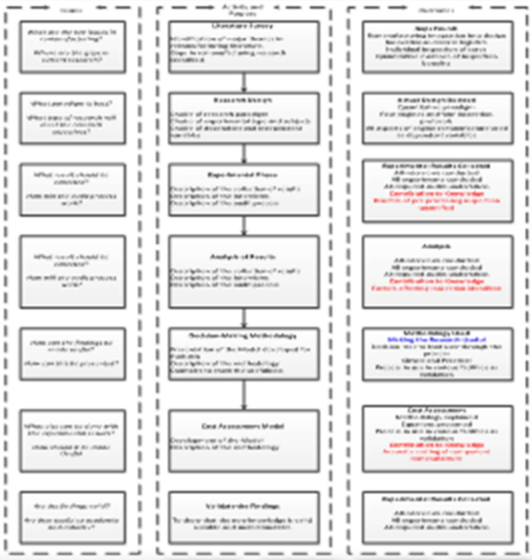


Overview of the Research

Causal Experimental research collecting hard data to find any links between the content of engine inspection before processing

Over 2000 engines of 4 types and 4 customers studied

All the results show the same thing



CAT Reman Services

Caterpillar Remanufacturing Services

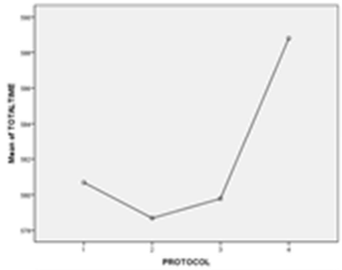
Experimental Results

Activity	% Change between Protocol 1 and Control				% Change between Protocol 3 and Control				% Change between Protocol 4 and Control			
	Engine A	Engine B	Engine C	Engine D	Engine A	Engine B	Engine C	Engine D	Engine A	Engine B	Engine C	Engine D
Decant and Inspect	-22.96	-24.37	-21.61	-23.23	40.49	46.57	22.66	50.63	163.91	176.96	176.96	214.96
Dis assembly	5.29	1.60	10.35	3.34	-2.49	-4.09	-20.06	-15.00	-2.15	-4.29	-4.29	-17.99
Block Remanufacture	0.51	1.16	2.12	5.05	-0.21	-1.94	0.63	-2.10	-0.17	-2.06	-2.06	-2.54
Head Remanufacture	1.15	0.75	-0.39	0.96	0.39	-2.21	-3.55	0.67	0.23	-2.05	-2.05	-0.56
Crankshaft Remanufacture	1.71	0.00	0.03	0.05	-0.20	0.00	-1.23	-2.75	-0.29	0.00	0.00	-2.46
Camshaft Remanufacture	1.03	-0.03	-0.17	0.3	1.09	0.10	0.04	0.04	1.05	0.04	0.04	0.14
Valve Remanufacture	-0.12	0.12	0.35	0.15	-0.35	-0.05	0.13	-0.02	0.00	0.06	0.06	0.03
Connecting Rods	0.12	0.13	-0.01	0.03	0.20	0.12	-0.02	-0.12	0.02	0.09	0.09	-0.04
Rocker Shaft Remanufacture			-0.05	-0.17			-0.05	-0.14				-0.15
Compressor Remanufacture				-0.1				-17.96				-19.23
Oil Pump Remanufacture		-0.26	-0.01	0.03		0.00	0.06	0.06		-0.21	-0.21	0.05
Fuel Lift Pump Remanufacture			3.96	0.55			-1.33	-4.49				-3.70
EGR Valve Remanufacture			1.14				-2.75					
Vacuum Pump Remanfacture		0.26	0.20	0.1		-0.12	-0.05	0.12		0.00	0.00	0.07
Starter Motor Remanufacture			7.26				-17.55					
Alternator Remanufacture			7.53				-6.65					
Flywheel Remanufacture			1.06				-1.46					
Turbocharger Remanufacture			4.15	-0.44			-16.70	-26.67				-25.60
Small Parts Remanufacture	0.04	1.20	5.55	2.59	0.00	-1.81	-13.52	-5.07	-0.03	-0.03	-1.56	-6.30
Engine Kitting			9.31	0.61			-4.07	-9.55				-6.51
Engine Assembly	-0.27	-0.20	-0.21	0.1	-0.35	-0.03	-0.30	-0.09	-0.35		-0.03	-0.09
Post-Production Test	-0.19	-0.05	0.19	0.13	0.00	-0.03	0.04	0.09	0.15	0.20	0.20	0.09
Paint, Pack and Despatch	0.09	-0.02	-0.02	0.13	0.23	-0.04	-0.04	0.00	0.11	-0.03	-0.03	0.06
Overall Remanufacture	0.43	0.27	2.74	0.76	0.31	-0.71	-5.36	-6.50	1.56	0.35	0.35	-6.22

CAT Reman Services

Caterpillar Remanufacturing Services

ANOVA - Engines A and B

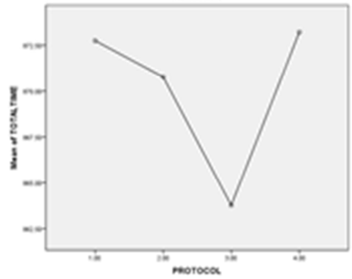


Engine A

ANOVA

TOTALTIME

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16747.848	3	5582.616	291.450	.000
Within Groups	20093.189	1049	19.155		
Total	36841.037	1052			

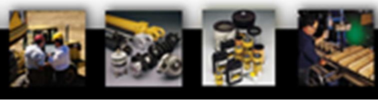


Engine B

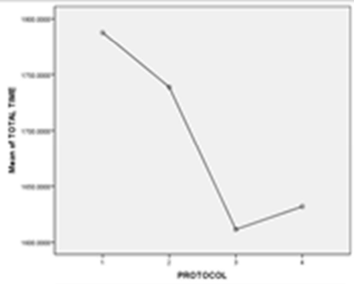
ANOVA

TOTALTIME

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5884.232	3	1961.411	116.230	.000
Within Groups	6868.214	407	16.875		
Total	12752.446	410			



ANOVA - Engines C and D

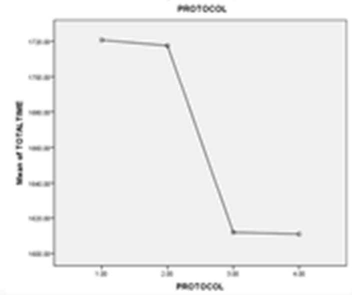


Engine C

ANOVA

TOTAL TIME

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2244064.267	3	748021.422	11352.218	.000
Within Groups	27411.110	416	65.892		
Total	2271475.378	419			



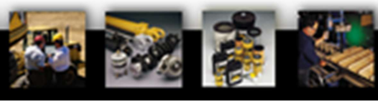
Engine D

ANOVA

TOTALTIME

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	904045.515	3	301348.505	4501.214	.000
Within Groups	20620.068	308	66.948		
Total	924665.583	311			

CAT Reman Services
Caterpillar Remanufacturing Services



Conclusions from the Results

- Majority of the components with reduced processing time had one or more of the three following traits:
  - Complex geometry including internal ports;
  - Large number of sub-components; or
  - Constructed from or comprising of multiple materials.

Other components benefitting from activity time reduction that do not fall into any of these categories are the crankshaft, the fuel lift pump and the flywheel.

These three components have very short activity times in common and, although the activity times were shortened during the experiment; in real terms, the actual time reduction was less than a minute in the major of instances.

More in depth Inspection of components with the characteristics above reduced overall processing times and so different levels of inspection for different models / components is beneficial.

Process Flow for Rushden

Questions

Thank you for your interest and patience.
Do you have any questions?

CAT Reman Services   Caterpillar Remanufacturing Services

APPENDIX V

Post Experimental Interview Transcripts

Post Research Interview:

Facility: Date:

Person:

Has seeing the experimental results changed your attitude to pre-processing inspection? Please explain your response.
Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
Did you notice any benefit to your job during the experimental phase? Please comment on how this was.
Do you believe that you facility should inspect core prior to processing? Please comment on why and to what level.

Post-Research Interview:

Facility: Rushden

Date: 30/01/2012

Person: Facility Manager

Has seeing the experimental results changed your attitude to pre-processing inspection? Please explain your response. Yes - I hadn't realised what an impact it could have. I have talked to the team and we will be carrying on with it.
Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is. Both - according to...(Logistics manager)'s figures we have less kits with shortages and less stock, although I don't know how much of the latter is from inspection.
Did you notice any benefit to your job during the experimental phase? Please comment on how this was. Some benefit - doesn't concern me directly but we have increased production output.
Do you believe that you facility should inspect core prior to processing? Please comment on why and to what level. Three from your figures.

Post-Research Interview:

Facility: Rushden

Date: 30/01/2012

Person: Disassembly Operator

Has seeing the experimental results changed your attitude to pre-processing inspection? Please explain your response.
It's better. I didn't think so but it is. I don't get so much rubbish in unless we need it and then I know up front.
Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
Quicker – It's not easy but I know what's coming.
Did you notice any benefit to your job during the experimental phase? Please comment on how this was.
Some – I know what's coming and we don't get our rear ends kicked for not meeting plan because we've had a couple of tricky mos.
Do you believe that you facility should inspect core prior to processing? Please comment on why and to what level.
Three gave the most

Post-Research Interview:

Facility: Rushden

Date: 31/01/2012

Person: Production Manager

Has seeing the experimental results changed your attitude to pre-processing inspection? Please explain your response.
Yes - it's better, in fact implementing more inspection has increased my throughput significantly and we are getting at least 5% more from each line we have it in place. I didn't believe it would work.
Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
Both, less material strategies and much better scheduling.
Did you notice any benefit to your job during the experimental phase? Please comment on how this was.
Yes big one for the reasons above.
Do you believe that you facility should inspect core prior to processing? Please comment on why and to what level.
Four - let's get everything we can.

Post-Research Interview:

Facility: Reshden

Date: 31/01/2012

Person: Logistics Manager

Has seeing the experimental results changed your attitude to pre-processing inspection? Please explain your response. Yes - I can't believe we didn't know. It's great, I get live feedback every day and we know where we are.
Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is. Both. My team is working much more efficiently we can plan much better now.
Did you notice any benefit to your job during the experimental phase? Please comment on how this was. Yes, we are carrying less stock because we have time to order and not have to have excess to cope. We have less shortages now, I can fill kits up knowing what's in the pipeline.
Do you believe that you facility should inspect core prior to processing? Please comment on why and to what level. Yes, on everything. We need to keep on getting this information.

Post-Research Interview:

Facility: Rushden

Date: 31/01/2022

Person: Assembly Operator

Has seeing the experimental results changed your attitude to pre-processing inspection? Please explain your response. No change, dirty stuff doesn't bother me.
Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is. It's a bit quicker, I've not had to start and stop so much for missing bits in kits.
Did you notice any benefit to your job during the experimental phase? Please comment on how this was. Yes, cos I've not had to stop so much. Mostly parts are there.
Do you believe that you facility should inspect core prior to processing? Please comment on why and to what level. Three - I think that's what you said

Post-Research Interview:

Facility: European

Date: 07/02/2012

Person: Ops Manager

Has seeing the experimental results changed your attitude to pre-processing inspection? Please explain your response.
Yes - it seems very beneficial, after this report.
Do you now think that pre-processing inspection makes subsequent remanufacturing activities easier or quicker? Please comment on why this is.
Both and I would like it in my facility here. Will you teach my people too?
Did you notice any benefit to your job during the experimental phase? Please comment on how this was.
No - not my facility yet.
Do you believe that you facility should inspect core prior to processing? Please comment on why and to what level.
Four, the engines we have here are more like your engine D. It would be good.

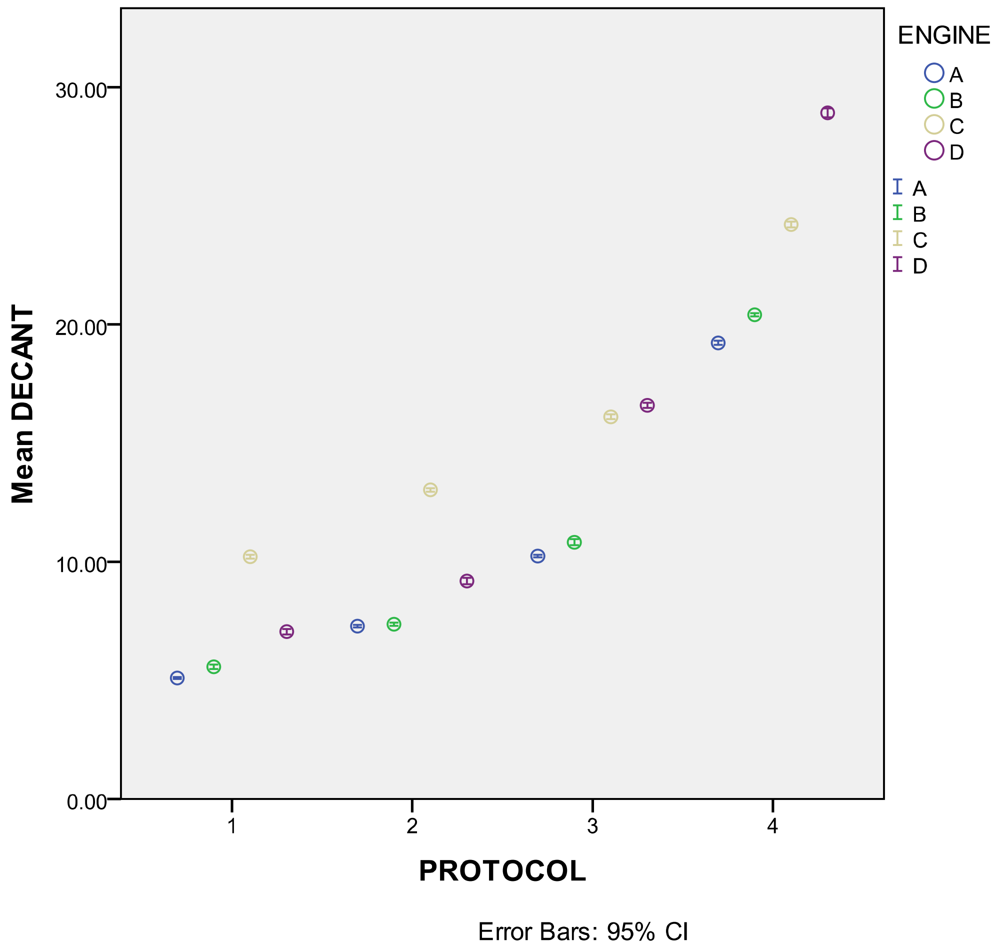
APPENDIX VI

ANOVA Results

Engine by Engine

Decant and Inspect Mean 95% Confidence

x-axis = protocol, y-axis = time in minutes



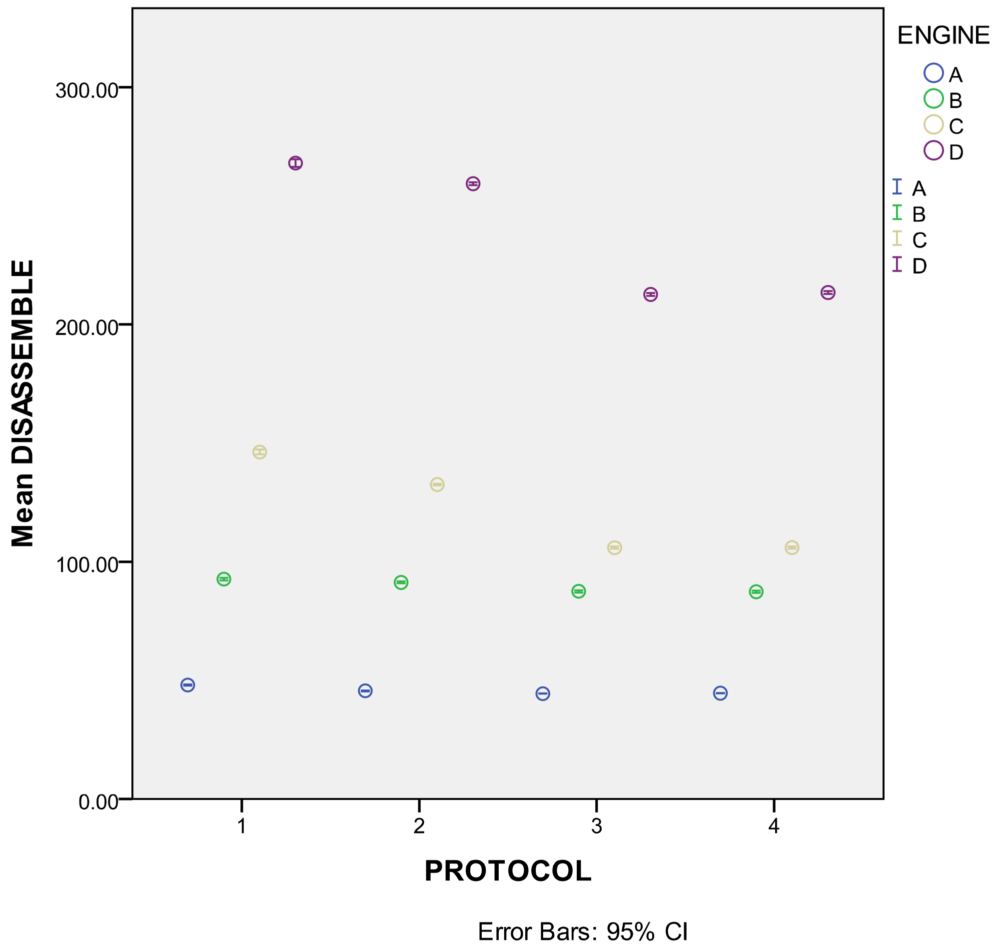
ANOVA

DECANT

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	75479.142	3	25159.714	3410.666	.000
Within Groups	16169.887	2192	7.377		
Total	91649.029	2195			

Disassembly

x-axis = protocol, y-axis = time in minutes



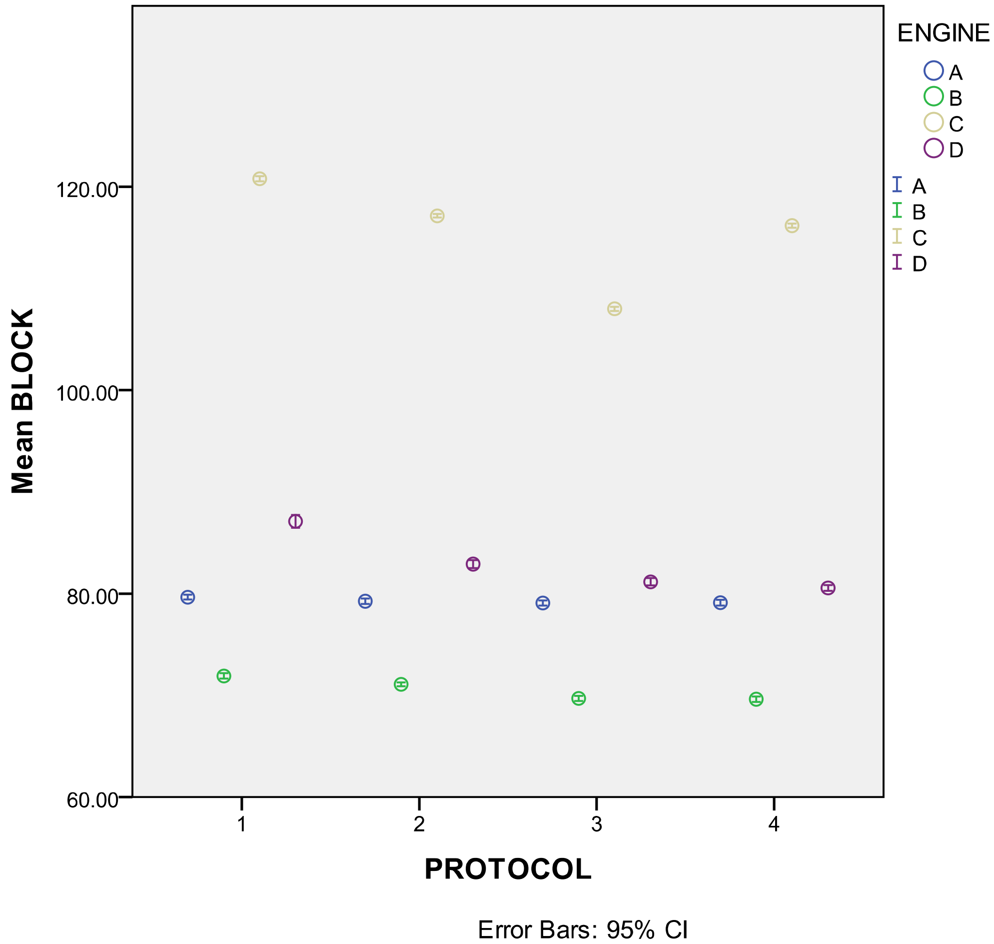
ANOVA

DISASSEMBLE

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	139512.867	3	46504.289	10.708	.000
Within Groups	9519680.079	2192	4342.920		
Total	9659192.946	2195			

Cylinder Block

x-axis = protocol, y-axis = time in minutes



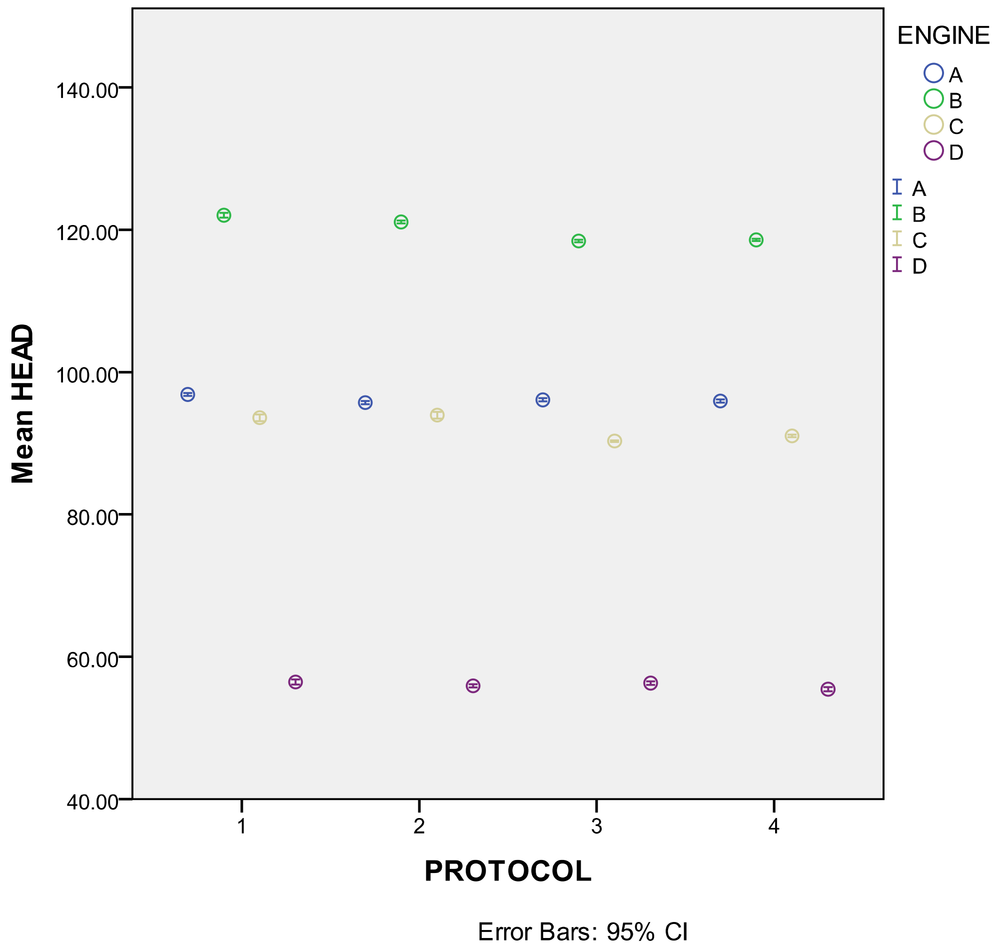
ANOVA

BLOCK

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4400.472	3	1466.824	6.104	.000
Within Groups	526783.328	2192	240.321		
Total	531183.800	2195			

Cylinder Head

x-axis = protocol, y-axis = time in minutes



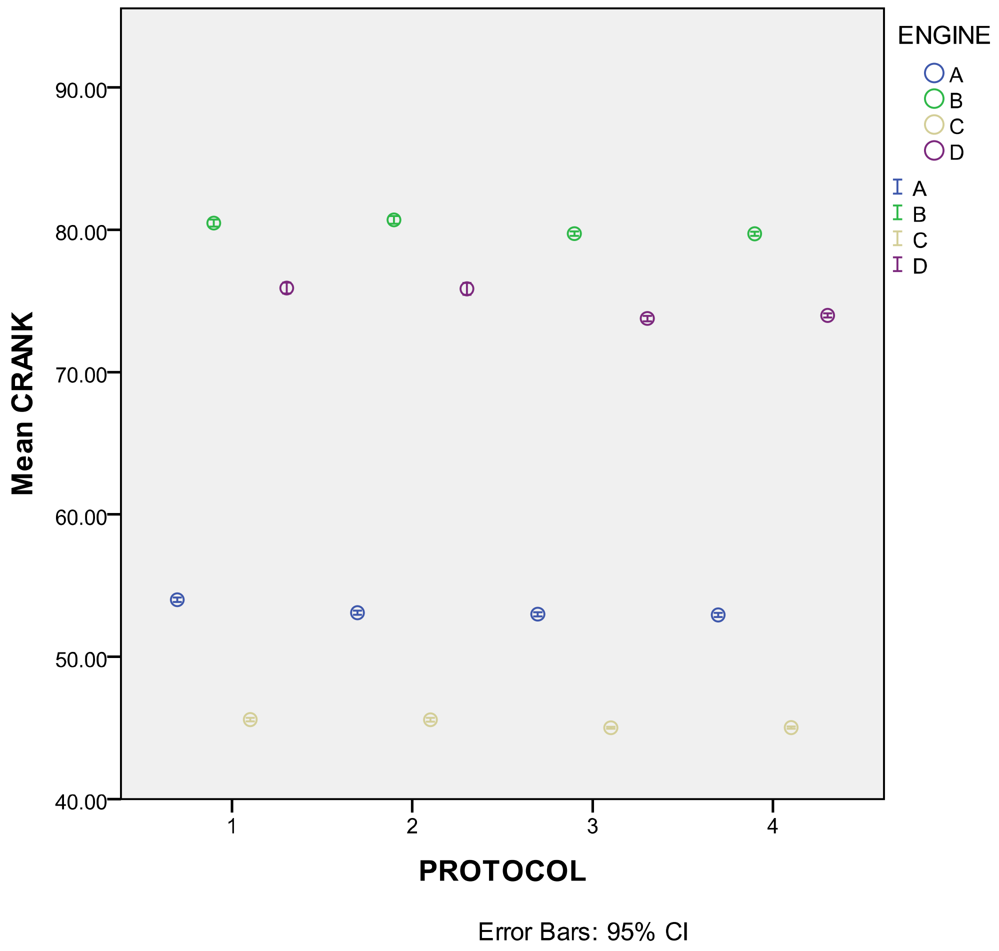
ANOVA

HEAD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1175.867	3	391.956	1.158	.324
Within Groups	741816.111	2192	338.420		
Total	742991.978	2195			

Crankshaft

x-axis = protocol, y-axis = time in minutes



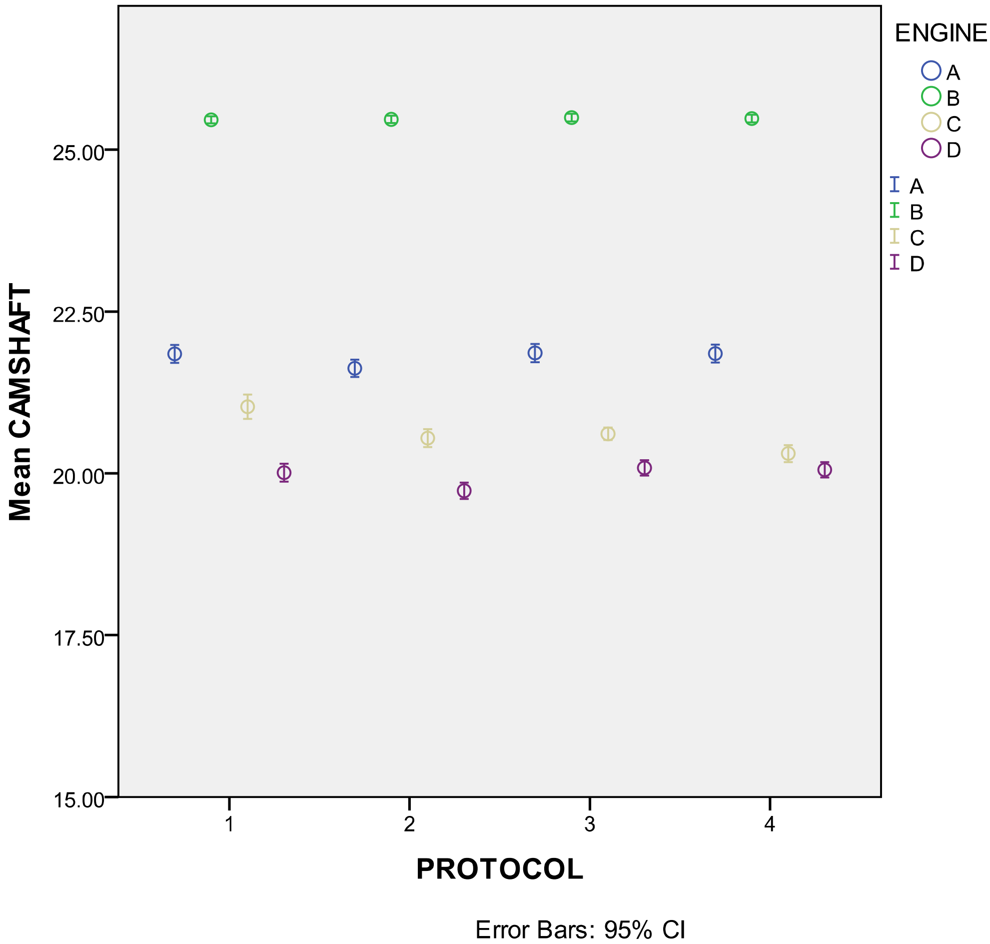
ANOVA

CRANK

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	481.434	3	160.478	.932	.425
Within Groups	377593.182	2192	172.260		
Total	378074.616	2195			

Camshaft

x-axis = protocol, y-axis = time in minutes



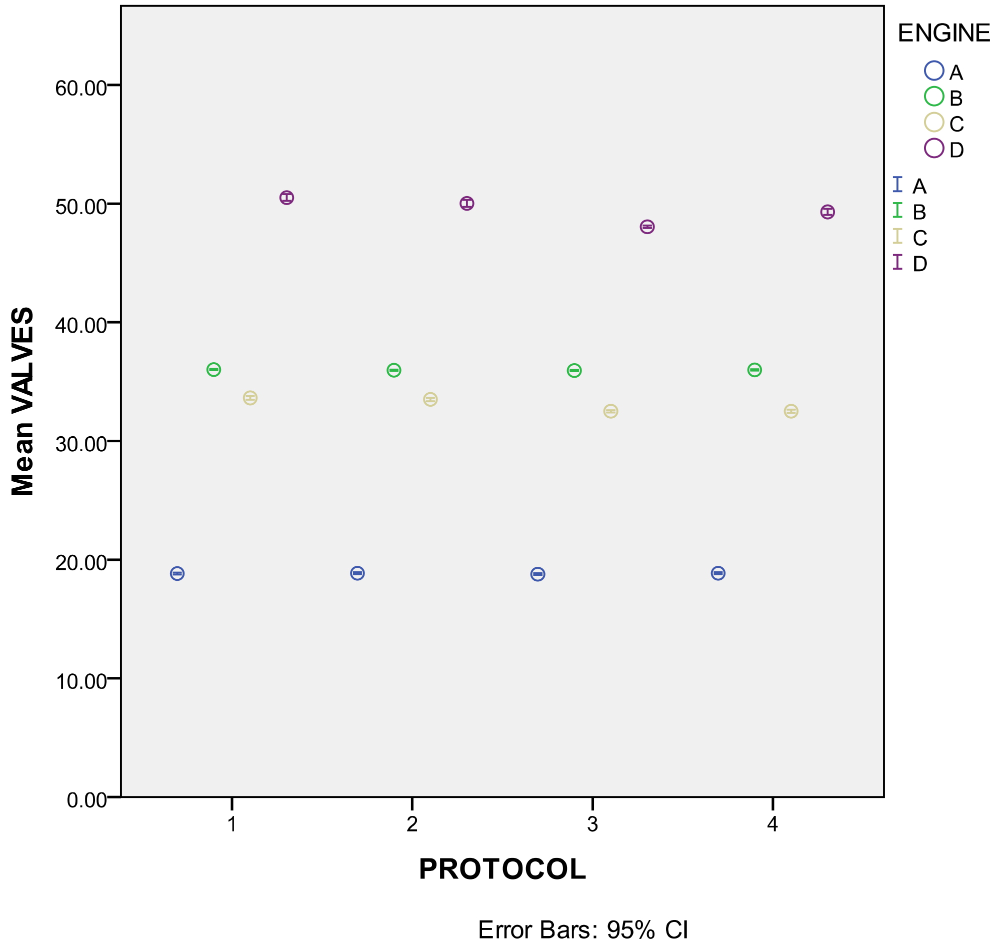
ANOVA

CAMSHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17.686	3	5.895	1.464	.222
Within Groups	8827.304	2192	4.027		
Total	8844.991	2195			

Valves

x-axis = protocol, y-axis = time in minutes



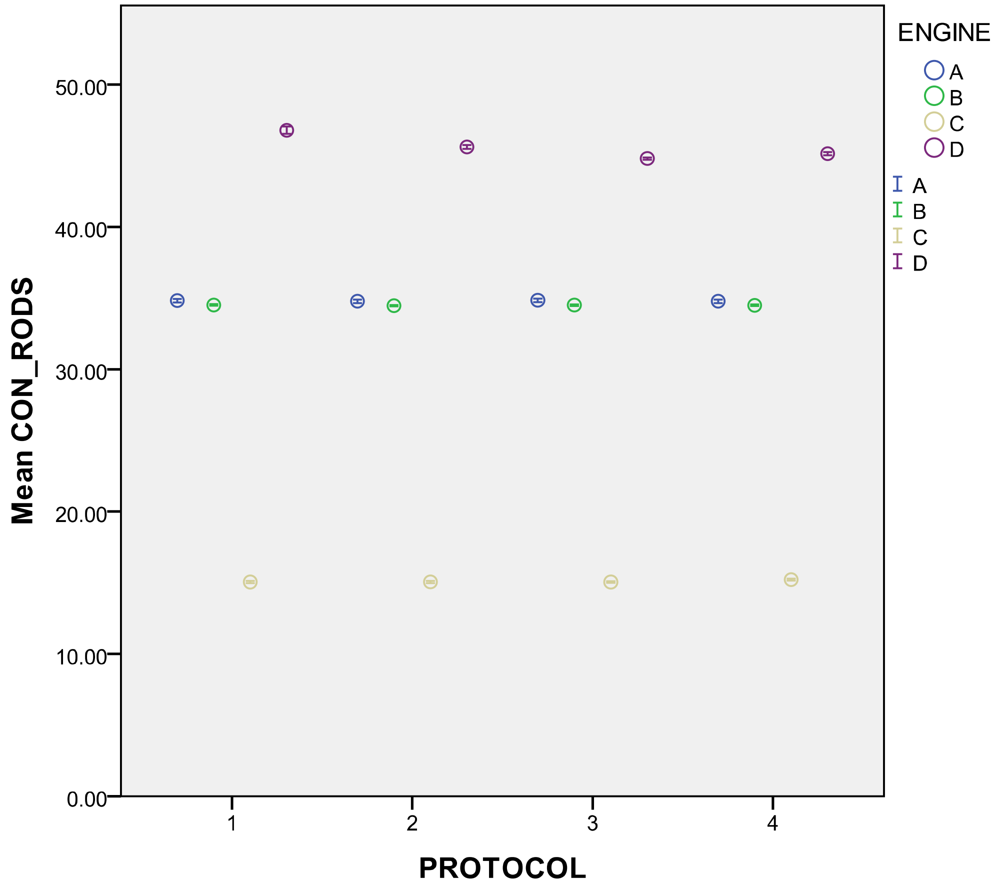
ANOVA

VALVES

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	131.163	3	43.721	.358	.783
Within Groups	267708.114	2192	122.130		
Total	267839.277	2195			

Con-rods

x-axis = protocol, y-axis = time in minutes



Error Bars: 95% CI

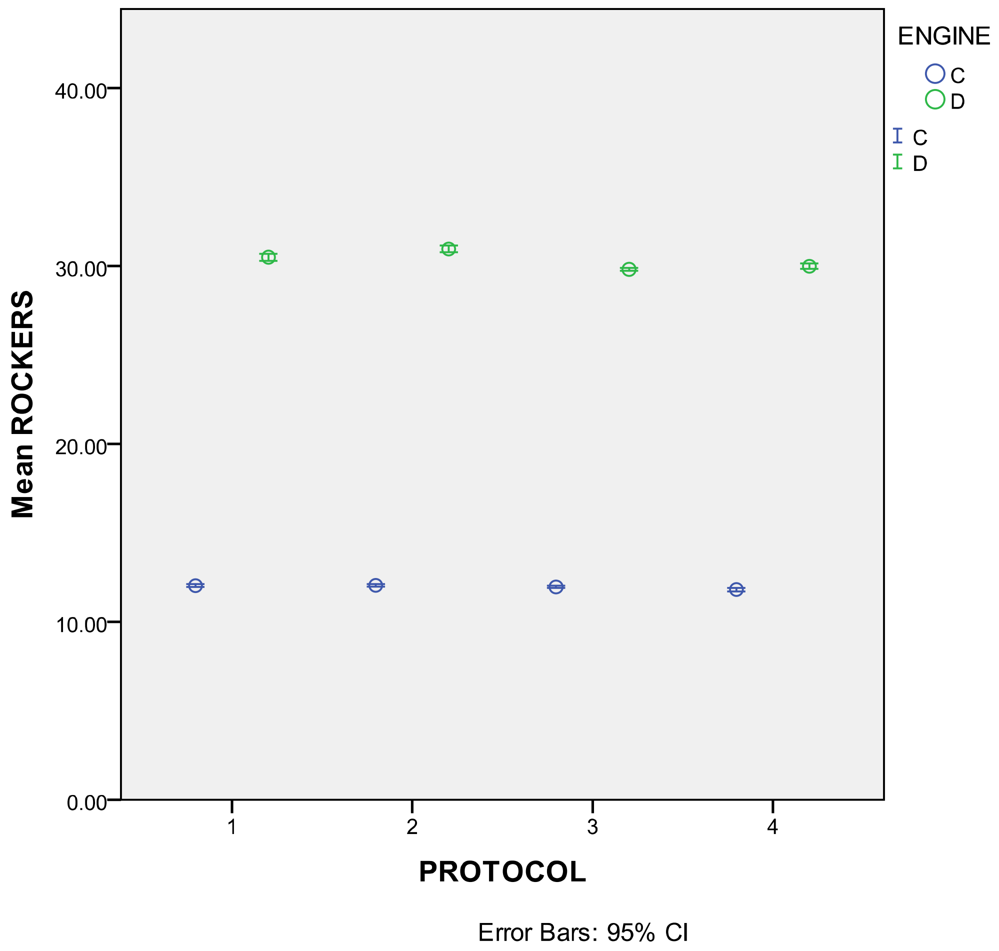
ANOVA

CON_RODS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	32.230	3	10.743	.124	.946
Within Groups	189446.297	2192	86.426		
Total	189478.527	2195			

Rocker Shaft

x-axis = protocol, y-axis = time in minutes



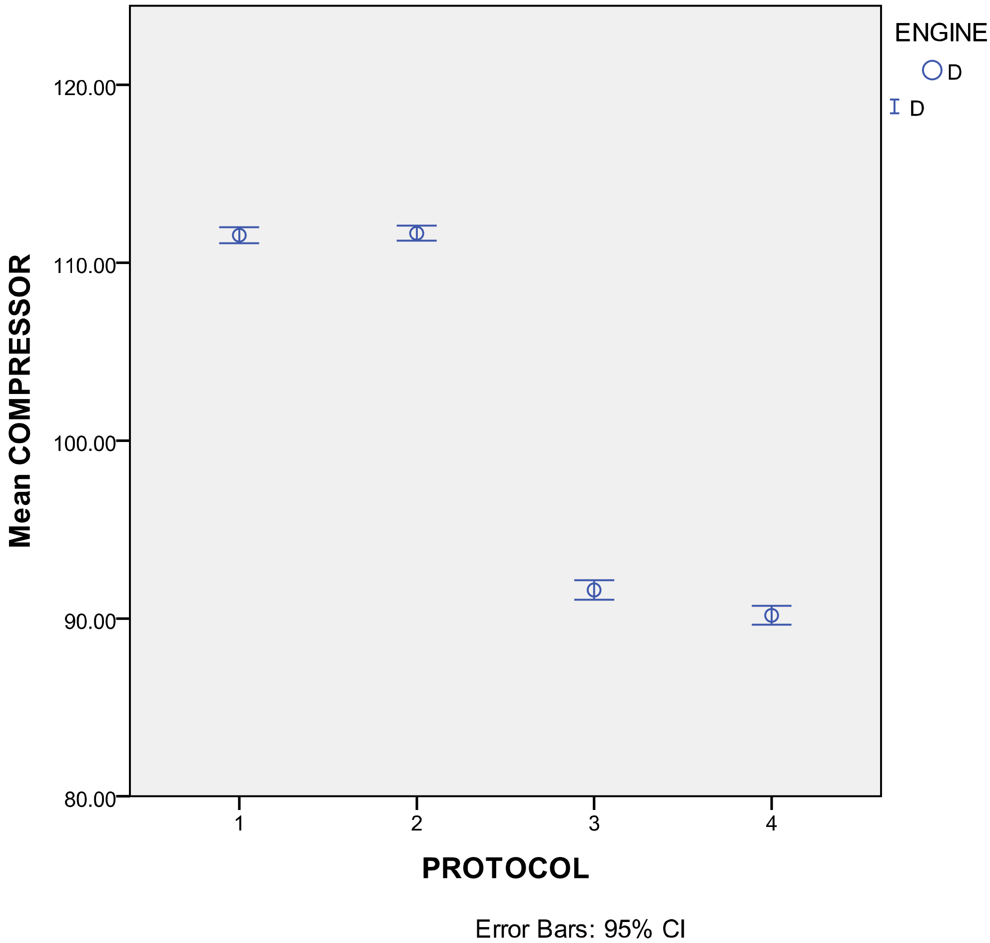
ANOVA

ROCKERS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	45.492	3	15.164	.182	.908
Within Groups	60523.816	728	83.137		
Total	60569.308	731			

