PERFORMANCE OF TWO TYPES OF METEOROLOGICAL BALLOONS IN UPPER AIR SOUNDINGS IN A TROPICAL REGION

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ABSTRACT

Nairobi Upper Air Station lies close to the equator (1°18"S, 36°45"E) at an altitude of 1795m above mean sea level (amsl).

The station has been in operation since 1954 and it normally conducts two ascents /soundings per day – at 0000z and 1200z. However, the frequency of Upper Air soundings occasionally reduce to one per day due to reasons pertaining budgetary constraints. Different types of Meteorological Balloons are used at the station but the two main ones are: 1) Totex Balloons (manufactured in Japan) and 2) Pawan Balloons (manufactured in India).

The purpose of the study was to compare the performance of the two types of Balloons in terms of their ability to cover the atmosphere adequately as required by Global Climate Observing System (GCOS).

Results indicate that Totex Balloons meet the GCOS requirements by capturing the atmosphere adequately within the tropical atmosphere. These results would provide National Meteorological services in tropical regions with an objective means of evaluating the performance of the various kinds of balloons found in the market prior to making a decision to procure them for use in Upper Air sounding observations.

1.0. INTRODUCTION

Nairobi Upper Air Station is located in a tropical region and is close to the equator (1°18"S, 36°45"E) at an altitude of 1795m above mean sea level (amsl).

The station which is part of the Global Climate Observing System (GCOS) Upper Air Network (GUAN) of Radiosondes was started in 1954. It normally conducts two events every day at 1200Z and 0000Z using Vaisala Radio Sondes. However, the frequency of ascents may reduce to one due to inadequate funds to procure the necessary consumables (Balloons and Radio sondes).

Since the inception of the station, it has received several meteorological balloons for testing for their performance and all except Totex and Pawan balloons were rejected for not meeting the performance standards.

Totex Balloons which are made from Japan, are currently in use at the station, and after several years of use, they have proved to be of good quality and satisfactory in performance. However, due to budgetary constraints, the station at times resorts to other types of Balloons such as Pawan balloons made from India. But the performance of the Pawan balloons still remain unknown since no attempt has been made to evaluate their performance against other types of ballons such as the Totex Balloons whose performance is already known.

Meteorological Balloons vary in both the materials they are made of and their properties. Totex Balloons are made of natural rubber latex, their bodies are of fine texture, their necks fit very well to the filling apparatus and when inflated, they assume spherical shape with evenly spread transparency. On the other hand, Pawan Balloons are made of synthetic latex, their bodies are of rough texture, their necks do not fit well into the filling apparatus and they have to be adapted in order to fit into the filling apparatus.

The purpose of this study was therefore to compare the performance of Totex and Pawan Balloons in upper Air soundings and their suitability in covering the atmosphere adequately to meet the minimum requirements for Global Climate Observing System (GCOS).

Balloons which are used for upper air observations should be of the extensible type and special in shape and of sufficient size and quality to enable the required load (usually 200g to 1kg) to be carried up to heights as great at 30 km at a rate of ascent sufficiently rapid to enable reasonable ventilation of the measuring elements (WMO-NO.8).

The best basic materials for extensible balloons are high – quality natural rubber latex and synthetic latex based upon polychloroprene. Natural Latex holds its shape better than polychloroprene and is stronger. It is less affected by temperature, but it is more affected by ozone and ultraviolet radiation at high altitudes, and has a shorter storage life (WMO-NO.8).

The performance of Balloons depend on their sizes and can carry greater payloads if the total lift is increased by using more gas and by increasing the volume of the balloon which in turn will affect the rate of ascent and the maximum height . However, the performance can be affected by rough handling during the filling of the balloon and by stresses induced during launching in gale conditions. In flight, the extension of the balloon may be affected by the loss of elasticity at low temperatures, by the chemical action of oxygen, ozone and ultraviolet radiation, and by faults of manufacture such as pin-holes or weak spots (WMO-NO.8).

2.0. DATA AND ANALYSIS

The data used in the study were obtained from the Radiosonde Section of the Kenya Meteorological Department (KMD). Data kept at the section was examined with the view to Identifying the data that used Totex Balloons and those that used Pawan Balloons.

The examination revealed several years in which Totex Balloons were used and a few years in which Pawan Balloons were used.

For purposes of this study, only two data sets corresponding to the years 2001 and 2003 in which Totex and Pawan Balloons were used, respectively were chosen for the study (Annexes 1 and 2).

