International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, Volume 2, Issue 3, March 2012)

Implementation of SPC Techniques in Automotive Industry: A Case Study

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***Abstract*: In this paper, an attempt has been made to implement the some statistical process control (SPC) techniques in the industry that is offering its customers the widest and latest range of sealing solutions for various applications in the automotive industry. The power of SPC lies in the ability to examine a process and the sources of variation in that process, using tools that give weightage to objective analysis over subjective opinions and that allow the strength of each source to be determined numerically. Only two main techniques i.e. cause and effect diagram and control charts are implemented in this industry out of seven SPC techniques. The present work deals with the study of defects in shocker seals of an automotive industry. It is found that after implementing the SPC tools to remove the root causes, the percentage rejection is reduced from 9.1% to 5% and process capability of 0.953 is achieved.**

***Keywords*— Cause and effect diagram, control charts, process capability index, casting defects and percentage rejection.**

I. INTRODUCTION

Statistical process control (SPC) is the application of statistical methods to the monitoring and control of a process to ensure that it operates at its full potential to produce conforming product. Under SPC, a process behaves predictably to produce as much conforming product as possible with the least possible waste. While SPC has been applied most frequently to controlling manufacturing lines, it applies equally well to any process with a measurable output. Key tools in SPC are control charts and cause & effect diagrams, focused on continuous improvement. Variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer.

With its emphasis on early detection and prevention of problems, SPC has a distinct advantage over other quality methods. In mass-manufacturing, the quality of the finished article was traditionally achieved through post-manufacturing inspection of the product; accepting or rejecting each article (or samples from a production lot) based on how well it met its design specifications. In contrast, Statistical Process Control uses statistical tools to observe the performance of the production process in order to predict significant deviations that may later result in rejected product.

Two kinds of variation occur in all manufacturing processes: both these types of process variation cause subsequent variation in the final product. The first is known as natural or common cause of variation and consists of the variation inherent in the process as it is designed. Common cause of variation may include variations in temperature, properties of raw materials, strength of an electrical current etc. The second kind of variation is known as special cause of variation, or assignable cause of variation, and happens less frequently than the first. With sufficient investigation, a specific cause, such as abnormal raw material or incorrect set-up parameters can be found for special cause variations. By observing at the right time what happened in the process that led to a change, the quality engineer or any member of the team responsible for the production line can troubleshoot the root cause of the variation that has crept in to the process and correct the problem. SPC indicates when an action should be taken in a process, but it also indicates when NO action should be taken. An example is a person who would like to maintain a constant body weight and takes weight measurements weekly. A person who does not understand SPC concepts might start dieting every time his or her weight increased, or eat more every time his or her weight decreased. This type of action could be harmful and possibly generate even more variation in body weight. SPC would account for normal weight variation and better indicate when the person is in fact gaining or losing weight.

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The preparatory phases of SPC involve several steps, using a number of different tools. Seven quality tools are available to help organizations to better understand and improve their processes. The essential tools for the discovery process are: Check Sheet, Cause-and-Effect Sheet, Flow Charting, Pareto Chart, Scatter Diagram, Histogram or probability plot and Control Charts.

Check sheets are simply charts for gathering data. When check sheets are designed clearly and cleanly, they assist in gathering accurate and pertinent data, and allow the data to be easily read and used. Cause-and-Effect or Fishbone diagram are also called Ishikawa diagrams because Kaoru Ishikawa developed them to search the root causes of problem. The fishbone chart organizes and displays the relationships between different causes for the effect that is being examined. This chart helps organize the brainstorming process. The major categories of causes are put on major branches connecting to the backbone and various sub-causes are attached to the branches. Flowcharting breaks the process down into its many sub-processes. Analyzing each of these separately minimizes the number of factors that contribute to the variation in the process. The Pareto chart can be used to display categories of problems graphically so they can be properly prioritized. The Pareto chart is named for a 19th century Italian economist who postulated that a small minority (20%) of the people owned a great proportion (80%) of the wealth in the land. The Scatter plot is another problem analysis tool. Scatter plots are also called correlation charts. A Scatter plot is used to uncover possible cause-and-effect relationships. It is constructed by plotting two variables against one another on a pair of axes. A Scatter plot cannot prove that one variable causes another, but it does show how a pair of variables is related and the strength of that relationship.

The probability plot is a graph of the cumulative relative frequencies of the data, plotted on a normal probability scale. The purpose of this plot is to show whether the data approximates a normal distribution. A histogram is a snapshot of the variation of a product or the results of a process. It often forms the bell shaped curve which is characteristic of a normal process. Control charts are an essential tool of continuous quality control. Control charts monitor processes to show how the process is performing and how the process and capabilities are affected by changes to the process. This information is then used to make quality improvements. Control charts are also used to determine the capability of the process. They can help to identify special or assignable cause for factors that impede peak performance.

Capability index value and comparing the calculated capability index to the desired index value, making a decision concerning process changes, and recommending any suggestions to reach the desired goal. The popularity of capability measures continues to increase because of the mentioned benefits. Terminology associated with this subject must be relatively easy and provide a common language for discussing quality on the shop floor with suppliers as well as with customers.

The Control charts may be classified: (i) control charts for variables and (ii) control charts for attribute. The control charts based on variable data that can be measured on a continuous scale i.e. weight, volume, temperature etc. are known as control charts for variables. The control charts based on discrete data i.e. counted as 'present' or 'not' are called control charts for attributes. When constructing attribute control charts, a subgroup is the group of units that are inspected to obtain the number of defects or the number of defective items.

Theory of $\bar{X}$ Charts

In $\overline{X}$ chart, means of small samples (3-5) are taken at regular intervals, plotted on a chart, and compared against two limits. The limits are known as upper control limit (UCL) and lower control limit (LCL). These limits are defined as under:

$$LCL = \bar{X} - A_2 R \quad \text{and} \quad UCL = \bar{X} + A_2 R$$

Where,

$\bar{X}$ is the target mean and factor A_2 depends on sample size. The process is assumed to be out of control when the sample average falls beyond these limits.

Theory of Range (R) charts

In these charts, the sample ranges are plotted in order to control the variability of a variable. The centreline of the R chart is known as average range. The range of a sample is simply the difference between the largest and smallest observation.