Compressor

x-axis = protocol, y-axis = time in minutes



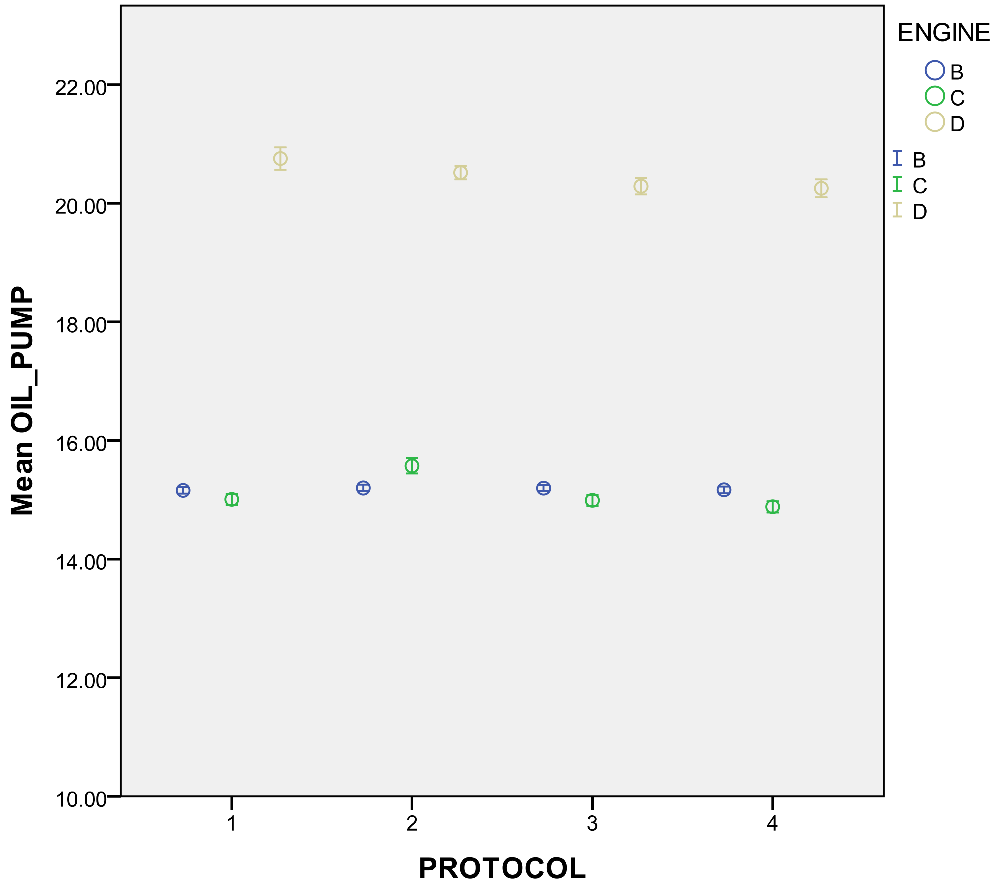
ANOVA

COMPRESSOR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33528.718	3	11176.239	2372.291	.000
Within Groups	1451.037	308	4.711		
Total	34979.755	311			

Oil Pump

x-axis = protocol, y-axis = time in minutes



Error Bars: 95% CI

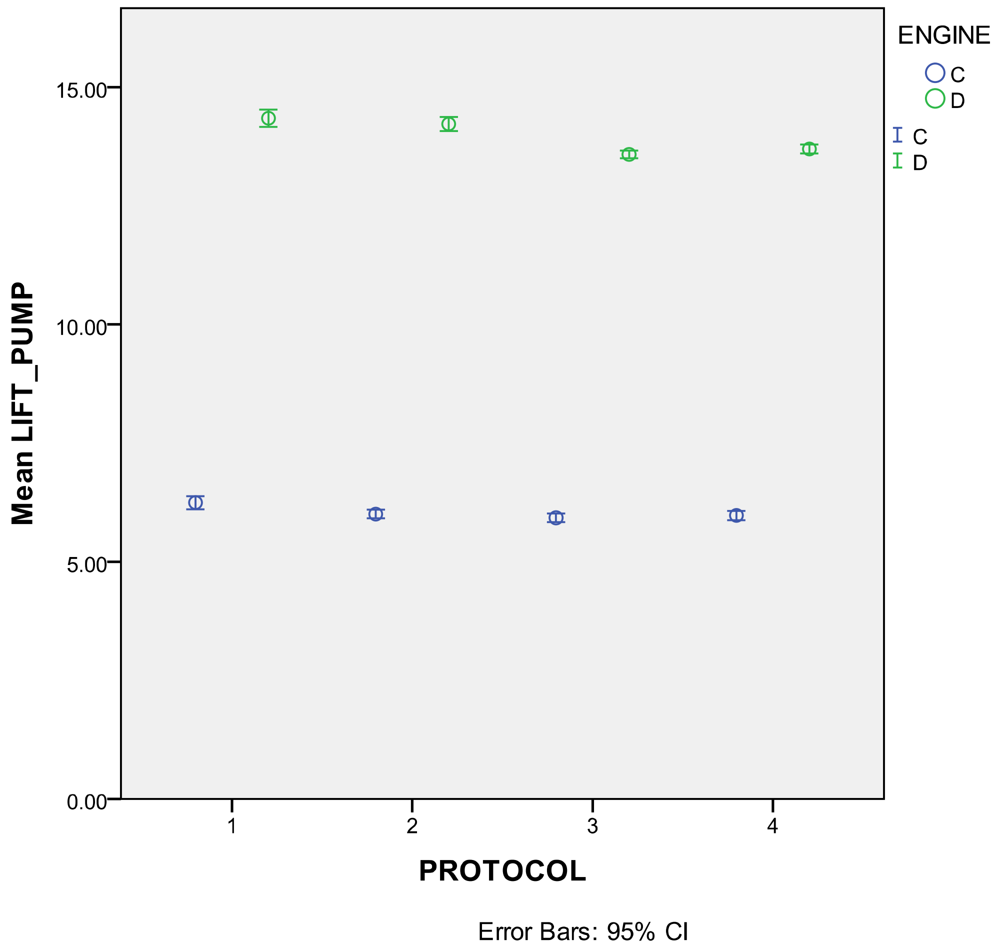
ANOVA

OIL_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19.197	3	6.399	1.088	.353
Within Groups	6700.153	1139	5.882		
Total	6719.350	1142			

Fuel Lift Pump

x-axis = protocol, y-axis = time in minutes



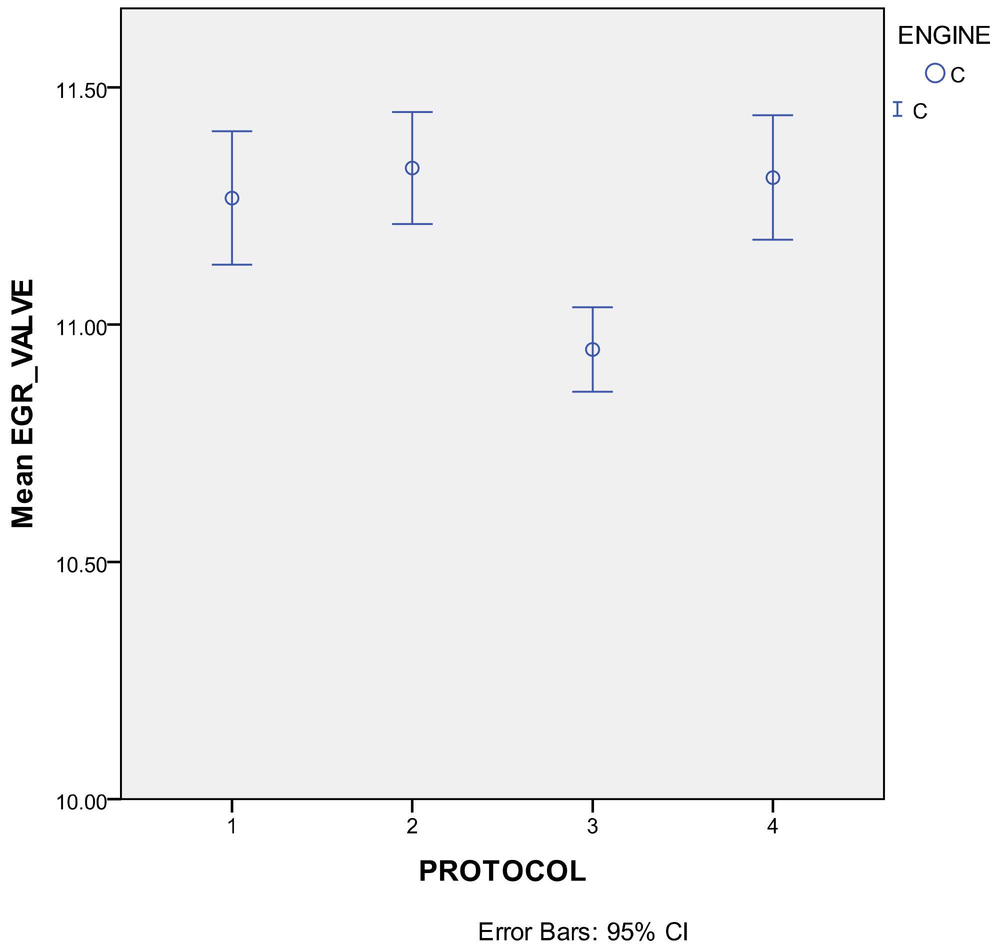
ANOVA

LIFT_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	32.434	3	10.811	.685	.561
Within Groups	11491.297	728	15.785		
Total	11523.731	731			

EGR Valve

x-axis = protocol, y-axis = time in minutes



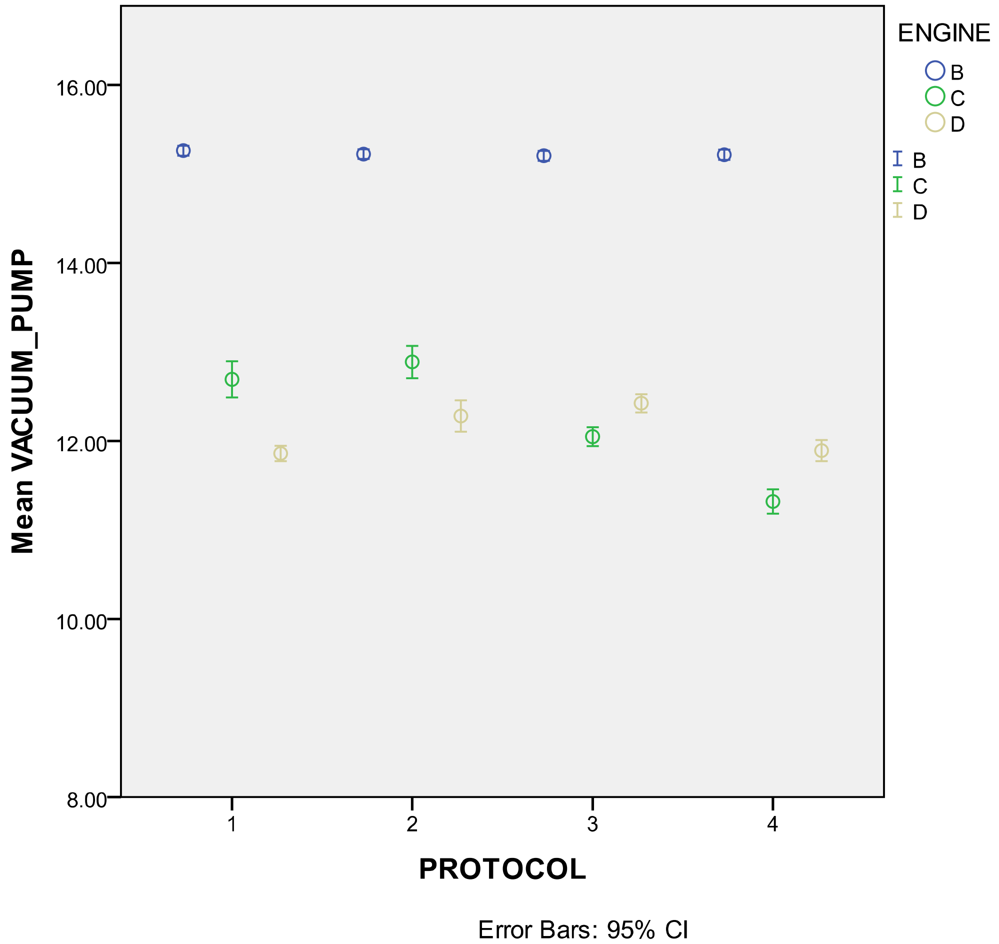
ANOVA

EGR_VALVE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.127	3	3.376	8.606	.000
Within Groups	163.173	416	.392		
Total	173.300	419			

Vacuum Pump

x-axis = protocol, y-axis = time in minutes



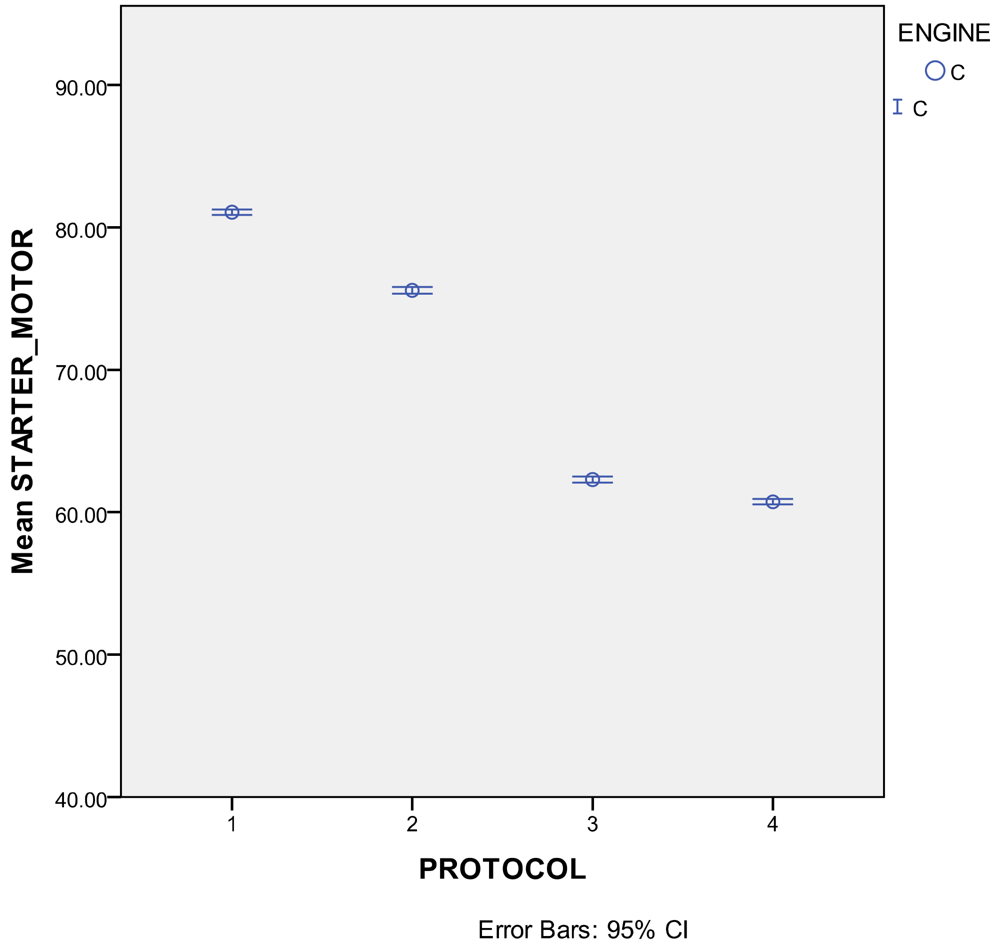
ANOVA

VACUUM_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	75.624	3	25.208	9.701	.000
Within Groups	2959.560	1139	2.598		
Total	3035.184	1142			

Starter Motor

x-axis = protocol, y-axis = time in minutes



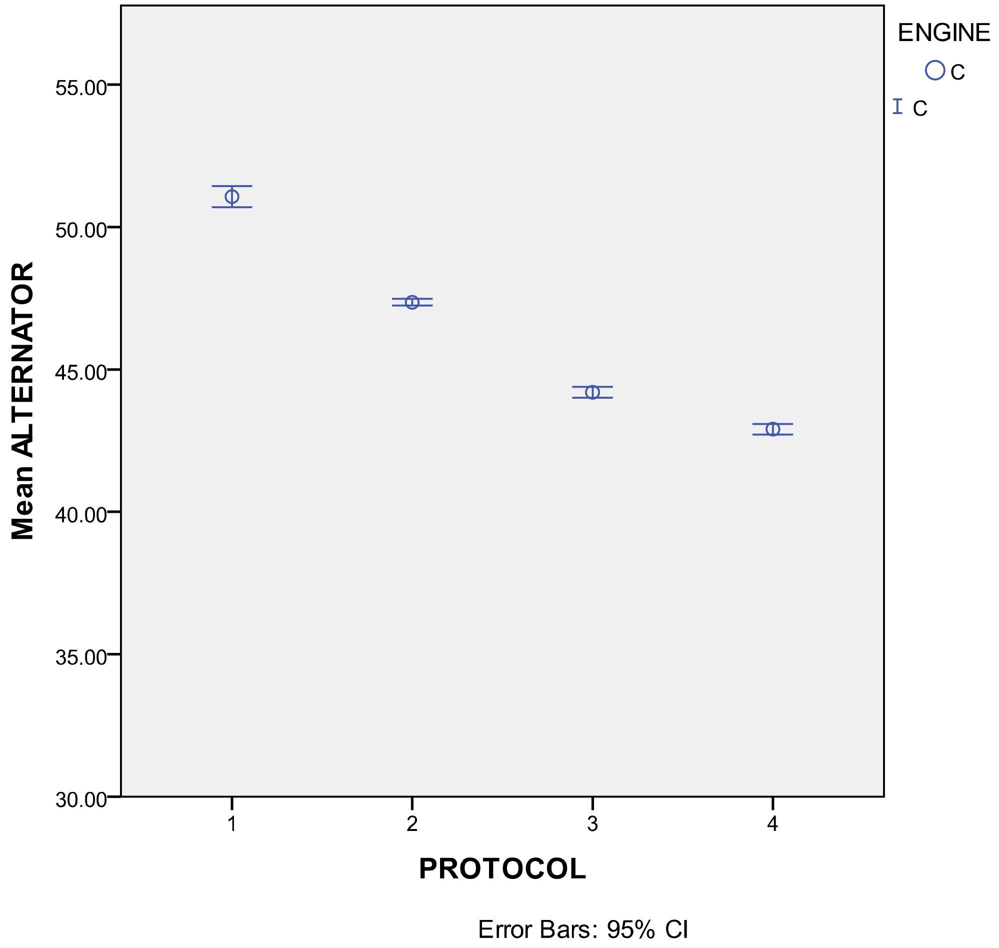
ANOVA

STARTER_MOTOR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	31333.610	3	10444.537	9148.865	.000
Within Groups	474.914	416	1.142		
Total	31808.524	419			

Alternator

x-axis = protocol, y-axis = time in minutes



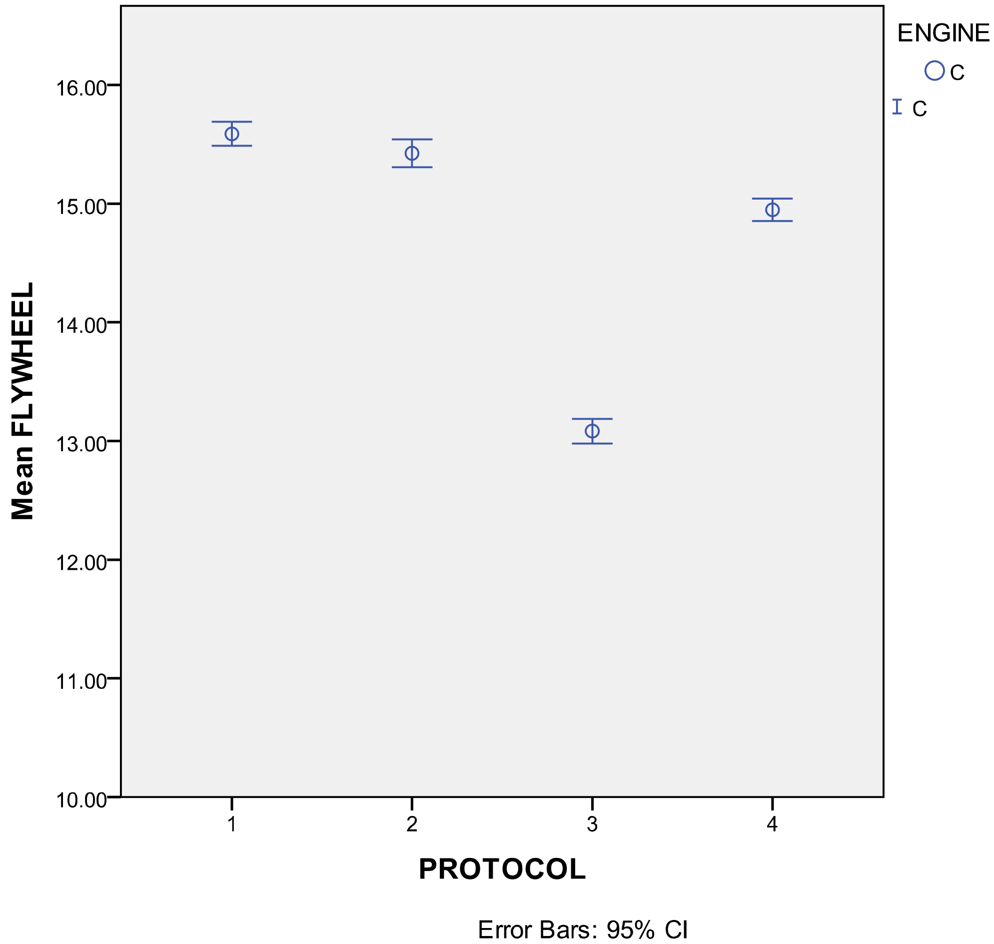
ANOVA

ALTERNATOR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4170.755	3	1390.252	931.633	.000
Within Groups	620.786	416	1.492		
Total	4791.540	419			

Flywheel

x-axis = protocol, y-axis = time in minutes



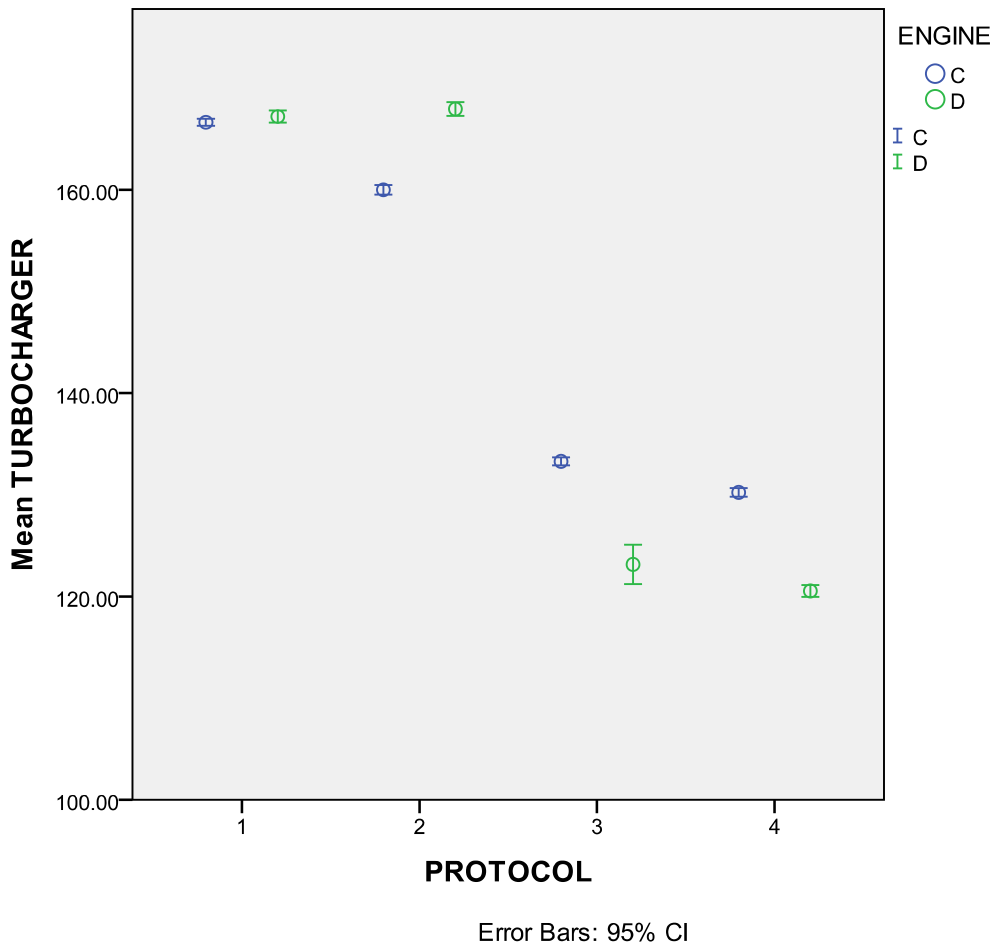
ANOVA

FLYWHEEL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	416.628	3	138.876	475.025	.000
Within Groups	121.620	416	.292		
Total	538.248	419			

Turbocharger

x-axis = protocol, y-axis = time in minutes



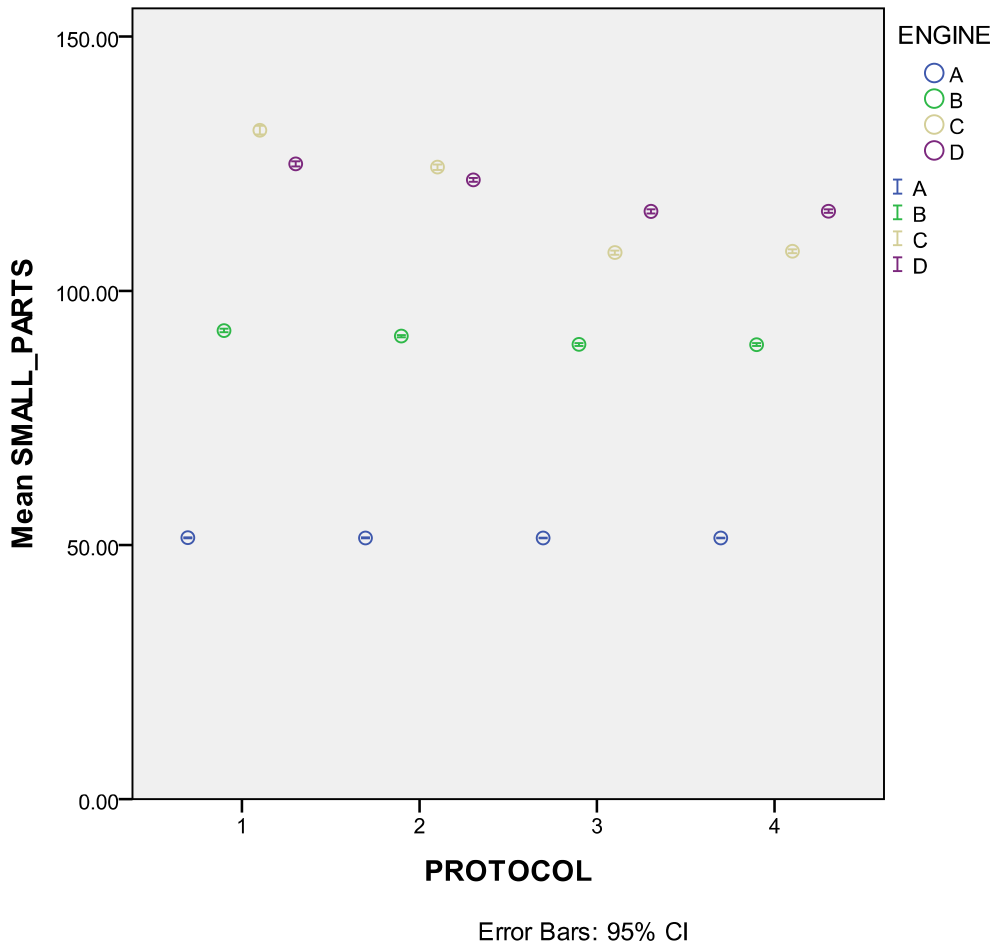
ANOVA

TURBOCHARGER

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	260460.318	3	86820.106	3000.815	.000
Within Groups	21062.626	728	28.932		
Total	281522.944	731			

Small Parts

x-axis = protocol, y-axis = time in minutes



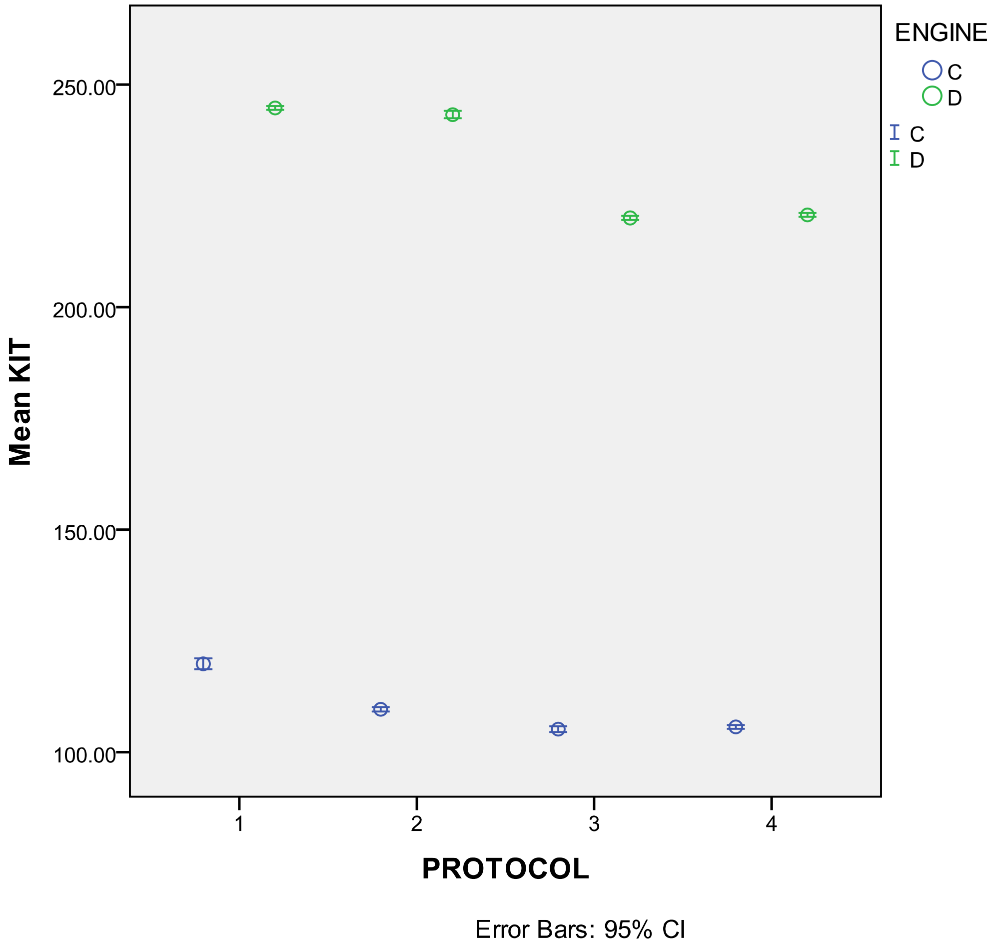
ANOVA

SMALL_PARTS

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	16918.327	3	5639.442	6.085	.000
Within Groups	2031593.456	2192	926.822		
Total	2048511.784	2195			

Kit

x-axis = protocol, y-axis = time in minutes



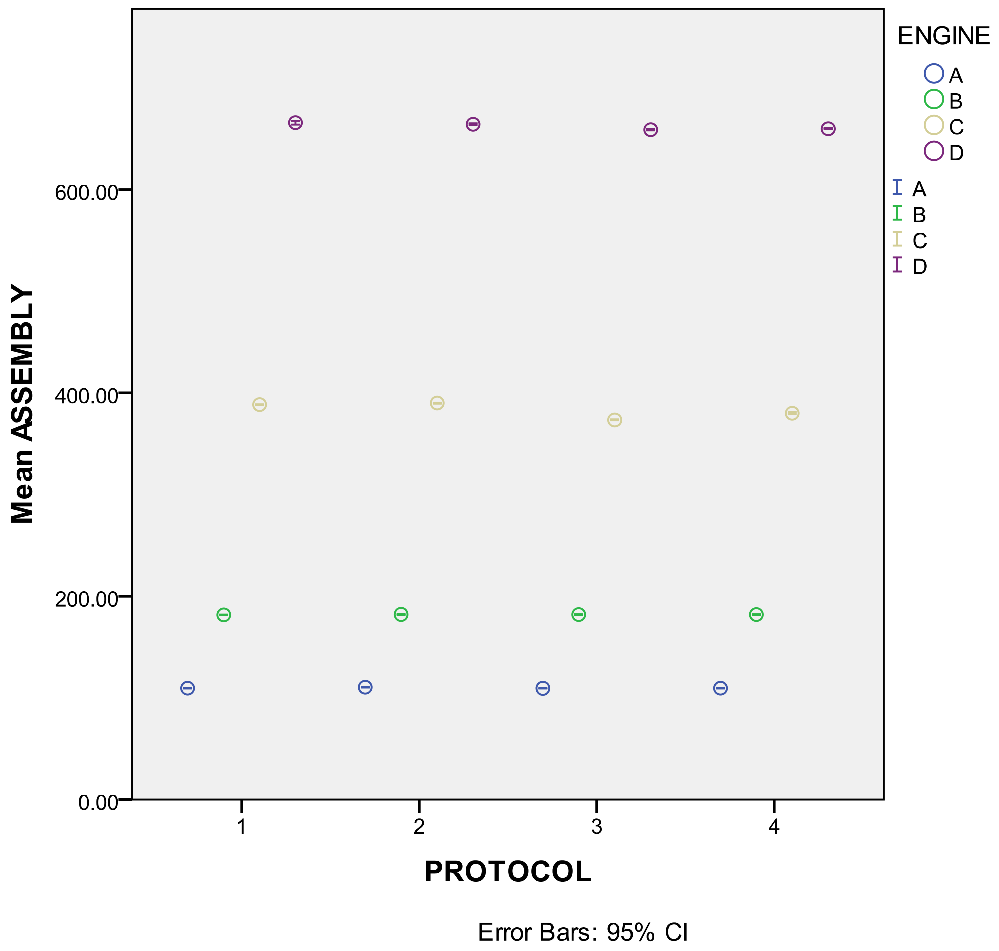
ANOVA

KIT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	49283.597	3	16427.866	4.449	.004
Within Groups	2687858.069	728	3692.113		
Total	2737141.665	731			

Engine Assembly

x-axis = protocol, y-axis = time in minutes



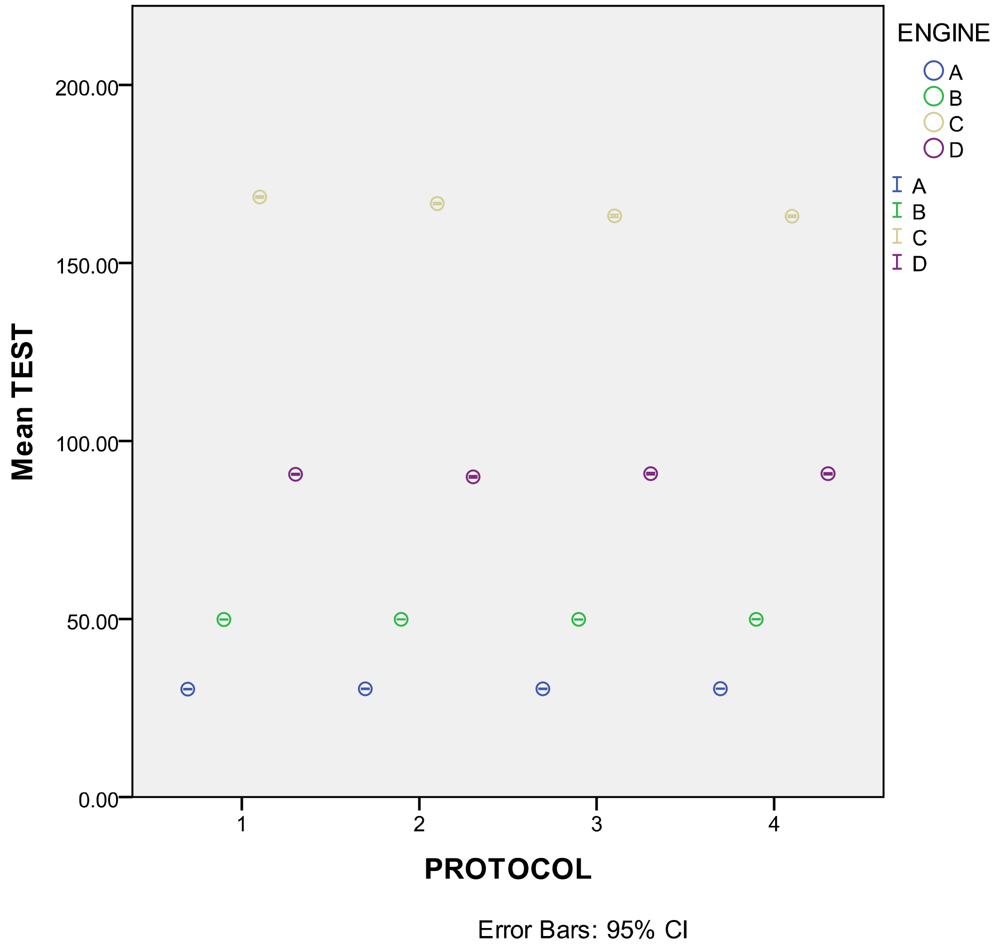
ANOVA

ASSEMBLY

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7274.804	3	2424.935	.064	.979
Within Groups	83056694.449	2192	37890.828		
Total	83063969.253	2195			

Post-Production Test

x-axis = protocol, y-axis = time in minutes



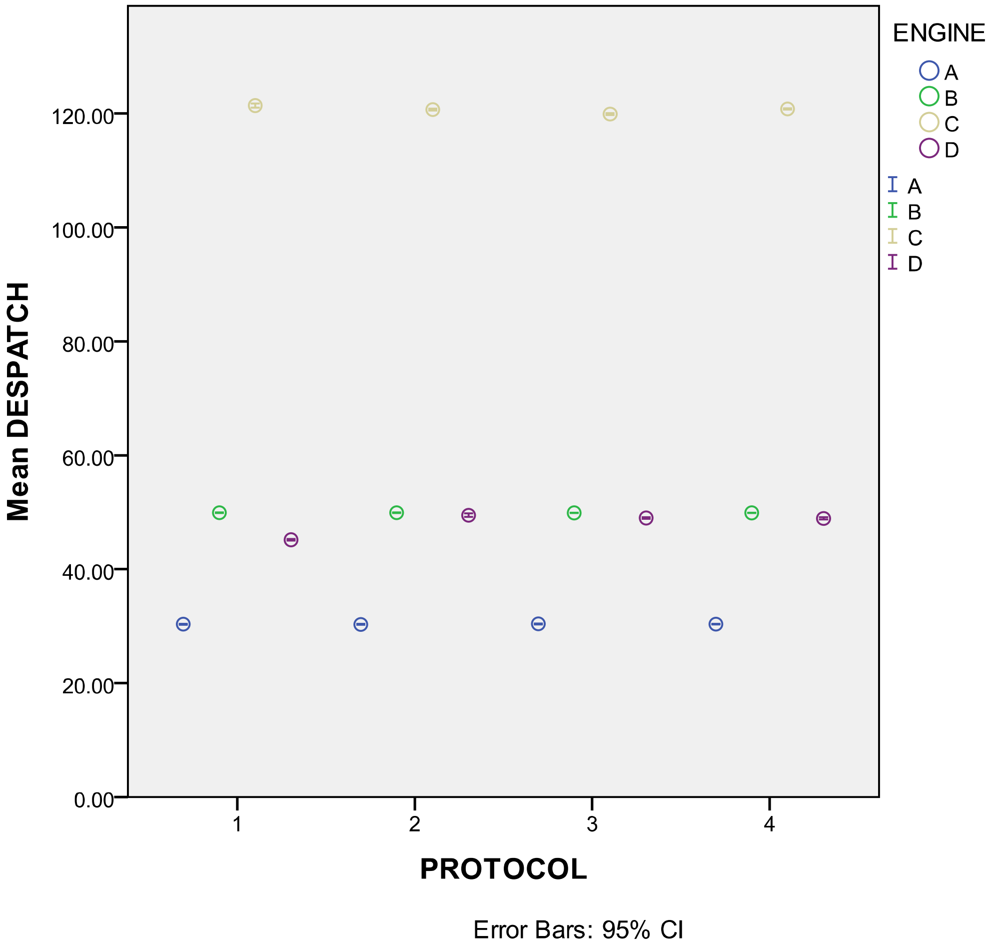
ANOVA

TEST

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	225.595	3	75.198	.029	.993
Within Groups	5772413.131	2192	2633.400		
Total	5772638.725	2195			

Paint, Pack and Despatch

x-axis = protocol, y-axis = time in minutes



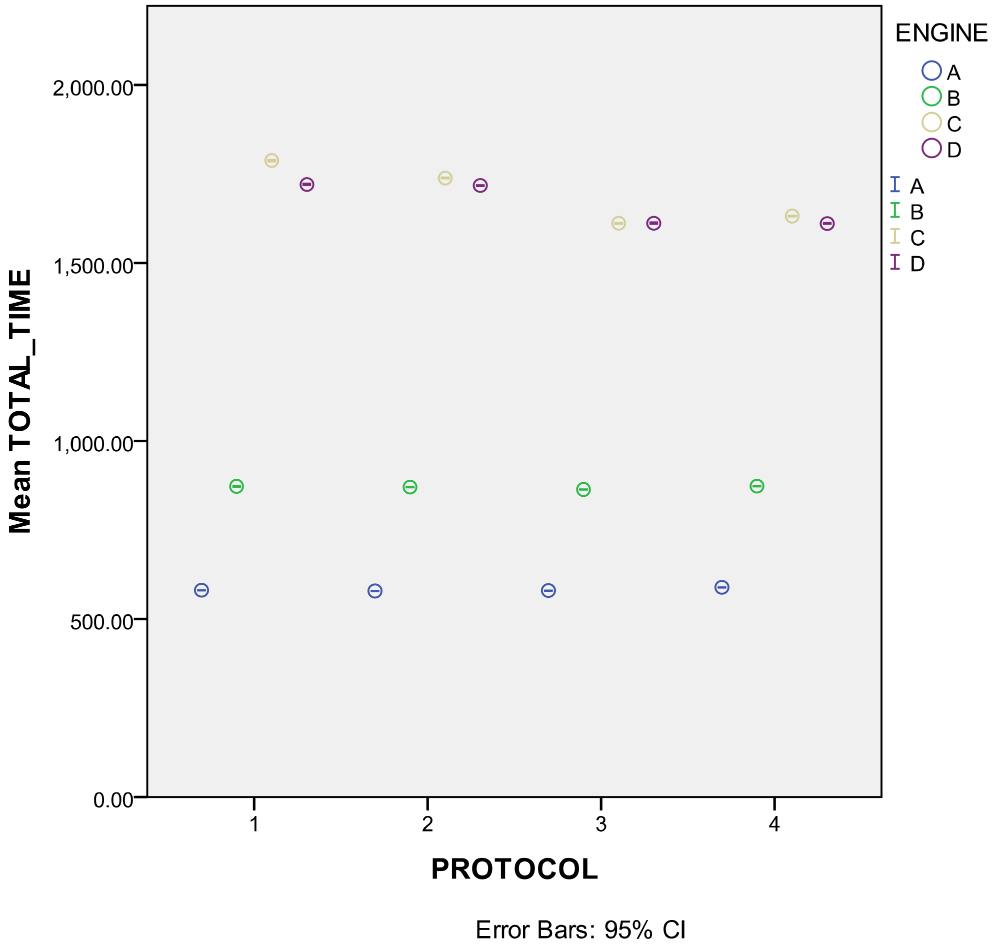
ANOVA

DESPATCH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	150.645	3	50.215	.044	.988
Within Groups	2477358.382	2192	1130.182		
Total	2477509.027	2195			