These data were then analyzed to obtain various descriptive statistics, namely: mean daily balloon burst heights, monthly highest Balloon burst heights, mean monthly balloon burst heights, and mean highest heights of Balloon Burst for the two Balloons were computed (Annexes 1 and 2). Mean highest/maximum heights of Balloon Burst for the two Balloons were also computed an tabulated together with their weights(g), diameters at release(cm), payloads(g), free lifts(g) and rates of ascent (ms-1) as shown in table 1.

3.0. RESULTS AND DISCUSSION

Fig.1 shows the mean daily Burst heights versus the months for Totex and Pawan balloons. These results show that, the burst heights of Totex Balloons are higher than those of Pawan Balloons. Similar results were obtained for the case of the monthly highest Balloon Burst heights versus the months (Fig.2) and the monthly mean highest Balloon Burst heights versus the balloon types (Fig.3).

Table 1 shows approximate figures for the performance of Totex and Pawan, in Upper Air Soundings during the years 2001 and 2003, respectively. These results showed that, for the same weight, diameter at release, payload, free lift, and rate of ascent, Totex Balloons burst at higher heights than the Pawan Balloons suggesting that other factors such as the materials and properties of the balloons could affect the performance of the balloons. As indicated earlier, Totex balloons are different from the Pawan Balloons both in the materials they are made of and in their properties and this could explain the observed difference in their in performance.

.The mean monthly highest balloon burst height for the Totex Balloon and the Pawan Balloon are: 15.7 mb and 35.2 mb, respectively Annexes, 1 and 2). The mean monthly balloon burst heights for Totex and Pawan Balloons are 34.7mb and 61.2mb, respectively. These mean values with the exception of the mean monthly highest balloon burst height, are lower than the minimum height of balloon burst required by GCOS. The minimum balloon burst height required by GCOS is 30mb (WMO-NO.544).