If R_1, R_2, ..., R_k, be the range of k samples, then the average range (R bar) is given by:-

$$\bar{R} = \frac{R_1 + R_2 + \ldots + R_k}{k}$$

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The upper and lower control limits of *R* chart are:

Upper control limit: $UCL_R = D_4 * \bar{R}$

Lower control limit: $LCL_R = D_3 * \bar{R}$

Where,

Factors, D_3 and D_4 depend only on sample size (n)

II. LITERATURE REVIEW

From the past literature survey, it is evident that some research on Statistical process Control is carried by previous researchers but still a lot of applied research in this field is required so as to explore the utilization of SPC technique in the area of production, manufacturing and design.

The control chart, introduced in 1924, allows management to look at processes rather than just at products. Shewhart discussed the concept of statistical control. He carefully stated that a control chart is not a test of statistical significance. In his first book on quality control, Shewhart [11] described to select the criterion (the three sigma limits). A control chart predicts that, in the absence of assignable causes, the process will operate as a random system and produce the present level of quality in the future. If that level of quality is not satisfactory, a fundamental change in the process is required.

Ishikawa [5] added the cause-and-effect chart as an aid to brainstorming, but all the rest of the methods were the same as those recommended by Juran [6]. The popularity of these problem-solving tools and the ease of their use caused many to adopt them. Kane [7] carried out a study on capability indices and examined the uses of capability indices along with their estimation procedure. When properly applied, statistical tools are an effective way for improving process quality. Costa [4] also studied the performance of $\overline{X}$ chart with variable sample size and variable sampling intervals. He compared the performance of his charts with Shewhart $\overline{X}$ charts and noticed that the charts proposed by him outperforms Shewhart's $\overline{X}$ chart with a large margin.

Chen and Ding [3] reviewed Cp, Cpk, Cpm and Cpmk, and their generalizations, and then proposed a new index Spmk for any underlying distribution, which takes into account the process variability, departure of the process mean from the target value, and proportion of non-conformity. Nelson [9] described the situation when one should not adjust the process so that over or frequent adjustments can be avoided. He described that due to lack of control charts, the technicians have a tendency to continuously adjust the process to keep it on target value. Chang and Gan [2] proposed the Shewhart charts for monitoring the variance component of the process. They provided the simple procedures for designing Shewhart charts for monitoring variance components.

Rahardja [12] compared the effectiveness of the X-Chart alone to that of the individuals and Moving Range Chart Combination (X/MR Charts), in terms of Average Run Length (ARL) after designing for a common "all OK" (in control) ARL. Comparison has been made under five different non-standard conditions, including both iid and non-iid circumstances. He conclude that adding the Moving Range chart to an X-chart, while generally not helpful for detecting iid departures from standard conditions, can be beneficial in detecting some non-iid conditions. Lillrank and Kujala [8] examined on the applicability of SPC in non-repetitive processes and open systems, non-routine processes and project-based business activities. They also proposed guidelines for adjusting the logic of common and specific causes for project-based businesses are proposed.

Prajapati and Mahapatra [10] proposed a joint $\overline{X}$ and R chart to monitor the process mean and variance simultaneously. They have suggested a very simple and effective design of proposed joint $\overline{X}$ and R chart to monitor the process mean and standard deviation. Sultana et al. [13] intended to combine the Hourly Data System (HDS) and Statistical Process Control (SPC) practices to improve manufacturing performances in manufacturing companies. The focus of their work is to find out the frequencies and time duration of machine breakdowns as well as the major causes of breakdowns affecting productivity. In this research SPC is used to increase total output identifying major loss times from various machine breakdowns using HDS. The obtained result shows that any breakdown can cause a huge cost and the best approach to address any breakdown is the preventive measure.

Wu and Yu [14] proposed a neural network-based identification model for both mean and variance shifts in correlated processes. The proposed model used a selective network ensemble approach named Discrete Particle Swarm Optimization (DPSOEN) to obtain the improved generalization performance, which outperforms those of single neural network. The model was capable of on-line monitoring mean and variance shifts, and classifying the types of shifts without considering the occurrence of both mean and variance shifts in one time. Result is significant it provided additional information a process changes, which could greatly aid identification of assignable causes.

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Abdolshah et al. [1] stated that process capability indices (PCIs) are appropriate tools to measure the inherent capability of a process, but most of them do not consider the losses of a process, while in today's competitive business environment, it is becoming more and more important for companies to evaluate and minimise their losses. They presented a review of loss-based PCIs such as Cpm, Cpmk, PCIθ, Cpc, Le and L″e. They also discussed characteristics of loss-based PCIs such as reject based, asymmetric, bounded, loss based and target based. Finally, they made some recommendations for developing a new loss-based process capability index with more excellent specifications.

III. INTRODUCTION OF INDUSTRY AND PRODUCTS

This firm is the collaboration of three industries to mark its presence as one of the largest firm of the automotive rubber parts industry, situated in northern India. It is recognized as the largest manufacturing company in the field of Automobile Rubber Parts in India, with its wide range of parts. It has also achieved TS-16949:2002, QS-9000 and ISO-9002 standards of quality assurance. Being the unchallenged market leader in the sealing technology, this group of companies together offers its customers the widest and latest range of sealing solutions for various applications in the automotive and other related fields. Its product range offers following class products:

- Oil Seals
- Radial Shaft Seals
- Shock Absorbers/Rod Seals
- Hydraulic Seals
- Shaft Seals
- Valve Stem Seals

3.1 BRIEF DESCRIPTION OF THE CASE STUDY

Shocker seals are the main components in this industry which needed more attention because of their higher rejection. These shocker seals have percentage rejection more than 9.1%, that's why; SPC techniques are required to implement on these products to reduce the percentage rejection. Manufacturing process for shocker seals is shown in Figure 1.

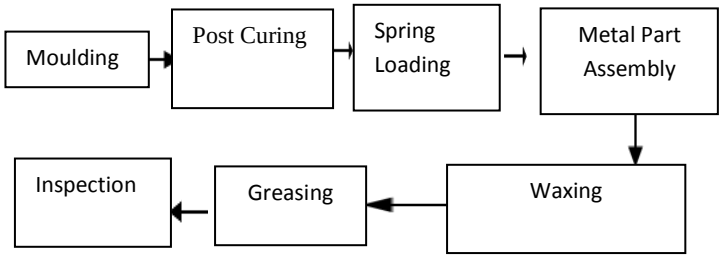

Figure 1 Flow process chart for production of shocker seals

3.2 CASE STUDY

The emphasis is given on the production of shocker seals because rejection level before implementing SPC tools for this product is 9.1%

The following main root causes are found in higher rejection of shocker seals of this industry.