Overall Remanufacturing Process

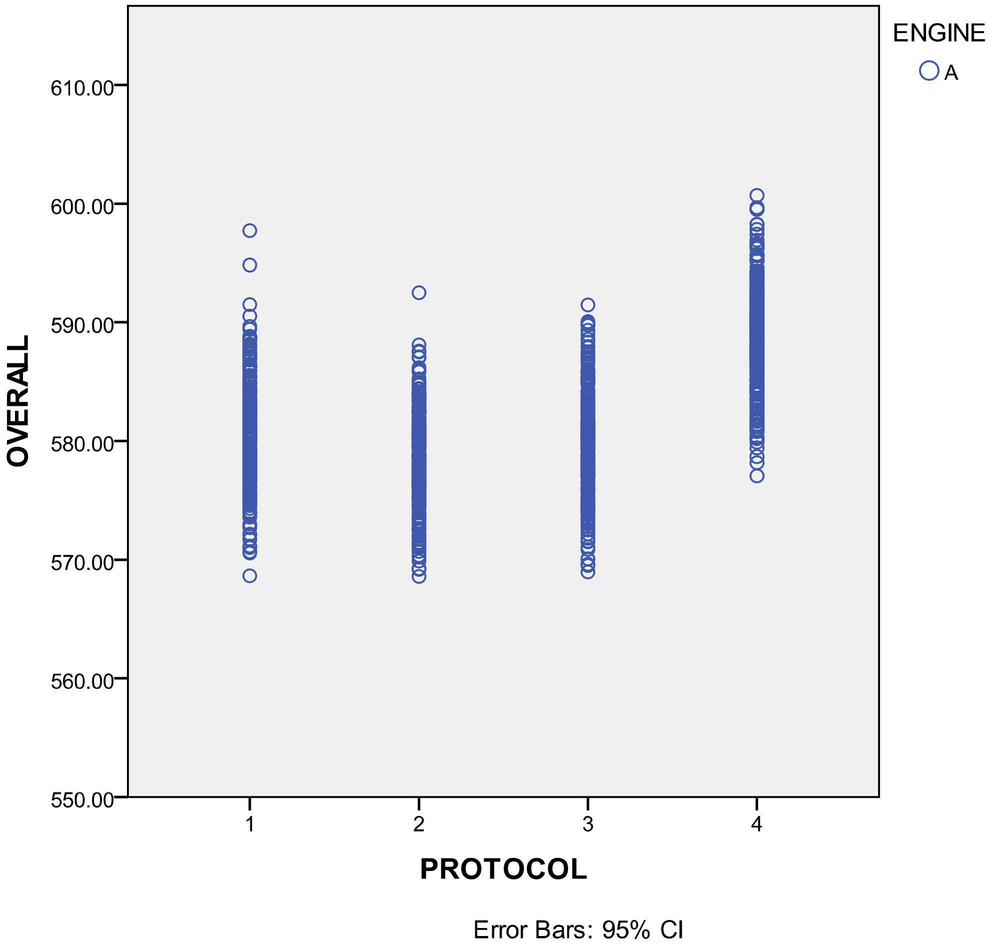
x-axis = protocol, y-axis = time in minutes



By Engine, Engine A

x-axis = protocol, y-axis = time in minutes

Overall A



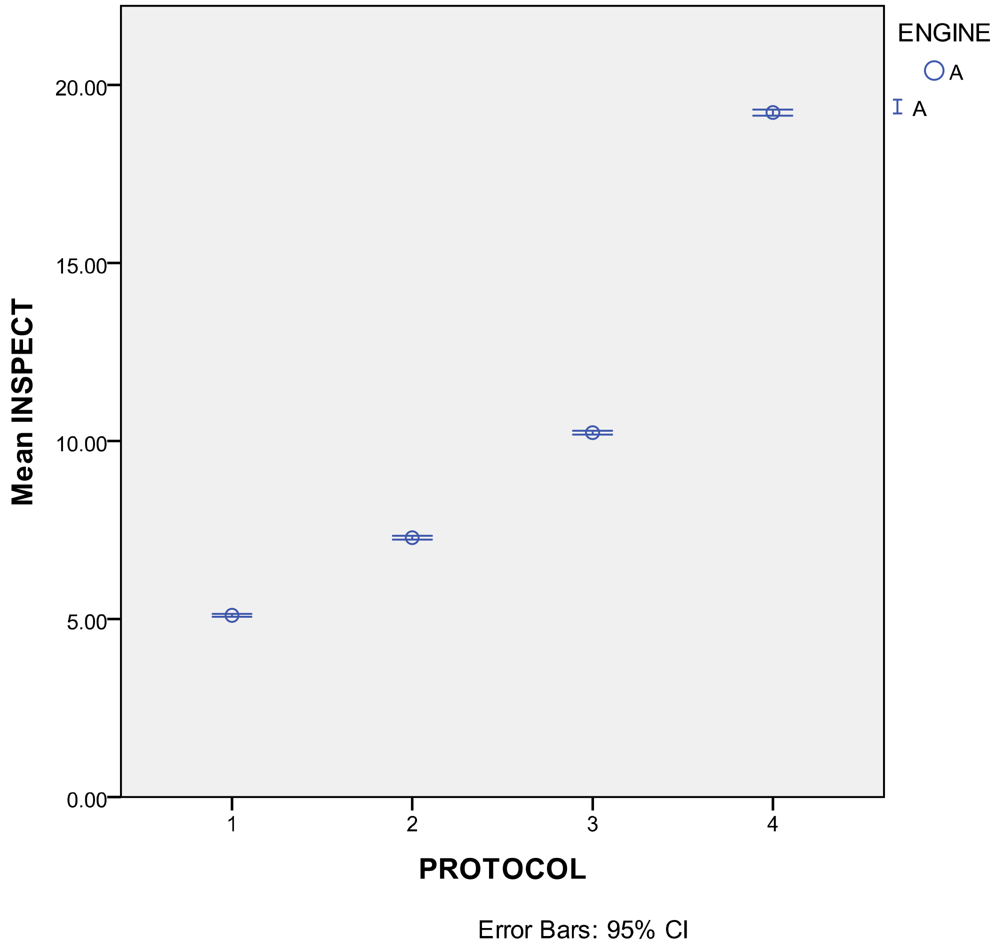
ANOVA

OVERALL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16747.848	3	5582.616	291.450	.000
Within Groups	20093.189	1049	19.155		
Total	36841.037	1052			

Decant and Inspect

x-axis = protocol, y-axis = time in minutes



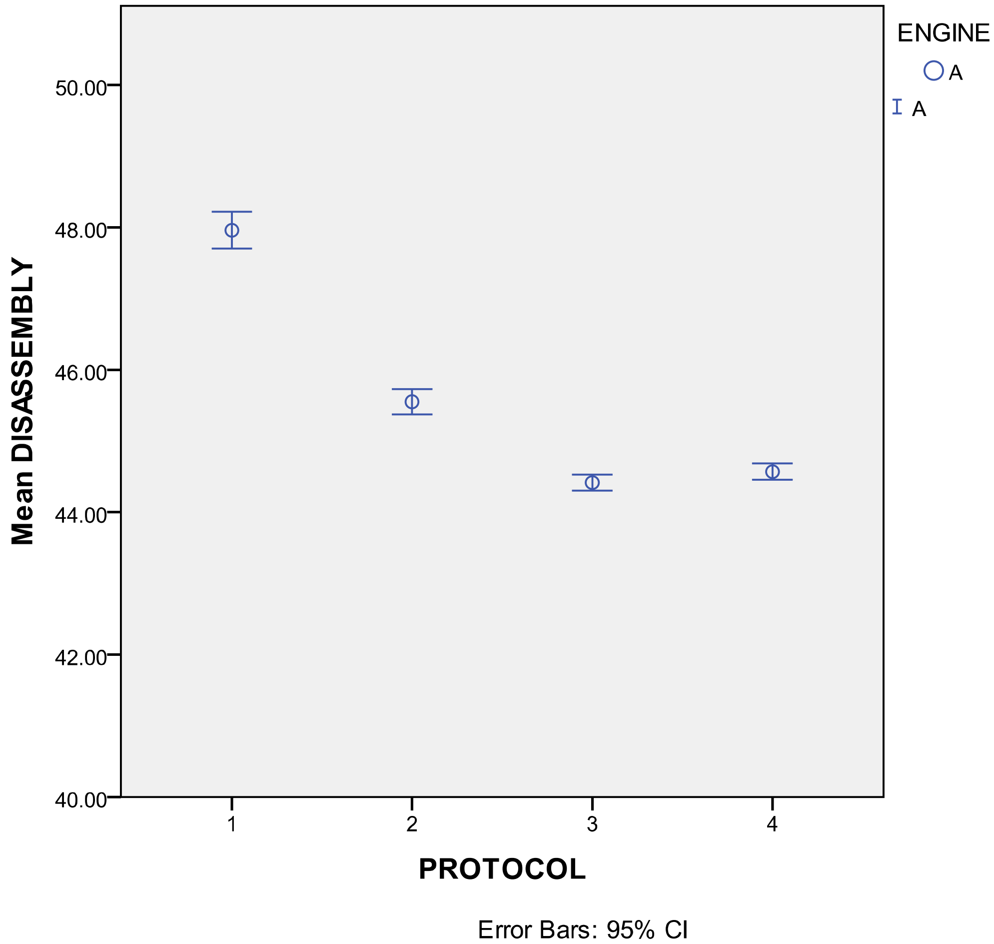
ANOVA

INSPECT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	30418.467	3	10139.489	39057.428	.000
Within Groups	272.325	1049	.260		
Total	30690.792	1052			

Cylinder Block

x-axis = protocol, y-axis = time in minutes



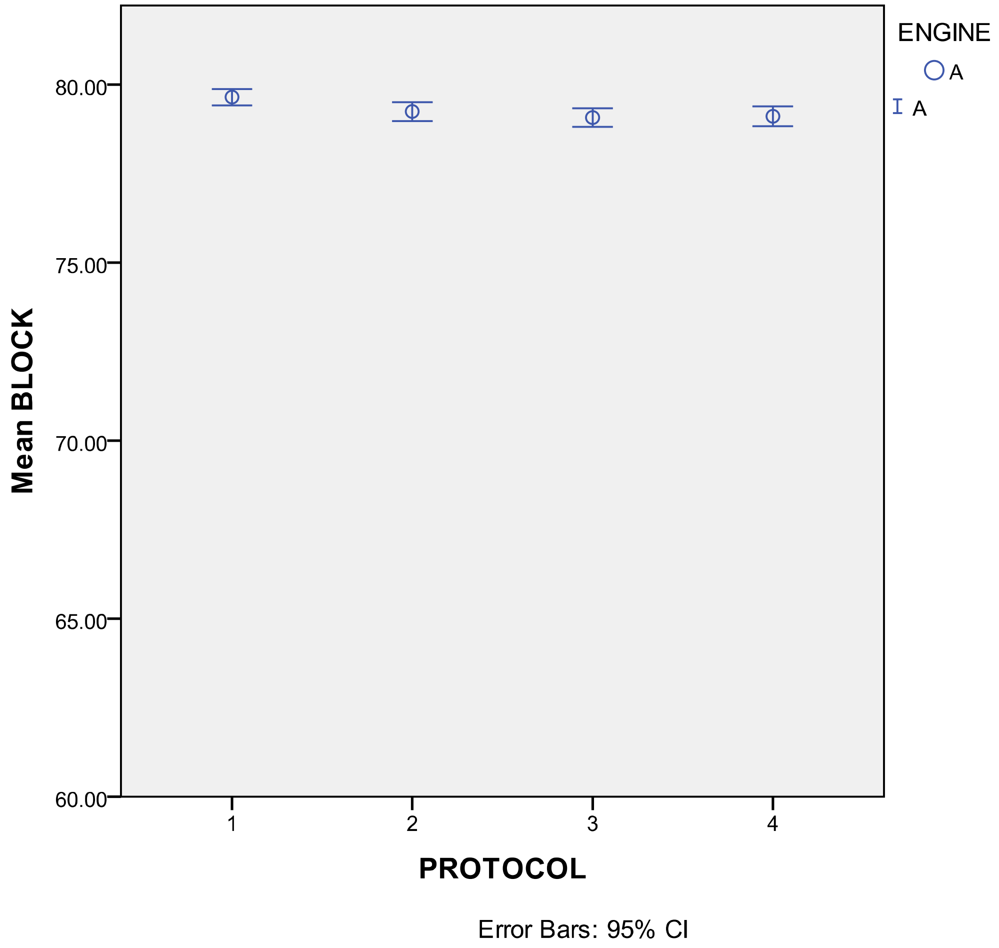
ANOVA

DISASSEMBLY

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2114.546	3	704.849	335.187	.000
Within Groups	2205.891	1049	2.103		
Total	4320.437	1052			

Cylinder Block

x-axis = protocol, y-axis = time in minutes



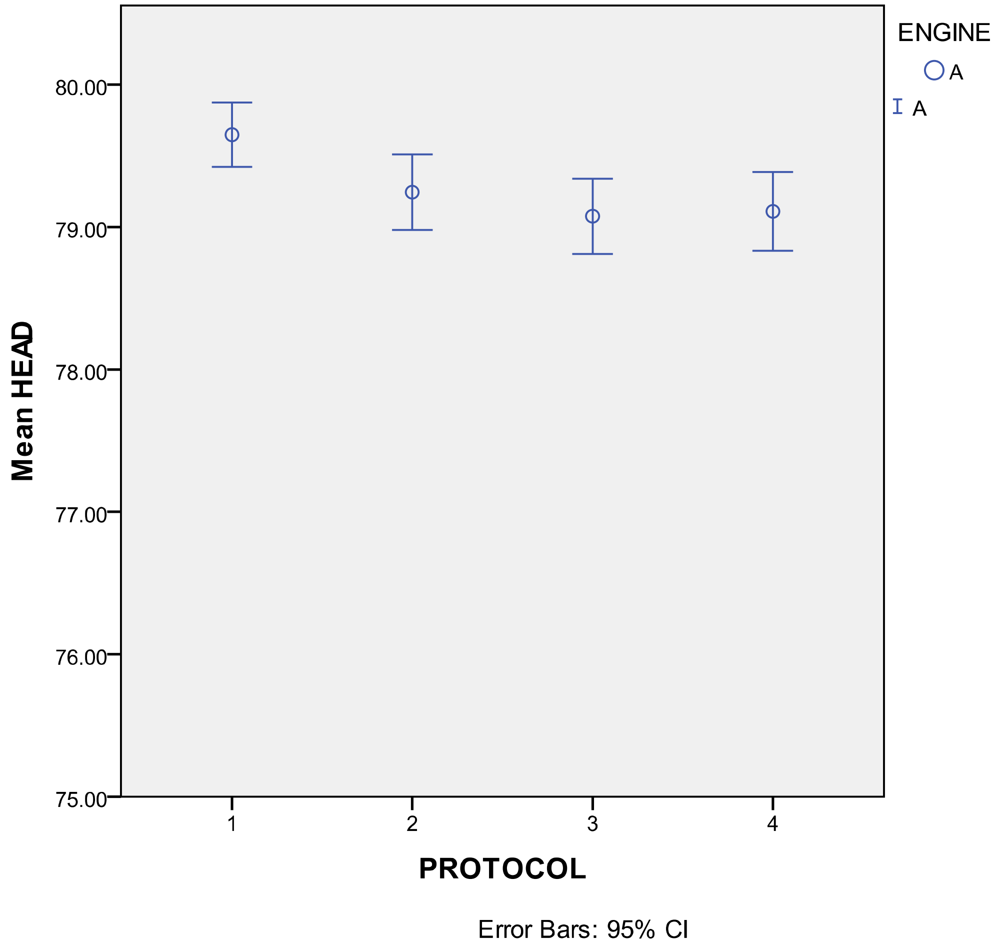
ANOVA

BLOCK

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	54.475	3	18.158	3.994	.008
Within Groups	4769.377	1049	4.547		
Total	4823.852	1052			

Cylinder Head

x-axis = protocol, y-axis = time in minutes



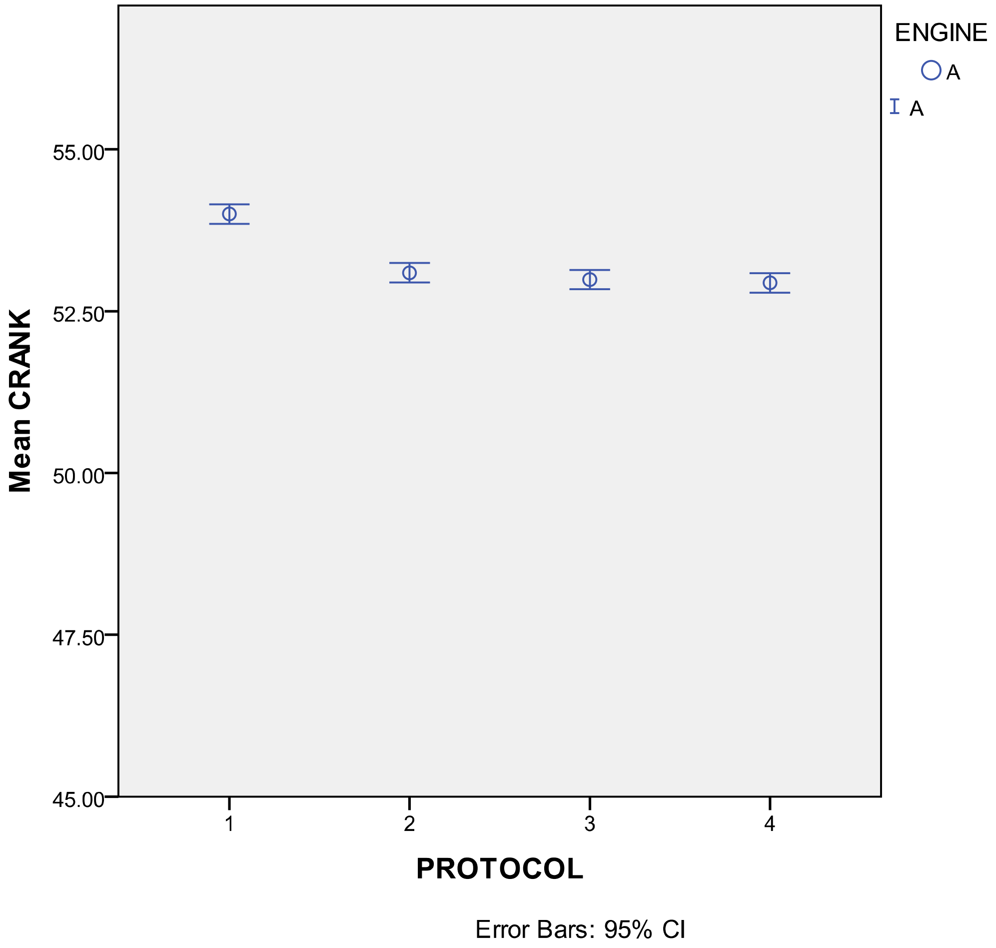
ANOVA

HEAD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	54.475	3	18.158	3.994	.008
Within Groups	4769.377	1049	4.547		
Total	4823.852	1052			

Crankshaft

x-axis = protocol, y-axis = time in minutes



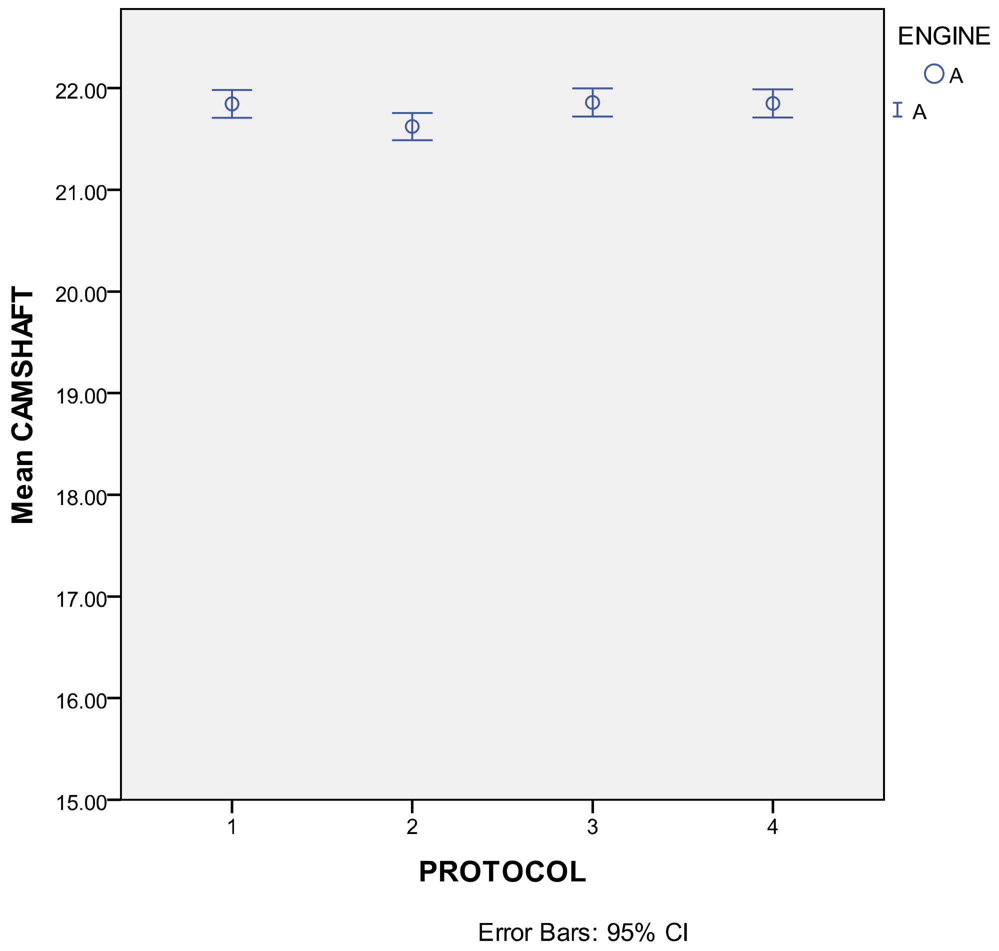
ANOVA

CRANK

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	198.548	3	66.183	42.919	.000
Within Groups	1617.592	1049	1.542		
Total	1816.140	1052			

Camshafts

x-axis = protocol, y-axis = time in minutes



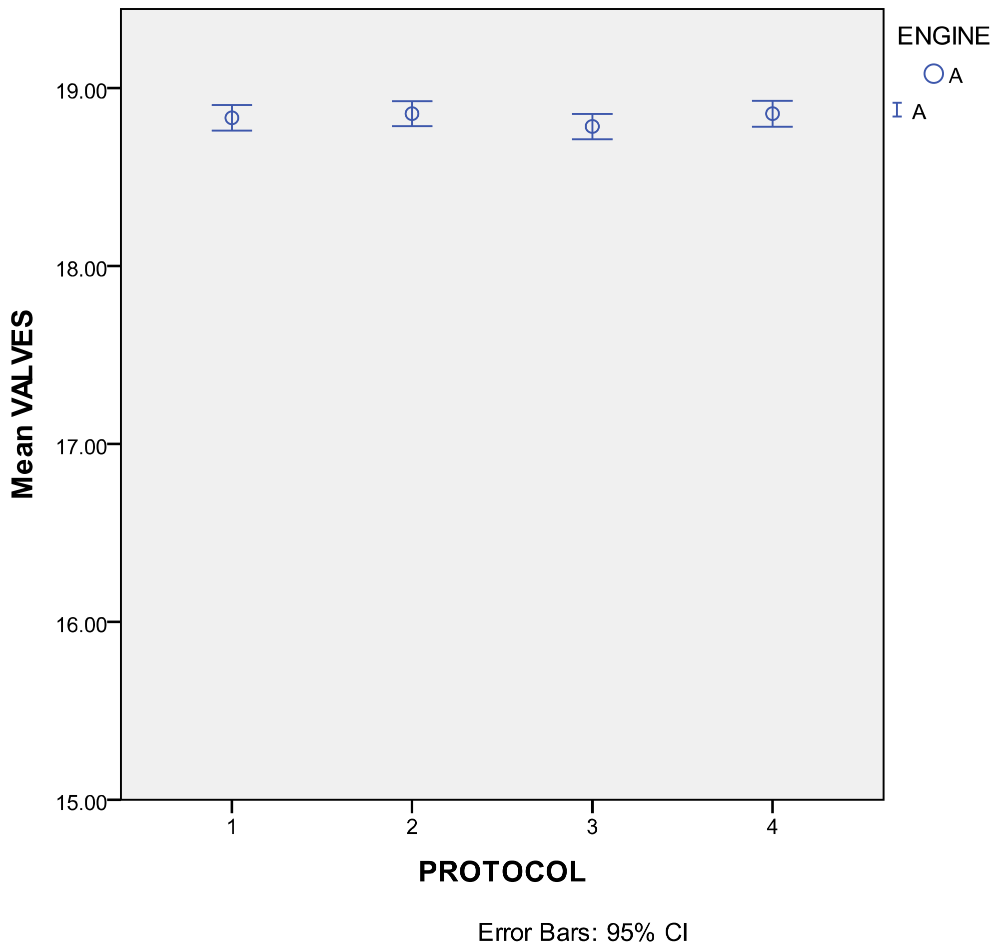
ANOVA

CAMSHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.494	3	2.165	1.683	.169
Within Groups	1348.833	1049	1.286		
Total	1355.326	1052			

Valves

x-axis = protocol, y-axis = time in minutes



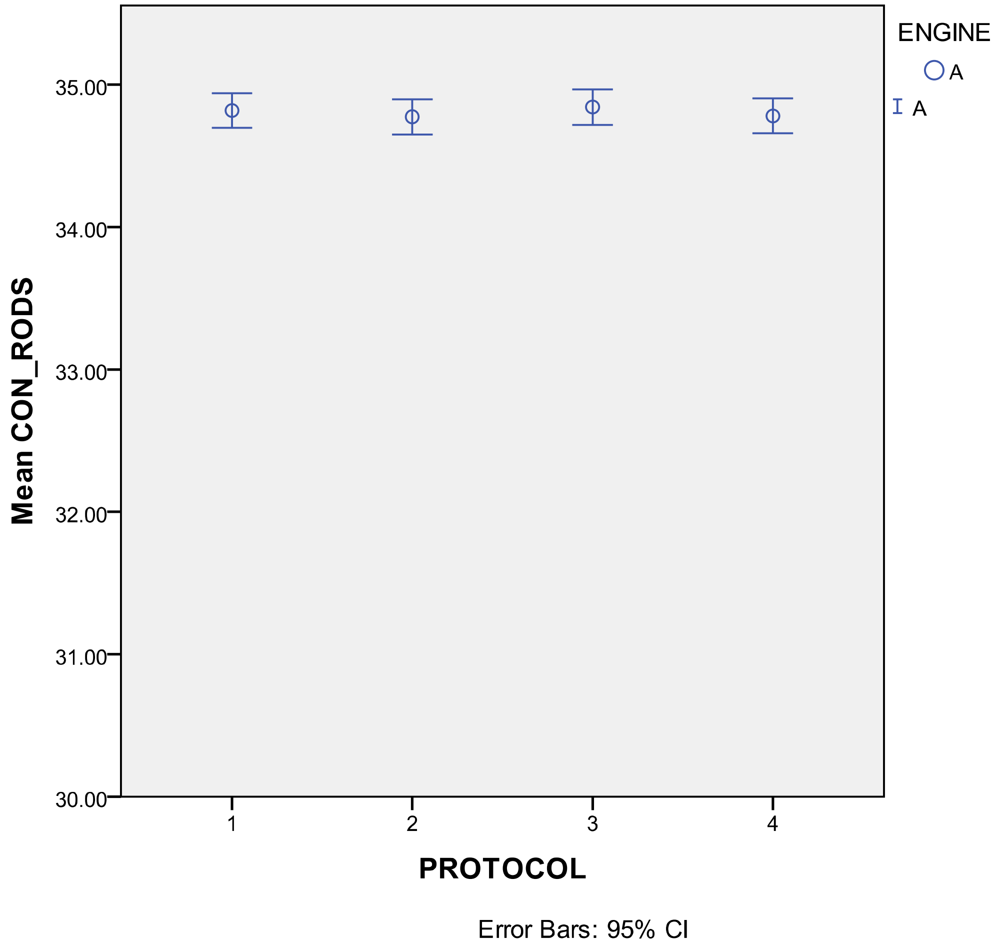
ANOVA

VALVES

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.909	3	.303	.874	.454
Within Groups	363.500	1049	.347		
Total	364.408	1052			

Con-Rods

x-axis = protocol, y-axis = time in minutes



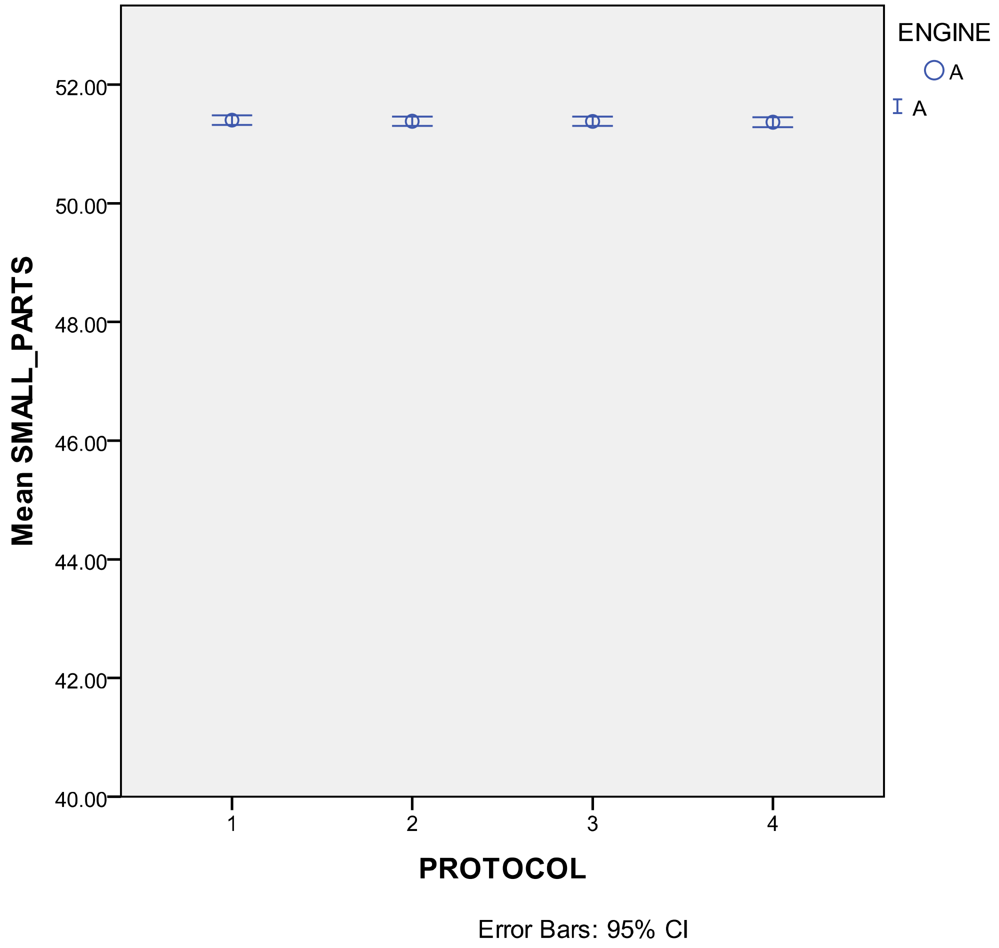
ANOVA

CON_RODS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.813	3	.271	.263	.852
Within Groups	1081.047	1049	1.031		
Total	1081.859	1052			

Small Parts

x-axis = protocol, y-axis = time in minutes



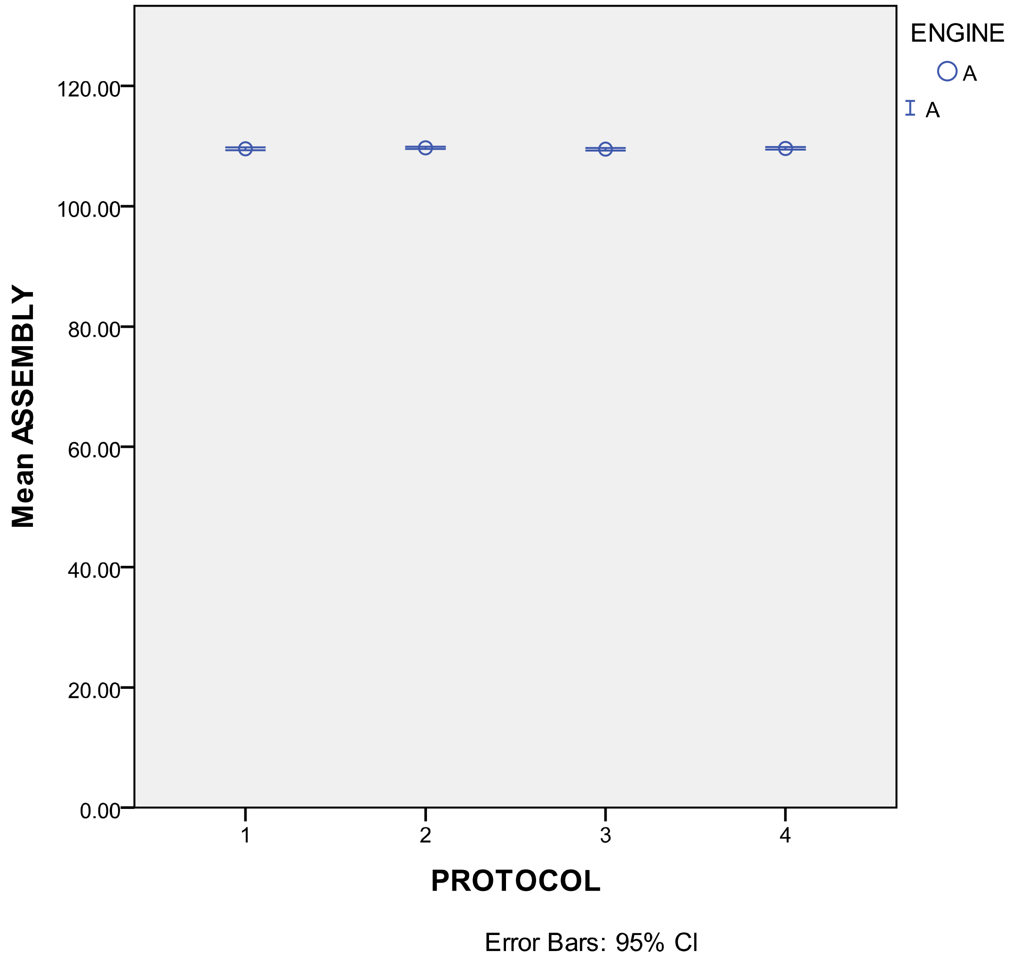
ANOVA

SMALL_PARTS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.170	3	.057	.128	.943
Within Groups	461.794	1049	.440		
Total	461.963	1052			

Engine Assembly

x-axis = protocol, y-axis = time in minutes



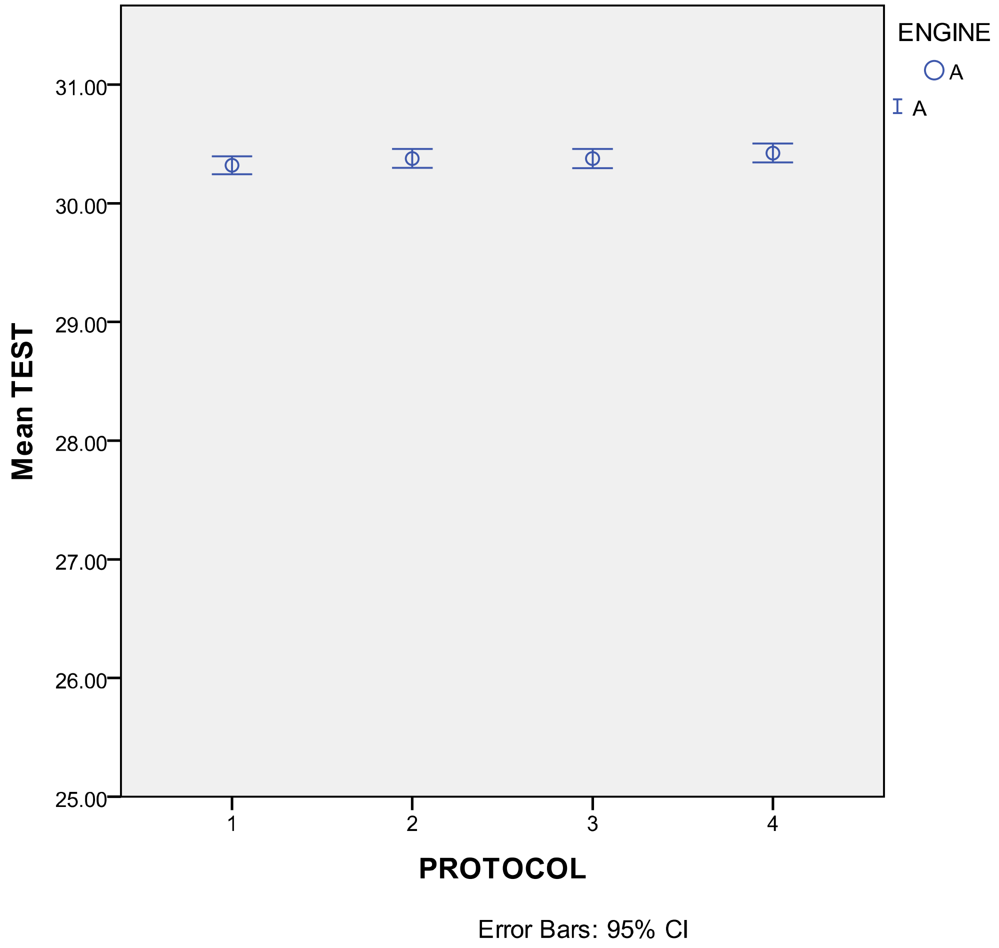
ANOVA

ASSEMBLY

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.704	3	2.568	.823	.481
Within Groups	3274.644	1049	3.122		
Total	3282.348	1052			

Post-Production Test

x-axis = protocol, y-axis = time in minutes



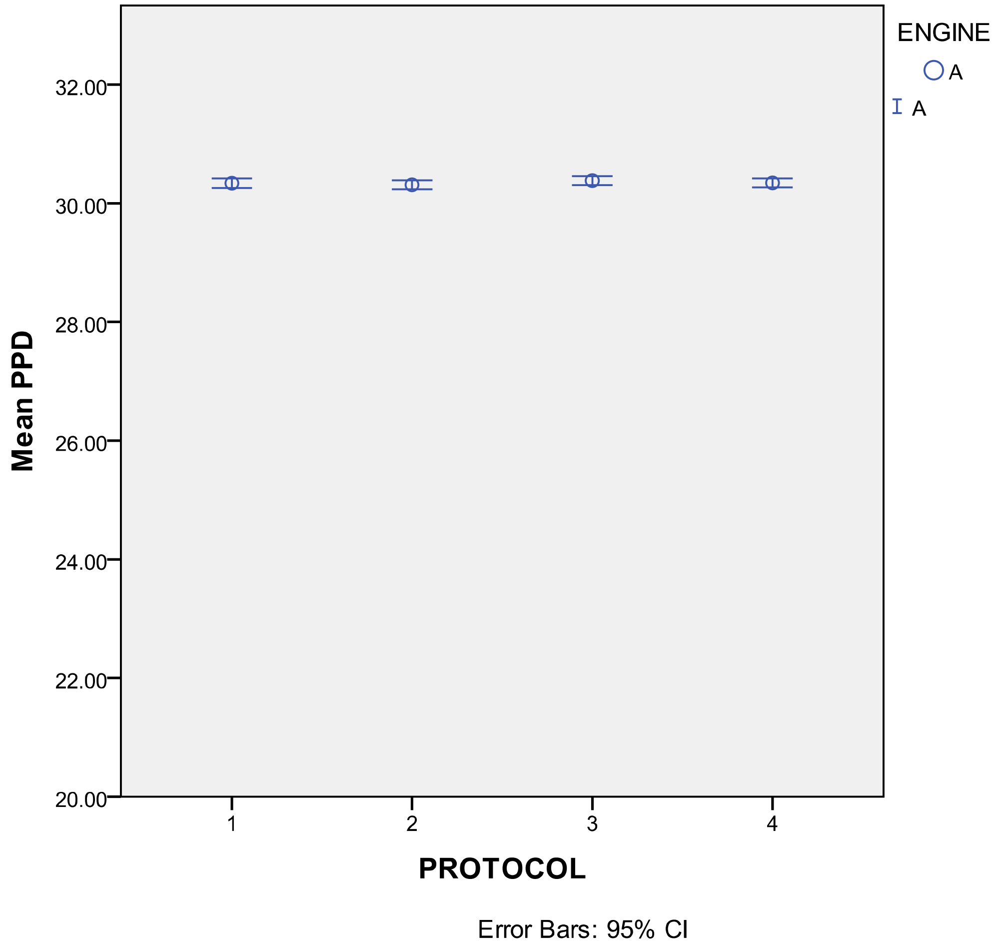
ANOVA

TEST

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.403	3	.468	1.084	.355
Within Groups	452.407	1049	.431		
Total	453.811	1052			

Paint, Pack and Despatch

x-axis = protocol, y-axis = time in minutes



ANOVA

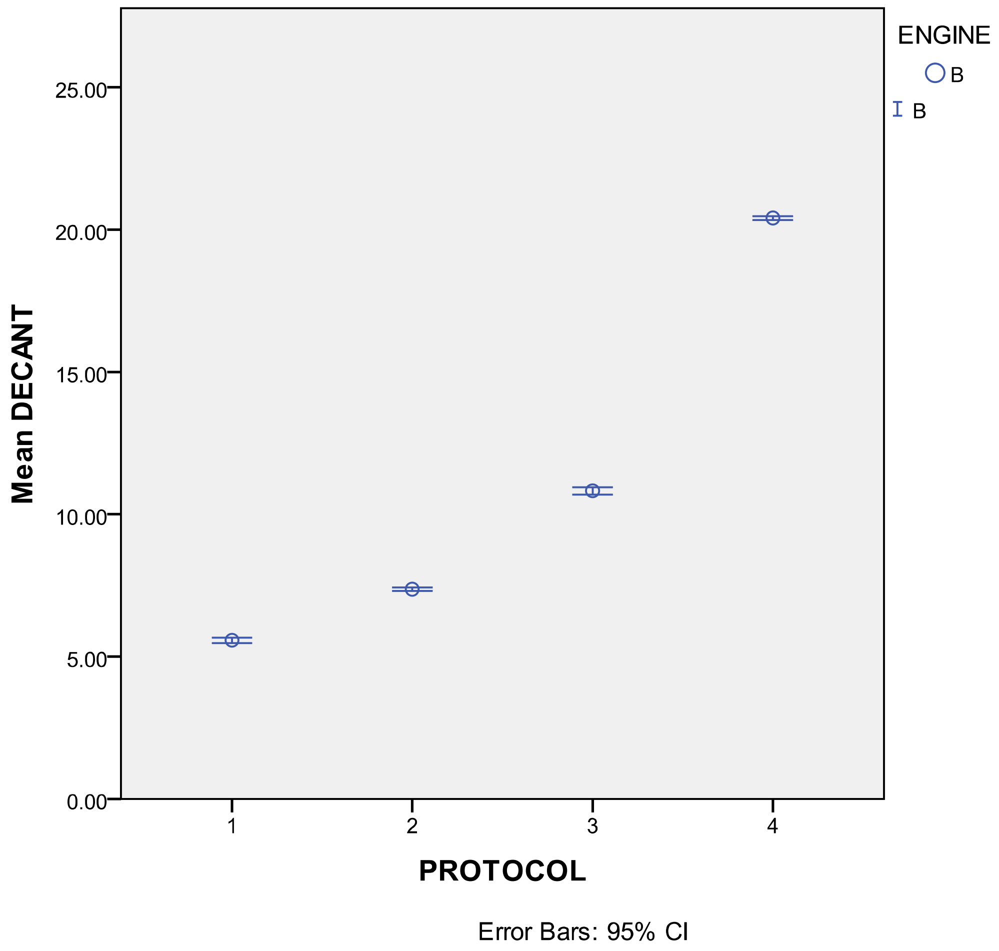
PPD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.658	3	.219	.530	.662
Within Groups	433.869	1049	.414		
Total	434.527	1052			