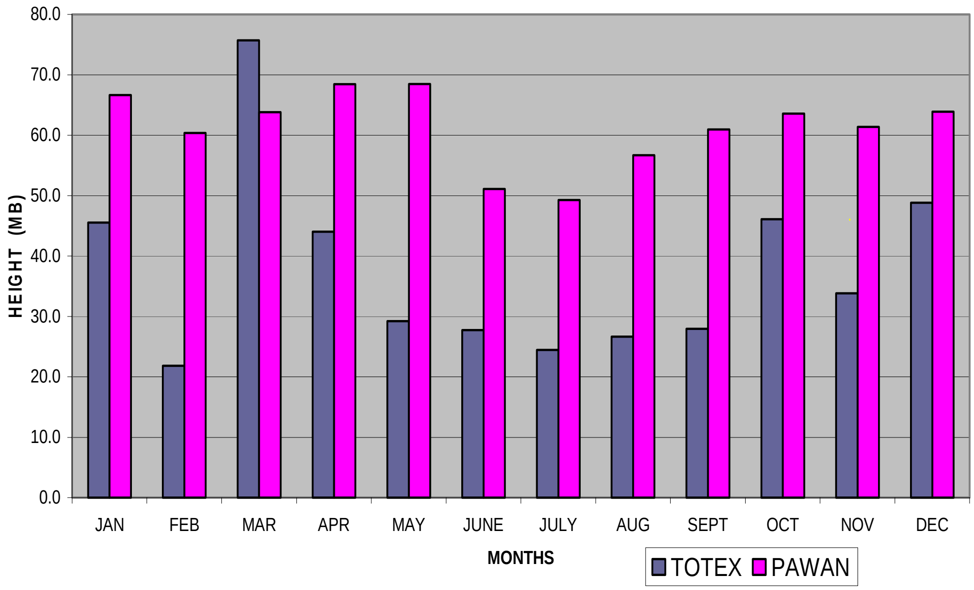

FIG 1. DAILY MEAN HEIGHTS OF BALLOON BURSTS FOR TOTEX AND PAWAN BALLOONS DURING THE YEARS 2001 AND 2003, RESPECTIVELY

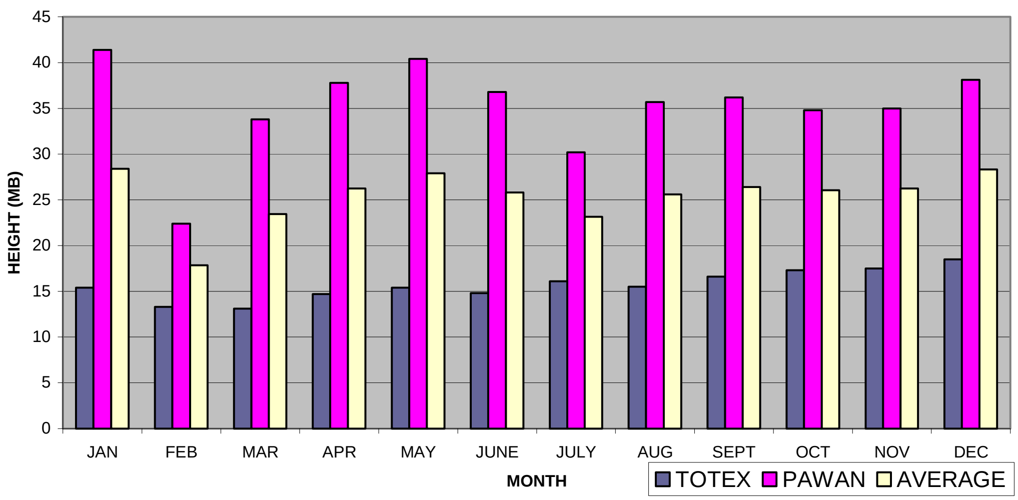

FIG 2. MONTHLY HIGHEST HEIGHTS OF BALLOON BURSTS FOR TOTEX AND PAWAN DURING THE YEARS 2001 AND 2003 RESPECTIVELY

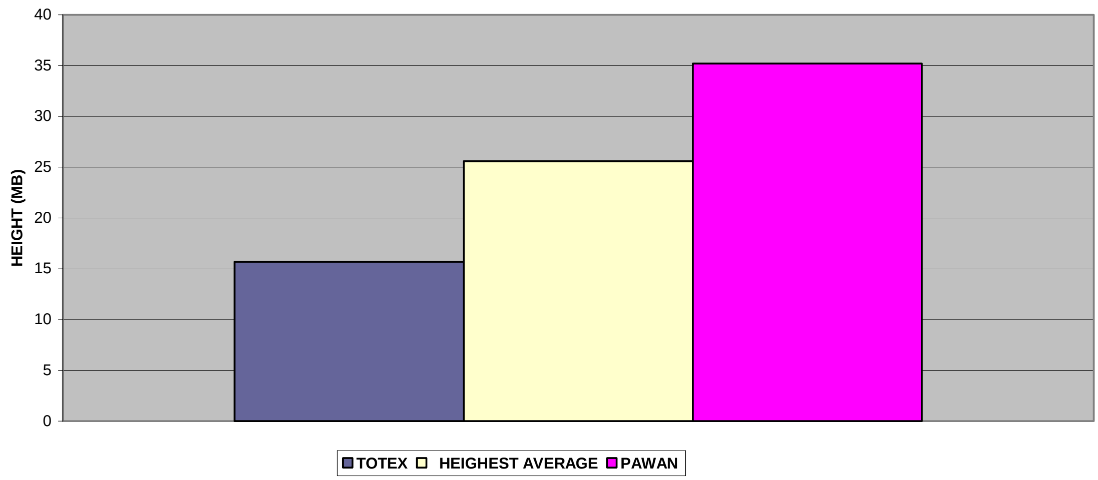

FIG 3 MONTHLY MEAN HIGHEST HEIGHTS OF BALLOON BURSTS FOR TOTEX AND PAWAN BALLONS DURING THE YEARS 2001 AND 2003 RESPECTIVELY