(i) Moulding

Moulding is the first process of manufacturing of shocker seals. It is found that various moulding defects are responsible for the rejection. Following defects are observed in this process, causing for rejection.

- Air trap
- Tear
- Knitting
- Foreign matter
- Curing
- Excess material
- Less material
- Dirty cavity

Probable causes of each defect are listed below:

Air trap

- Insufficient Vacuum
- Improper Environmental temperature

Tear

- Higher temperature
- Improper manual loading

Material (excess/less)

- Improper setting of grub screw volume

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Cold bit

- Improper cleaning of nozzle hole
- Dirty Top portion of mould

Trimming

- Offset trimming problem
- Spiral Lining problem
- Step Trimming problem

Ishikawa (cause & Effect) diagram is shown for shocker seals in Figure 2.

Components moved to assy line after washing

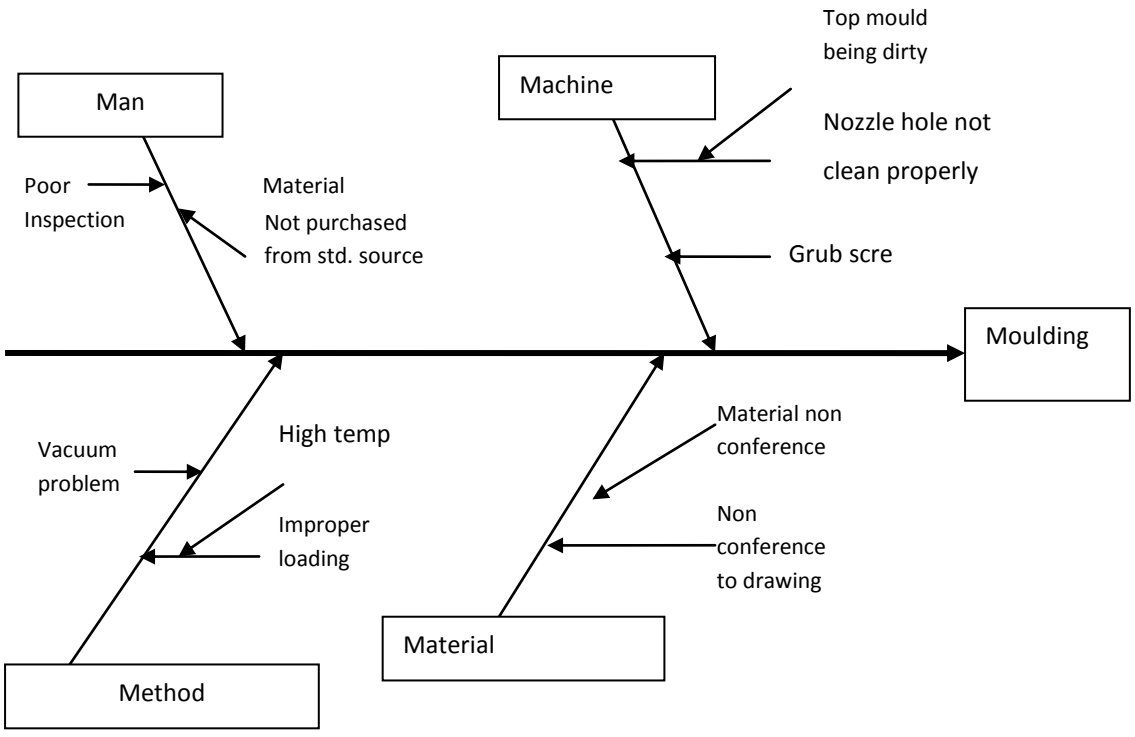

Figure 2 Cause and effect diagram for shocker seals

Following recommendations are given to eliminate various root causes.

3.2.1 Recommendations to remove the moulding defects:

- In-process inspection is must for each manufacturing operation.
- Adequate Vacuum must be created.
- Proper Environmental temperature should be maintained
- Maintain temperature of the casting between 1900^0C to 2100^0C.
- Manual loading should be replaced by mechanised loading.
- Grubbed screw volume should be maintained at the required level.
- Clean the nozzle hole properly.
- Clean top portion of mould properly.
- Trimming should be done very carefully.

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3.3 IMPLEMENTATION OF $\overline{X}$ AND RANGE (R) CHARTS TO DIAMETERS OF SHOCKER SEALS

The sample size (n) of 4 is considered and 400 observations of outer diameter of shocker seals for are taken in random manner. These observations are taken after removing the root causes as suggested in section 3.2.1. The observations before the case study are not included because of the limitation of length of the paper. The concept of sub-grouping is followed when observations are taken. These observations are shown in Table 1A (Appendix A).

Target outer diameter of shocker seals = 62 mm ± 0.10 mm (tolerance)
So, upper and lower specification limits can be calculated as:
Upper specification Limit (USL) = 62.10 mm and

Lower specification Limit (USL) = 59.90 mm

3.3.1 Mean ($\overline{X}$) Chart

Mean or Average of one sample can be calculated as:

$$\overline{X} = (X_1 + X_2 + X_3 + X_4) \div 4$$

Where, n is the sample size = 4 (for this case)

Similarly, Mean or Average of 400 samples can be calculated as

$$\overline{\overline{X}} = \frac{\sum (\overline{X}_1 \ldots \overline{X}_k)}{k}$$

Where, k is the number of subgroups = 400 (for this case)
$\overline{\overline{X}}$ = 24800.70/400 = 62.002 mm and Average range can be calculated as:

$$\overline{R} = \frac{\sum (R_1 \ldots R_k)}{k} = 30.02/400 = 0.075$$

Upper control limit = $UCL_x = \overline{\overline{X}} + A_2 * \overline{R}$

= 62.002+0.738×0.075= 62.06 mm

Lower control limit = $LCL_x = \overline{\overline{X}} - A_2 * \overline{R}$

= 62.002 - 0.738×0.075= 61.94 mm

A_2 = 0.738, D_4 = 2.28, D_3= 0 (values of these factor, corresponding to sample size, are available in all the books of Quality control)

3.3.2 Range (R) Chart

$$Range = X_{max} - X_{min}$$

$$\overline{R} = \frac{\sum (R_1 \ldots R_k)}{k}$$

= 30.02/400 = 0.075,

where, k is the number of subgroups = 400

Upper control limit on R chart: $UCL_R = D_4 * \overline{R}$ — 2.28* 0.075 = 0.171

Lower control limit on R chart: $LCL_R = D_3 * \overline{R}$ — 0*0.075 = 0

3.3.3 Calculation of Process capability (C_p)

Population standard deviation (σ') = $\overline{R}$/d2 where, d2 = 2.059 (for sample size of 4)

σ' = 0.075/2.059 = 0.036

So Process capability (Cp) = 6σ' = 6×0.036= 0.21

To be process under control,

(USL – LSL) ≥ 6σ'

(61.10-59.90) ≥ = 6×0.036= 0.21

0.20 ≥ 0.21

So, process is almost under the control and rejection level has been reduced after removing the root causes of rejection.