By Engine, Engine B

Decant and Inspect

x-axis = protocol, y-axis = time in minutes



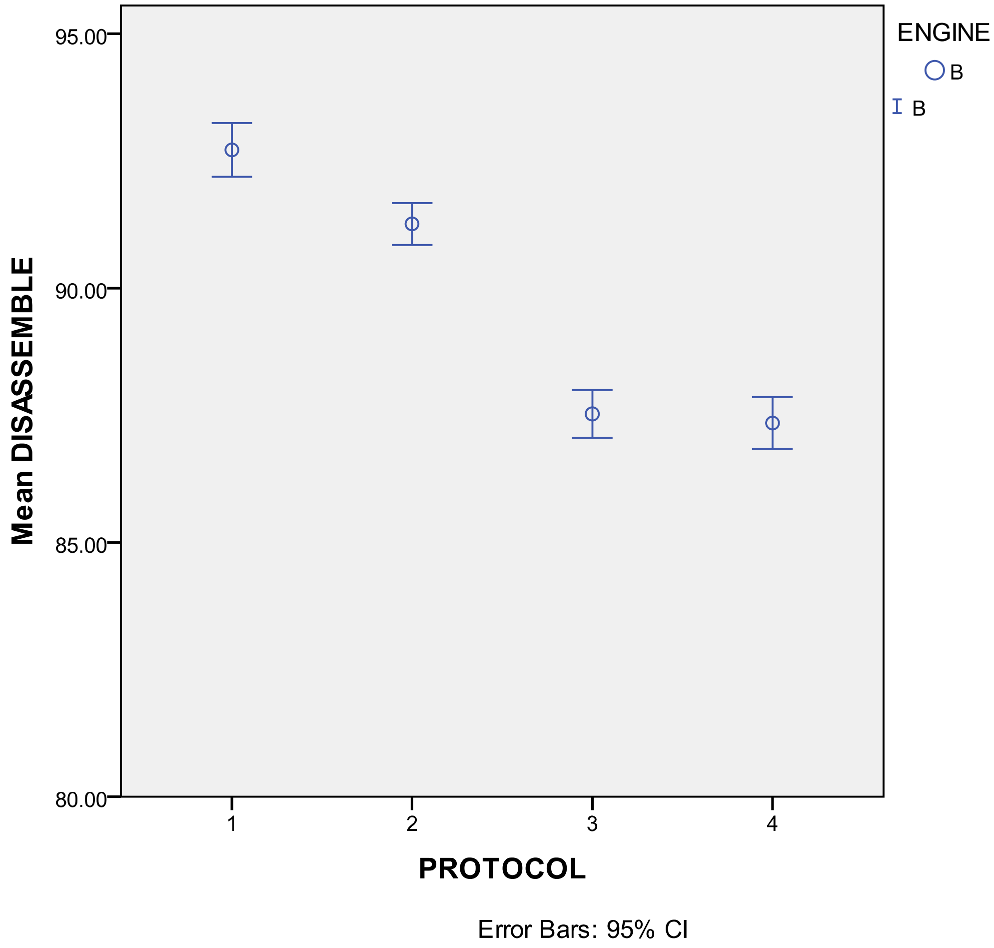
ANOVA

DECANT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13426.142	3	4475.381	20054.215	.000
Within Groups	90.828	407	.223		
Total	13516.970	410			

Disassembly

x-axis = protocol, y-axis = time in minutes



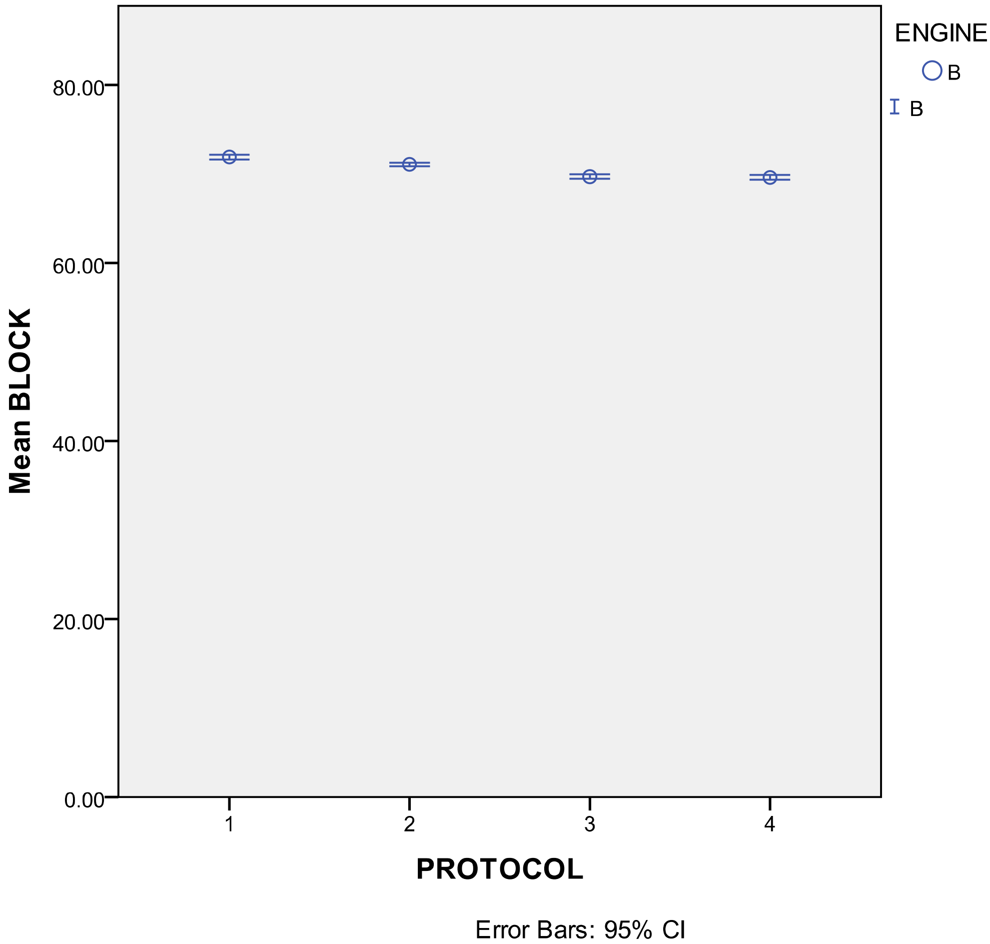
ANOVA

DISASSEMBLE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2240.222	3	746.741	123.248	.000
Within Groups	2465.945	407	6.059		
Total	4706.167	410			

Cylinder Block

x-axis = protocol, y-axis = time in minutes



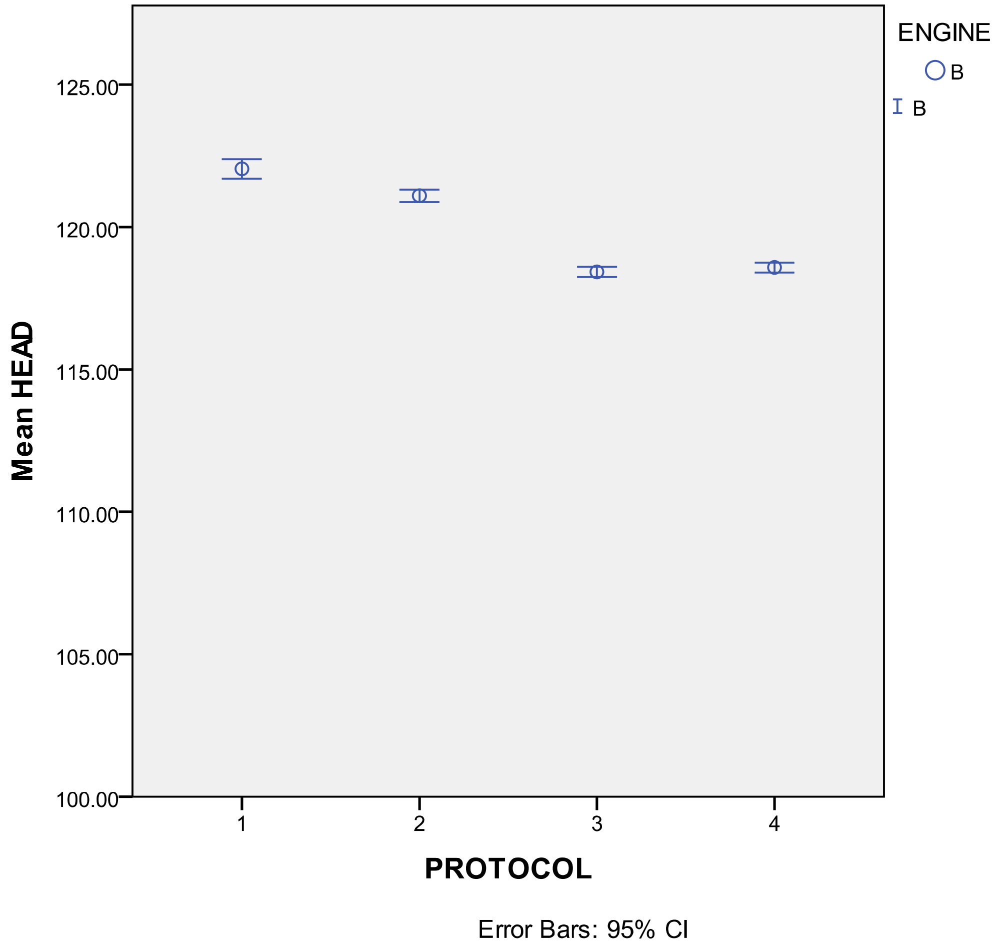
ANOVA

BLOCK

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	380.947	3	126.982	79.633	.000
Within Groups	649.002	407	1.595		
Total	1029.949	410			

Cylinder Head

x-axis = protocol, y-axis = time in minutes



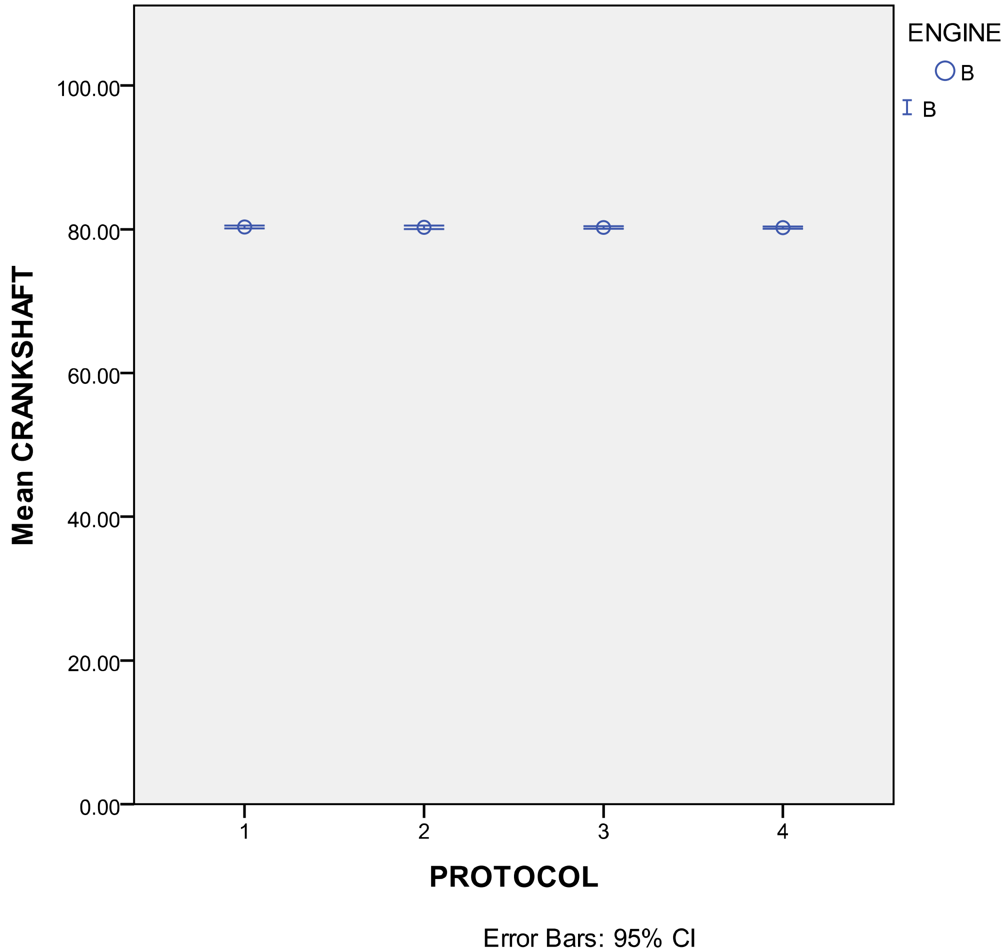
ANOVA

HEAD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1015.741	3	338.580	228.382	.000
Within Groups	603.384	407	1.483		
Total	1619.125	410			

Crankshaft

x-axis = protocol, y-axis = time in minutes



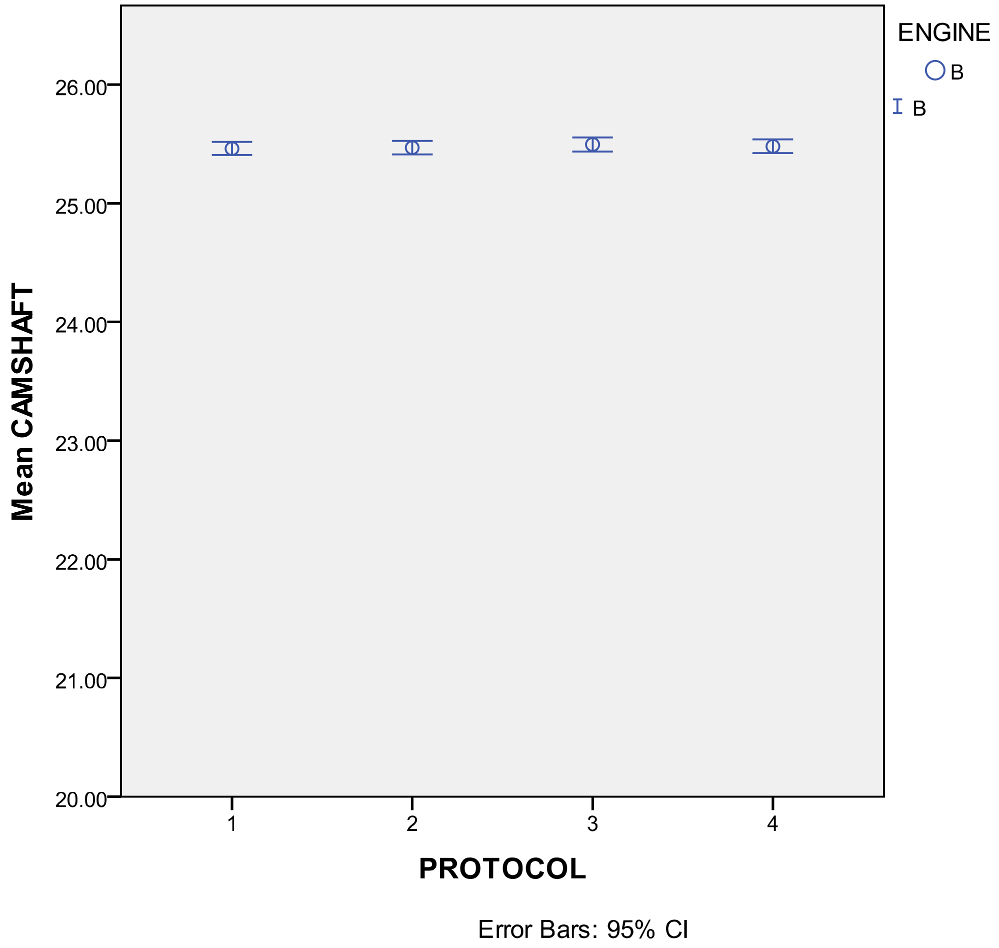
ANOVA

CRANKSHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.576	3	.192	.170	.914
Within Groups	460.185	407	1.131		
Total	460.761	410			

Camshaft

x-axis = protocol, y-axis = time in minutes



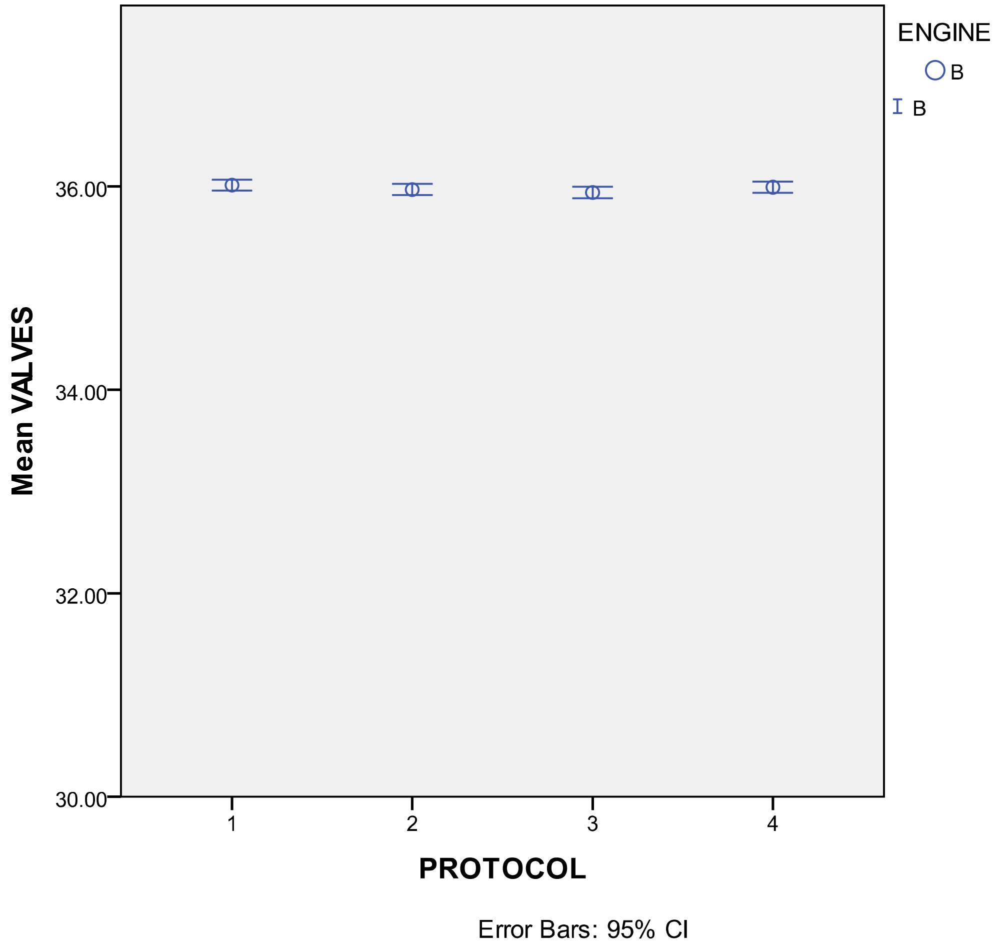
ANOVA

CAMSHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.069	3	.023	.266	.850
Within Groups	34.987	407	.086		
Total	35.055	410			

Valves

x-axis = protocol, y-axis = time in minutes



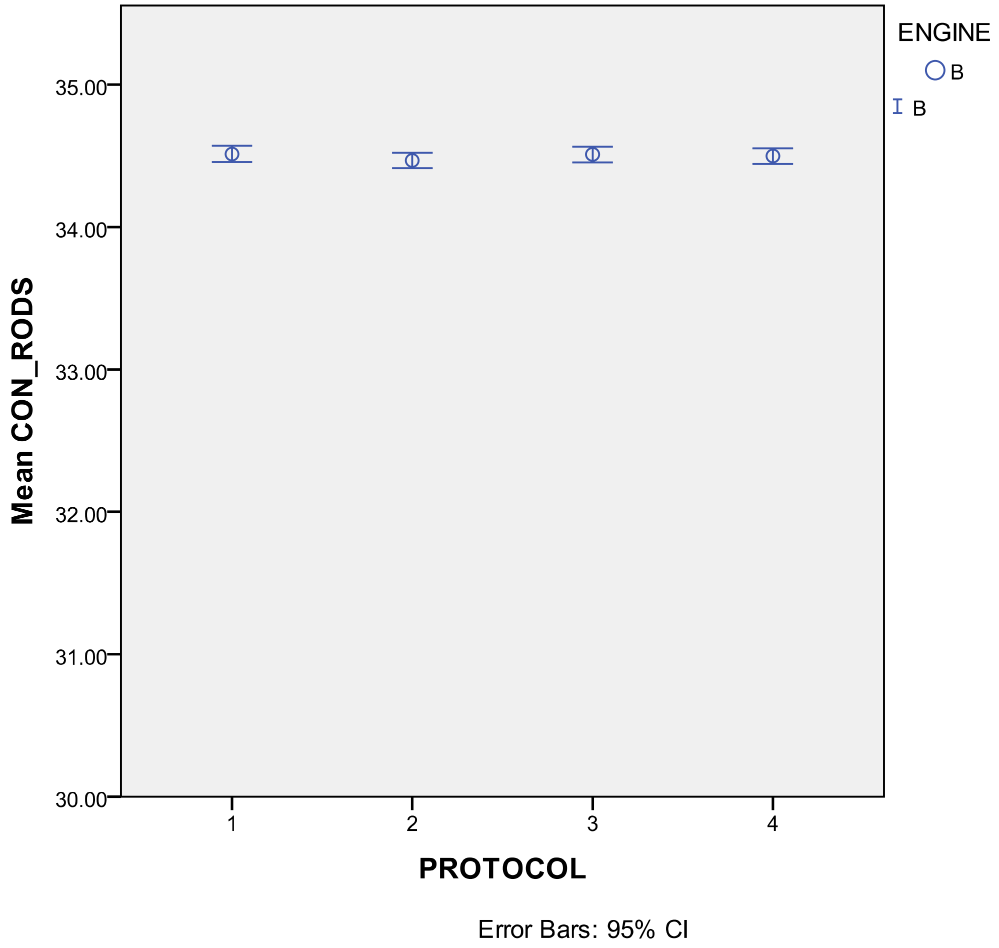
ANOVA

VALVES

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.290	3	.097	1.223	.301
Within Groups	32.214	407	.079		
Total	32.505	410			

Con-Rods

x-axis = protocol, y-axis = time in minutes



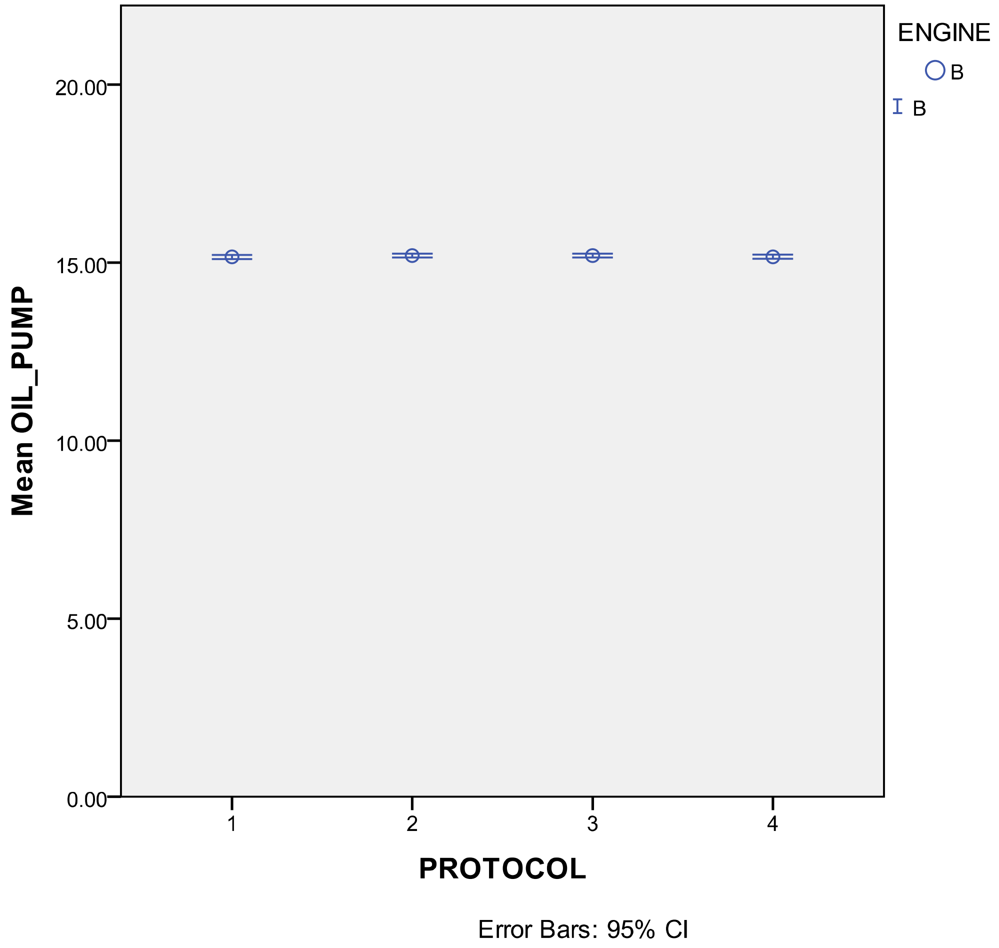
ANOVA

CON_RODS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.131	3	.044	.550	.649
Within Groups	32.354	407	.079		
Total	32.485	410			

Oil Pump

x-axis = protocol, y-axis = time in minutes



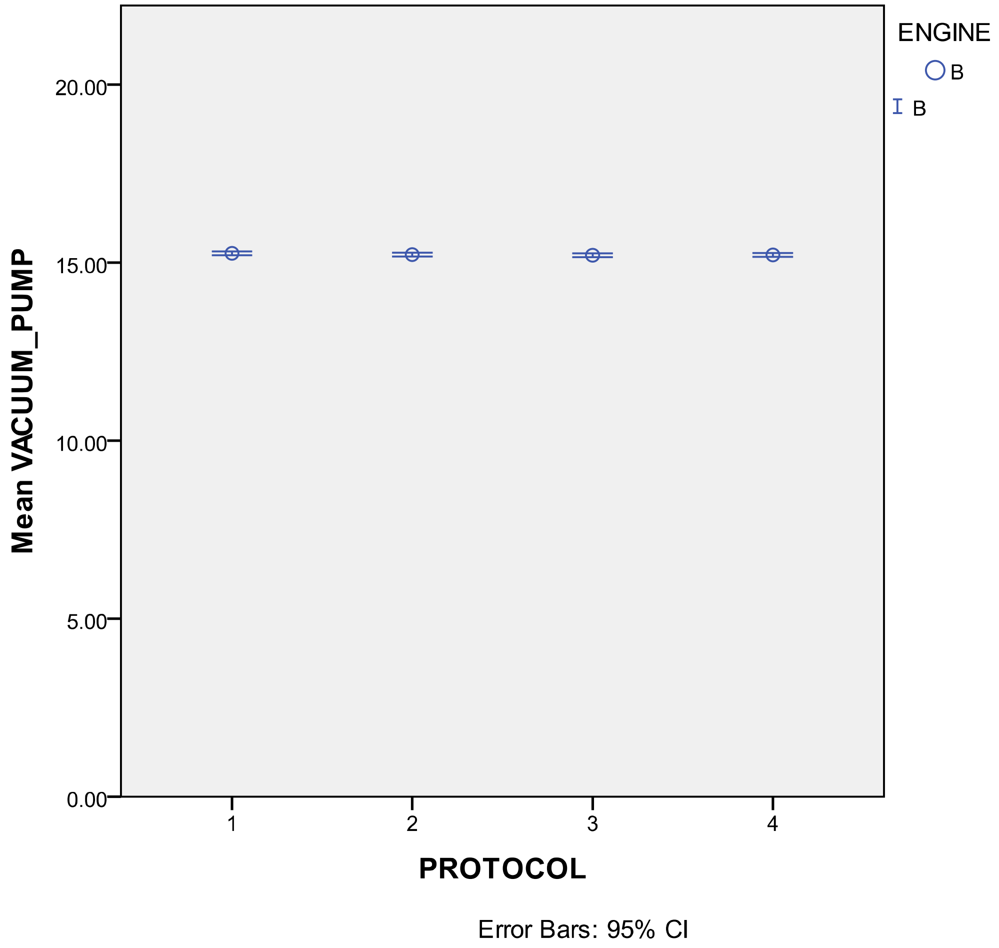
ANOVA

OIL_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.127	3	.042	.539	.656
Within Groups	31.971	407	.079		
Total	32.098	410			

Vacuum Pump

x-axis = protocol, y-axis = time in minutes



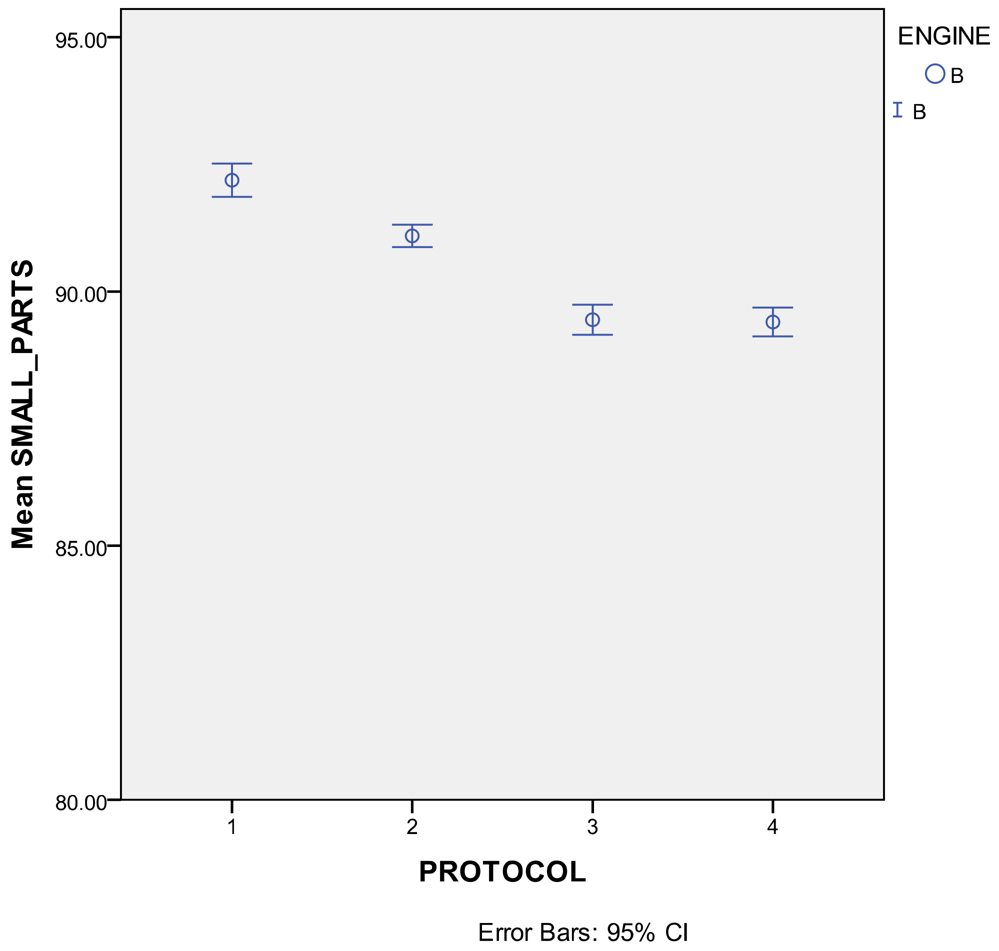
ANOVA

VACUUM_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.188	3	.063	.791	.500
Within Groups	32.231	407	.079		
Total	32.418	410			

Small Parts

x-axis = protocol, y-axis = time in minutes



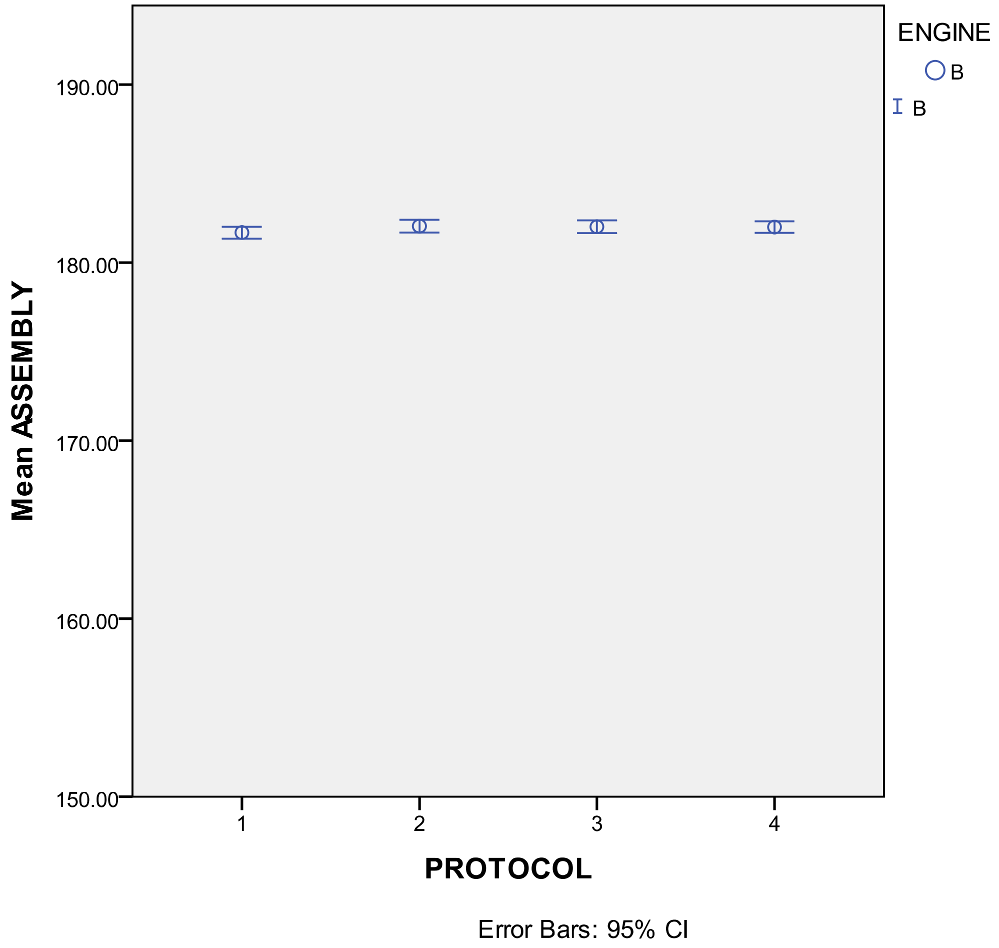
ANOVA

SMALL_PARTS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	567.705	3	189.235	89.705	.000
Within Groups	858.579	407	2.110		
Total	1426.283	410			

Assembly

x-axis = protocol, y-axis = time in minutes



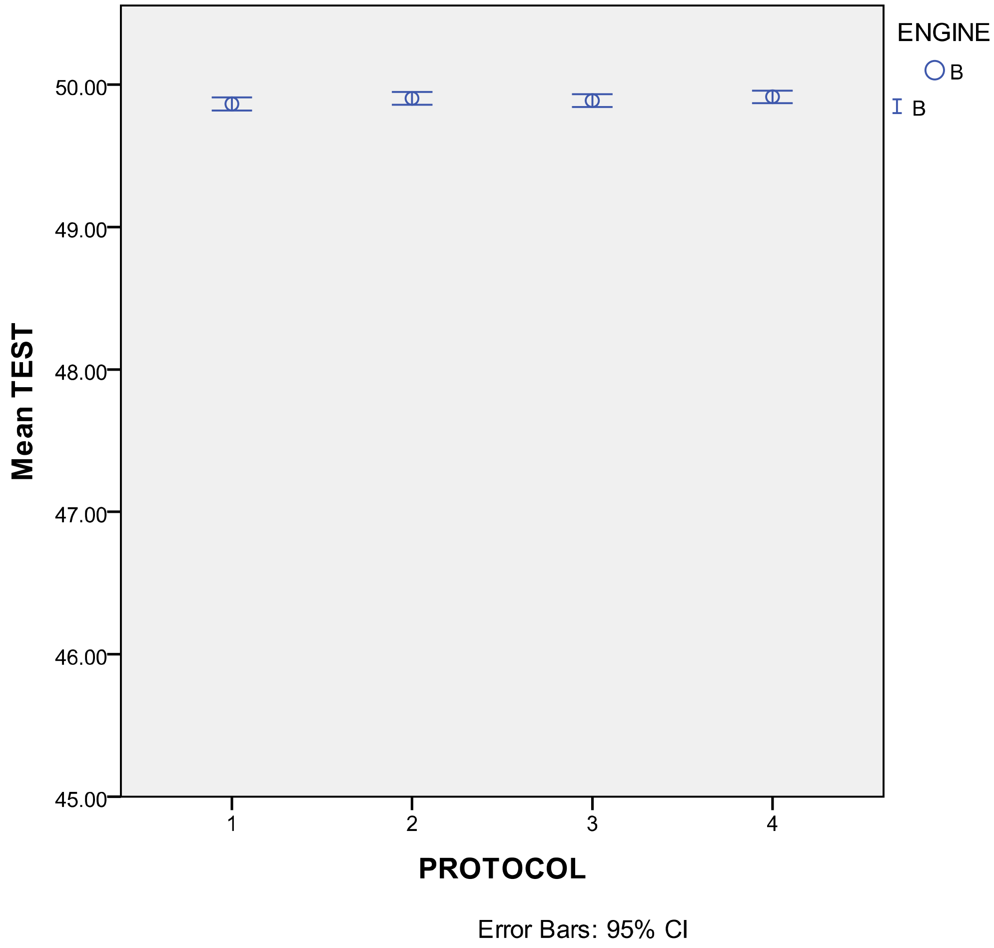
ANOVA

ASSEMBLY

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.914	3	2.971	.972	.406
Within Groups	1244.188	407	3.057		
Total	1253.103	410			

Test

x-axis = protocol, y-axis = time in minutes



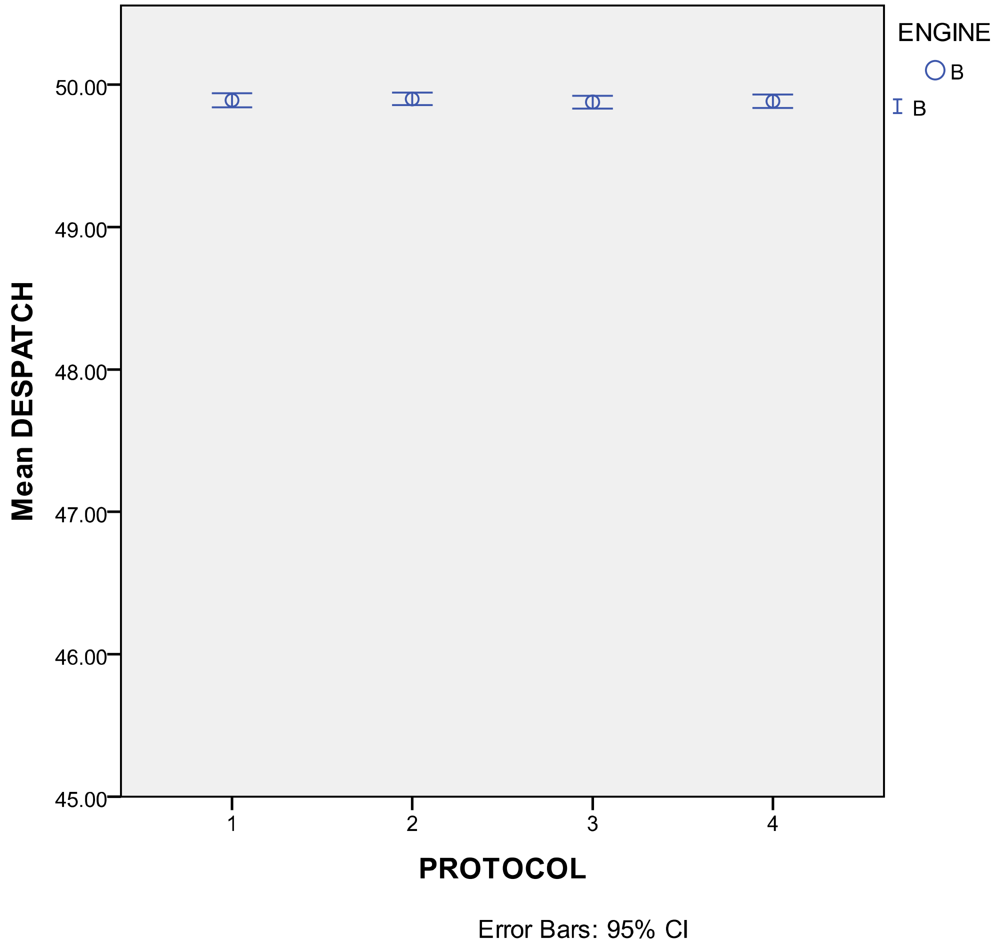
ANOVA

TEST

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.145	3	.048	.941	.421
Within Groups	20.947	407	.051		
Total	21.092	410			

PPD

x-axis = protocol, y-axis = time in minutes



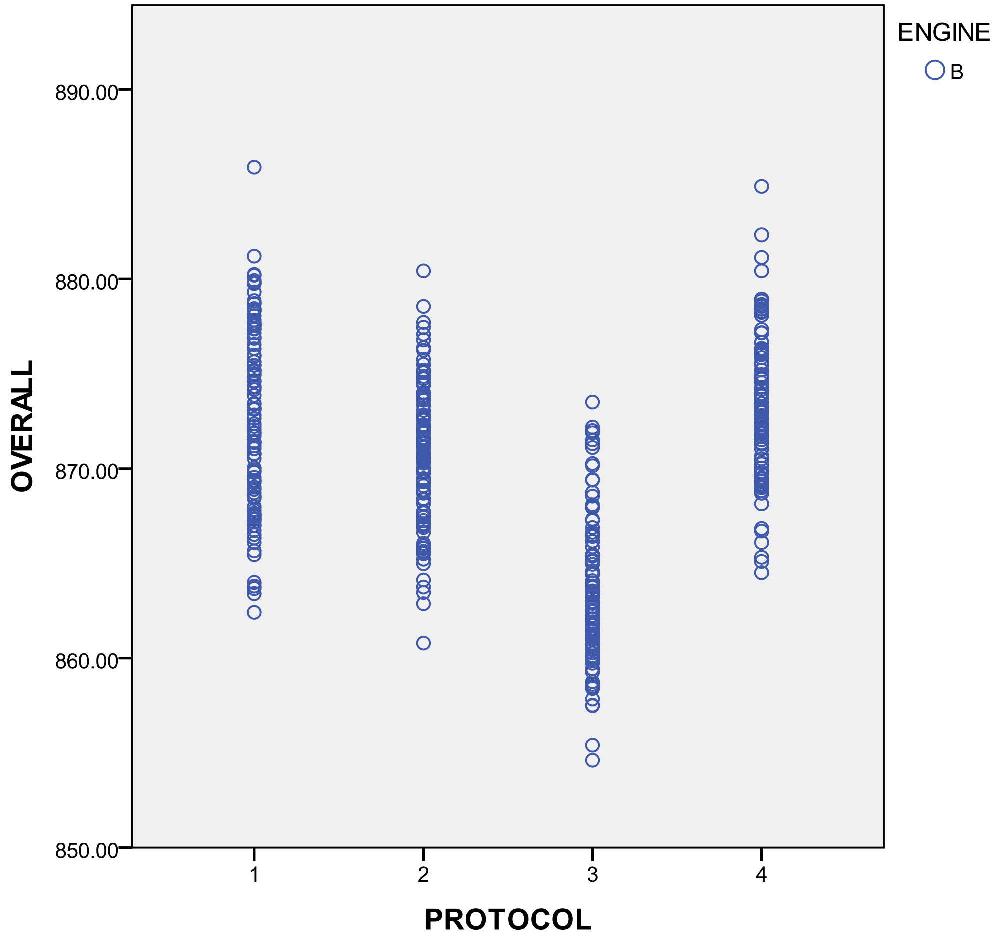
ANOVA

DESPATCH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.028	3	.009	.167	.918
Within Groups	22.936	407	.056		
Total	22.965	410			