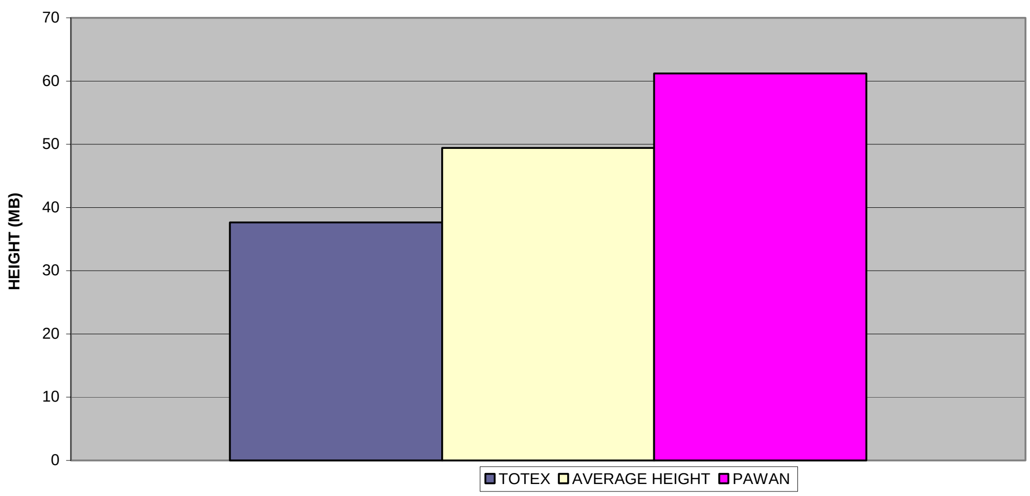

FIG 4. MONTHLY AVERAGE MEAN HEIGHTS OF BALLOON BURST FOR BOTH PAWAN AND TOTEX BALLOONS DURING THE YEARS 2001 AND 2003, RESPECTIVELY

Table 1: The Performance of Totex and Pawan Balloons in Upper Air soundings during the years 2001 and 2003, respectively

Weight (g) 350	Latex Rubber	Pawan
Diameter at release (cm)	156	156
Payload (g)	630	630
Free lift (g)	2.1	2.1
Rate of ascent (ms^{-}1)	5.2	5.3
Mean Maximum Height of burst (mb)	15.7	35.2

These results show that, on average, the balloon burst heights for Totex Balloons were higher than those of the Pawan Balloons. Since the same weight, diameter at release, the free lift, Payload, and rate of ascent were the same, one would have expected the maximum height of Balloon Burst to have been the same for both Balloons. However, this was not the case (table1). These findings suggest that the performance of balloons in Upper Air Soundings could be attributed to other factors such as the material and properties of the balloons, the quality of the balloons, the effect of the weather conditions and the chemical composition of the atmosphere prevailing at the time and years of observations. Totex Balloons are made of natural latex rubber and it is of fine texture whereas Pawan Balloons are made of synthetic latex rubber and of rough texture.

4.0. CONCLUSION

This study has shown that, on average, Totex Balloons have higher performance than the Pawan Balloons in Upper Air sounding. This implies that in choosing meteorological balloons for procurement for use in upper Air soundings, Totex balloons would be preferred more than the Pawan balloons besides other factors that could affect the performance of the balloons. The choice of a balloon for meteorological purposes is dictated by the load, if any, to be carried, the rate of ascent, the altitude required, whether the balloon is to be used for visual tracking, and the colour (WMO-NO.8).

In addition, the average Burst heights of Totex Balloons compare favourably with the GCOS minimum requirement for balloon burst of 30mb.

5.0. RECOMMENDATIONS

Based on the results of the study, the following recommendations are made:-

a) Since Totex Balloons have higher performance in upper Air Soundings than the Pawan Balloons they should be recommended for procurement for use in a tropical region Upper Air station such as Nairobi;

b) The study was limited in the sense that the data used in the study was based on two different years with different and unique atmospheric conditions and this could have affected the flights of the balloons leading to different observations/data and results. Therefore, further research is necessary to eliminate the possible bias in the data and results by using the balloons in the soundings simultaneously or in parallel or near real time to subject the balloons to similar atmospheric conditions;

c) Recent experience in our Upper air station indicated that by using balloons of bigger size than 350g such as 800g, it is possible to increase the balloon bursting height to about 5mb thus covering the atmosphere adequately to meet the GCOS requirements for measuring atmospheric chemical composition for climate monitoring.

6.0. REFERENCES

1. WMO-NO.8 (1996): Guide to Meteorological Instruments and Methods of Observation, Sixth edition.

2. WMO-NO.544 (2003 edition): Manual on the Global Observing System, Volume 1.

7.0. ACKNOWLEDGEMENT

I wish to thank the staff of the Kenya Meteorological Department (KMD), Radiosonde section, for availing their time to assist me in extracting the data used in the study and my peers for accepting to proof read my research paper and for their valuable and useful comments they made ion the same.

Last but by no means least; I wish to thank WMO through CIMO for accepting my paper for presentation during the forthcoming TECH-O-2006.