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The Process Capability ratio can also be calculated as:

Process Capability ratio = (USL-LSL)/ 6σ'

= [(61.10-59.90)/ 6×0.036] = 0.953

3.3.4 Calculation of Process capability Index (C_{pk})

Process capability Index (C_{pk}) can be calculated as:

C_{pk} = Minimum [($\overline{X}$ - LCL)/3σ', (UCL – $\overline{X}$)/ 3σ']

= Min.[(62.002 – 61.94)/ 3* 0.036 , (62.06 – 62.002)/ 3* 0.036]

C_{pk} = Min. [0.58, 0.54] = 0.54

So, Process capability Index (C_{pk}) of the process is 0.54

Although 400 observations of the shocker seals are taken, only plots of 100 observations for $\overline{X}$ and are R charts are shown in Figures 3 and 4 respectively. These observations are taken after removing the root causes of rejection. It is clear from the Figures 3 and 4 that all the observations are falling within the control limits on both $\overline{X}$ and R charts.

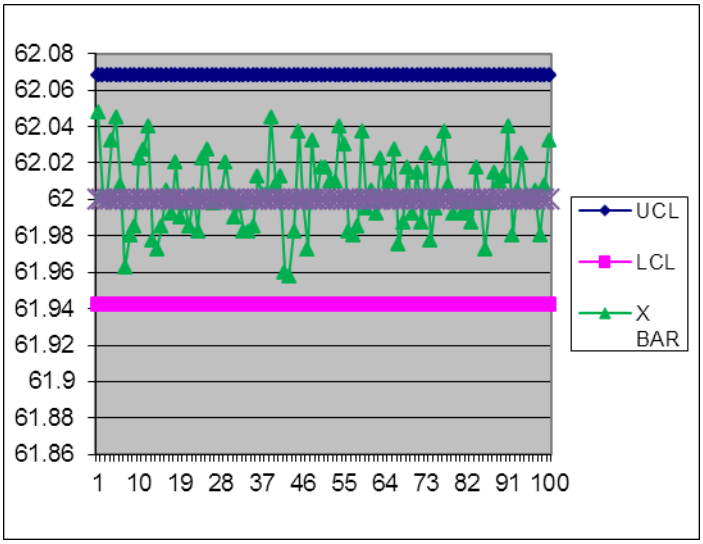

Figure 3 Graphical representation of $\overline{X}$ chart

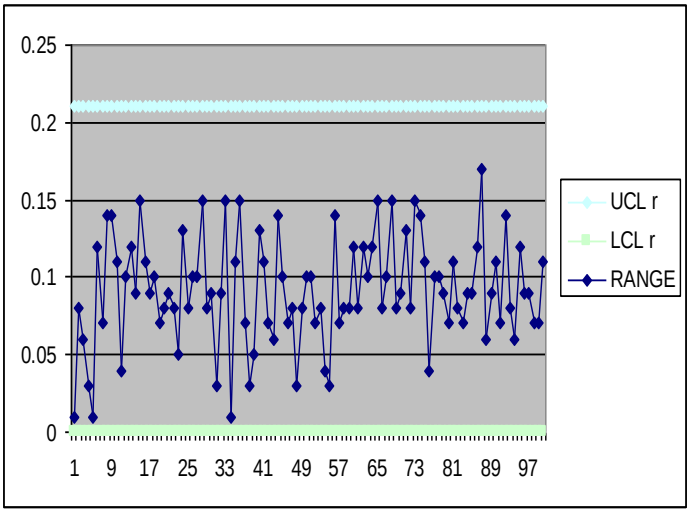

Figure 4 Graphical representation of R chart

IV. CONCLUSIONS

The present work deals with the study of shocker seals. The basic requirements of the manufacturing processes are studied then the statistical process control of the specific process is found out. SPC analysis may easily help in improving the efficiency of the manufacturing process thus decreasing the number of defective products, thus saving a lot of re-work cost and valuable time. For each specific product the suggested preventions can considerably decrease the loss to the industry in terms of both money and time. Although, improvement in rejection level of all the other products of the industry is noticed, shocker seals were the main concern because the rejection level of this product was more than 9.1%. After implementing the required suggestions/recommendations for shocker seals, it is found that process capability is improved and it is greater than required. Out of 400 observations of outer diameter of Shocker seals, no any observation is falling outside of control limits on both $\overline{X}$ and R charts.

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International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, Volume 2, Issue 3, March 2012)

APPENDIX: A

Table 1A – Observation of outer diameter of shocker seal for after the case study