Overall B

x-axis = protocol, y-axis = time in minutes



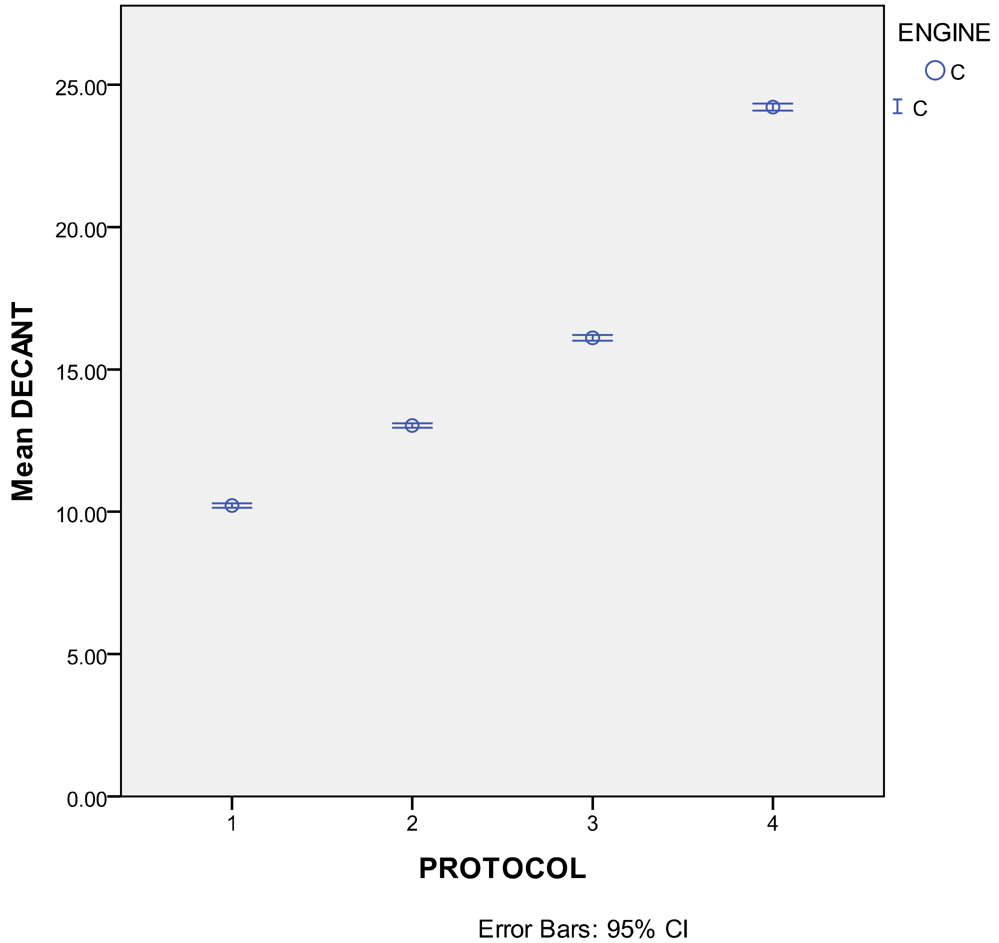
ANOVA

OVERALL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5884.232	3	1961.411	116.230	.000
Within Groups	6868.214	407	16.875		
Total	12752.446	410			

By Engine, Engine C

Decant and Inspect



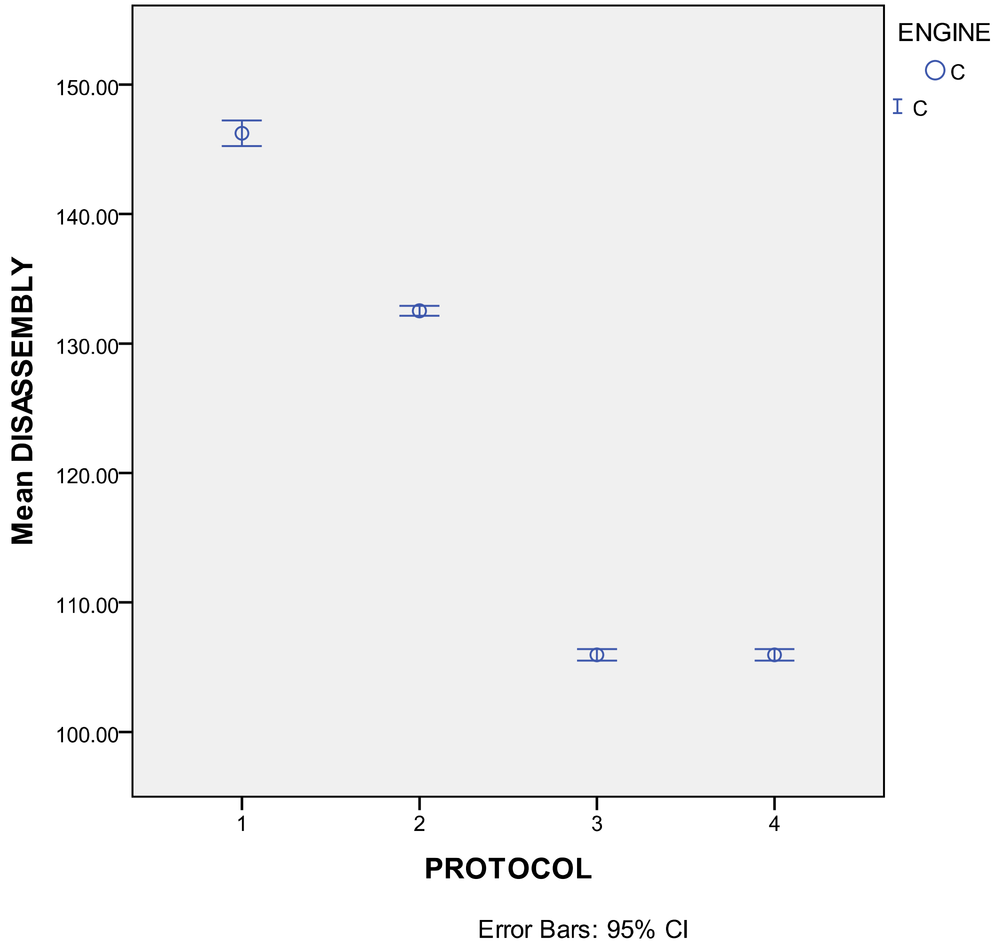
ANOVA

DECANT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11558.597	3	3852.866	15866.294	.000
Within Groups	101.019	416	.243		
Total	11659.615	419			

Disassembly

x-axis = protocol, y-axis = time in minutes



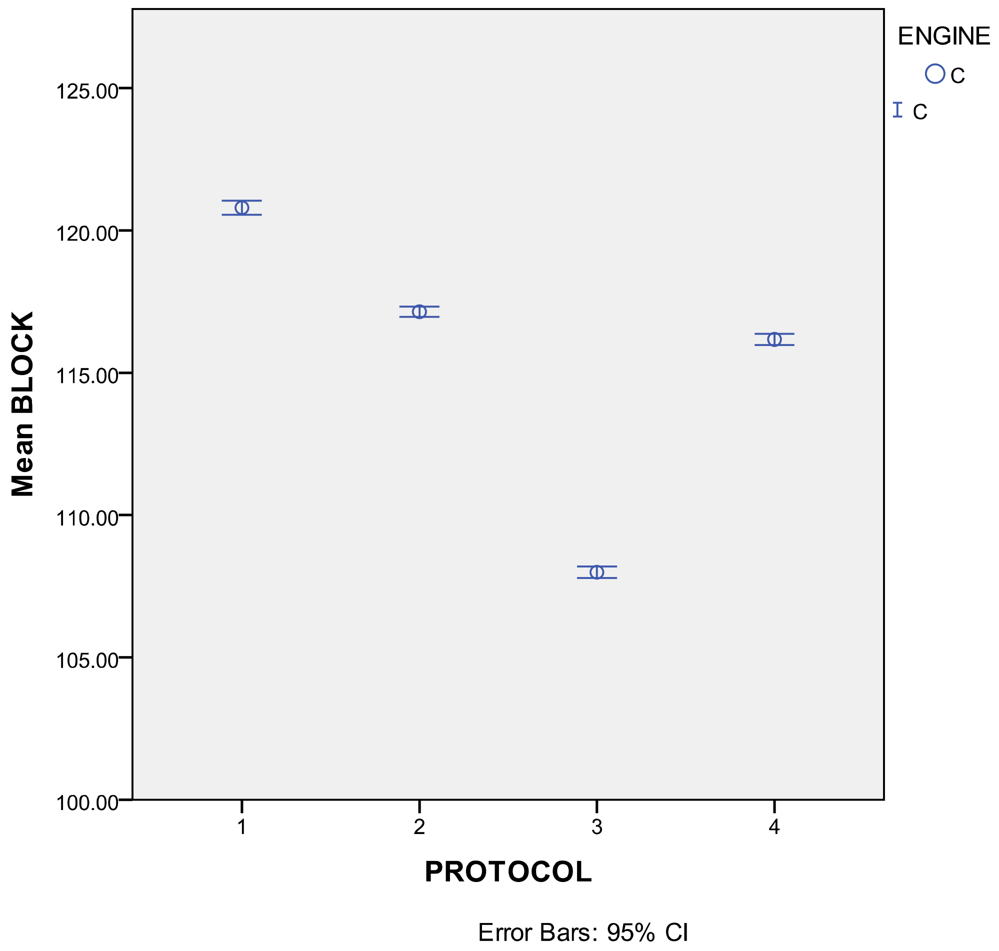
ANOVA

DISASSEMBLY

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	127012.902	3	42337.634	4124.573	.000
Within Groups	4270.128	416	10.265		
Total	131283.030	419			

Cylinder Block

x-axis = protocol, y-axis = time in minutes



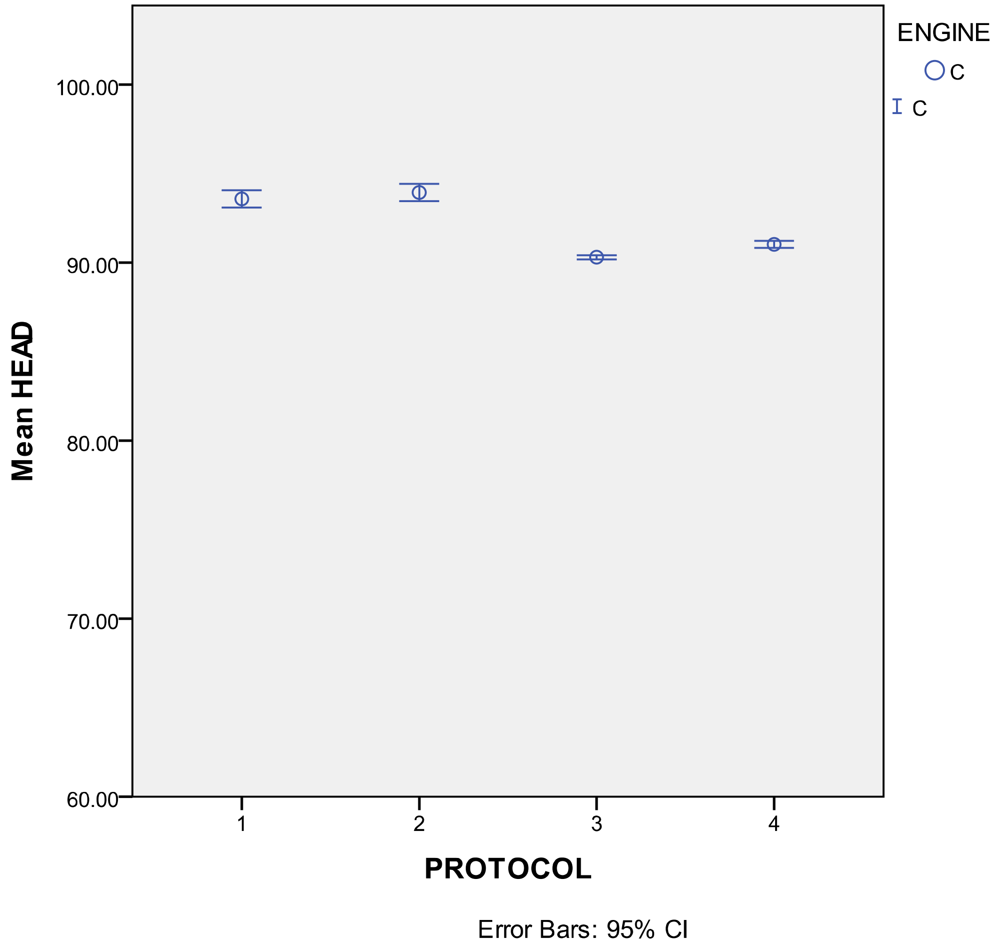
ANOVA

BLOCK

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9170.988	3	3056.996	2603.591	.000
Within Groups	488.445	416	1.174		
Total	9659.433	419			

Cylinder Head

x-axis = protocol, y-axis = time in minutes



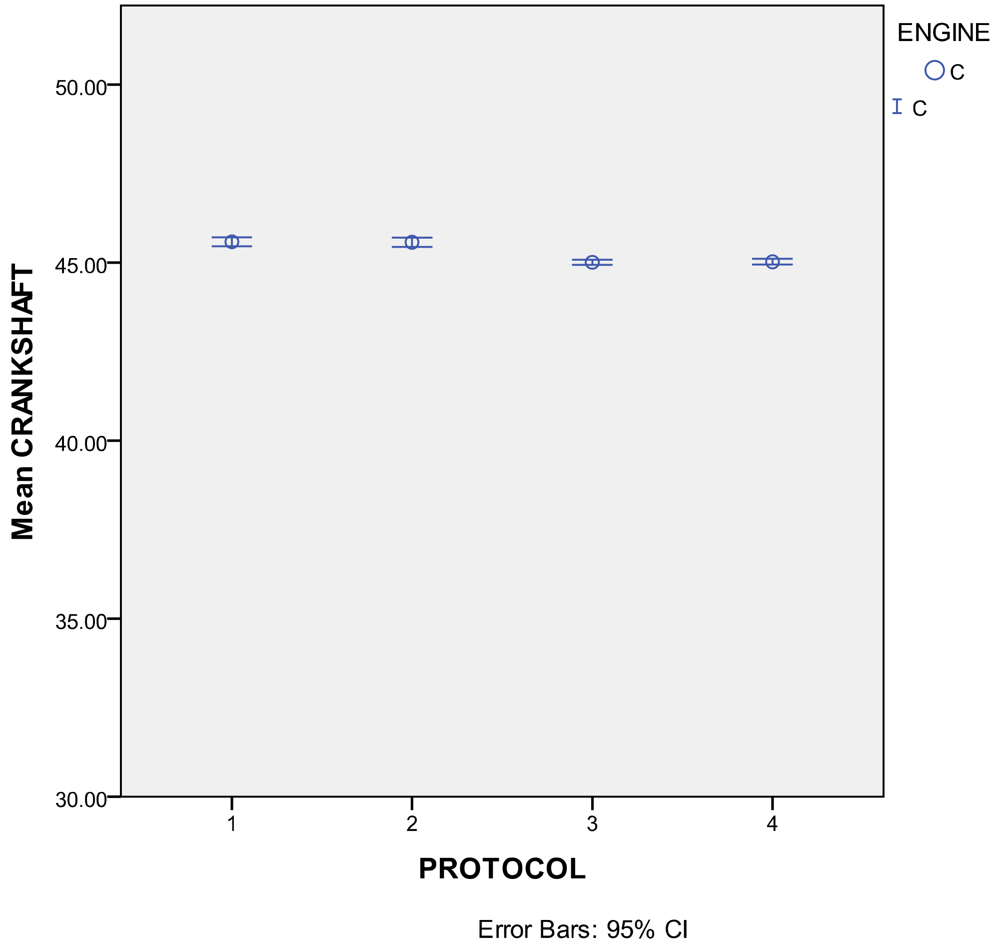
ANOVA

HEAD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1041.182	3	347.061	99.446	.000
Within Groups	1451.809	416	3.490		
Total	2492.991	419			

Crankshaft

x-axis = protocol, y-axis = time in minutes



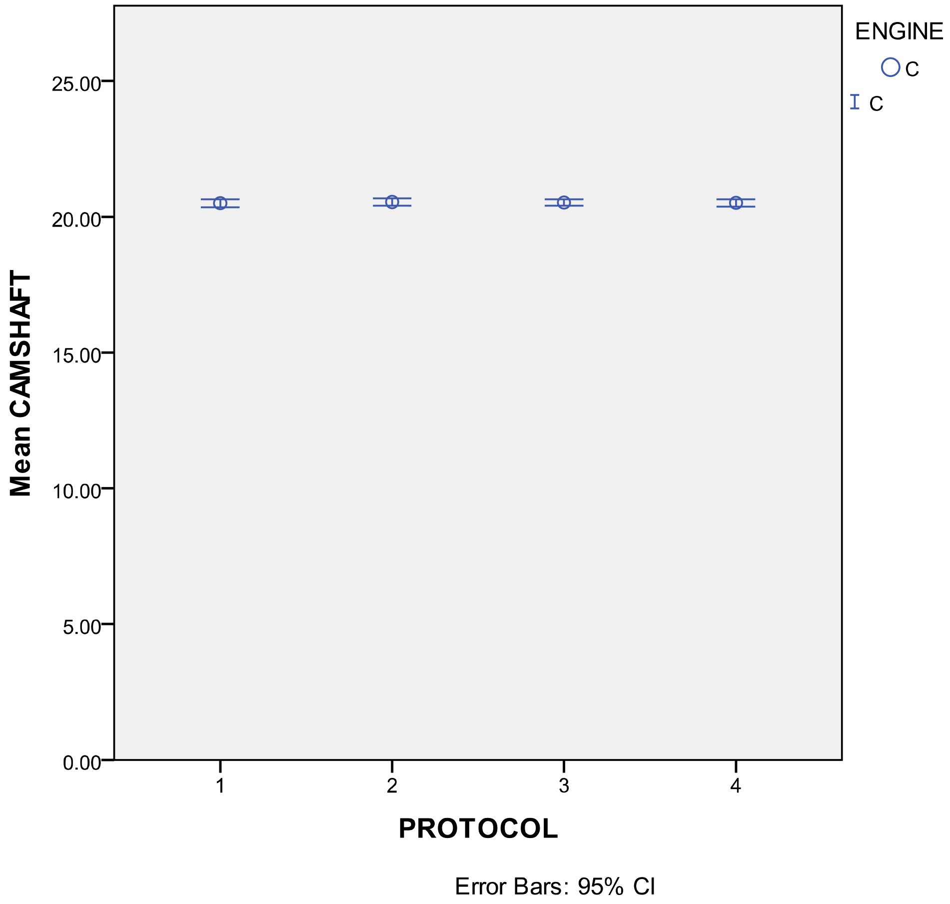
ANOVA

CRANKSHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.117	3	11.039	36.474	.000
Within Groups	125.902	416	.303		
Total	159.019	419			

Camshaft

x-axis = protocol, y-axis = time in minutes



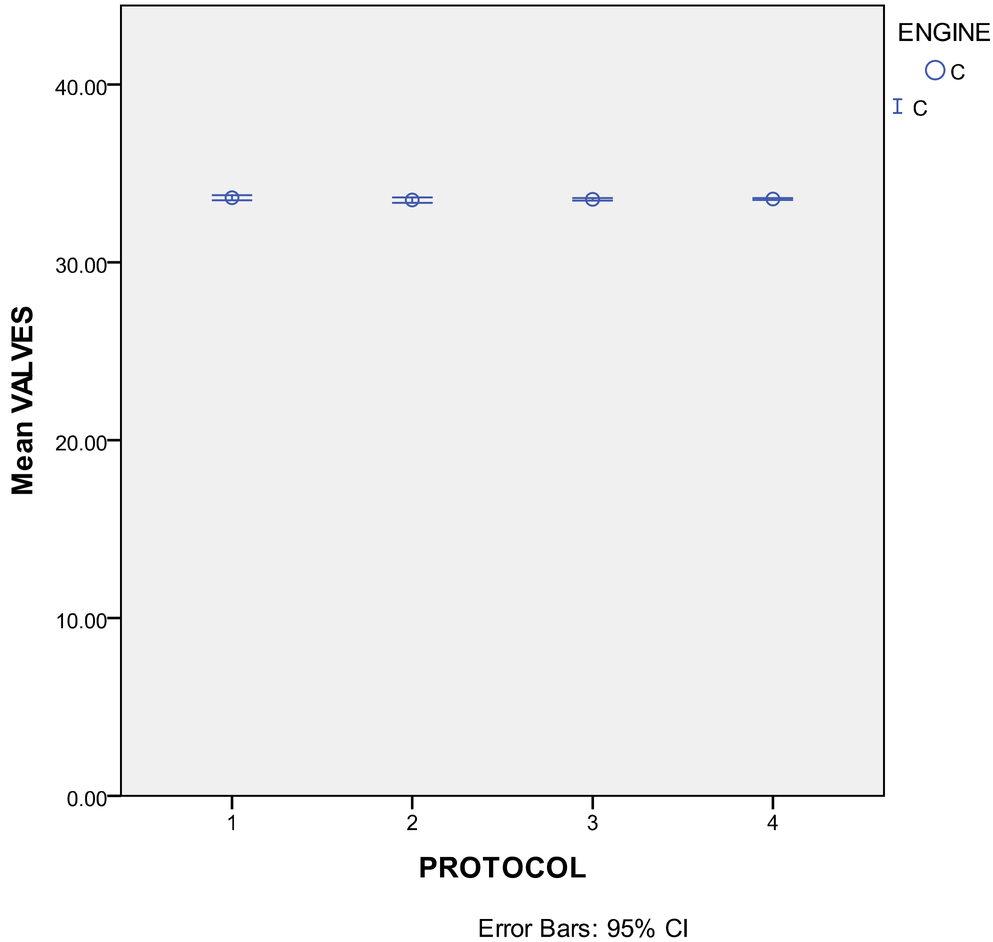
ANOVA

CAMSHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.114	3	.038	.079	.972
Within Groups	200.530	416	.482		
Total	200.644	419			

Valves

x-axis = protocol, y-axis = time in minutes



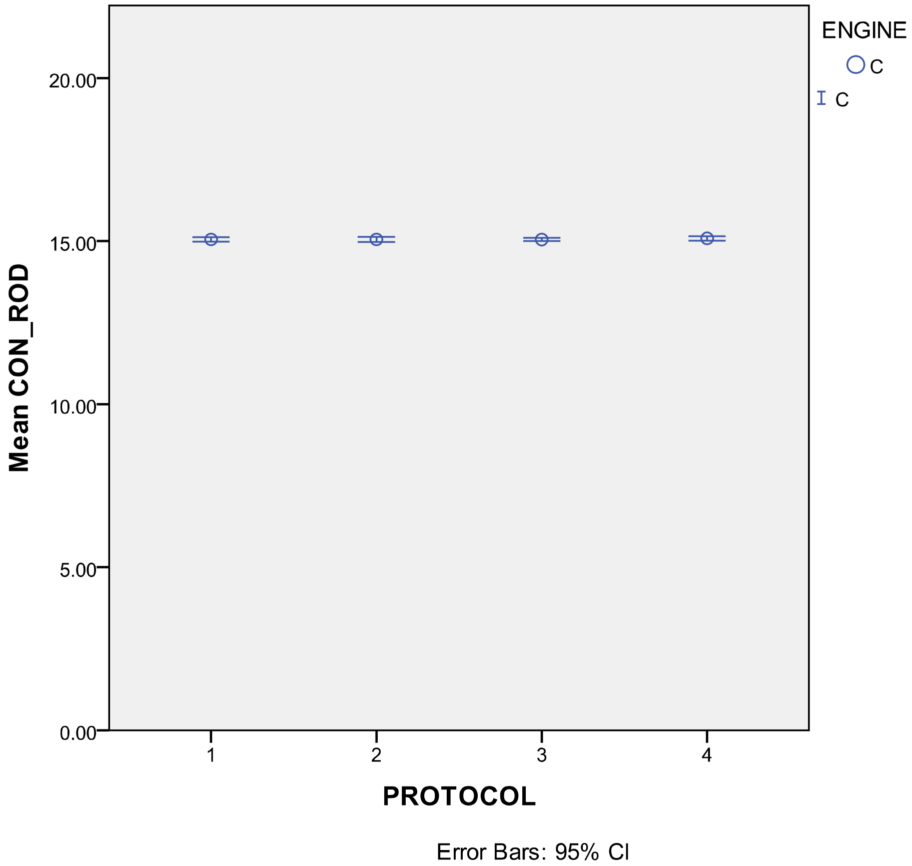
ANOVA

VALVES

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.862	3	.287	.840	.472
Within Groups	142.301	416	.342		
Total	143.163	419			

Con-rods

x-axis = protocol, y-axis = time in minutes



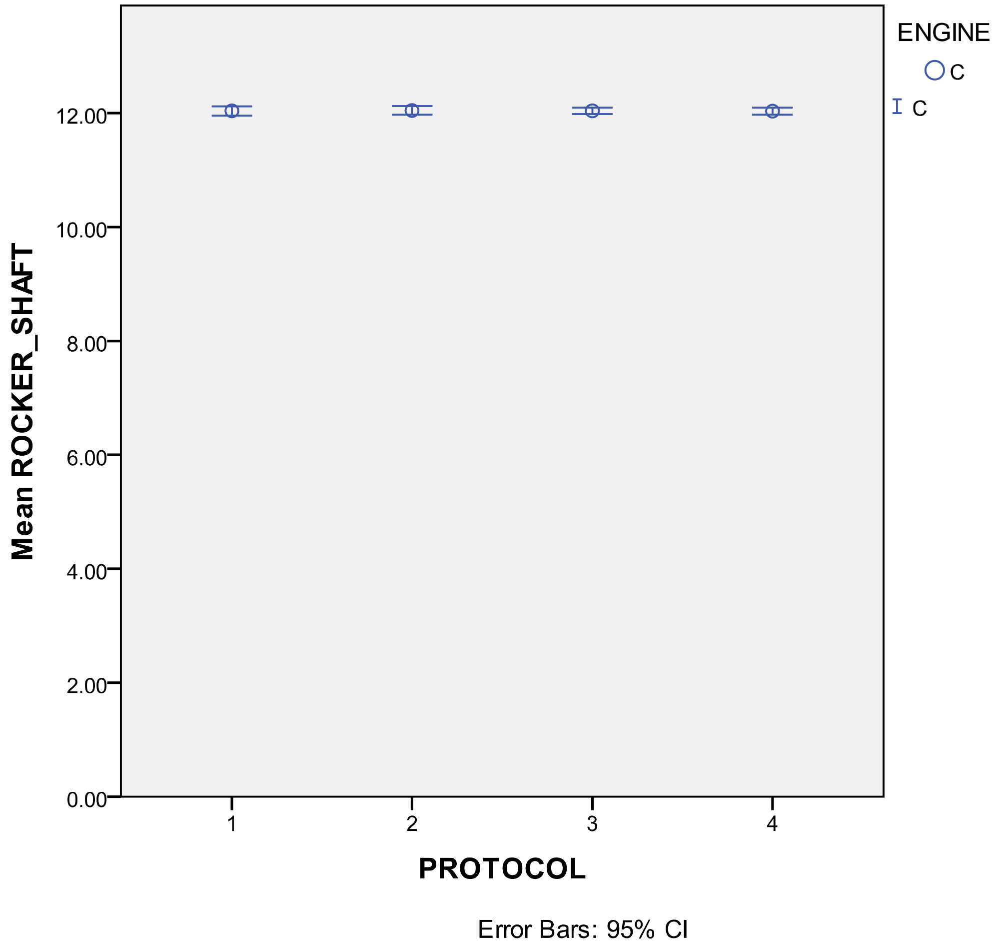
ANOVA

CON_ROD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.085	3	.028	.225	.879
Within Groups	52.077	416	.125		
Total	52.162	419			

Rocker shaft

x-axis = protocol, y-axis = time in minutes



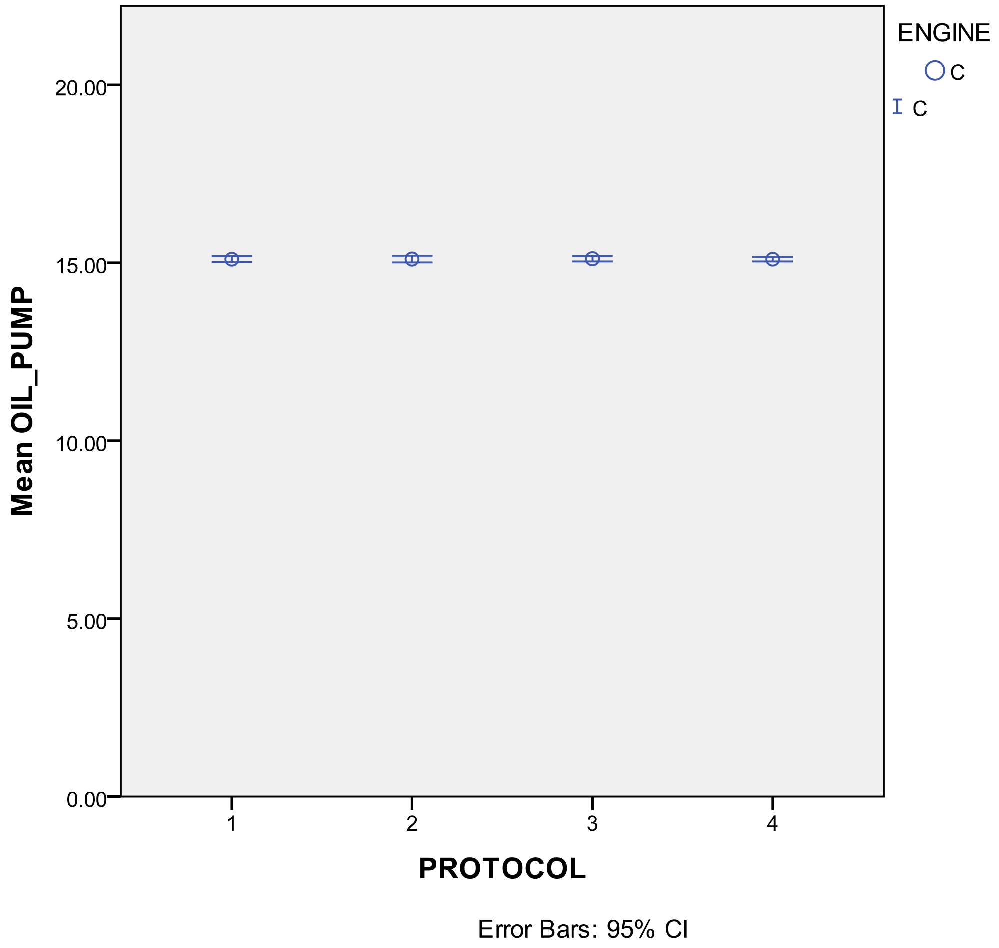
ANOVA

ROCKER_SHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.008	3	.003	.020	.996
Within Groups	53.912	416	.130		
Total	53.920	419			

Oil Pump

x-axis = protocol, y-axis = time in minutes



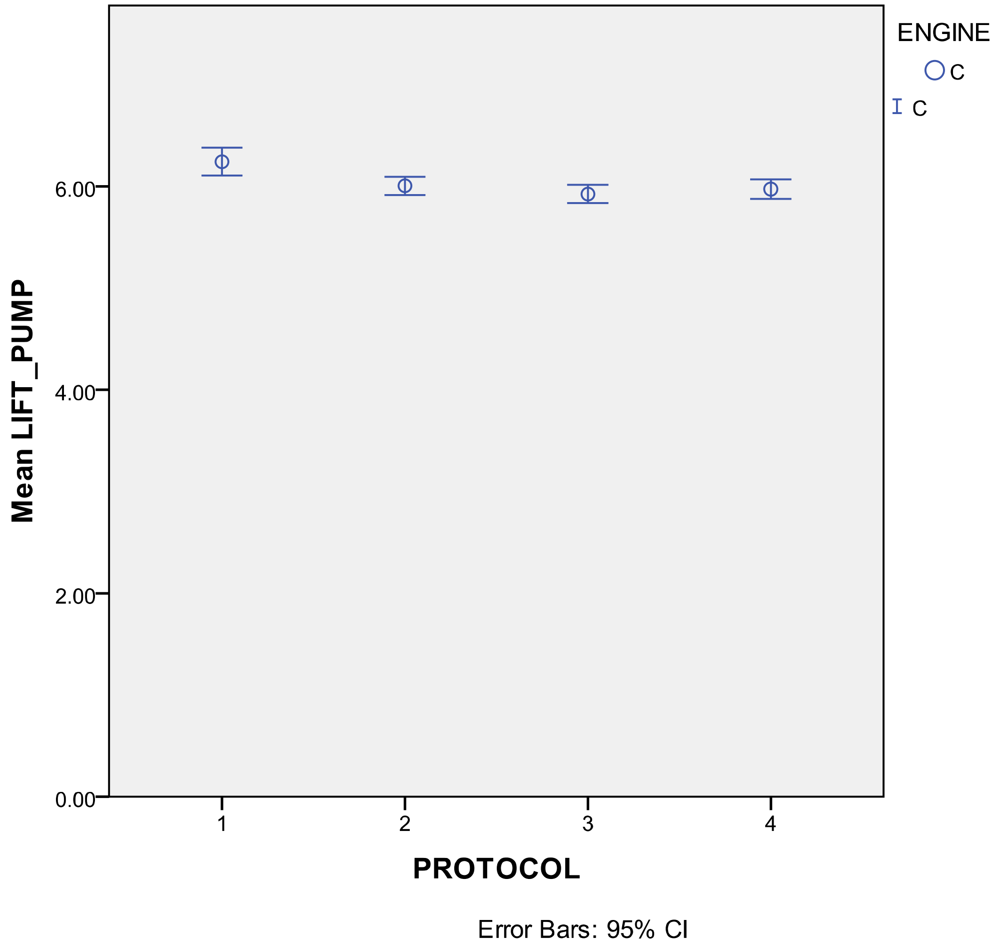
ANOVA

OIL_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.012	3	.004	.025	.995
Within Groups	67.685	416	.163		
Total	67.697	419			

Lift Pump

x-axis = protocol, y-axis = time in minutes



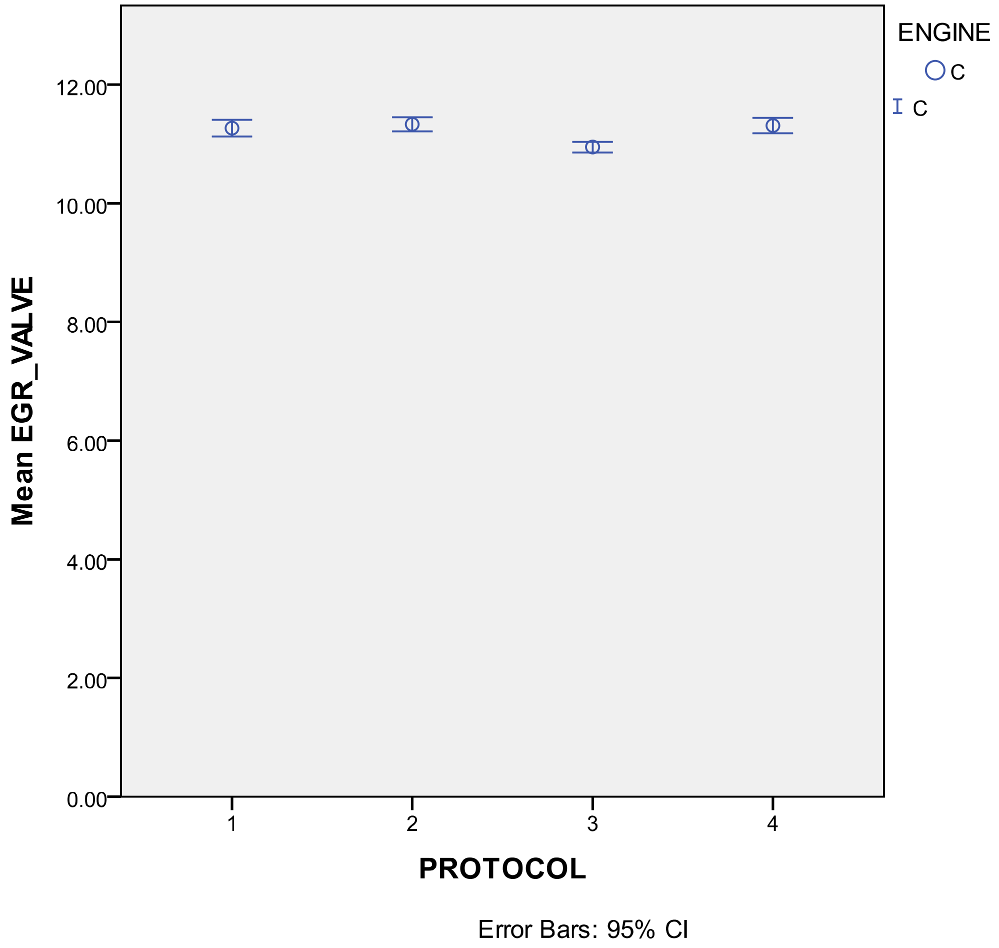
ANOVA

LIFT_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.265	3	2.088	7.046	.000
Within Groups	123.305	416	.296		
Total	129.571	419			

EGR Valve

x-axis = protocol, y-axis = time in minutes



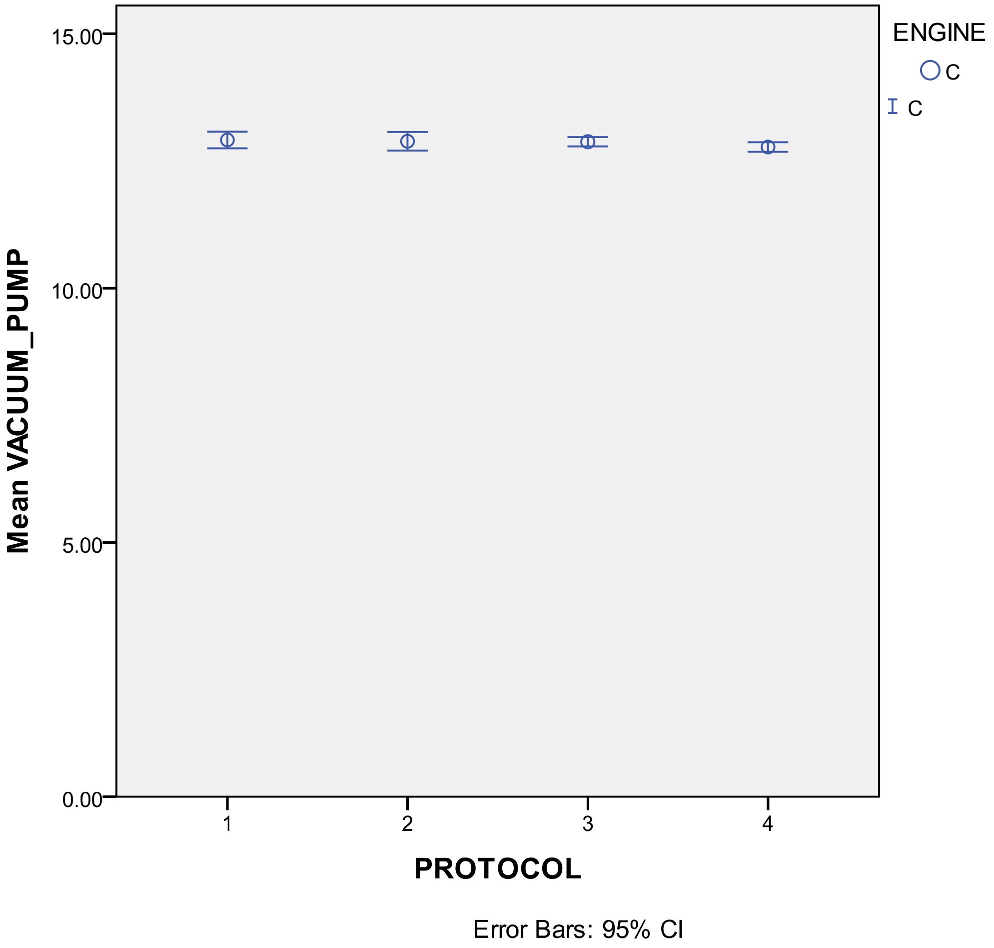
ANOVA

EGR_VALVE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.127	3	3.376	8.606	.000
Within Groups	163.173	416	.392		
Total	173.300	419			

Vacuum Pump

x-axis = protocol, y-axis = time in minutes



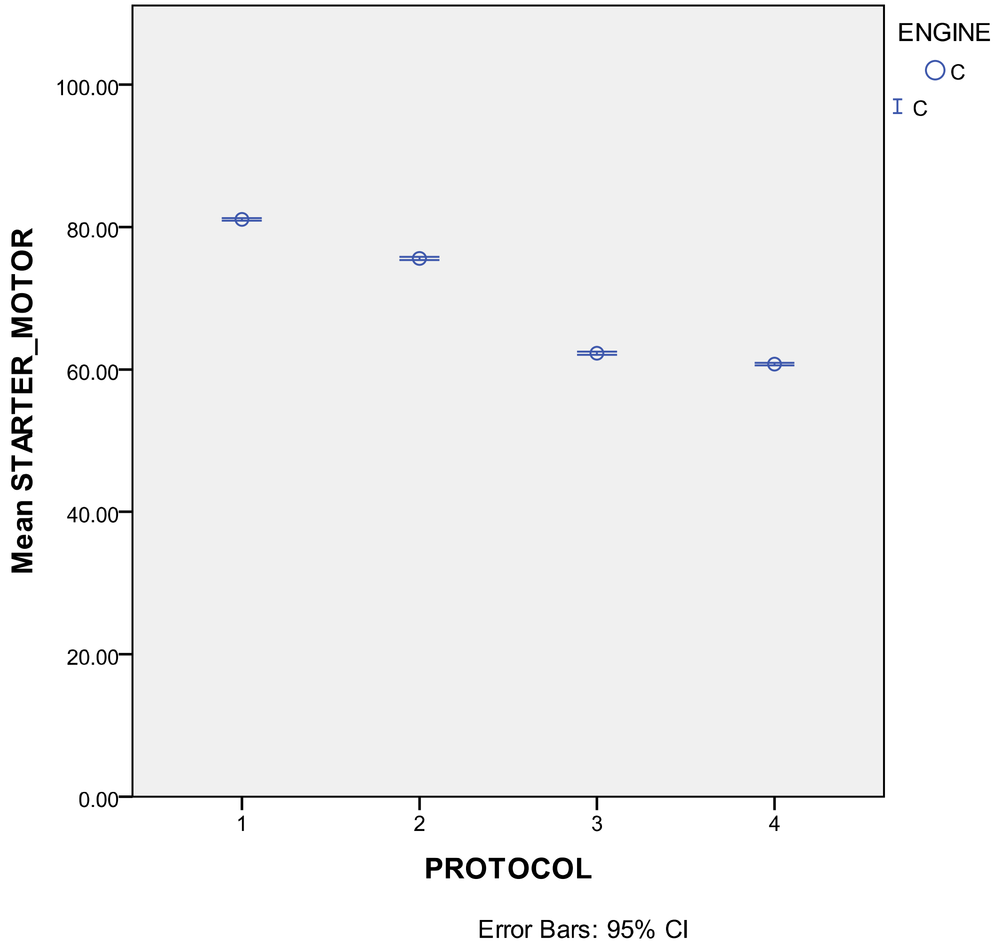
ANOVA

VACUUM_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.192	3	.397	.773	.509
Within Groups	213.711	416	.514		
Total	214.903	419			

Starter Motor

x-axis = protocol, y-axis = time in minutes



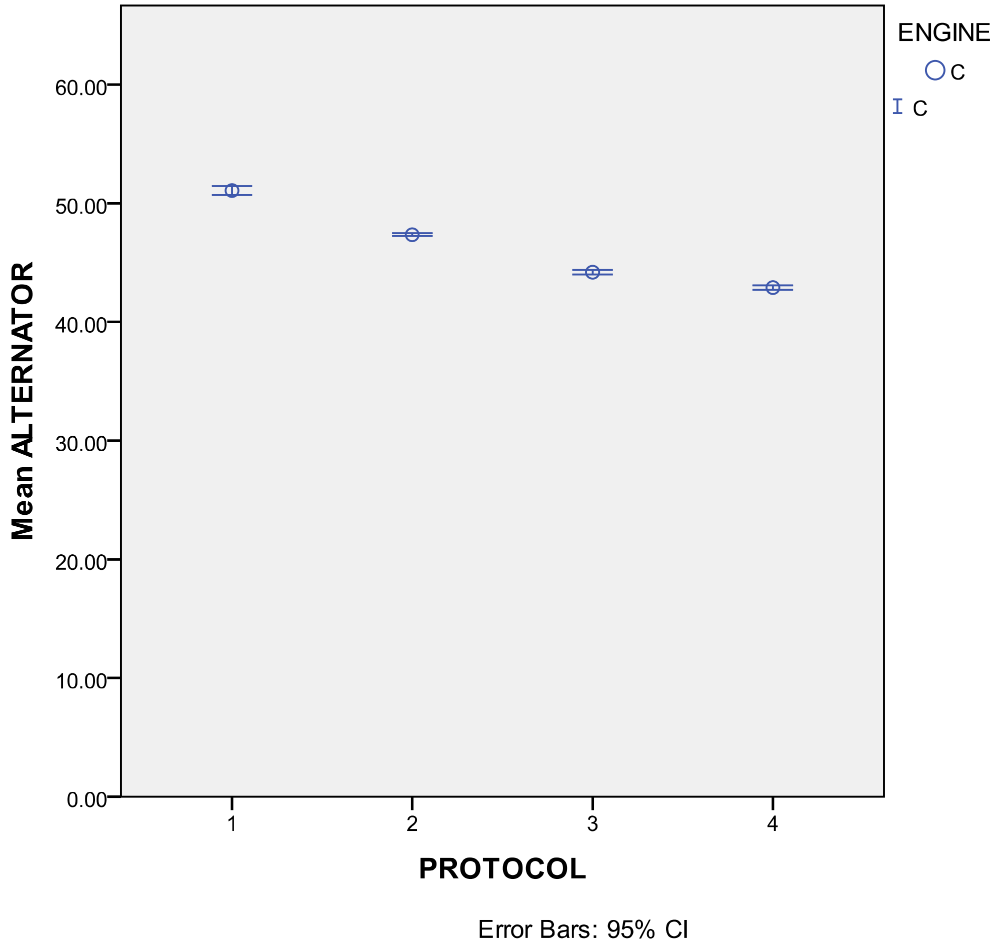
ANOVA

STARTER_MOTOR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	31333.610	3	10444.537	9148.865	.000
Within Groups	474.914	416	1.142		
Total	31808.524	419			

Alternator

x-axis = protocol, y-axis = time in minutes



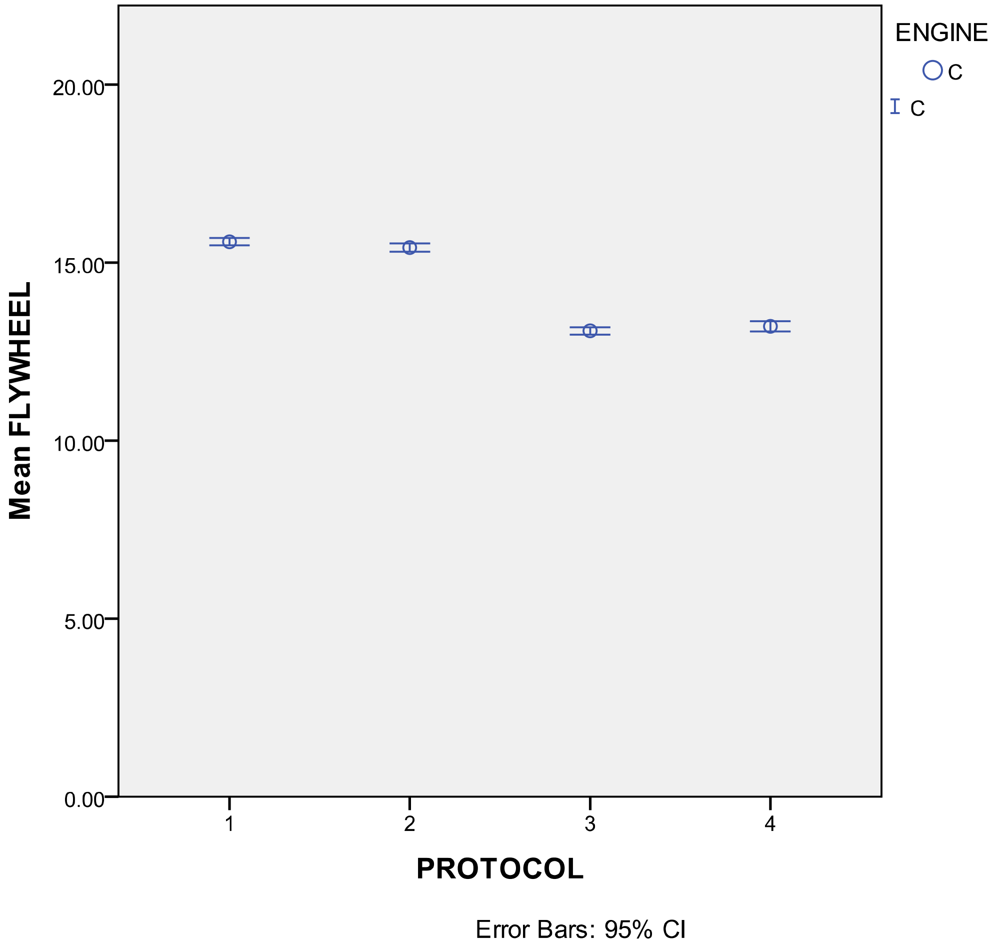
ANOVA

ALTERNATOR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4170.755	3	1390.252	931.633	.000
Within Groups	620.786	416	1.492		
Total	4791.540	419			

Flywheel

x-axis = protocol, y-axis = time in minutes



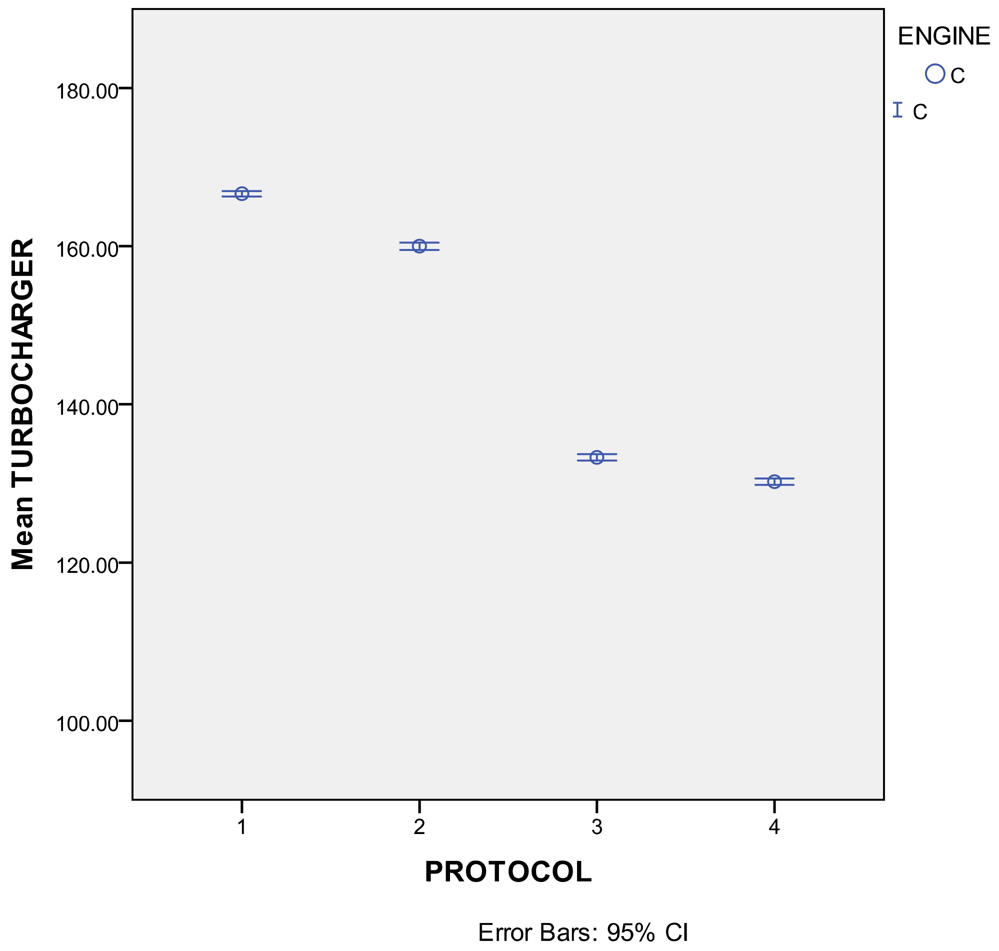
ANOVA

FLYWHEEL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	585.689	3	195.230	525.403	.000
Within Groups	154.578	416	.372		
Total	740.266	419			

Turbocharger

x-axis = protocol, y-axis = time in minutes



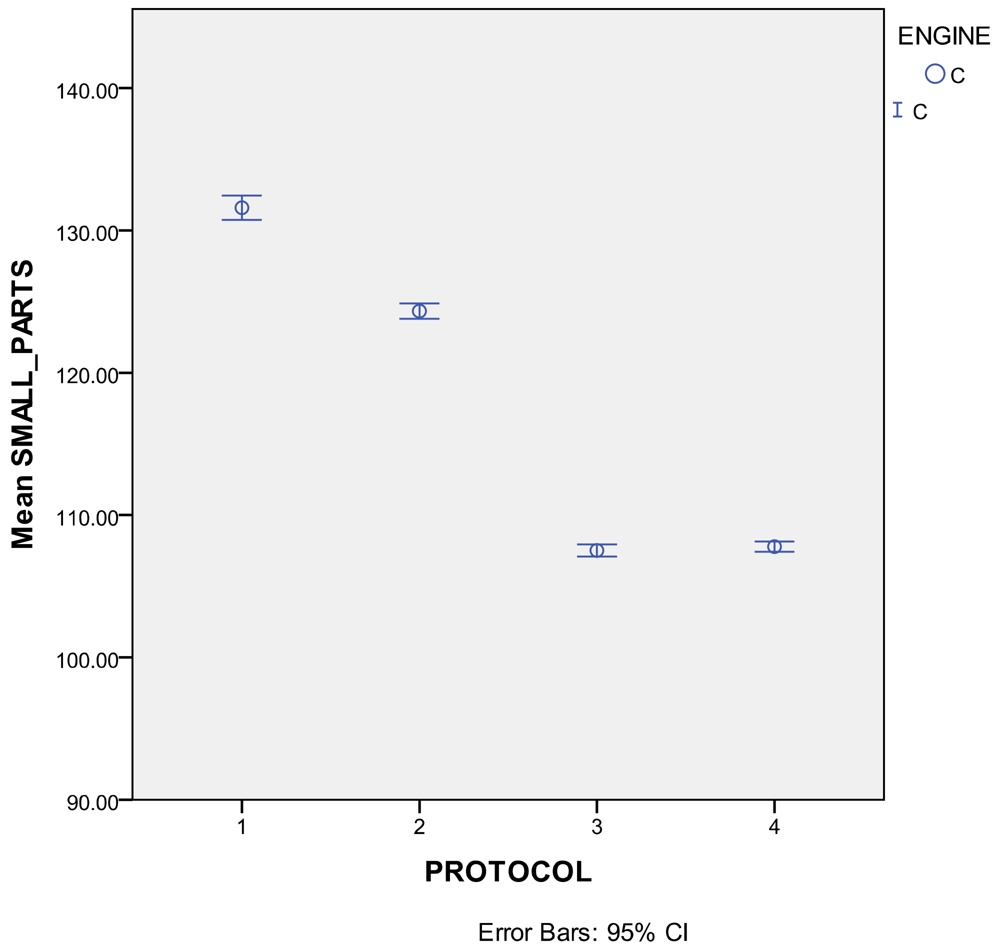
ANOVA

TURBOCHARGER

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	107318.832	3	35772.944	7903.420	.000
Within Groups	1882.925	416	4.526		
Total	109201.756	419			

Small Parts

x-axis = protocol, y-axis = time in minutes



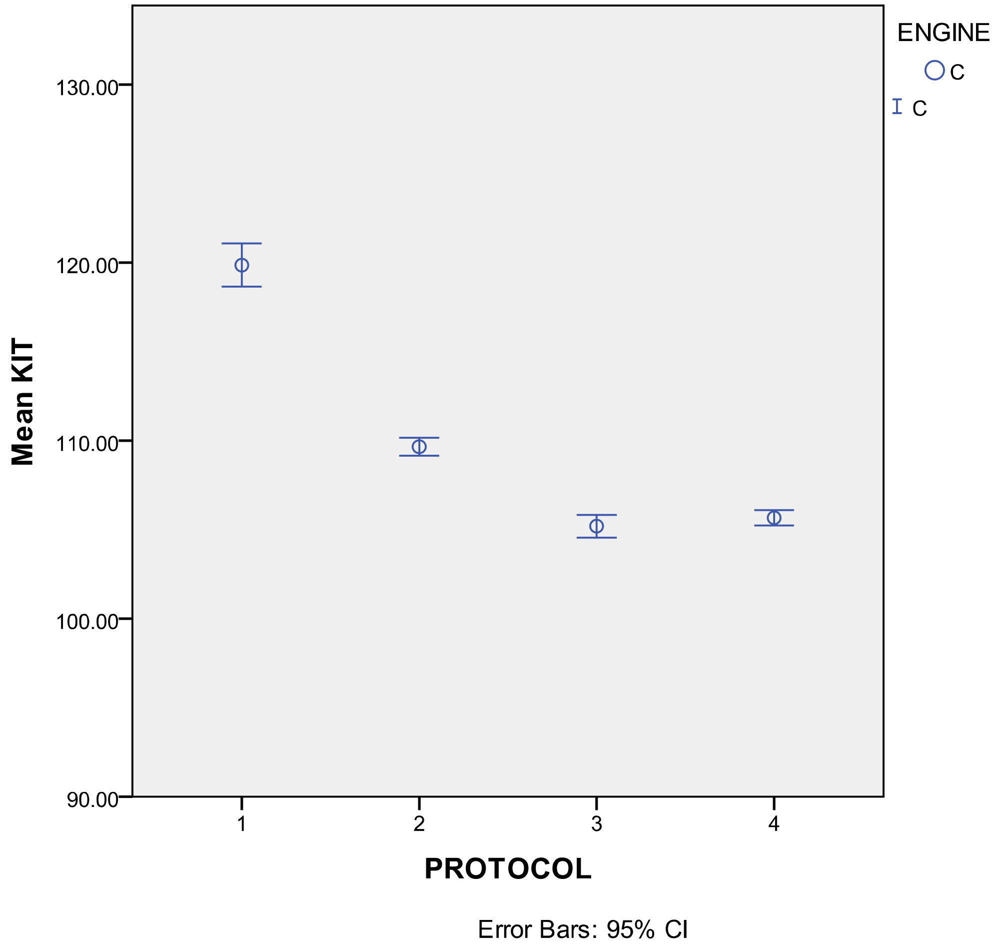
ANOVA

SMALL_PARTS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	46018.215	3	15339.405	1755.069	.000
Within Groups	3635.864	416	8.740		
Total	49654.079	419			

Engine Kit

x-axis = protocol, y-axis = time in minutes



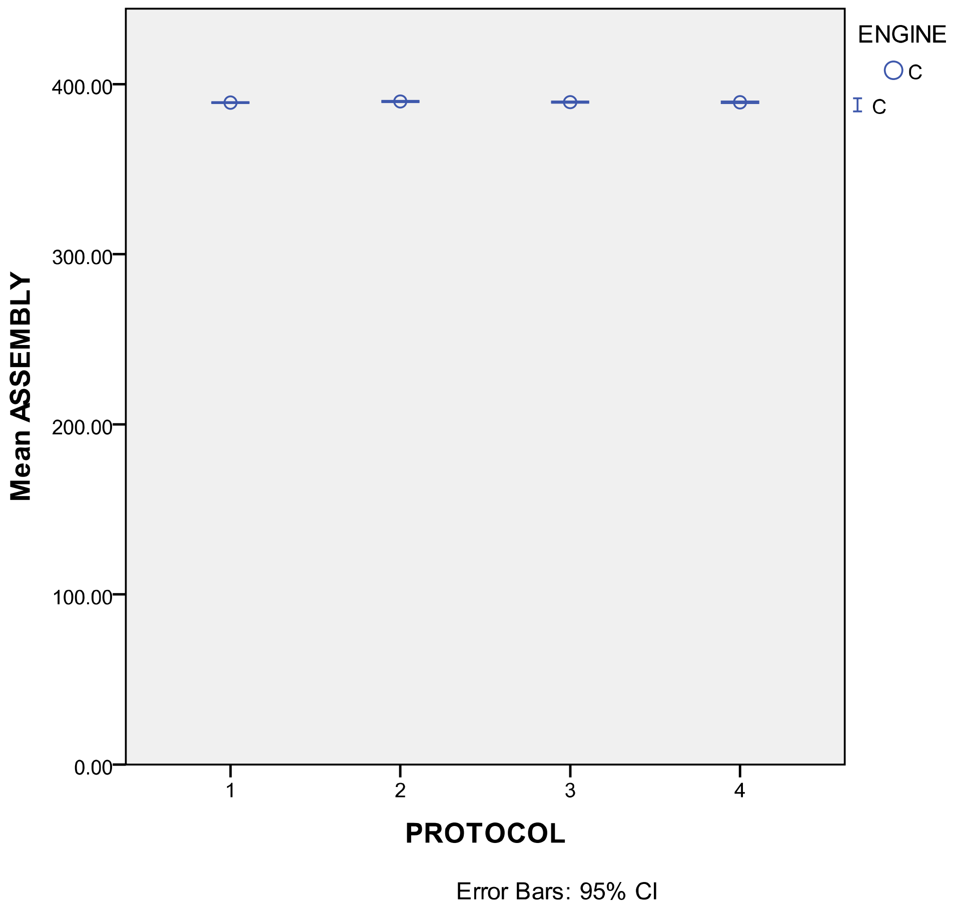
ANOVA

KIT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14536.299	3	4845.433	316.104	.000
Within Groups	6376.702	416	15.329		
Total	20913.002	419			

Assembly

x-axis = protocol, y-axis = time in minutes



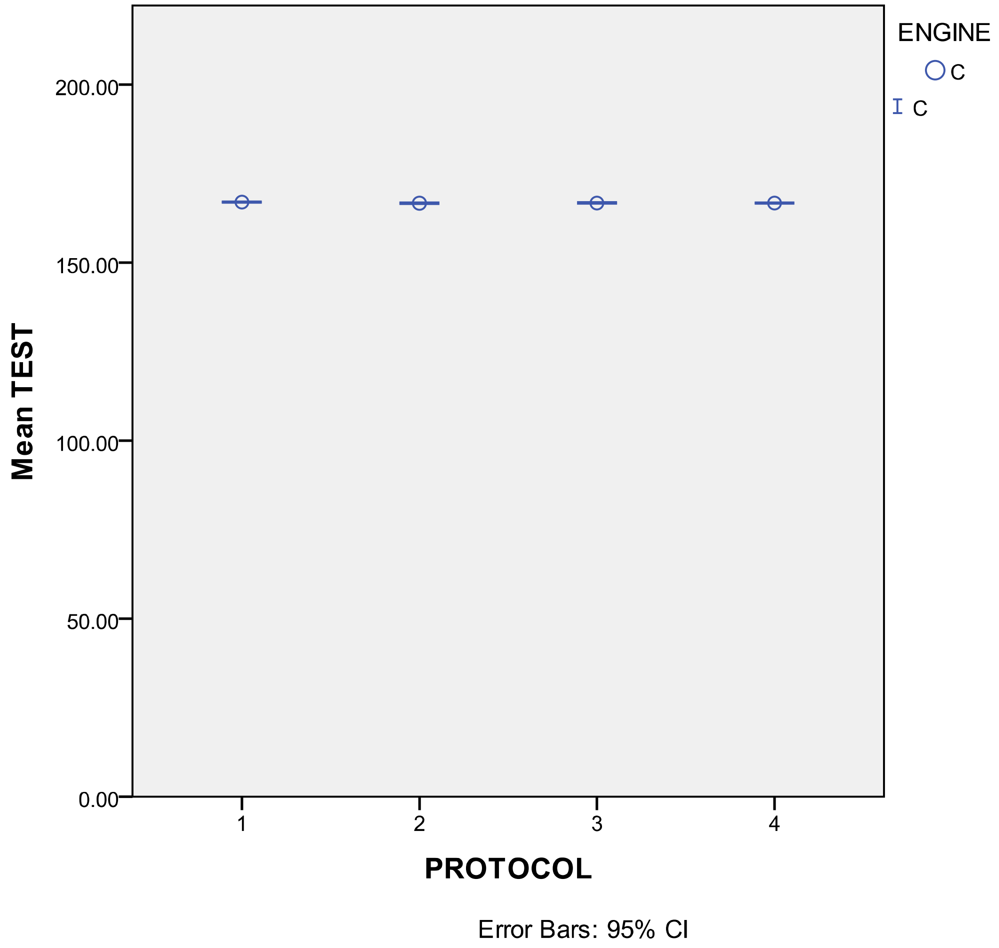
ANOVA

ASSEMBLY

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	29.542	3	9.847	2.480	.061
Within Groups	1651.749	416	3.971		
Total	1681.290	419			

Post-Production Test

x-axis = protocol, y-axis = time in minutes



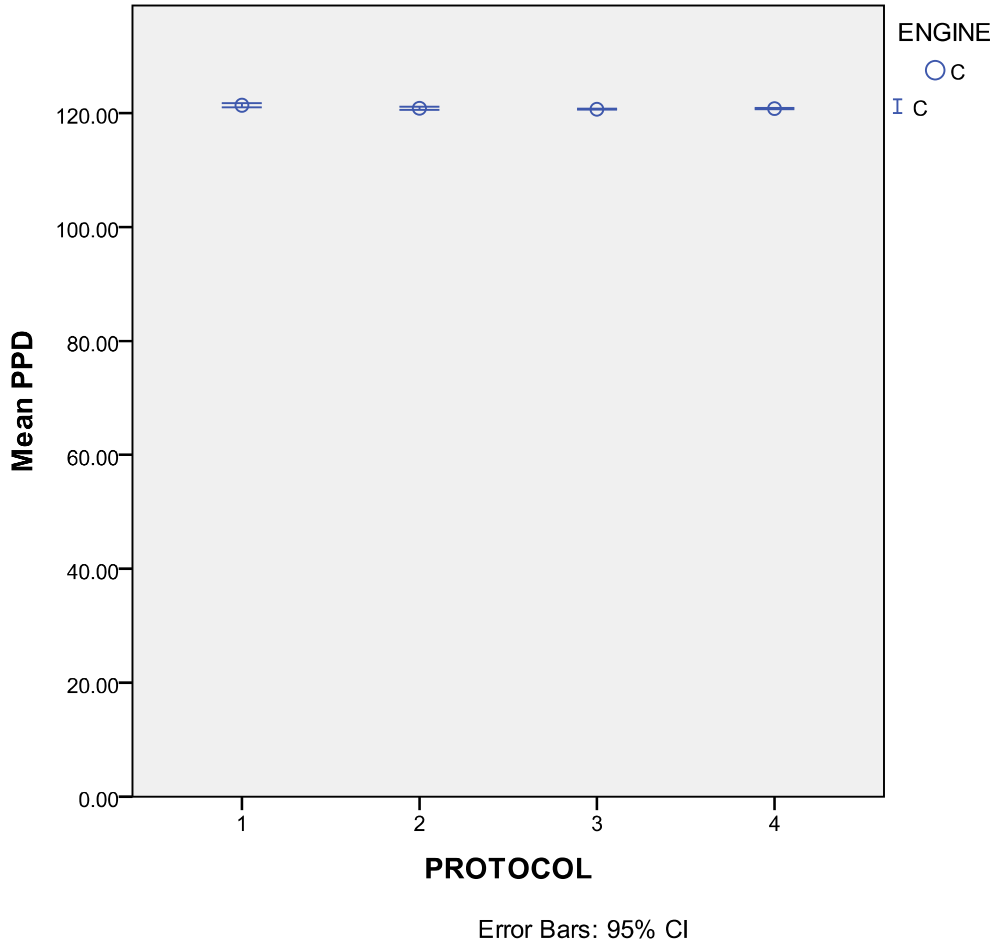
ANOVA

TEST

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.826	3	2.275	1.995	.114
Within Groups	474.430	416	1.140		
Total	481.256	419			

Paint, Pack and Despatch

x-axis = protocol, y-axis = time in minutes



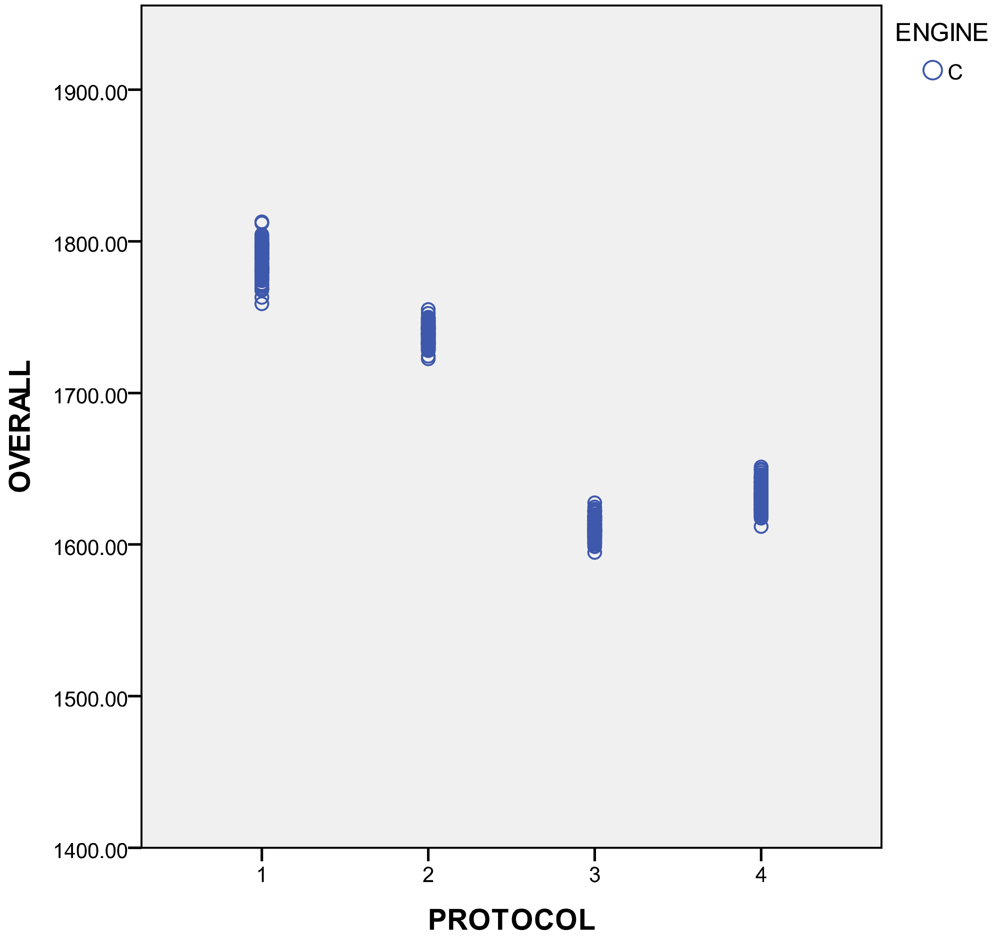
ANOVA

PPD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.227	3	2.076	1.488	.217
Within Groups	580.254	416	1.395		
Total	586.482	419			

Overall

x-axis = protocol, y-axis = time in minutes



ANOVA

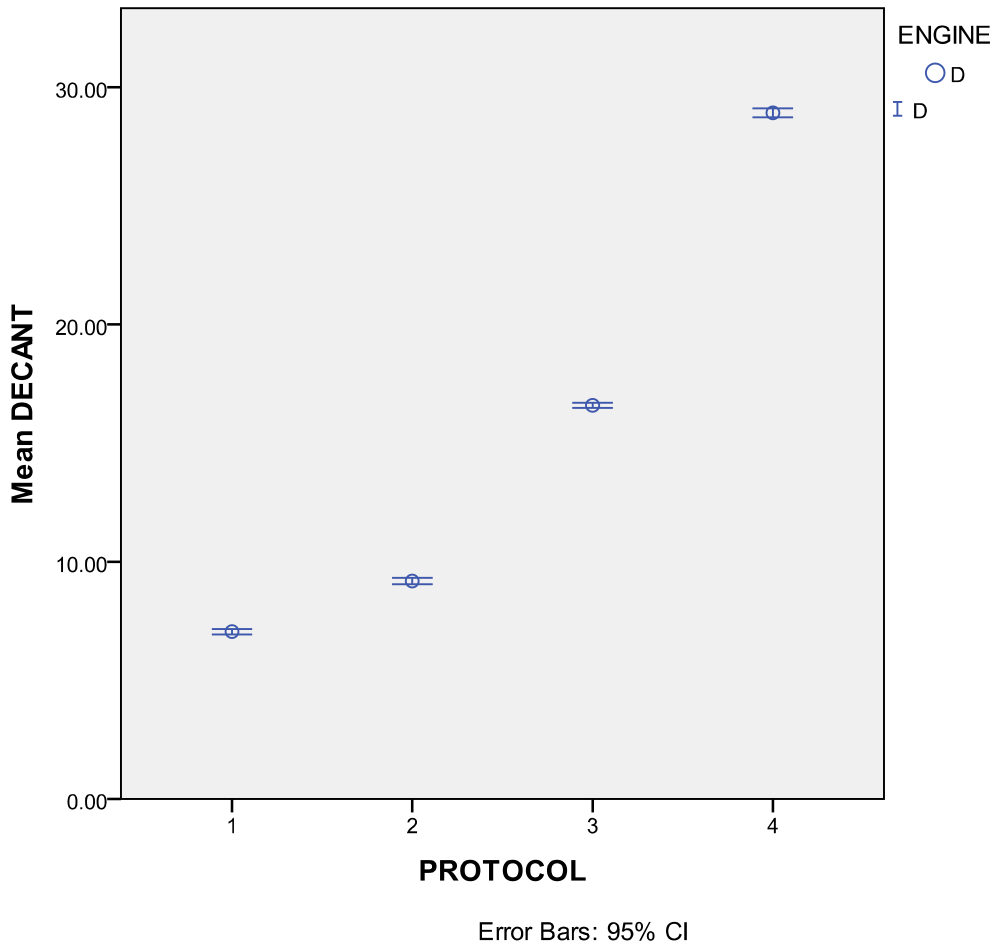
OVERALL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2244064.267	3	748021.422	11352.218	.000
Within Groups	27411.110	416	65.892		
Total	2271475.378	419			

By Engine, Engine D

Decant and Inspect

x-axis = protocol, y-axis = time in minutes



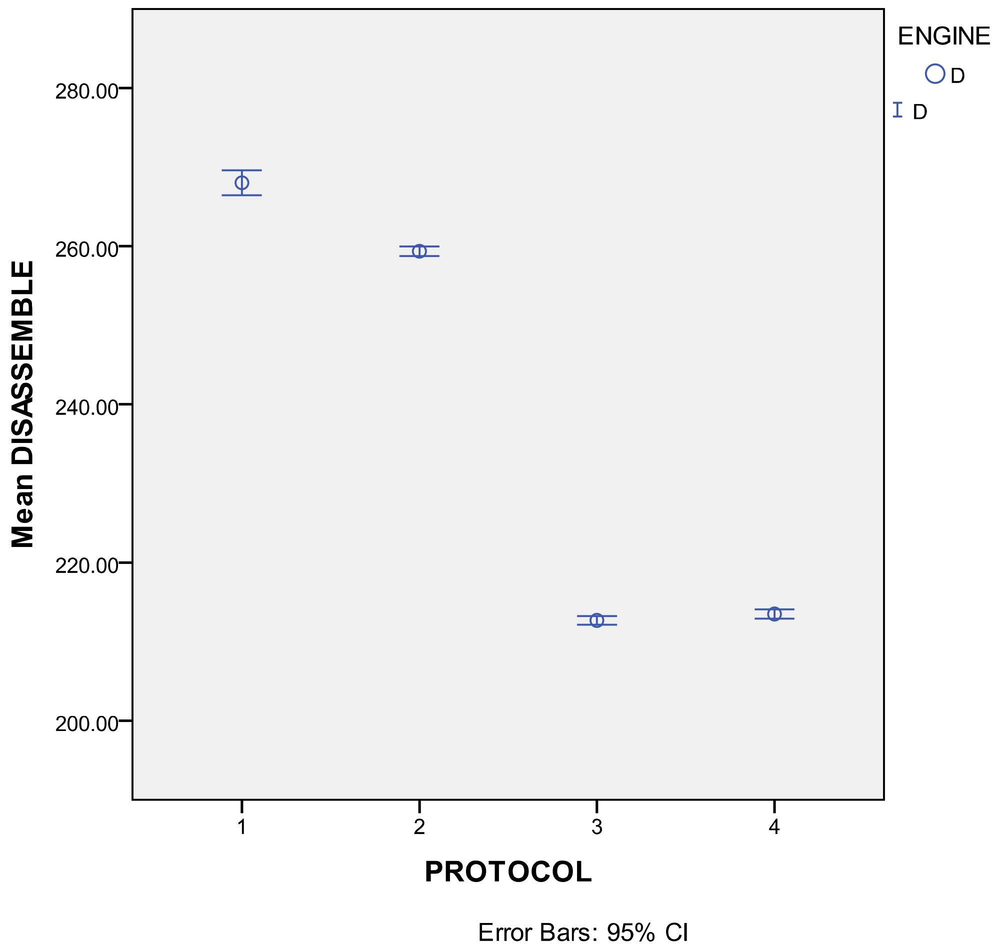
ANOVA

DECANT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22836.161	3	7612.054	19297.274	.000
Within Groups	121.494	308	.394		
Total	22957.656	311			

Disassembly

x-axis = protocol, y-axis = time in minutes



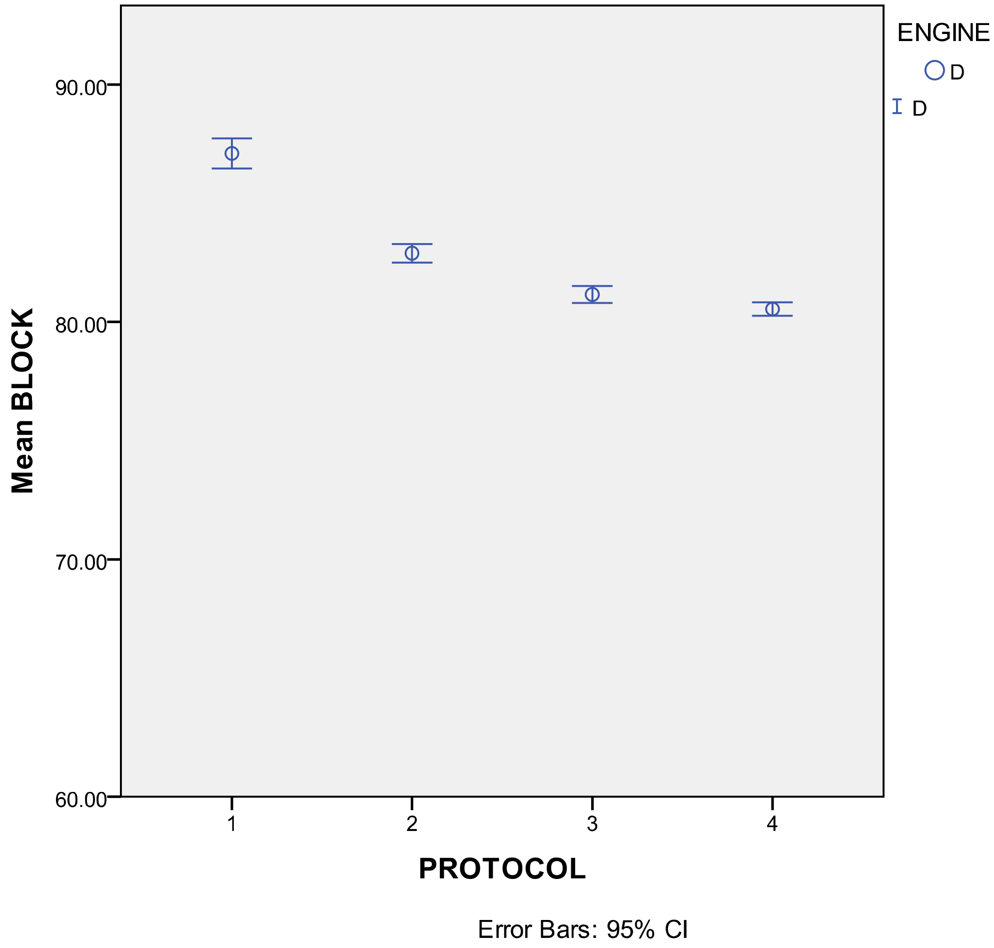
ANOVA

DISASSEMBLE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	202769.346	3	67589.782	3881.122	.000
Within Groups	5363.824	308	17.415		
Total	208133.170	311			

Cylinder Block

x-axis = protocol, y-axis = time in minutes



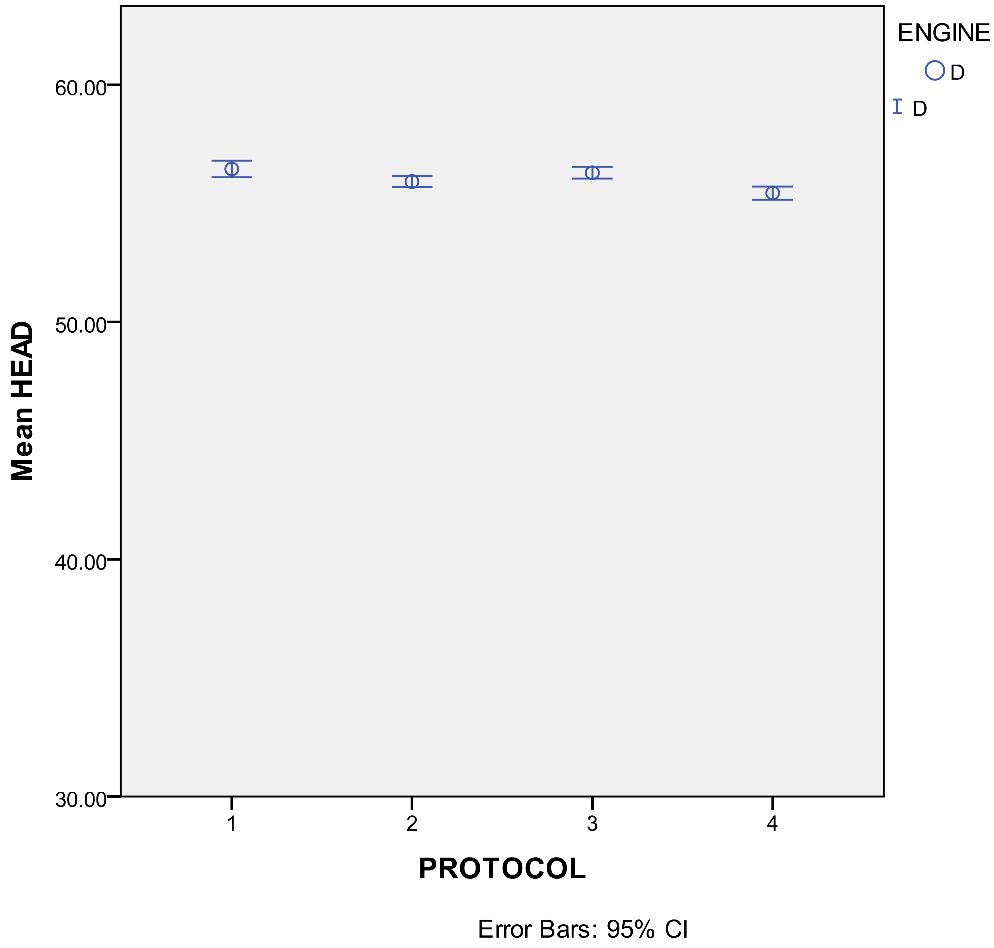
ANOVA

BLOCK

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2050.306	3	683.435	181.754	.000
Within Groups	1158.147	308	3.760		
Total	3208.454	311			

Cylinder Head

x-axis = protocol, y-axis = time in minutes



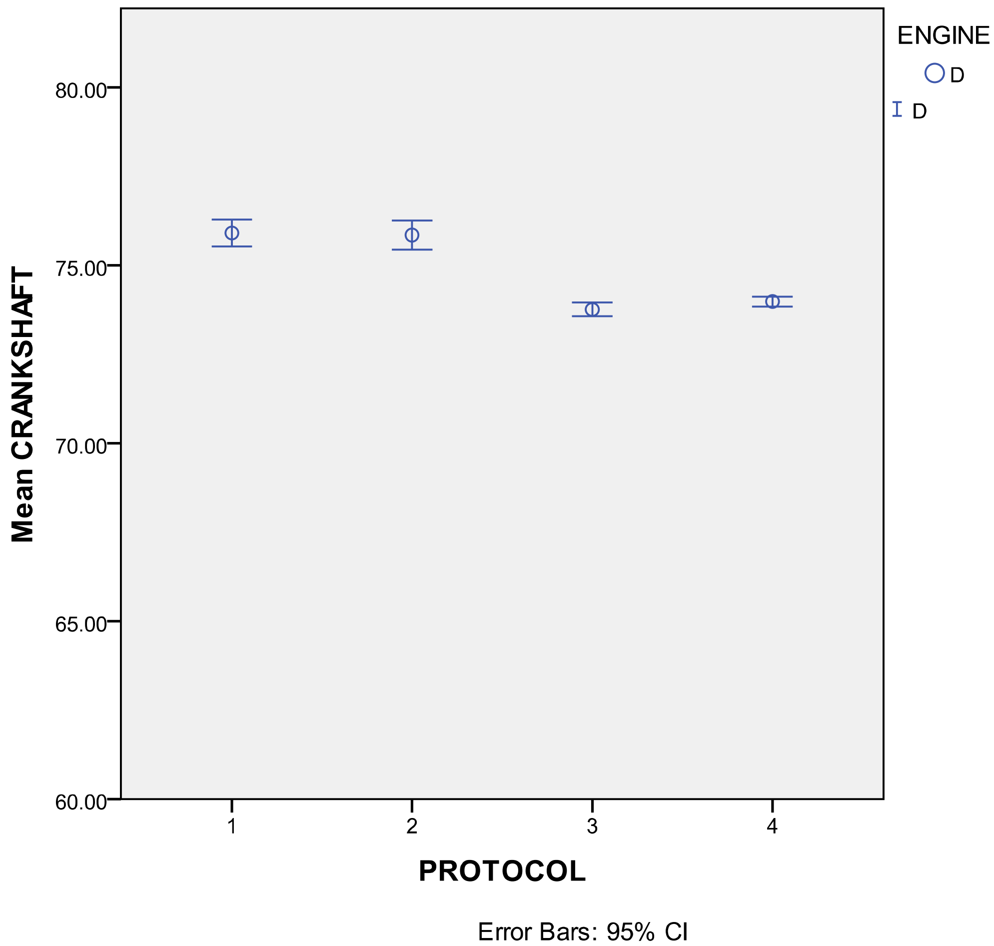
ANOVA

HEAD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	47.899	3	15.966	10.171	.000
Within Groups	483.510	308	1.570		
Total	531.408	311			

Crankshaft

x-axis = protocol, y-axis = time in minutes



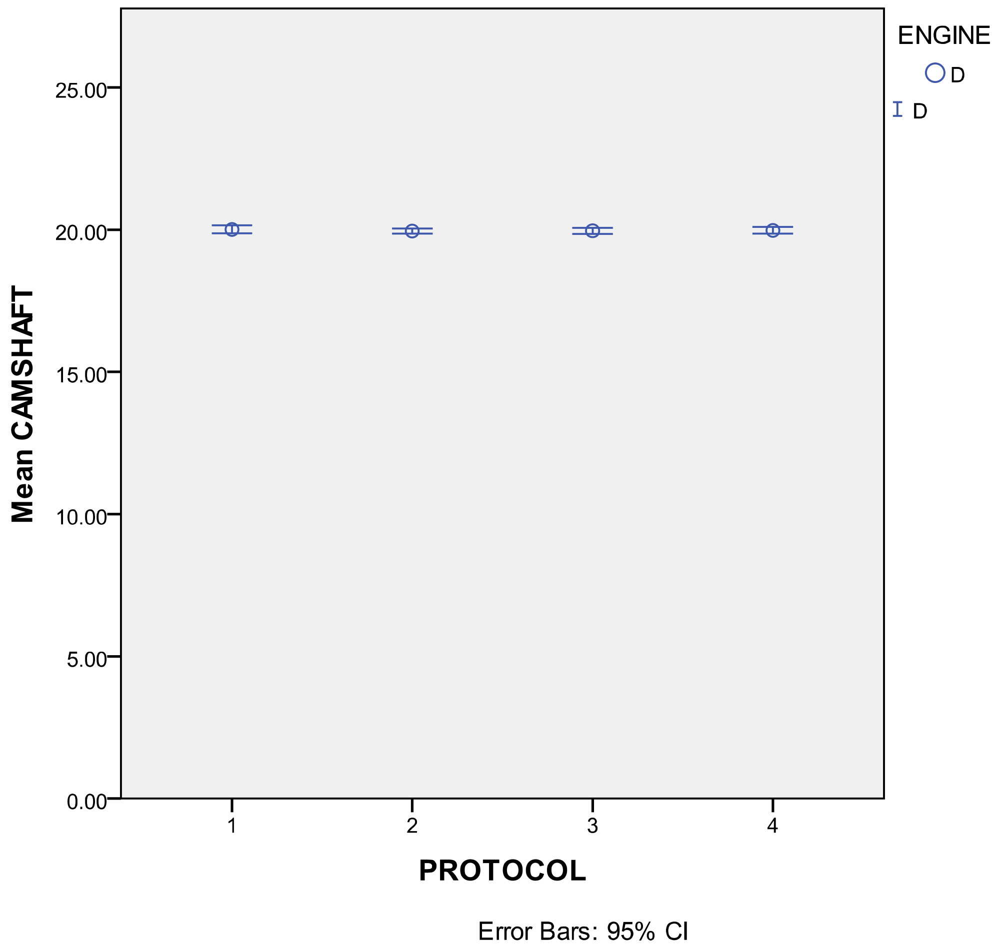
ANOVA

CRANKSHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	316.352	3	105.451	58.078	.000
Within Groups	559.231	308	1.816		
Total	875.584	311			