S. NO.	X_1	X_2	X_3	X_4	$\overline{X}$	R
1	62.05	62.05	62.04	62.05	62.0475	0.01
2	62.04	61.96	61.97	62.04	62.0025	0.08
3	61.99	61.98	61.99	62.04	62	0.06
4	62.04	62.02	62.02	62.05	62.0325	0.03
5	62.05	62.04	62.05	62.04	62.045	0.01
6	62.08	61.95	62.04	61.96	62.0075	0.12
7	61.92	61.97	61.99	61.97	61.9625	0.07
8	61.93	62.07	61.95	61.97	61.98	0.14
9	61.9	62.04	62.01	61.99	61.985	0.14
10	62.02	61.96	62.07	62.04	62.0225	0.11
11	62.01	62.01	62.04	62.05	62.0275	0.04
12	62.07	62.03	61.98	62.08	62.04	0.1
13	62.04	61.92	61.97	61.98	61.9775	0.12
14	61.96	61.98	62.02	61.93	61.9725	0.09
15	61.97	62.02	62.05	61.9	61.985	0.15
16	61.94	62.05	62.01	62.02	62.005	0.11
17	61.98	61.92	62.06	62.01	61.9925	0.09
18	62.02	61.97	62.02	62.07	62.02	0.1
19	62.05	61.96	61.94	62.01	61.99	0.07
20	61.98	62.01	62.04	61.96	61.9975	0.08
21	61.95	62.04	61.98	61.97	61.985	0.09
22	61.97	62.08	62.02	61.94	62.0025	0.08
23	62.01	61.98	61.96	61.98	61.9825	0.05
24	62.04	61.95	62.08	62.02	62.0225	0.13
25	62.06	62.02	61.98	62.05	62.0275	0.08
26	62.05	61.97	62.02	61.95	61.9975	0.1
27	62.04	61.94	62.05	61.97	62	0.1
28	62.04	61.98	61.92	62.07	62.0025	0.15
29	62.05	62.02	61.97	62.04	62.02	0.08
30	62.04	62.05	61.96	61.96	62.0025	0.09
31	61.96	61.98	62.01	62.01	61.99	0.03
32	61.97	61.95	62.04	62.03	61.9975	0.09
33	61.97	61.97	62.07	61.92	61.9825	0.15
34	61.99	61.98	61.98	61.98	61.9825	0.01
35	62.04	61.93	61.95	62.02	61.985	0.11
36	62.05	61.9	62.05	62.05	62.0125	0.15
37	61.98	62.02	62.04	61.97	62.0025	0.07
38	62.02	62.01	61.99	61.99	62.0025	0.03
39	62.05	62.07	62.04	62.02	62.045	0.05
40	61.92	62.01	62.05	62.05	62.0075	0.13
41	61.97	61.96	62.08	62.04	62.0125	0.11
42	61.96	61.97	61.92	61.99	61.96	0.07
43	62.01	61.94	61.93	61.95	61.9575	0.06
44	62.04	61.98	61.9	62.01	61.9825	0.14
45	62.08	61.98	62.02	62.07	62.0375	0.1
46	61.98	61.97	62.01	62.04	62	0.07
47	61.95	62.02	61.94	61.98	61.9725	0.08
48	62.02	62.05	62.04	62.02	62.0325	0.03
49	61.97	62.01	61.98	62.05	62.0025	0.08
50	62.03	62.06	62.02	61.96	62.0175	0.1

51	61.97	62.05	62.07	61.98	62.0175	0.1
52	61.99	62.04	62.04	61.97	62.01	0.07
53	62.02	62.04	61.96	62.02	62.01	0.08
54	62.05	62.05	62.01	62.05	62.04	0.04
55	62.04	62.04	62.03	62.01	62.03	0.03
56	61.99	61.96	61.92	62.06	61.9825	0.14
57	61.95	61.97	61.98	62.02	61.98	0.07
58	62.01	61.97	62.02	61.94	61.985	0.08
59	62.07	61.99	62.05	62.04	62.0375	0.08
60	62.04	62.04	61.92	61.98	61.995	0.12
61	61.98	62.05	61.97	62.02	62.005	0.08
62	61.97	62.08	61.96	61.96	61.9925	0.12
63	62.02	61.98	62.01	62.08	62.0225	0.1
64	62.05	61.93	62.04	61.98	62	0.12
65	62.01	61.93	62.08	62.02	62.01	0.15
66	62.06	62.02	61.98	62.05	62.0275	0.08
67	62.02	62.01	61.95	61.92	61.975	0.1
68	61.94	62.07	62.02	61.92	61.9875	0.15
69	62.04	62.01	62.05	61.97	62.0175	0.08
70	61.98	62.05	61.98	61.96	61.9925	0.09
71	62.02	62.08	61.95	62.01	62.015	0.13
72	61.96	61.98	61.97	62.04	61.9875	0.08
73	62.08	61.93	62.01	62.08	62.025	0.15
74	61.99	61.9	62.04	61.98	61.9775	0.14
75	61.95	62.02	62.06	61.95	61.995	0.11
76	62.01	62.01	62.05	62.02	62.0225	0.04
77	62.07	62.07	62.04	61.97	62.0375	0.1
78	62.04	62.01	62.04	61.94	62.0075	0.1
79	61.98	61.96	62.05	61.98	61.9925	0.09
80	61.97	61.97	62.04	62.02	62	0.07
81	62.02	61.94	61.96	62.05	61.9925	0.11
82	62.05	61.98	61.97	61.98	61.995	0.08
83	62.01	62.02	61.97	61.95	61.9875	0.07
84	62.06	62.05	61.99	61.97	62.0175	0.09
85	62.02	61.95	62.04	61.98	61.9975	0.09
86	61.94	61.97	62.05	61.93	61.9725	0.12
87	62.04	62.07	61.98	61.9	61.9975	0.17
88	61.98	62.04	62.02	62.02	62.015	0.06
89	62.02	61.96	62.05	62.01	62.01	0.09
90	61.96	62.01	62.01	62.07	62.0125	0.11
91	62.08	62.03	62.04	62.01	62.04	0.07
92	61.98	61.92	62.06	61.96	61.98	0.14
93	62.02	61.98	62.05	61.97	62.005	0.08
94	62.05	62.02	62.04	61.99	62.025	0.06
95	61.92	62.01	62.04	62.04	62.0025	0.12
96	61.97	61.96	62.05	62.02	62	0.09
97	61.96	61.97	62.04	62.05	62.005	0.09
98	62.01	61.94	61.96	62.01	61.98	0.07
99	62.04	61.98	61.97	62.04	62.0075	0.07
100	62.08	62.02	61.97	62.06	62.0325	0.11
101	61.96	61.98	61.97	61.98	61.9725	0.02
102	61.97	62.02	61.94	61.95	61.97	0.08
103	61.97	62.02	61.98	62.02	61.9975	0.05
104	61.99	62.05	62.02	61.97	62.0075	0.08
105	62.04	62.04	62.05	61.94	62.0175	0.11
106	62.05	61.99	61.95	61.98	61.9925	0.1
107	61.98	61.95	61.97	62.02	61.98	0.07
108	62.02	62.01	62.07	62.05	62.0375	0.06
109	62.05	62.07	62.04	61.98	62.035	0.09
110	61.92	62.04	61.96	61.95	61.9675	0.12