Camshaft

x-axis = protocol, y-axis = time in minutes



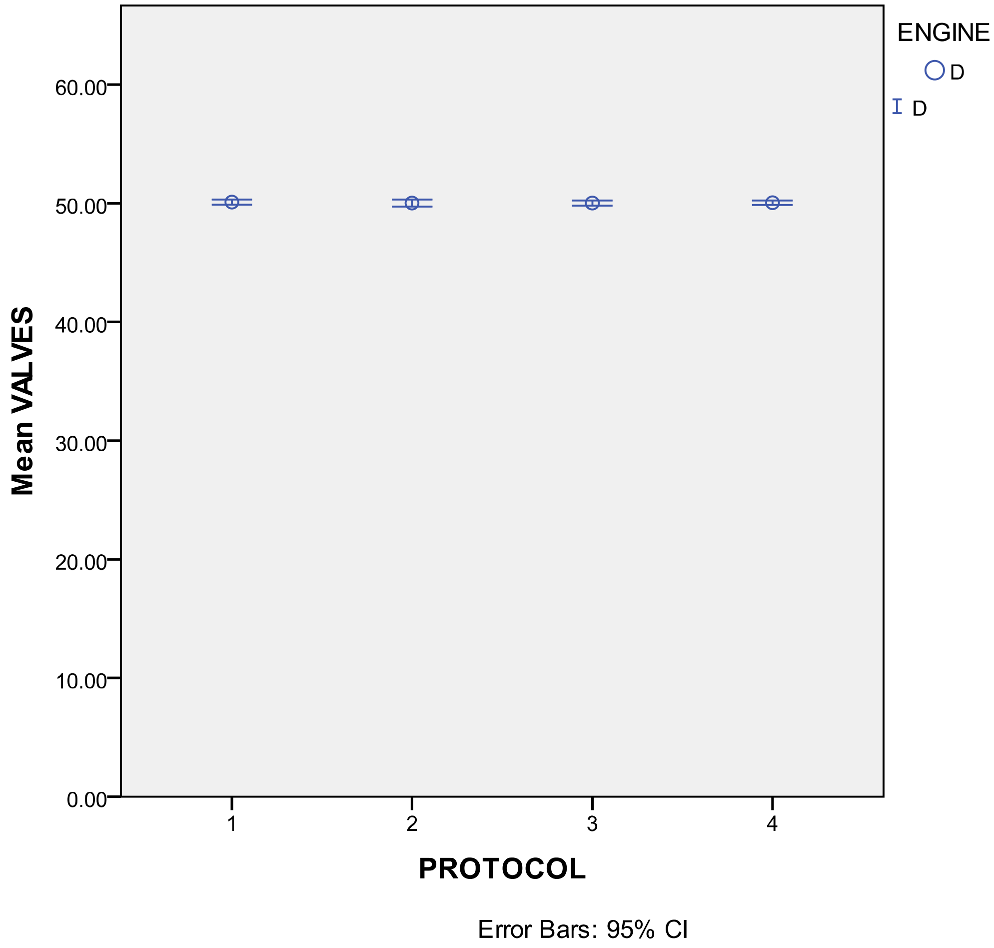
ANOVA

CAMSHAFT

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.172	3	.057	.225	.897
Within Groups	78.316	308	.254		
Total	78.488	311			

Valves

x-axis = protocol, y-axis = time in minutes



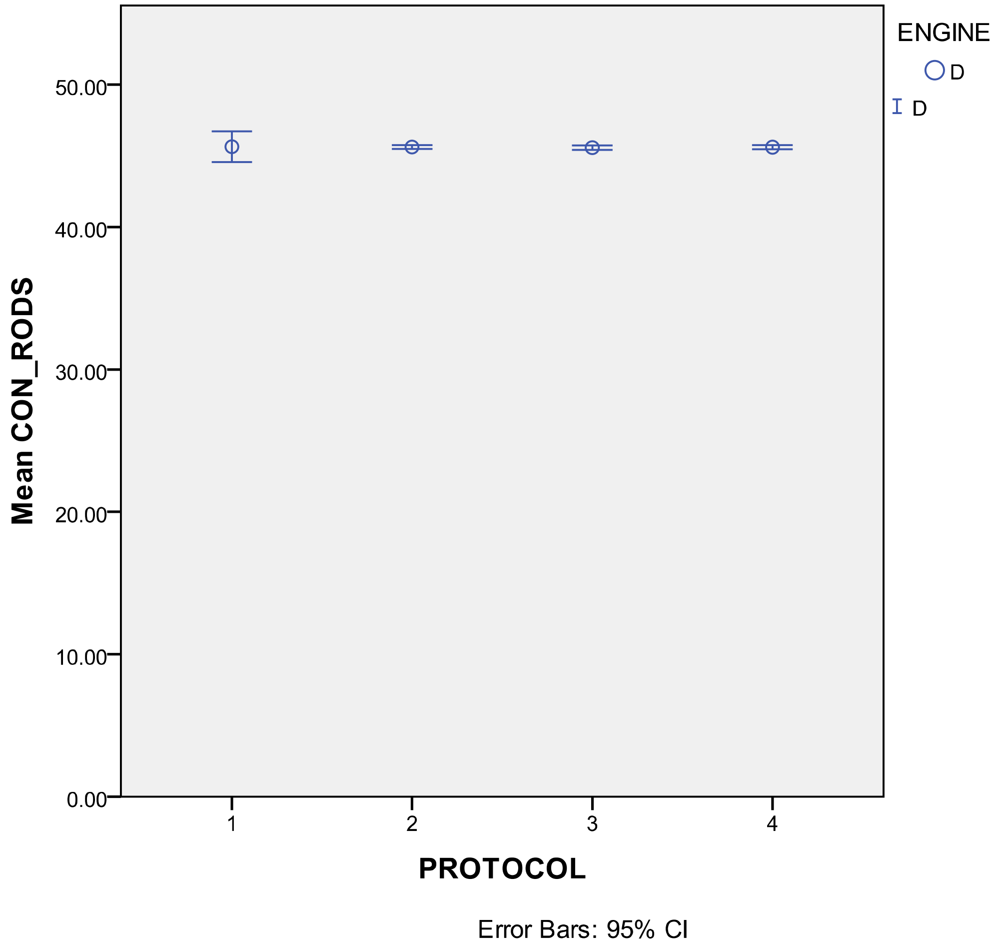
ANOVA

VALVES

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.346	3	.115	.108	.956
Within Groups	330.534	308	1.073		
Total	330.880	311			

Con Rods

x-axis = protocol, y-axis = time in minutes



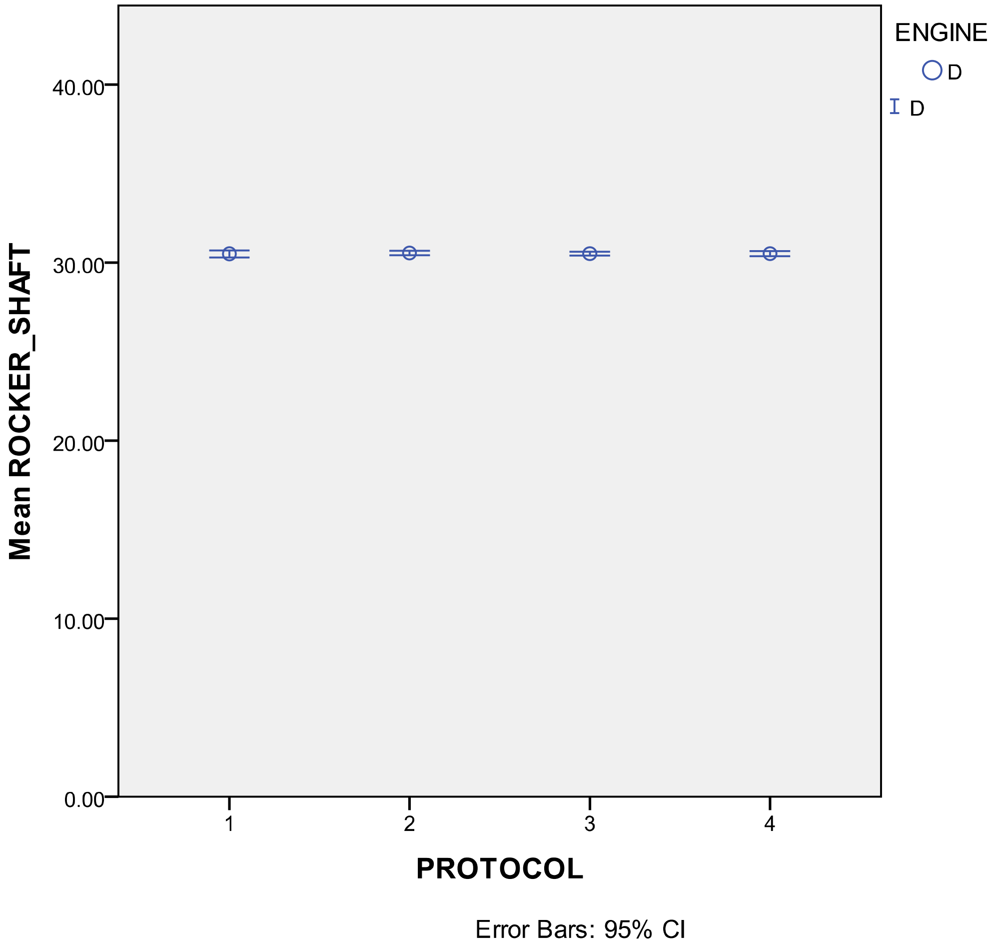
ANOVA

CON_RODS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.200	3	.067	.011	.998
Within Groups	1842.919	308	5.984		
Total	1843.119	311			

Rocker Shaft

x-axis = protocol, y-axis = time in minutes



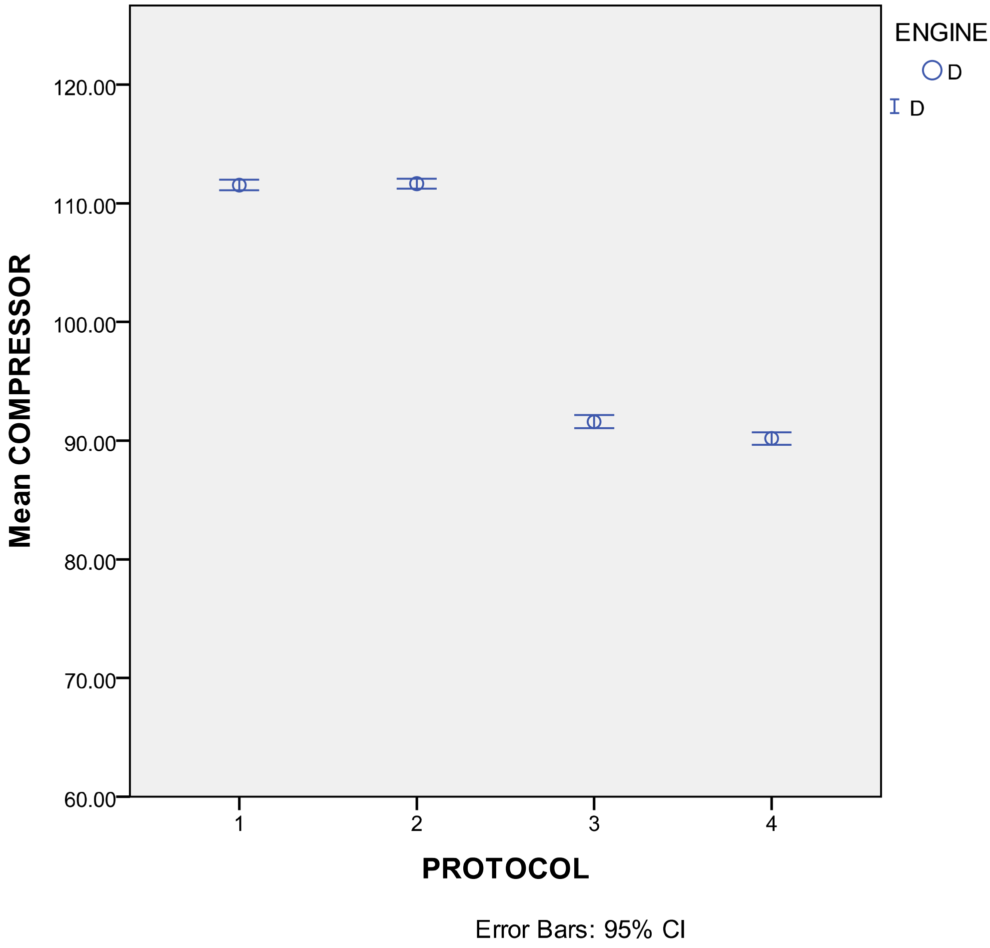
ANOVA

ROCKER_SHAFT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.134	3	.045	.103	.958
Within Groups	133.068	308	.432		
Total	133.202	311			

Compressor

x-axis = protocol, y-axis = time in minutes



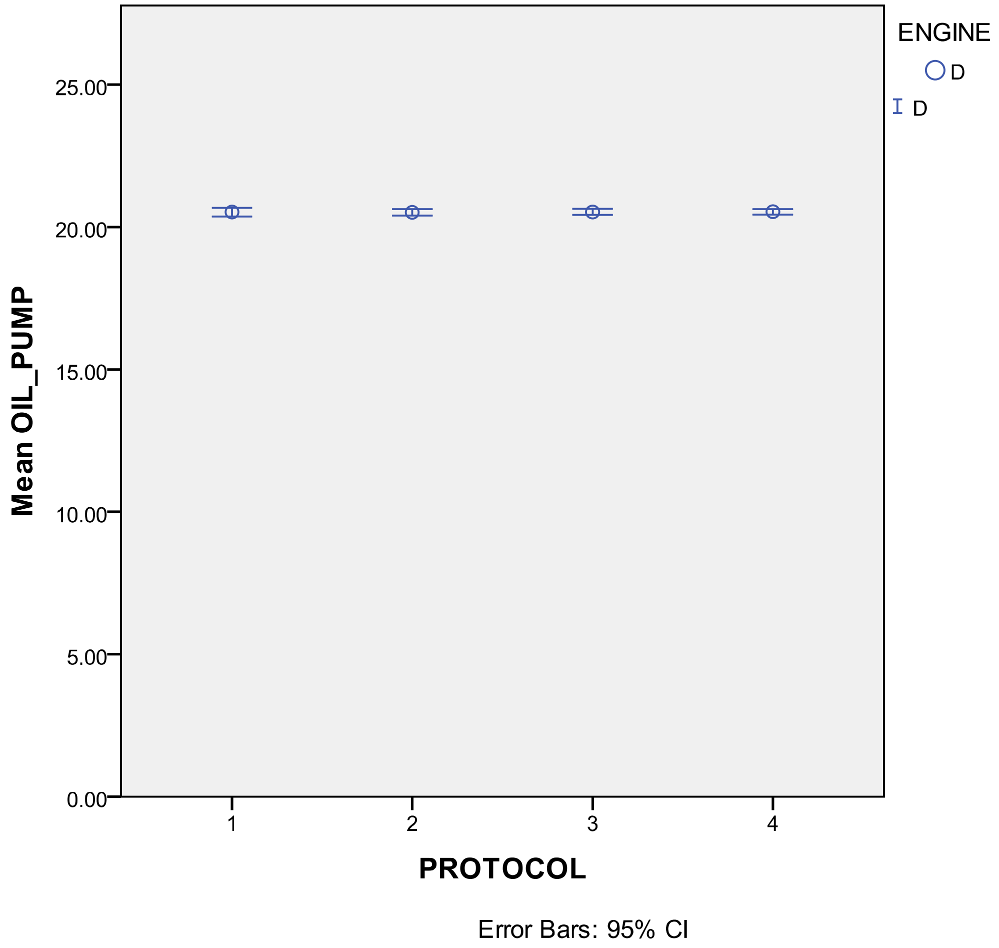
ANOVA

COMPRESSOR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33528.718	3	11176.239	2372.291	.000
Within Groups	1451.037	308	4.711		
Total	34979.755	311			

Oil Pump

x-axis = protocol, y-axis = time in minutes



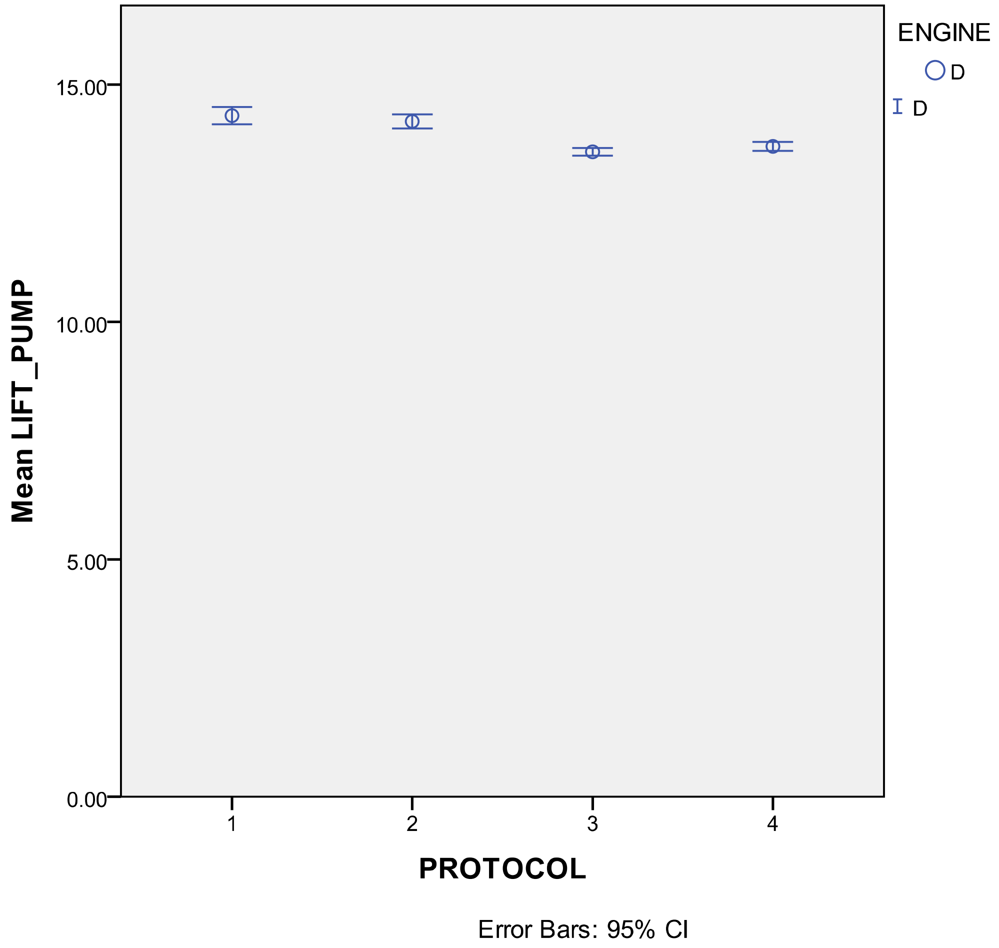
ANOVA

OIL_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.013	3	.004	.016	.995
Within Groups	86.080	308	.279		
Total	86.093	311			

Fuel Lift Pump

x-axis = protocol, y-axis = time in minutes



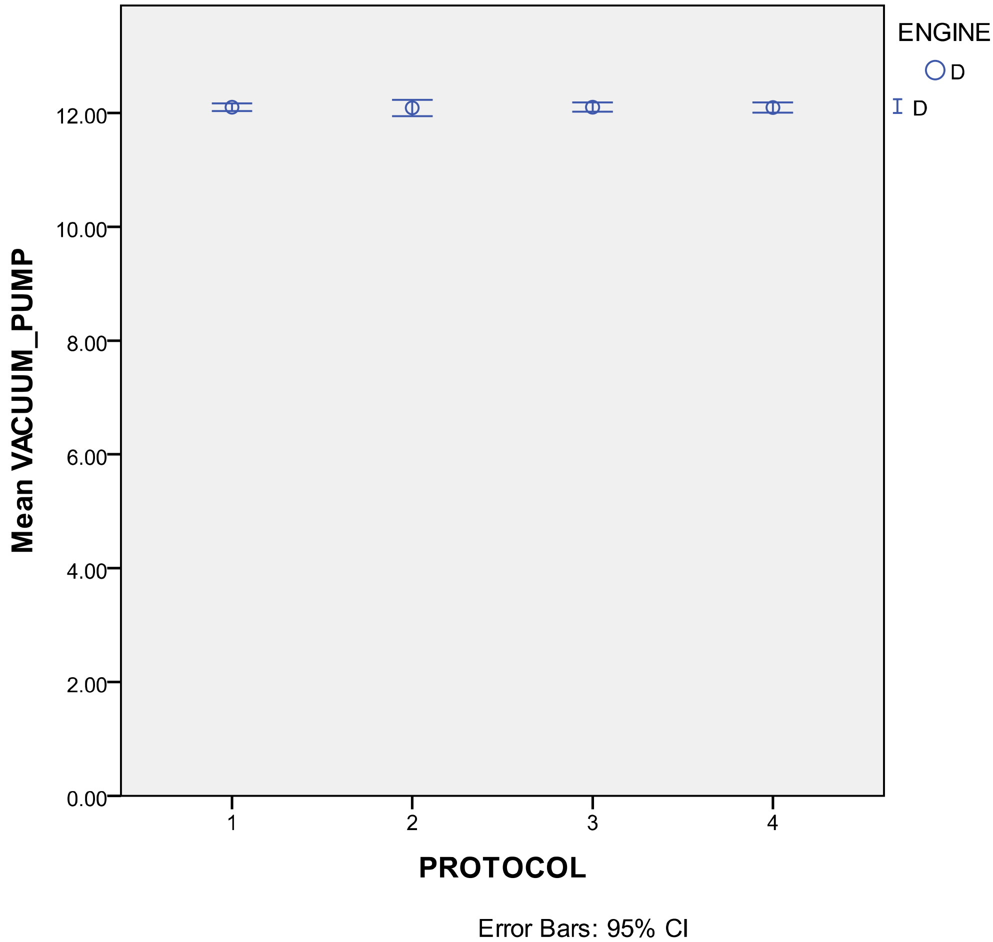
ANOVA

LIFT_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.356	3	11.119	32.130	.000
Within Groups	106.582	308	.346		
Total	139.938	311			

Vacuum Pump

x-axis = protocol, y-axis = time in minutes



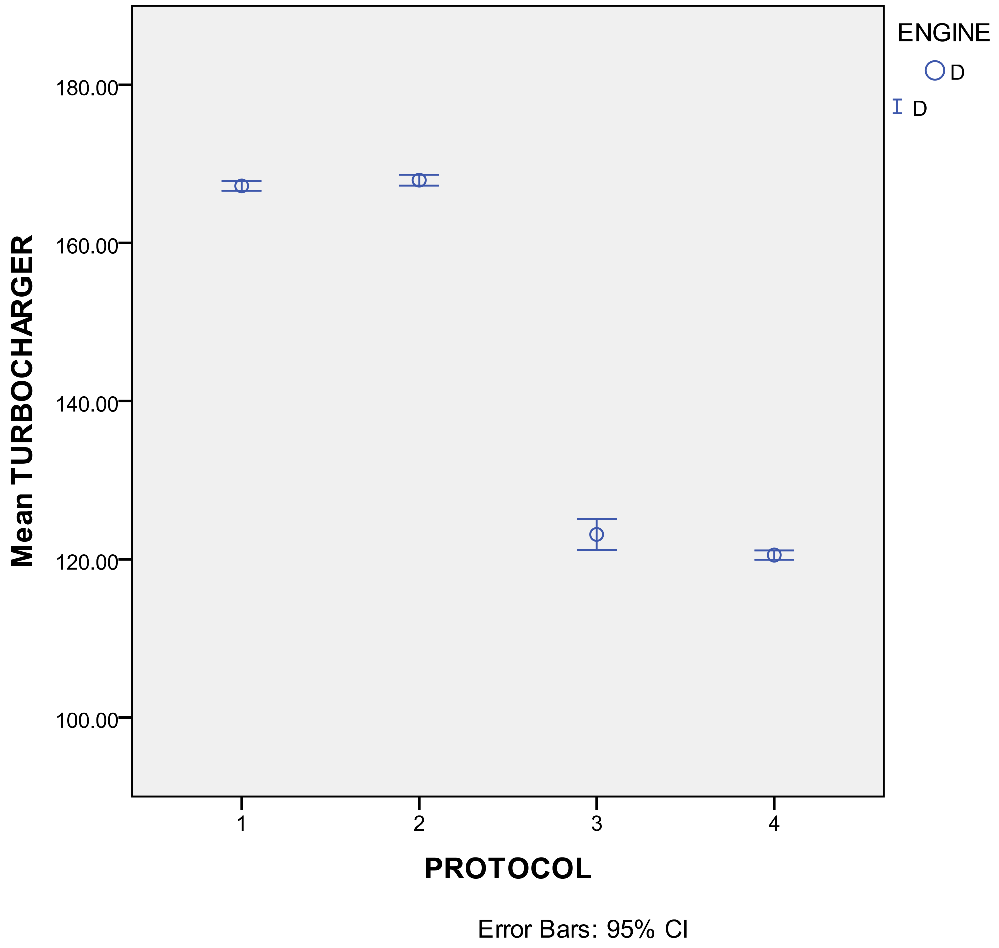
ANOVA

VACUUM_PUMP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.010	3	.003	.017	.997
Within Groups	59.605	308	.194		
Total	59.615	311			

Turbocharger

x-axis = protocol, y-axis = time in minutes



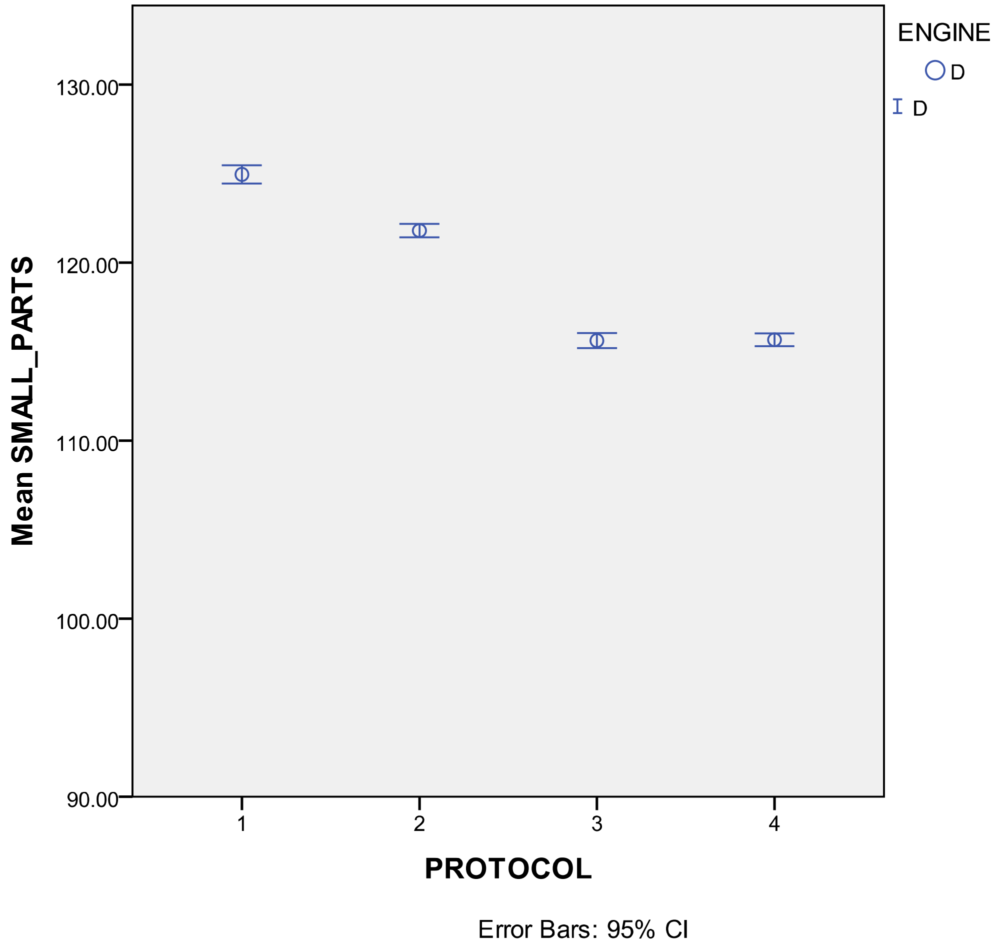
ANOVA

TURBOCHARGER

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	163460.525	3	54486.842	2232.850	.000
Within Groups	7515.932	308	24.402		
Total	170976.457	311			

Small Parts

x-axis = protocol, y-axis = time in minutes



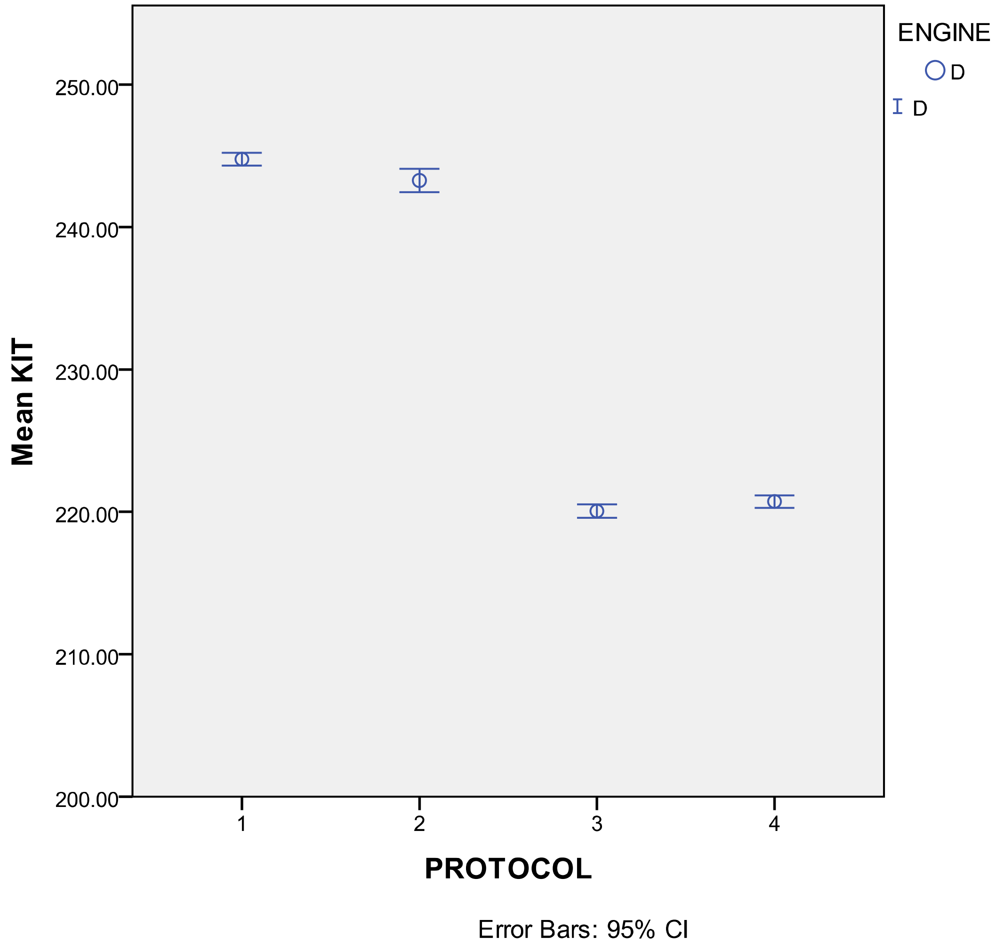
ANOVA

SMALL_PARTS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5053.179	3	1684.393	480.829	.000
Within Groups	1078.956	308	3.503		
Total	6132.135	311			

Engine Kit

x-axis = protocol, y-axis = time in minutes



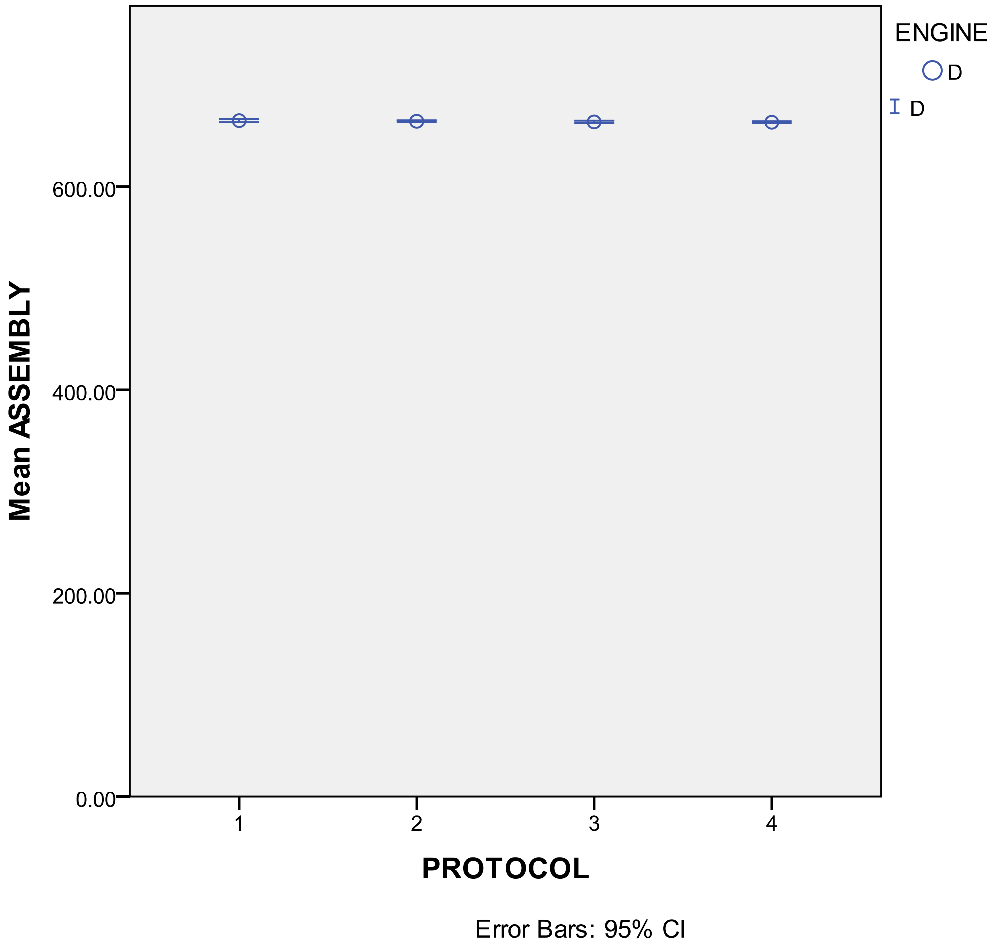
ANOVA

KIT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	43670.844	3	14556.948	2270.412	.000
Within Groups	1974.769	308	6.412		
Total	45645.613	311			

Assembly

x-axis = protocol, y-axis = time in minutes



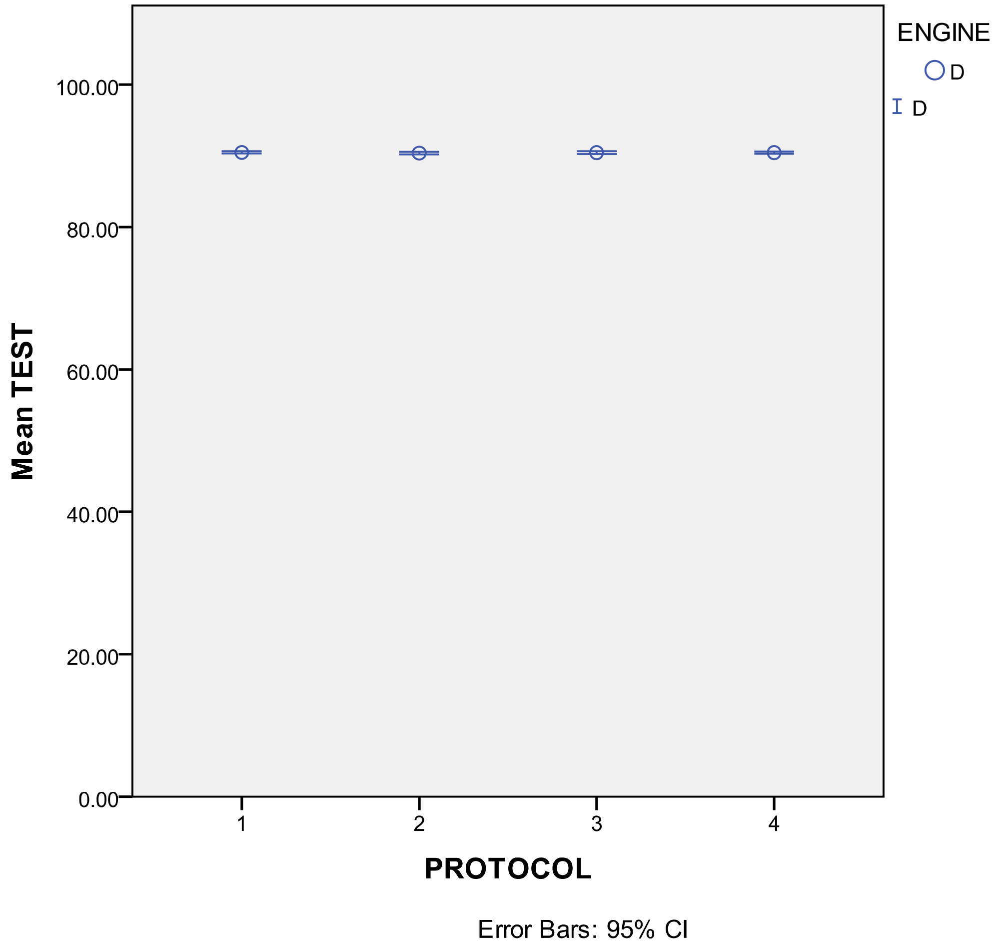
ANOVA

ASSEMBLY

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	117.809	3	39.270	1.497	.215
Within Groups	8078.351	308	26.228		
Total	8196.160	311			

Post-Production Test

x-axis = protocol, y-axis = time in minutes



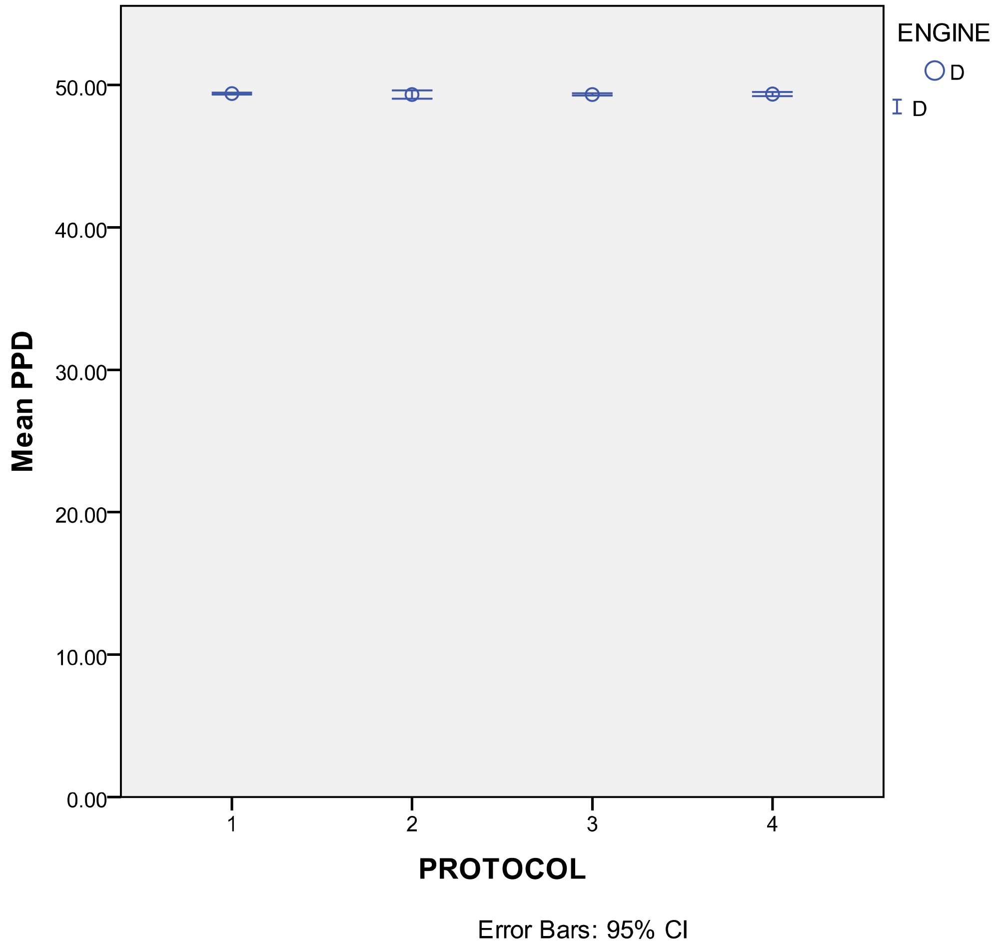
ANOVA

TEST

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.611	3	.204	.331	.803
Within Groups	189.599	308	.616		
Total	190.210	311			

PPD

x-axis = protocol, y-axis = time in minutes



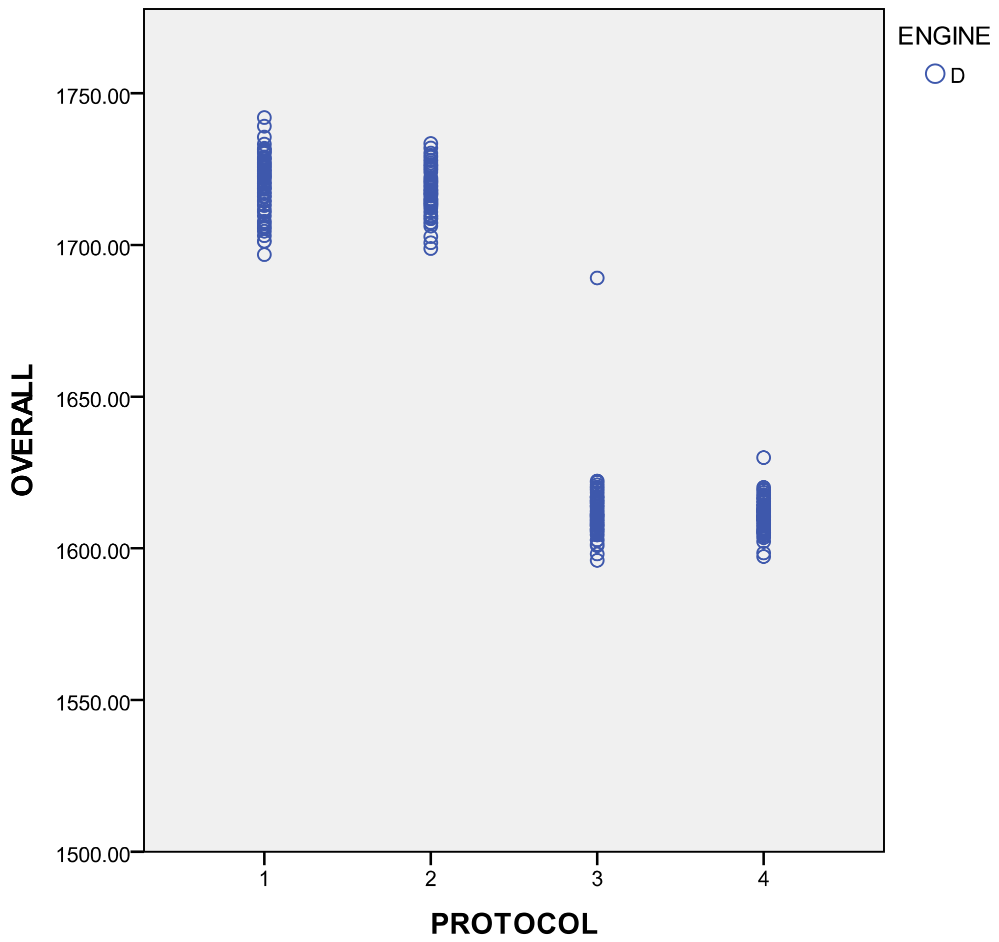
ANOVA

PPD

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.232	3	.077	.138	.937
Within Groups	172.229	308	.559		
Total	172.462	311			

Overall

x-axis = protocol, y-axis = time in minutes



ANOVA

OVERALL

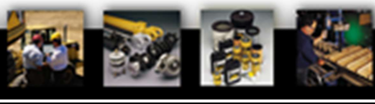
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	904045.515	3	301348.505	4501.214	.000
Within Groups	20620.068	308	66.948		
Total	924665.583	311			

Appendix VII

Cost Assessment Presentation Slides

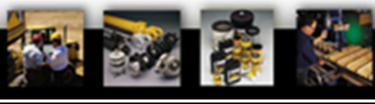
Altering the Manner in which we Cost Remanufacturing
Experimental Feedback

Sara Ridley
Section Manager, Rushden



Content

- Overview of Research
- Experimental Results
- Analysis of Results
- Conclusions from the Analysis
- New Method for Costing Remanufacture
- Questions



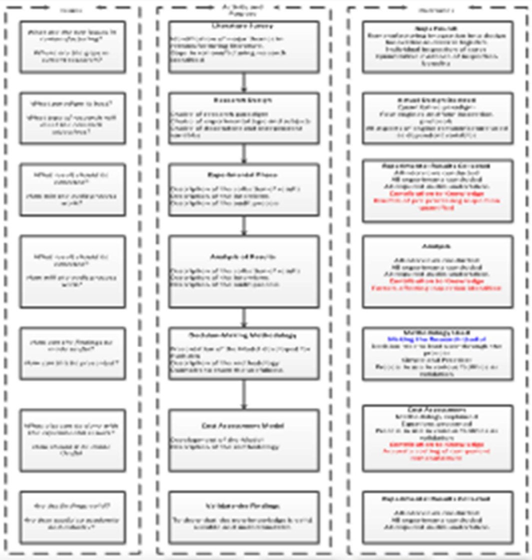
CAT Reman Services Caterpillar Remanufacturing Services

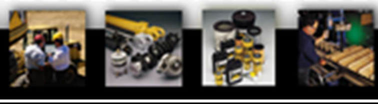
Overview of the Research

Causal Experimental research collecting hard data to find any links between the content of engine inspection before processing

Over 2000 engines of 4 types and 4 customers studied

All the results show the same thing

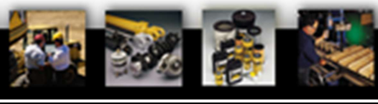




CAT Reman Services Caterpillar Remanufacturing Services

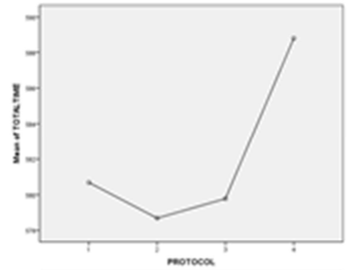
Experimental Results

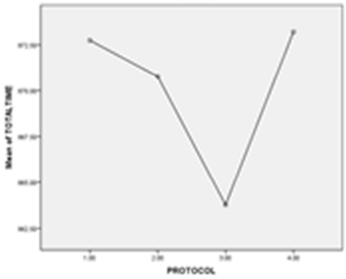
Activity	% Change between Protocol 1 and Control				% Change between Protocol 3 and Control				% Change between Protocol 4 and Control			
	Engine A	Engine B	Engine C	Engine D	Engine A	Engine B	Engine C	Engine D	Engine A	Engine B	Engine C	Engine D
Decant and Inspect	-29.96	-24.37	-21.61	-23.23	40.49	46.57	22.66	50.63	163.91	176.96	176.96	214.96
Disassembly	5.29	1.60	10.35	3.34	-2.49	-4.09	-20.06	-15.00	-2.15	-4.29	-4.29	-17.99
Block Remanufacture	0.51	1.16	3.12	5.05	-0.21	-1.94	0.63	-2.10	-0.17	-2.06	-2.06	-2.54
Head Remanufacture	1.15	0.76	-0.39	0.96	0.39	-2.21	-3.55	0.67	0.23	-2.05	-2.05	-0.56
Crankshaft Remanufacture	1.71	0.00	0.03	0.05	-0.20	0.00	-1.23	-2.75	-0.29	0.00	0.00	-2.46
Camshaft Remanufacture	1.03	-0.03	-0.17	0.3	1.09	0.10	0.04	0.04	1.05	0.04	0.04	0.14
Valve Remanufacture	-0.12	0.12	0.35	0.15	-0.35	-0.05	0.13	-0.02	0.00	0.06	0.06	0.03
Connecting Rods	0.12	0.13	-0.01	0.03	0.20	0.12	-0.02	-0.12	0.02	0.09	0.09	-0.04
Rocker Shaft Remanufacture			-0.05	-0.17			-0.05	-0.14				-0.15
Compressor Remanufacture				-0.1				-17.96				-19.23
Oil Pump Remanufacture		-0.26	-0.01	0.03		0.00	0.06	0.06		-0.21	-0.21	0.05
Fuel Lift Pump Remanufacture			3.96	0.85			-1.33	-4.49				-3.70
EGR Valve Remanufacture			1.14				-3.75					
Vacuum Pump Remanfacture		0.26	0.20	0.1		-0.12	-0.05	0.12		0.00	0.00	0.07
Starter Motor Remanufacture			7.26				-17.55					
Alternator Remanufacture			7.53				-6.65					
Flywheel Remanufacture			1.06				-1.46					
Turbocharger Remanufacture			4.15	-0.44			-16.70	-26.67				-25.60
Small Parts Remanufacture	0.04	1.20	5.85	2.59	0.00	-1.51	-13.52	-5.07	-0.03	-0.03	-1.56	-6.30
Engine Kitting			9.31	0.61			-4.07	-9.55				-9.51
Engine Assembly	-0.37	-0.20	-0.21	0.1	-0.35	-0.03	-0.30	-0.09	-0.35		-0.03	-0.09
Post-Production Test	-0.19	-0.05	0.19	0.13	0.00	-0.03	0.04	0.09	0.15	0.20	0.20	0.09
Paint, Pack and Despatch	0.09	-0.02	-0.02	0.13	0.23	-0.04	-0.04	0.00	0.11	-0.03	-0.03	0.06
Overall Remanufacture	0.43	0.27	2.74	0.76	0.31	-0.71	-5.36	-6.50	1.56	0.35	0.35	-6.22



CAT Reman Services Caterpillar Remanufacturing Services

ANOVA - Engines A and B





Engine A

ANOVA

TOTALTIME

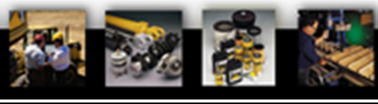
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16747.848	3	5582.616	291.450	.000
Within Groups	20093.189	1049	19.155		
Total	36841.037	1052			

Engine B

ANOVA

TOTALTIME

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5884.232	3	1961.411	116.230	.000
Within Groups	6868.214	407	16.875		
Total	12752.446	410			



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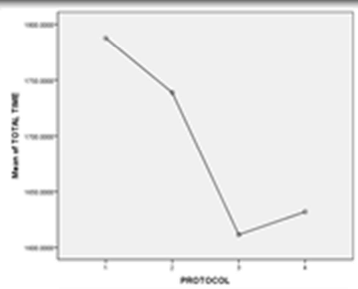
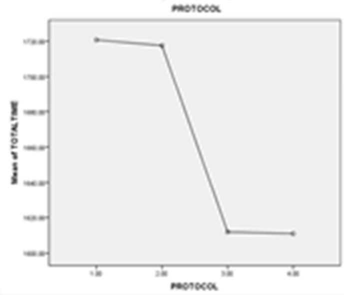
ANOVA - Engines C and D





Engine C

ANOVA

TOTAL TIME

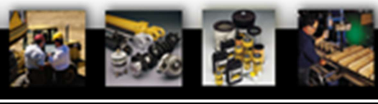
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2244064.267	3	748021.422	11352.218	.000
Within Groups	27411.110	416	65.892		
Total	2271475.378	419			

Engine D

ANOVA

TOTALTIME

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	904045.515	3	301348.505	4501.214	.000
Within Groups	20620.068	308	66.948		
Total	924665.583	311			



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Conclusions from the Results

- Majority of the components with reduced processing time had one or more of the three following traits:
  - Complex geometry including internal ports;
  - Large number of sub-components; or
  - Constructed from or comprising of multiple materials.

More in depth Inspection of components with the characteristics above reduced overall processing times and so different levels of inspection for different models / components is beneficial.

Part of this research highlighted that the current method of costing, using an amalgamated rate and not accounting for specialised technologies (e.g. metal deposition) and scrap rates in specific locations, gives an inaccurate measure.

Overall scrap rates were more or less unchanged however, the point at which the material was scrapped moved further towards the front of the process.

This is important because less work has been undertaken and wasted.

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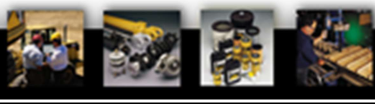

New Method for Costing Remanufacture

Notation of the relevant factors:

Time (in minutes) = t;
Labour rates (in GBP per minute) = $r_1, r_2, r_3 \ldots r_n$;
Scrap rates = $s_1, s_2, s_3 \ldots s_n$;
Licenced technology = l;
Overheads (in GBP per minute) = o; and
Cost of new materials = m.

$$\text{Cost} = m + (((t_1 \times (1-s_1) \times (r_1+o)) + (((t_2 \times (1-s_2) \times (r_2+o)) + ((t_2 \div t) \times l)) + ((t_3 \times (1-s_3)\ (r_3+o)) \ldots + ((t_n \times (1-s_n)\ (r_n+o)))$$

This equation takes all the appropriate factors into account to make an accurate cost assessment for a remanufactured product. The most accurate assessment for a complex assembly can be made by breaking down the bill of materials and summing the cost of each part of the assembly once assessed separately.

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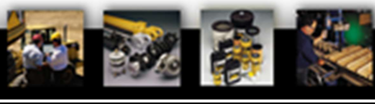

New Method for Costing Remanufacture

This method was trialled using three different engines. The Standard costs on MFGPro (as audited and agreed for 2012) and the actual costs from last month (September) were compared with a BoM analysis using the new method

The table below shows the results:

Case	% Variance from Actual – Traditional Method	% Variance from Actual – New Method
A	-7.61%	-2.18%
B	-3.36%	-2.09%
C	-4.12%	+1.44%

It can clearly be seen that the new method was able to assess costs much more accurately than the current method.

100% accuracy was not attained, normally due to factors not accounted for e.g. no core delivery requiring additional sourcing from scrap dealers etc.

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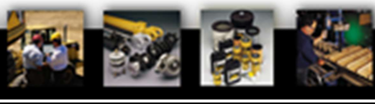
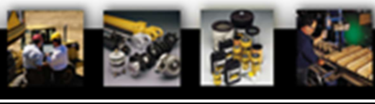


Questions

Thank you for your interest and patience.

Do you have any questions?

CAT Reman Services Caterpillar Remanufacturing Services



References

A

Adams, W.M. (2006). "The Future of Sustainability: Re-thinking Environment and Development in the Twenty-first Century" Report of the IUCN Renowned Thinkers Meeting, 29–31 January 2006

Adler, D. P. (2007) "Comparing energy and other measures of environmental performance in the manufacturing and remanufacturing of engine components" MSc dissertation: Michigan Technological University

Amezquita, T., Hammond, R., Salazar, M. and Bras, B. (1996) " Characterizing the remanufacturability of engineering systems" Proceedings of ASME advances in design automation Conference, September 17-20, Boston, Massachusetts, USA, DE-vol. 82, pp. 271-278

Andreu, J. (1995) "The remanufacturing process" Manchester Metropolitan University, UK

Antony, J. (2003) "Design of Experiments for Engineers and Scientists" Butterworth-Heinemann: Oxford

Aras, N., Boyaci, T. and Verter, V. (2004) "The effect of categorizing returned products in Remanufacturing" IIE Transactions 36, pp. 319–331.

Ayres, R. Ferrer, G. and Van Leynseele, T. (1997) "Eco-efficiency, asset recovery and remanufacturing" Centre for the Management of Environmental Resources; IN SEAD; Fontainebleau; France

B

Bao, X., Tang, O. and Jianhua, J. (2008) "Applying the minimum relative entropy method for binomial distribution in a remanufacturing system" International Journal of Production Economics, 113 (2008) pp. 969-979

Bacon, R. (c. 1267) "Opus Tertium" Translation as stated in Popular Science (Aug 1901), 337, Cattell: New York

Barlow, R. J. (1989) "Statistics: A Guide to the Use of Statistical Methods in the Physical Sciences" Reprint ed. Chicester: John Wiley and Sons Ltd.

The Basel Convention [online]. Available from: http://www.basel.int/index.html

Bird, J. (2010) "Higher Engineering Mathematics" 6th ed. Oxford: Newnes

Brannen, J. (2005) "Mixing Methods: The Entry of Qualitative and Quantitative Approaches into the Research Process" International Journal of Social Research Methodology, 8: 3, pp. 173-184

Brent, A.C. and Steinhilper, R. (2004) “Opportunities for remanufactured electronic products from developing countries: Hypotheses to characterise the perspectives of a global remanufacturing industry” Proceedings of 7th AFRICON Conference in Africa Vol. 2, pp. 891-896

British Standards Institution (2009) “BSI 8887-2. Design for Manufacture, Assembly, Disassembly and End-of-Life Processing (MADE) Part 2: terms and definitions 2009”

Burns, N. and Grove, S.K. (1999) “Understanding Nursing Research.” (2nd ed.) Philadelphia: W.B. Saunders Company

C

Campbell, D. J. and Stanley, J. C. (1963) “Experimental and quasi-experimental designs for research” Chicago: Rand-McNally

Çorbacioğlu, U. and van der Laan, E.A. (2007) “Setting the holding cost rates in a two product system with remanufacturing” International Journal of Production Economics 109, pp. 185–194

Cox, D. R. (2006) “Principles of statistical inference” Cambridge New York: Cambridge University Press

Charness, G., Gneezy, U. and Kuhn, M.A. (2011) "Experimental methods: Between-subject and within-subject design" Journal of Economic Behavior & Organization 81 (2012) pp. 1– 8

Chung, S.L., Wee, H.M. and Yang, P.C. (2008) "Optimal policy for a closed-loop supply chain inventory system with remanufacturing" Mathematical and Computer Modelling 48, pp. 867–881

Cresswell, J. W. (1998) "Qualitative Inquiry and Research Design: Choosing Among Five Traditions" London: Sage Publications

Cummings, L. L. (1978) "Toward organizational behaviour." Academy of Management Review, Vol. 3, pp. 90-98.

D

DEFRA (2003) "Landfill Directive Briefing Paper" London: DEFRA Available at: http://www.defra.gov.uk/environment/waste/strategy/legislation/landfill/ {Accessed on 20th January 2010}

DEFRA (2009) "estimated total annual waste arisings, by sector" London: DEFRA Available at: http://www.defra.gov.uk/evidence/statistics/environment/waste/kf/wrkf02.htm {Accessed on 17th January 2010}

DEFRA (2010) “Commercial and industrial waste generation and management”. [online] Available from:
http://www.defra.gov.uk/statistics/environment/waste/wrfg03-indcom

de Oliveira Simonetto, E. and Borenstein, D. (2007) “A decision support system for the operational planning of solid waste collection” Waste Management **27** (10) (2007), pp. 1286–1297

DePuy, G.W., Usher, J.S., Walker, R.L. and Taylor, G.D. (2007) “Production planning for remanufactured products” Production Planning & Control 18, pp. 573–583

Dobos, I. and Richter, K. (2000) “The integer EOQ repair and waste disposal model - further analysis” Central European Journal of Operations Research 8, pp. 173–194

Dobos, I. and Richter, K. (2006) “A production/recycling model with quality consideration” International Journal of Production Economics 104, pp. 571–579

Donnan, P.T. (2000) “Experimental research” In: Cormack, D. (Ed.) The Research Process in Nursing, (4th ed.). Oxford: Blackwell Science Ltd.

Dowie, T. and Simon, M. (1994) “Guidelines for designing for disassembly and recycling” Proceedings of the R95 Conference on Recovery, Recycling, Re-integration, Geneva, Switzerland, (EMPA).

Dowlatshahi, S. (2000) "Interfaces" Sustainable Business, Vol. 30, No. 3, (May - Jun., 2000), pp. 143-155

Duta, L. and Filip, F.G. (2008) "Control and decision-making process in disassembling used electronic products" Studies in Informatics and Control 17, pp. 17–26

E

Easterby-Smith, M., Thorpe, R. and Lowe, A. (2004). "Management Research" 2nd ed. London: Sage Publications

Eisenhardt, K. (1989). "Building Theories from Case Study Research" Academy of Management Review, 14(4), pp. 532-550

El Saadany, A.M.A. and Jaber, M.Y. (2008) "The EOQ repair and waste disposal model with switching costs" Computers & Industrial Engineering 55, pp. 219–233

Errington, M. (2009) "Business Processes and Strategic Framework for Inspection in Remanufacturing" PhD Dissertation, The University of Exeter, UK

European Union (1993) "Towards Sustainability - the European Community Programme of policy and action in relation to the environment and sustainable development" Available from: http://ec.europa.eu/environment/actionpr.htm {Accessed on 23rd November 2009}

European Union (2000). Directive of The European Parliament and of The Council on End-of Life Vehicles. 2000/53/EC

European Union (2003). Directive of The European Parliament and of The Council on Waste Electrical and Electronic Equipment (WEEE). 2002/96/EC

F

Ferguson, M., Guide, V.D.R., Koca, E. and Souza, G. (2009) "The value of quality grading in remanufacturing" Production and Operations Management 18 (3), pp. 300–314

Ferrer, G. (2001) "On the widget remanufacturing operation" European Journal of Operational Research 135, pp. 373–393

Ferrer, G. (2003) "Yield information and supplier responsiveness in remanufacturing operations" European Journal of Operational Research 149, pp. 540–556

Ferrer, G. and Ketzenberg, M. (2004) "Value of information in remanufacturing complex products" IIE Transactions 36, pp. 265–277

Fisher, R. A. (1925) “Statistical Methods for Research Workers” Oliver and Boyd Ltd.: Edinburgh

Fleischmann, M., Bloemhof-Ruwaard, J.M., Dekker, R., van der Laan, E., van Nunen, J. and Van Wassenhove, L.N. (1997) “Quantitative models for reverse logistics: a review” European Journal of Operational Research 103, pp. 1–17

Fleischmann, M., Van Nunen, J.A.E.E. and Grave, B. (2003) “Integrating closed-loop supply chains and spare-parts management at IBM” Interfaces 33, pp. 44–56

G

Galton, Francis (1883) “Inquiries into Human Faculty and Its Development” London: MacMillan

Garst, John (2002). "Chasing John Henry in Alabama and Mississippi: A Personal Memoir of Work in Progress" Tributaries: Journal of the Alabama Folklife Association Vol. 5: pp. 92–129

Georgiadis, P. and Vlachos, D. (2004) “The effect of environmental parameters on product recovery” European Journal of Operational Research 157 (2004), pp. 449-464

Giuntini, R. and Gaudette, K. (2003) “Remanufacturing: the next great opportunity for boosting US productivity”. Business Horizons 46(6): pp. 41–48

Gonzalez, B. and Adenso-Diaz, B. (2006) “A scatter search approach to the optimum disassembly sequence problem” Computers & Operations Research 33, pp. 1776–1793

Gosset, W.S. under the pseudonym “Student” (1908) “The probable error of a mean” Biometrika 6 (1) pp. 1-25 Available from: http://biomet.oxfordjournals.org/content/6/1/1 {Accessed on 12th March 2010}

Guide, V.D.R. Jr. (1996) “Scheduling using drum-buffer-rope in a remanufacturing environment” International Journal of Production Research 34, pp. 1081–1091

Guide, V.D.R. Jr. and Spencer, M.S. (1997) “Rough-cut capacity planning for remanufacturing firms” Production Planning & Control 8, pp. 237–244

Guide, V.D.R. Jr. (1999) “Remanufacturing production planning and control: U.S industry best practice and research issues” Second International Working Paper on Re-use; Eindhoven, pp. 101- 114

Guide, V. D. R. Jr. and Gupta, S.M. (1999) "A queuing network model for remanufacturing production systems” Proceedings of the Second International Seminar on Reuse, Eindhoven, the Netherlands, 1-3 March 1999, pp. 115-128

Guide, V.D.R. Jr. (2000) “Production planning and control for remanufacturing: industry practice and research needs” Journal of Operations Management 18, pp. 467–483

Gummeson, E. (1993) "Case study research in management methods for generating qualitative data" Stockholm University, Department of Business Administration, Preliminary Script edition 2

Gummesson, E. (1999) “Qualitative Methods in Management Research” (2nd ed.) Sage: California

Gupta, S.M., Veerakamolmal, P. (2001) “Aggregate planning for end-of-life products” In: Sarkis, J. (Ed.), Greener Manufacturing and Operations: From Design to Delivery and Back. Greenleaf Publishing Ltd., Sheffield, U.K. pp 205–222

H

Hammond, R., Amezquita, T. and Bras, B. (1998) “Issues in the Automotive Parts Remanufacturing Industry – A Discussion of Results from Surveys Performed among Remanufacturers” Georgia: Georgia Institute of Technology

Hartman, R. (1946) “The Structure of Value: Foundations of Scientific Axiology” Carbondale: Southern Illinois University Press

Hatcher, G.D., Ijomah, W.L., and Windmill, J.F.C. (2011) “Design for Remanufacture: a literature review and further research needs” Journal of Cleaner Production 19 (2011) pp. 2004-2014

Hatcher, G.D., Ijomah, W.L., and Windmill, J.F.C. (2013) “Integrating design for remanufacture into the design process: the operational factors” Journal of Cleaner Production 39 (2013) pp. 200-208

Hauser, W. and Lund, R.T. (2003) “The remanufacturing industry: anatomy of a giant”.
Boston, Massachusetts: Department of Manufacturing Engineering, Boston University

Haynsworth, H. C. and Lyons, R. T. (1987) "Remanufacturing by design, the missing link" Production & Inventory Management; Second Quarter, pp. 24 -28

Hazen, B.T., Cegielski, C. and Hanna, J.B. (2011) "Diffusion of green supply chain management: Examining perceived quality of green reverse logistics", The International Journal of Logistics Management, Vol. 22 Iss: 3, pp. 373 – 389

Hormozi, A., (1996) “Remanufacturing and its consumer, economic and environmental benefits” APEX Remanufacturing Symposium, 20–22 May 1996, Dayton, Ohio, USA, pp. 3–5. IEEE. IEEE Standard for Functional Modeling

Hundal, M. (2000) “Design for recycling and remanufacture” Proceedings of International Design Conference - DESIGN 2000. Dubrovnik, May 23 - 26, 2000. University of Zagreb

Hussey, J. and Hussey, R. (1997). “Business research: a practical guide for undergraduate and postgraduate students.” Basingstoke: Macmillan Business

I

Ijomah, W.L. (2002) “A model-based definition of the generic remanufacturing business process” PhD Dissertation: The University of Plymouth, UK

Ijomah, W.L., Childe, S., McMahon, C. and Hammond, G.P. (2005) A robust description and tool for remanufacturing: a resource and energy recovery strategy. Proceedings of EcoDesign 2005: fourth international symposium on environmentally conscious design and inverse manufacturing, December 12–14, Tokyo, Japan, 2005.

Ijomah, W.L., McMahon, C., Hammond, G. and Newman, S. (2007) “Development of design for remanufacturing guidelines to support sustainable manufacturing” Robotics and Computer Integrated Manufacturing 23, pp. 712-719

Ijomah, W.L. (2008) “A tool to improve training and operational effectiveness in remanufacturing” International Journal of Computer Integrated Manufacture, 1 - 26, Volume 21, Issue 6

Ijomah, W.L. (2009).”Addressing decision making for remanufacturing operations and design-for-remanufacture” International Journal of Sustainable Engineering 2 (2), pp. 91-202

Ilgin, M.A. and Gupta, S.M. (2008) “Joint optimization of transportation and spare parts inventory policies in a reverse logistics network using optquest” Proceedings of the 2008 ASME International Mechanical Engineering Congress and Exposition, Boston, MA, November 2–6, pp. 877–885

Ilgin, M.A. and Gupta, S.M. (2010) “Environmentally conscious manufacturing and product recovery (ECMPRO): A review of the state of the art” Journal of Environmental Management 91 (2010) pp. 563–591

Inderfurth, K., de Kok, A.G. and Flapper, S.D.P. (2001) “Product recovery in stochastic remanufacturing systems with multiple reuse options” European Journal of Operational Research 133, pp. 130–152

Iversen, G.R. and Norporth, H. (1987) “Analysis of Variance” Sage University Paper Series on Quantitative Applications in the Social Sciences, No. 07-001

J

Jack, B. and Clarke, A.M. (1998) “The value of quantitative research in nursing” Professional Nurse 13:1, pp. 753–756

Jayal, A.D., Badurdeen, F., Dillon Jr., O. W. and Jawahir, I.S. (2010) "Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels" CIRP Journal of Manufacturing Science and Technology 2 (2010) pp. 144–152

Jayaraman, V. (2006) "Production planning for closed-loop supply chains with product recovery and reuse: an analytical approach" International Journal of Production Research 44, pp. 981–998

Jebb, R. C. (trans.) (1909) "The Rhetoric of Aristotle" Cambridge: University Press.

Jones, G. R. and Butler, J. E. (1988) "Costs, Revenue and Business-Level Strategy" Academy of Management Review vol. 13, no. 2, pp. 202-213

K

Karakayali, I., Emir-Farinas, H. and Akcali, E. (2007) "An analysis of decentralized collection and processing of end-of-life products" Journal of Operations Management 25, pp. 1161–1183

Kernbaum, S., Franke, C. and Seliger, G. (2006) "Flat Screen Monitor Disassembly and Testing for Remanufacture" Conference Proceedings at 13th CIRP International Conference on Life Cycle Engineering, Leuven, Belgium.

Kempthorne, O. (1973) “The Design and Analysis of Experiments” Malabar: Krieger Publishing Company

Kim, H.J., Lee, D.H., Xirouchakis, P. and Kwon, O.K. (2009) “A branch and bound algorithm for disassembly scheduling with assembly product structure” Journal of the Operational Research Society 60, pp. 419–430

Kim, K., Jeong, B. and Jeong, S. (2005) “Optimization model for remanufacturing system at strategic and operational level” Computational Science and Its Applications – ICCSA 2005. Springer, Berlin, pp. 566–576

Kim, K., Song, I., Kim, J. and Jeong, B. (2006) “Supply planning model for remanufacturing system in reverse logistics environment” Computers & Industrial Engineering 51, pp. 279–287

Kim, H.J., Kernbaum, S. and Seliger, G. (2009) “Emulation-based control of a disassembly
system for LCD monitors” International Journal of Advanced Manufacturing Technology, 40, pp. 383–392

Knox, K. (2004) “A Researcher’s Dilemma - Philosophical and Methodological Pluralism” Electronic Journal of Business Research Methods, Volume 2, Issue 2, 2004, pp. 119-128

Koh, S.G., Hwang, H., Sohn, K.I., and Ko, C.S. (2002). "An optimal ordering and recovery policy for reusable items" Computers and Industrial Engineering, 43, pp. 59–73

Kongar, E. and Gupta, S.M. (2006) "Disassembly to order system under uncertainty" Omega 34, pp. 550–561

Konstantaras, I. and Papachristos, S. (2007) "Optimal policy and holding cost stability regions in a periodic review inventory system with manufacturing and remanufacturing options." European Journal of Operational Research 178, pp. 433–448

Kopacek, P. and Kopacek, B. (2006) "Intelligent, flexible disassembly" International Journal of Advanced Manufacturing Technology 30, pp. 554–560

Kroll, E. and Hanft, T.A. (1998) "Quantitative evaluation of product disassembly for recycling" Research in Engineering Design 10, pp. 1–14

Kulkani A., Ralph, D. and McFarlane, D. (2007) "Value of RFID in remanufacturing" International Journal of Services Operations and Informatics, vol. 2, no. 3/2007, pp. 225-252

The Kyoto Protocol (2005) United Nations Framework Convention on Climate Change (UNFCCC) [online]. Available from: http://unfcc.int/kyoto-protocol/items/2830.php {Accessed on 26th November 2009}

L

Lambert, A.J.D. and Gupta, S.M. (2002) “Demand-driven disassembly optimization for electronic products” Journal of Electronics Manufacturing 11, pp. 121–135

Langella, I.M. (2007) “Heuristics for demand-driven disassembly planning” Computers & Operations Research 34, pp. 552–577

Lee, H.B., Cho, N.W. and Hong, Y.S. (2010) “A hierarchical end-of-life decision model for determining the economic levels of remanufacturing and disassembly under environmental regulations” Journal of Cleaner Production, doi: 10.1016/j.jclepro.2010.04.010

Li, J.R., Khoo, L.P. and Tor, S.B. (2006) “Generation of possible multiple components disassembly sequence for maintenance using a disassembly constraint graph” International Journal of Production Economics 102, pp. 51–65

Li, J.R., Gonzalez, M. and Zhu, Y. (2009) “A hybrid simulation optimization method for production planning of dedicated remanufacturing” International Journal of Production Economics 117, pp. 286–301

Liang, Y., Pokharel, S. and Lim, G. H. (2007) “Pricing used products for remanufacturing” European Journal of Operational Research 193 (2009) pp. 390–395

Lipsey, M. W. and Hurley, S. M. (2009) “Design sensitivity: Statistical power for applied experimental research” In L. Bickman & D. Rog (Eds). “The SAGE Handbook of Applied Social Research Methods” (2nd ed.) Los Angeles: Sage, Chapter 2, pp. 44-76

Low, M., Williams, D. and Dixon, C. (1996) “Choice of end-of-life product management strategy: a case study in alternative telephone concepts” IEEE International Symposium on Electronics and the Environment, IEEE. 1996; pp. 112-117

Low, M., Williams, D. and Dixon, C. (1997) “The economics of end of life management strategy choice: routes to revenue generation from mature products” IEEE International Symposium on Electronics and the Environment, New York: IEEE, 1997; pp. 291-296

Lu, L.Y.Y., Wu, C.H. and Kuo, T.C. (2007) “Environmental principles applicable to green supplier evaluation by using multi-objective decision analysis” International Journal of Production Research 45, pp. 4317–4331

Lund, R.T. (1984), "Remanufacturing: the experience of the USA and implications for the developing countries" World Bank Technical Paper No. 3

Lund, R.T. (1996), “The Remanufacturing Industry: Hidden Giant.” Boston University: Boston, MA.

Lundberg, G. C. (1976) “Hypothesis creation in organizational behavior research” Academy of Management Review, Vol. 1 (2), pp. 5-12

Lundmark, P., Sundin, E. and Björkman, M. (2009) “Industrial Challenges within the Remanufacturing System” Proceedings of Swedish Production Symposium, Stockholm, Sweden, pp. 132-138

M

Mähl, M. and Östlin, J. (2007) “Lean Remanufacturing – Material Flows at Volvo Parts Flen” Masters Dissertation: Uppsala University: Sweden

McCaskey, D. (1994) “Anatomy of adaptable manufacturing in the remanufacturing environment” APICS Remanufacturing Seminar Proceedings, USA, 1994, pp. 42–45

McMaster, P. (1989) "Renaissance in remanufacturing" Manufacturing Engineer, October,
pp. 23-24

Millar, A. (2007) “The State of Knowing” Philosophical Issues, Volume 17, pp. 179-196

Minner, S. (2001) “Strategic safety stocks in reverse logistics supply chains” International Journal of Production Economics 71, pp. 417–428

Mostard, J. and Teunter, R. (2006) “The newsboy problem with resalable returns: a single period model and case study” European Journal of Operational Research 169, pp. 81–96

Moustakas, C. E. (1994) “Phenomenological Research Methods” Beverly Hills, CA: Sage

Mukhopadhyay, S. and Ma, H. (2008) “Joint procurement and production decisions in remanufacturing under quality and demand uncertainty” International Journal of Production Economics 120 (2009) pp. 5–17

Mulhall, A. (1994) “The experimental approach and randomized controlled trials.” In:
Hardey, M. and Mulhall, A. (Eds.), “Nursing Research: Theory and Practice” London: Chapman and Hall.

N

Navin-Chandra, D. (2003) “Re-star; a design tool for the environmental recovery analysis” ICED 93 International Conference on *Engineering Design*, The Hague, The Netherlands, pp. 780–787

O

Office of National Statistics (2010) “Quarterly Report Labour market statistics October 2010” Available from: http://www.statistics.gov.uk/pdfdir/lmsuk1010.pdf {Accessed on 16th November 2010}

O’Neill, J. (1998) “Practical Reasoning and Mathematical Argument” *Studies in History and Philosophy of Science* 29 (1998), pp. 195-205

Östlin, J., Sundin, E. and Björkman, M. (2008) “Importance of closed-loop supply chain relationships for product remanufacturing” International Journal of Production Economics 115, pp. 336–348

Östlin, J., Sundin, E. and Björkman, M. (2008) “Business Drivers for Remanufacturing” LCE 2008: 15th CIRP International Conference on Life Cycle Engineering: Conference Proceedings, p. 581, CIRP

P

Parahoo, K. (1997) “Nursing Research: Principles, Process and Issues” London: Macmillan.

Patton, M. Q. (1980) “Qualitative evaluation methods” Beverly Hills, CA: Sage

Petrakis, L. (1993) "recycling technologies and market opportunities" Conference proceedings at Brookhaven National Laboratories, USA

Pokharel, S. and Mutha, A. (2009) “Perspectives in reverse logistics: A review” Resources, Conservation and Recycling, 53, pp. 175–182

Polit, D.F. and Hungler, B.P. (1999) “Nursing Research: Principles and Methods” (6th ed.) Philadelphia: J. B. Lippincott.

Polit, D.F., Beck, C.T. and Hungler, B.P. (2001) “Essentials of Nursing Research: Methods, Appraisal and Utilisation” (5th ed.) Philadelphia: J. B. Lippincott.

R

Richardson, J. (2000) “The use of randomized control trials in complementary therapies: exploring the issues” Journal of Advanced Nursing 32:2, pp. 398–406.

Richter, K. (1997) “Pure and mixed strategies for the EOQ repair and waste disposal Problem” OR Spectrum 19, pp. 123–129

Richter, K. and Dobos, I. (1999) “Analysis of the EOQ repair and waste disposal problem with integer setup numbers” International Journal of Production Economics 59, pp. 463–467

Robotis, A., Boyaci, T. and Verter, V. (2012) “Investing in reusability of products of uncertain remanufacturing cost: The role of inspection capabilities” International Journal of Production Economics 140 (2012) pp. 385-395

Rubio, S. and Corominas, A. (2008) “Optimal manufacturing-remanufacturing policies in a lean production environment” Computers & Industrial Engineering 55, pp. 234–242

Rugrungruang, F. (2008) “An Integrated Methodology for Assessing Physical and Technological Life of Products for Reuse” PhD thesis, University of New South Wales, Australia

Runes, D. A. (ed.) (1948) “The Diary and Sundry Observations of Thomas A. Edison” Philosophical Library: New York

S

Schultmann, F., Zumkeller, M. and Rentz, O. (2006) “Modeling reverse logistic tasks within closed-loop supply chains: an example from the automotive industry” European Journal of Operational Research 171, pp. 1033–1050

Seitz, M. (2006) “A critical assessment of motives for product recovery: the case of engine remanufacturing” Journal of Cleaner Production 15 (2007) pp. 1147-1157

Seliger, G., Basdere, B., Keil, T. and Rebafka, U. (2002) “Innovative processes and tools for disassembly” CIRP Annals – Manufacturing Technology 51, pp. 37–40

Shepherd, S., Bonsall, P. and Harrison, G. (2012) “Factors affecting future demand for electric vehicles: A model based study” Transport Policy 20 (2012) pp. 62-74

Shu, L. and Flowers, W. (1995) “Considering remanufacture and other end-of-life options in selection of fastening and joining methods” IEEE International Symposium on Electronics and the Environment, Orlando, FL: IEEE, 1995, pp. 1-6

Shu, L. and Flowers, W. (2003) “A structured approach to design for remanufacture” ASME Winter Annual Meeting on Information Based Approaches to Concurrent Engineering

Solomon, R. L. (1949) “An extension of control group design” Psychological Bulletin, 46, pp. 137-150

Soskice, J. (1985) “Metaphor and religious language” Oxford, UK: Clarendon

Steinhilper, R. (1998)”Remanufacturing: The Ultimate Form of Recycling” Stuttgart: Fraunhofer IRB Verlag

Steinhilper, R. (2005) “Remanufacturing across the world: business and benefits” International Symposium on Remanufacturing and Sustainable Product Development, Seoul, Korea.

Sullivan, J. L., Costic, M. M. and Han, W. (1998) "Automotive Life Cycle Assessment:
Overview, Metrics, and Examples" SAE Technical Paper 980467

Sundin, E., and Lee, H.M. (2012) "In what way is remanufacturing good for the environment?" Design for Innovative Value Towards a Sustainable Society. Springer Netherlands, pp. 552-557

Sundin, E. (2004) "Product and process design for successful remanufacturing" PhD thesis,
Linköpings Universitet, Linköping, Sweden

Sundin, E., Lindahl, M. and Ijomah, W.L. (2009) "Product design for product/ service
systems: design experiences from Swedish industry" Journal of Manufacturing Technology Management 20 (5) pp. 723-753

T

Tang, O. and Teunter, R. (2006) "Economic lot scheduling problem with returns" Production & Operations Management 15, pp. 488–497

Tang, O., Grubbström, R.W. and Zanoni, S. (2007) "Planned lead time determination in a make-to-order remanufacturing system" International Journal of Production Economics 108, pp 426–435

Tagaras, G. and Zikopoulos, C. (2008) “Optimal location and value of timely sorting of used items in a remanufacturing supply chain with multiple collection sites” International Journal of Production Economics 115 (2008) pp. 424– 432

Teunter, R.H. (2001) “Economic ordering quantities for recoverable item inventory systems” Naval Research Logistics 48, pp. 484–495

Teunter, R.H. (2004) “Lot-sizing for inventory systems with product recovery” Computers & Industrial Engineering 46, pp. 431–441

Teunter, R.H. and Flapper, S.D.P. (2010) “Optimal core acquisition and remanufacturing policies under uncertain core quality fractions” European Journal of Operational Research, doi: 10.1016/j.ejor. 2010.06.015

Thomas K. W. and Tymon W. G. (1982) "Necessary properties of relevant research: Lessons from recent criticism of organisational science" Academy of Management Review, Vol. 7 No I, pp. 345-352

Thorn, B.K. and Rogerson, P. (2002) “Take it back” Industrial Engineer 34 (4) pp. 34-40

Torres, F., Gil, P., Puente, S.T., Pomares, J. and Aracil, R. (2004) "Automatic PC disassembly for component recovery" International Journal of Advanced Manufacturing Technology 23, pp. 39–46

U

UK HM Government (2002) "The Landfill (England and Wales) Regulations 2002" Environmental Protection England and Wales, Statutory Instrument 2002, No. 1559

UK HMRC (2012) "Overview of Tax Legislation and Rates [online] Available from: http://www.hmrc.gov.uk/budget2012/ootlar-main.pdf

United Nations Commission on Sustainable Development. Indicators of sustainable development: guidelines and methodologies. United Nations, 2001; Available from: http://www.un.org/esa/sustdev/natlinfo/indicators/indisd/indisd-mg2001.pdf. {Accessed on 13th February 2010}

United Nations General Assembly (1987) "Report of the World Commission on Environment and Development: Our Common Future." Transmitted to the General Assembly as an Annex to document A/42/427 - Development and International Co-operation: Environment

United Nations World Summit (2005) "High Level Plenary Meeting of the 60th Session of the General Assembly" 14th - 16th September 2005. Available from: http://www.un.org/summit2005/ {Accessed on 21st February 2010}

V

Van Dalen, D. (1979) “Understanding educational research” New York: McGraw-Hill

Van der Laan, E., Salomon, M. and Dekker, R. (1999a) “An investigation of lead-time effects in manufacturing/remanufacturing systems under simple PUSH and PULL control strategies” European Journal of Operational Research 115, pp. 195–214

Van der Laan, E., Salomon, M., Dekker, R. and Wassenhove, L.V. (1999b) “Inventory control in hybrid systems with remanufacturing” Management Science 45, pp. 733–747

Vandermerwe, S. and Oliff, M. (1991) "Corporate challenge for an age of reconsumption" The Columbia Journal of World Business, Vol. 27, No. 3, pp. 7-25

Vlachos, D. and Dekker, R. (2003) “Return handling options and order quantities for single period products” European Journal of Operational Research 151, pp. 38–52

Vlachos, D., Georgiadis, P. and Iakovou, E. (2007) “A system dynamics model for dynamic capacity planning of remanufacturing in closed-loop supply chains” Computers & Operations Research 34, pp. 367–394

W

Wand, Y. and Weber, R. (1993) “On the ontological expressiveness of information systems analysis and design grammars” European Journal of Information Systems 3, pp. 217-237

Weigl-Seitz, A., Hohm, K., Seitz, M. and Tolle, H. (2006) “On strategies and solutions for automated disassembly of electronic devices” The International Journal of Advanced Manufacturing Technology 30, pp. 561–573

Westkämper, E., Feldman, K., Reinhart, G. and Seliger, G. (1999) “Integrated development of assembly and disassembly” Annals of the CIRP 1999; 48 (2) pp. 557-65

X

Xanthopoulos, A. and Iakovou, E. (2009) “On the optimal design of the disassembly and recovery processes” Waste Management 29, pp. 1702–1711

Y

Yan, N. (2012) “Dynamic Models and Coordination Analysis of Reverse Supply Chain with Remanufacturing” Proceedings of 2012 International Conference on Applied Physics and Industrial Engineering. Physics Procedia 24 (2012) pp. 1357-1363

Yang, M. and Chen, M. (2005) “Life Cycle of Remanufactured Engines” Journal of Central South University of Technology October 2005 Issue 2 pp. 81-85

Yin, R., (1994) “Case Study Research: Design and Methods” 2nd ed. Sage: London

Yount, W. R. (2006) “Research Design and Statistical Analysis in Christian Ministry” (4th ed.) W. R. Yount [Online] Available from: http://www.napce.org/documents/research-design-yount/13_experiment_4th.pdf {Accessed on 19th January 2010}

Yu, C. and Ohlund, B. (2010) “Threats to Validity of Research Design” [online] Available from: http://www.creative-wisdom.com/teaching/WBI/threat.shtml {Accessed on 17th February 2010}

Yuksel, H. (2010) “Design of Automobile engines for remanufacture with quality Function Deployment” International Journal of Sustainable Engineering 3 (3), pp. 170-180

Z

Zanoni, S., Ferretti, I. and Tang, O. (2006) “Cost performance and bullwhip effect in a hybrid manufacturing and remanufacturing system with different control policies” International Journal of Production Research 44, pp. 3847–3862

Zikopoulos, C. and Tagaras, G. (2007) “On the attractiveness of sorting before disassembly in Remanufacturing” IIE Transactions, 40:3, pp. 313-323