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111	61.97	61.98	62.01	61.97	61.9825	0.04
112	61.96	62.02	62.03	61.98	61.9975	0.07
113	62.01	62.05	61.92	61.93	61.9775	0.13
114	62.04	61.96	61.98	61.9	61.97	0.14
115	62.08	61.98	62.02	62.02	62.025	0.1
116	61.98	61.97	62.05	62.01	62.0025	0.08
117	61.95	62.02	61.97	62.07	62.0025	0.12
118	62.02	62.05	61.99	62.01	62.0175	0.06
119	61.97	62.01	62.02	61.96	61.99	0.06
120	62.03	62.06	62.05	61.97	62.0275	0.09
121	61.97	62.02	62.04	61.94	61.9925	0.1
122	61.99	61.94	61.99	61.98	61.975	0.05
123	62.02	62.04	61.95	61.98	61.9975	0.09
124	62.05	61.98	62.01	61.97	62.0025	0.08
125	62.04	62.02	61.98	62.02	62.015	0.06
126	61.99	61.96	61.95	62.05	61.9875	0.1
127	61.95	62.08	62.02	62.01	62.015	0.13
128	62.01	61.98	61.97	62.06	62.005	0.09
129	62.07	62.02	61.94	62.05	62.02	0.13
130	62.04	62.05	61.98	62.04	62.0275	0.07
131	61.98	61.92	62.02	62.04	61.99	0.12
132	61.97	61.92	62.05	62.05	61.9975	0.13
133	62.02	61.97	61.98	62.04	62.0025	0.07
134	62.05	61.96	61.95	61.96	61.98	0.1
135	62.01	62.01	61.97	61.97	61.99	0.04
136	62.02	62.04	61.98	61.97	62.0025	0.07
137	61.94	62.08	61.93	61.99	61.985	0.15
138	62.04	61.98	61.9	62.04	61.99	0.14
139	61.98	61.95	62.02	62.05	62	0.1
140	62.02	62.02	62.01	62.08	62.0325	0.07
141	61.96	61.97	62.07	61.98	61.995	0.11
142	62.08	61.94	62.01	61.93	61.99	0.15
143	61.98	61.97	61.96	61.9	61.9525	0.08
144	62.02	61.99	61.97	62.02	62	0.05
145	62.05	62.04	61.94	62.01	62.01	0.11
146	61.92	62.05	61.98	62.07	62.005	0.15
147	61.97	61.98	61.98	62.01	61.985	0.04
148	61.96	62.02	61.97	62.05	62	0.09
149	62.01	62.05	62.02	62.08	62.04	0.07
150	62.04	62.01	62.05	61.98	62.02	0.07
151	62.07	62.04	62.01	61.93	62.0125	0.14
152	61.98	62.06	62.06	61.9	62	0.16
153	61.95	62.05	62.05	62.02	62.0175	0.1
154	62.05	62.04	62.04	62.01	62.035	0.04
155	62.04	62.04	62.04	62.07	62.0475	0.03
156	61.99	62.05	62.05	62.01	62.025	0.06
157	62.04	62.04	62.04	61.96	62.02	0.08
158	62.05	61.96	61.96	61.97	61.985	0.09
159	62.08	61.97	61.97	61.94	61.99	0.14
160	61.92	61.97	61.97	61.98	61.96	0.06
161	61.93	61.97	61.99	62.02	61.9775	0.09
162	61.9	61.94	62.04	62.05	61.9825	0.15
163	62.02	61.98	62.05	61.95	62	0.1
164	62.01	62.02	62.08	61.97	62.02	0.11
165	61.94	62.02	61.98	62.07	62.0025	0.13
166	62.04	62.05	61.93	62.04	62.015	0.12
167	61.98	62.01	61.9	61.96	61.9625	0.11
168	62.02	62.06	62.02	62.01	62.0275	0.05
169	62.07	62.02	62.01	62.03	62.0325	0.06
170	62.04	61.94	62.07	61.92	61.9925	0.15

171	61.96	62.04	62.01	61.98	61.9975	0.08
172	62.01	61.98	62.05	62.02	62.015	0.07
173	62.03	62.02	62.08	62.01	62.035	0.07
174	61.92	61.96	61.98	61.96	61.955	0.06
175	61.98	62.08	61.93	61.97	61.99	0.15
176	62.02	61.98	61.9	61.94	61.96	0.12
177	62.05	62.02	62.02	61.98	62.0175	0.07
178	61.92	62.05	62.01	62.02	62	0.13
179	61.97	61.92	62.07	61.97	61.9825	0.15
180	61.96	61.97	62.01	61.97	61.9775	0.05
181	62.01	61.96	61.96	61.94	61.9675	0.07
182	62.04	62.01	61.97	61.98	62	0.07
183	62.08	62.04	61.94	62.02	62.02	0.14
184	61.98	62.08	61.98	62.05	62.0225	0.1
185	61.95	61.96	62.02	61.95	61.97	0.07
186	62.02	61.97	62.05	61.97	62.0025	0.08
187	62.05	61.97	61.95	62.07	62.01	0.12
188	61.98	61.99	61.97	62.04	61.995	0.07
189	61.95	62.04	62.07	61.96	62.005	0.12
190	61.97	62.05	62.04	62.01	62.0175	0.08
191	62.01	61.98	61.96	62.03	61.995	0.07
192	62.04	62.02	62.01	61.92	61.9975	0.12
193	62.06	61.95	62.03	61.98	62.005	0.11
194	62.05	61.97	61.92	62.02	61.99	0.13
195	62.04	61.98	61.98	62.05	62.0125	0.07
196	62.04	61.93	62.02	61.97	61.99	0.11
197	62.05	61.9	62.01	61.99	61.9875	0.15
198	62.04	62.02	61.96	62.02	62.01	0.08
199	61.96	62.01	61.97	62.05	61.9975	0.09
200	61.97	62.07	61.94	62.01	61.9975	0.13
201	61.97	62.04	61.9	62.02	61.9825	0.14
202	62.07	62.04	62.02	61.97	62.025	0.1
203	62.04	62.05	62.01	62.03	62.0325	0.04
204	61.96	62.04	62.07	61.97	62.01	0.11
205	62.01	61.96	62.01	61.99	61.9925	0.05
206	62.03	61.97	61.96	62.02	61.995	0.07
207	61.92	61.97	61.97	62.05	61.9775	0.13
208	61.98	61.99	61.94	62.04	61.9875	0.1
209	62.02	62.04	61.98	61.99	62.0075	0.06
210	62.05	62.05	61.98	61.95	62.0075	0.1
211	61.97	61.98	61.97	62.01	61.9825	0.04
212	61.99	62.02	62.02	62.07	62.025	0.08
213	62.02	62.05	62.05	62.04	62.04	0.03
214	62.05	62.01	62.01	61.98	62.0125	0.07
215	62.04	62.04	62.06	61.97	62.0275	0.09
216	61.99	62.06	62.05	62.02	62.03	0.07
217	61.95	62.05	62.04	62.05	62.0225	0.1
218	62.01	62.04	62.04	62.01	62.025	0.03
219	62.07	62.04	62.05	62.06	62.055	0.03
220	62.04	62.05	62.04	62.02	62.0375	0.03
221	61.98	62.04	61.96	61.94	61.98	0.1
222	62.02	61.96	61.97	62.04	61.9975	0.08
223	62.05	61.97	61.97	61.98	61.9925	0.08
224	61.96	61.97	61.99	62.02	61.985	0.06
225	61.98	61.97	62.04	61.96	61.9875	0.08
226	61.97	61.94	62.05	62.08	62.01	0.14
227	62.02	61.98	62.08	61.99	62.0175	0.1
228	62.05	62.02	61.98	61.95	62	0.1
229	62.01	62.05	61.93	62.01	62	0.12
230	62.06	61.95	61.93	62.07	62.0025	0.14

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231	62.02	61.97	62.02	62.04	62.0125	0.07
232	61.94	62.07	62.01	61.98	62	0.13
233	62.04	62.04	62.07	61.97	62.03	0.1
234	61.98	61.96	62.01	62.02	61.9925	0.06
235	62.02	62.01	62.05	62.05	62.0325	0.04
236	61.96	62.03	62.08	62.01	62.02	0.12
237	62.08	61.92	61.98	62.06	62.01	0.16
238	61.98	61.98	61.93	62.02	61.9775	0.09
239	62.02	62.02	61.9	61.94	61.97	0.12
240	62.05	62.05	62.02	62.04	62.04	0.03
241	61.92	61.97	62.01	61.98	61.97	0.09
242	61.92	61.99	62.07	62.02	62	0.15
243	61.97	62.02	62.01	61.96	61.99	0.06
244	61.96	62.05	61.96	62.08	62.0125	0.12
245	62.01	62.04	61.97	61.98	62	0.07
246	62.04	61.99	61.94	62.02	61.9975	0.1
247	62.08	61.95	61.98	62.05	62.015	0.13
248	61.98	62.01	62.02	61.92	61.9825	0.1
249	61.95	61.98	62.05	61.97	61.9875	0.1
250	62.02	61.95	61.95	61.96	61.97	0.07
251	61.97	62.02	61.97	62.01	61.9925	0.05
252	61.94	61.97	62.07	62.04	62.005	0.13
253	61.98	61.94	62.04	62.08	62.01	0.14
254	62.02	61.98	61.96	61.96	61.98	0.06
255	62.05	62.02	62.01	61.97	62.0125	0.08
256	61.98	62.05	62.03	61.97	62.0075	0.08
257	61.95	61.98	61.92	61.99	61.96	0.07
258	61.97	61.95	61.98	62.04	61.985	0.09
259	61.98	61.97	62.02	62.05	62.005	0.08
260	61.93	61.98	62.01	61.98	61.975	0.08
261	61.9	61.93	61.96	62.02	61.9525	0.12
262	62.02	61.9	61.97	62.05	61.985	0.15
263	62.01	62.02	61.94	61.92	61.9725	0.1
264	62.07	62.01	61.98	61.97	62.0075	0.1
265	62.01	62.07	62.02	61.96	62.015	0.11
266	61.96	62.01	61.98	62.01	61.99	0.05
267	61.97	61.96	62.02	62.04	61.9975	0.08
268	61.99	61.97	62.02	62.08	62.015	0.11
269	62.04	61.94	62.05	61.98	62.0025	0.11
270	62.02	61.98	62.04	61.95	61.9975	0.09
271	62.05	61.98	61.99	62.02	62.01	0.07
272	62.01	61.97	61.95	61.97	61.975	0.06
273	62.04	62.02	62.01	62.03	62.025	0.03
274	62.06	62.05	62.07	61.97	62.0375	0.1
275	61.98	62.01	62.04	61.99	62.005	0.06
276	61.95	62.06	61.98	62.02	62.0025	0.11
277	62.02	62.05	62.02	62.05	62.035	0.03
278	61.97	62.04	62.05	62.04	62.025	0.08
279	61.94	62.04	61.96	61.99	61.9825	0.1
280	61.98	62.05	61.98	61.95	61.99	0.1
281	62.02	62.04	61.97	62.01	62.01	0.07
282	62.05	61.96	62.02	62.07	62.025	0.11
283	61.98	61.97	62.05	62.04	62.01	0.08
284	61.95	61.97	62.01	61.98	61.9775	0.06
285	61.97	61.99	62.06	61.97	61.9975	0.09
286	61.98	62.04	62.02	62.02	62.015	0.06
287	61.93	62.05	61.94	62.05	61.9925	0.12
288	61.9	62.08	62.04	62.01	62.0075	0.18
289	62.02	61.98	61.98	62.02	62	0.04
290	62.01	61.93	62.02	61.94	61.975	0.09

291	62.07	61.9	61.96	62.04	61.9925	0.17
292	62.01	62.02	62.08	61.98	62.0225	0.1
293	61.96	62.01	61.98	62.02	61.9925	0.06
294	61.97	62.07	62.02	61.98	62.01	0.1
295	61.94	62.01	62.05	61.95	61.9875	0.11
296	61.98	62.05	61.92	61.97	61.98	0.13
297	61.98	62.08	61.92	62.01	61.9975	0.16
298	61.97	61.98	61.97	62.04	61.99	0.07
299	62.02	61.93	61.96	62.06	61.9925	0.13
300	62.05	61.9	62.01	62.05	62.0025	0.15
301	62.01	62.02	62.04	62.04	62.0275	0.03
302	62.06	62.01	62.08	62.04	62.0475	0.07
303	62.05	62.07	61.98	62.05	62.0375	0.09
304	62.04	62.01	61.95	62.04	62.01	0.09
305	62.04	61.96	62.02	61.96	61.995	0.08
306	62.05	61.97	61.97	61.97	61.99	0.08
307	62.04	61.94	61.94	61.97	61.9725	0.1
308	61.96	61.98	61.97	61.99	61.975	0.03
309	61.97	62.02	61.99	62.04	62.005	0.07
310	61.97	62.05	62.04	62.05	62.0275	0.08
311	61.99	61.95	62.05	61.98	61.9925	0.1
312	62.04	61.97	61.98	62.02	62.0025	0.07
313	62.05	62.07	62.02	62.05	62.0475	0.05
314	62.08	62.04	62.05	61.92	62.0225	0.16
315	61.98	61.96	62.01	61.97	61.98	0.05
316	61.93	62.01	62.04	61.96	61.985	0.11
317	61.9	62.03	62.06	62.01	62	0.16
318	62.02	61.92	62.05	62.04	62.0075	0.13
319	62.01	61.9	62.04	62.08	62.0075	0.18
320	62.07	62.02	62.04	61.98	62.0275	0.09
321	62.01	62.01	62.05	61.95	62.005	0.1
322	62.05	62.07	62.04	62.02	62.045	0.05
323	62.08	62.01	61.96	61.97	62.005	0.12
324	61.98	62.05	61.97	62.03	62.0075	0.08
325	61.93	62.08	61.97	61.97	61.9875	0.15
326	61.9	61.98	61.97	61.99	61.96	0.09
327	62.02	61.93	61.94	62.02	61.9775	0.09
328	62.01	61.9	61.98	62.05	61.985	0.15
329	62.07	62.02	62.02	62.04	62.0375	0.05
330	62.01	62.01	62.02	61.99	62.0075	0.03
331	61.96	62.07	62.05	61.95	62.0075	0.12
332	61.97	62.01	62.01	62.01	62	0.04
333	61.94	61.96	62.06	62.07	62.0075	0.13
334	61.98	61.97	62.02	62.04	62.0025	0.07
335	62.02	61.94	61.94	61.98	61.97	0.08
336	62.05	61.98	62.04	61.97	62.01	0.08
337	61.95	62.02	61.98	62.02	61.9925	0.07
338	61.97	62.05	62.02	62.05	62.0225	0.08
339	62.07	61.95	61.96	62.01	61.9975	0.12
340	62.04	61.97	62.08	62.07	62.04	0.11
341	61.96	62.07	61.98	62.04	62.0125	0.11
342	62.01	62.04	62.02	61.96	62.0075	0.08
343	62.03	61.96	62.05	62.01	62.0125	0.09
344	61.92	62.01	61.92	62.03	61.97	0.11
345	61.98	62.03	61.97	61.92	61.975	0.11
346	62.02	61.92	61.96	61.98	61.97	0.1
347	62.01	61.98	62.01	62.02	62.005	0.04
348	61.96	62.02	62.04	62.05	62.0175	0.09
349	61.97	62.01	62.08	61.97	62.0075	0.11
350	61.94	61.96	61.96	61.99	61.9625	0.05

351	61.98	62.01	61.97	62.02	61.995	0.05
352	62.02	62.07	61.97	62.05	62.0275	0.1
353	61.97	62.01	61.99	62.04	62.0025	0.07
354	61.97	62.05	62.04	61.99	62.0125	0.08
355	61.94	62.08	62.05	61.95	62.005	0.14
356	61.98	61.98	61.98	62.01	61.9875	0.03
357	62.02	61.93	62.02	61.98	61.9875	0.09
358	62.05	61.9	61.93	61.95	61.9575	0.15
359	61.95	62.02	61.93	62.02	61.98	0.09
360	61.97	62.01	62.02	61.97	61.9925	0.05
361	62.07	62.07	62.01	61.94	62.0225	0.13
362	62.04	62.01	62.07	61.98	62.025	0.09
363	61.96	61.96	62.01	62.02	61.9875	0.06
364	62.01	61.97	62.05	62.05	62.02	0.08
365	62.03	61.94	62.08	61.98	62.0075	0.14
366	61.92	61.98	61.98	61.95	61.9575	0.06
367	61.98	62.02	61.93	61.97	61.975	0.09
368	62.02	62.05	61.9	61.98	61.9875	0.15
369	62.01	61.95	62.02	61.93	61.9775	0.09
370	61.96	61.97	62.01	61.9	61.96	0.11
371	61.97	62.07	62.07	62.02	62.0325	0.1
372	61.94	62.04	62.01	62.01	62	0.1
373	61.9	61.96	61.96	62.07	61.9725	0.17
374	62.02	62.01	61.97	62.01	62.0025	0.05
375	62.01	62.03	61.94	61.96	61.985	0.09
376	62.07	61.92	61.98	61.97	61.985	0.15
377	62.01	61.9	62.02	61.94	61.9675	0.12
378	61.96	62.02	62.05	61.98	62.0025	0.09
379	61.97	62.01	61.95	61.98	61.9775	0.06
380	61.94	62.07	61.97	61.97	61.9875	0.13
381	61.98	61.95	62.07	62.02	62.005	0.12
382	61.98	62.01	62.04	62.05	62.02	0.07
383	61.97	62.07	61.96	62.01	62.0025	0.11
384	62.02	62.04	62.01	62.06	62.0325	0.05
385	62.05	61.98	62.03	62.05	62.0275	0.07
386	62.01	62.02	61.92	62.04	61.9975	0.12
387	62.06	62.05	61.98	62.04	62.0325	0.08
388	62.05	61.96	62.02	62.05	62.02	0.09
389	62.04	61.98	62.01	62.04	62.0175	0.06
390	62.04	61.97	61.96	61.96	61.9825	0.08
391	62.05	62.02	61.97	61.97	62.0025	0.08
392	62.04	62.05	61.94	61.97	62	0.11
393	61.96	62.01	61.98	61.99	61.985	0.05
394	61.97	62.06	62.02	62.04	62.0225	0.09
395	61.97	62.02	61.98	62.05	62.005	0.08
396	61.99	61.94	62.02	62.08	62.0075	0.14
397	62.04	62.04	62.02	61.98	62.02	0.06
398	62.05	61.98	62.05	61.93	62.0025	0.12
399	62.08	62.02	62.04	61.9	62.01	0.18
400	61.98	61.96	61.99	62.02	61.9875	0.06
Total					**24800.7**	**36.82**