ANNEX 1. HEIGHTS OF BALLOON BURST USING TOTEX BALLOON IN MILLIBARS DURING THE YEAR 2001 AT HOUR: 2300 GMT

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	28.3	21.2	23.5	22.8	22.2	29.1	17.6	19.3	34.2		40.2	56.7
2	17.4	15.8	16.7	20.3	19.1	77.7	21.6	25.9	28.3	91.9	22.6	99.4
3	17.2	22.7	15.3	14.7	117.1	107.2	18.9	16.6	22.1	37.7	23	22
4	92	17	16.5	16.8	81.8	72.5	21.4	15.5	22.9	22.7	18.5	21.5
5	92.6	18.6	19.5	55.8	21.3	19.2	19.2	22.7	24.3	58.2	17.5	117.9
6	104.6	22	591.3	89.7	15.4	28.5	26.1	24	22.8	28.6	20.8	29.1
7	24.9	14.6	91.7	23.8	28.4	23.5	28.8	96.2	17.4	18.2	_	28.4
8	144.7	17	18.1	142.4	16.7	18.5	16.1	22.3	24.5	33	19.4	20.8
9	23.9	20.4	14	112.7	21.2	22.8	22.8	23.6	16.6	76.6	66.6	32.1
10	137.4	17.2	15.8	22.2	98	19.8	22.5	22.5	18.9	26.1	19.2	23.1
11	17	17.7	13.1	24.6	49.1	19.5	_	17	25.7	27.3	29.5	22.6
12	35.6	13.3	99.9	97.6	20.2	24.2	29.3	25.3	16.7	82.3	22.6	21.1
13	41.2	20	22.8	98.2	17.4	21.6	25.2	17.7	93.7	23.1	100.4	67.7
14	_	23.2	17.2	21.1	18	14.8	23.6	41.3	17.8	88.8	21.9	184.6
15	17.3	16.5	17.8	83.6	17.1	26.2	17.8	_	20.9	18	53.6	18.8
16	21.4	18.2	17.7	31.1	18	19.8	29.2	23.8	19.2	20.3	23.3	18.5
17	16.1	18.5	18.1	24.2	20.1	19.1	22.9	16.3	23	21.4	19.3	49.1
18	18.2	17.4	18.3	20.4	17.2	19.4	28	23.2	16.9	38.2	29.2	23
19	19.2	21.5	39	20.8	20.2	19.5	92.4	19.2	21.5	22.3	20.1	32.9
20	23.3	48.2	19.3	102.9	17.6	32.3	16.1	19	26	91.5	17.6	66.8
21	19.5	14.8	23	29.9	15.5	20.2	19.5	19.3	22.3	20	29.4	110
22	16.6	15.1	18.4	28.9	18.2	15.3	18.7	17.8	75.9	112.4	22.6	73.1
23	_	20	16.2	20.1	15.8	17.1	22.4	18	27.8	109.5	82.4	27.7
24	84.8	38.8	130.1	37.3	27.4	17.7	18	22.1	22.6	25.5	25.4	84.3
25	127.5	16.3	108.8	16.3	19.3	24.3	16.1	20	29.2	72.1	90.3	23.6
26	96.9	68.8	96.6	59.8	24	22.8	31.4	110.2	16.6	94.1	30.8	112.7
27	17.8	15.9	82.6	15.7	23.6	18.4	24.7	21.1	20.3	_	49.2	23.6
28	16.1	20	29.1	25.7	29.4	20.7	20.7	16.3	69.1	18.1	18.7	28.7
29	15.6	_	568.9	18.4	32.3	15.3	19.4	19.2	22.7	17.3	24	24.4
30	17.2	_	104.2	23	20.6	24.4	21.1	20	20.7	21.1	22.3	21.1
31	15.4	_	62.5	_	23.6	_	21.8	23.6	26.2	20.8	_	27.3
TOTAL	**1319.7**	**610.7**	**2346**	**1320.8**	**905.8**	**831.4**	**733.3**	**799**	**866.8**	**1337.1**	**980.4**	**1512.6**
MEAN HEIGHT OF BALLOON BURST	**45.5**	**21.8**	**75.7**	**44.0**	**29.2**	**27.7**	**24.4**	**26.6**	**28.0**	**46.1**	**33.8**	**48.8**
HIGHEST HEIGHT OF BALLOON BURST	**15.4**	**13.3**	**13.1**	**14.7**	**15.4**	**14.8**	**16.1**	**15.5**	**16.6**	**17.3**	**17.5**	**18.5**
LOWEST HEIGHT OF BALLOON BURST	**144.7**	**68.8**	**591.3**	**142.4**	**117.1**	**107.2**	**92.4**	**110.2**	**93.7**	**112.4**	**100.4**	**184.6**
MEAN HEIGHEST HEIGHT OF BALLOON BURST	**15.6833**											
MEAN LOWEST HEIGHT OF BALLOON BURST	**155.433**											
AVERAGE MEAN HEIGHT OF BALLOON BURST	**37.6416**											

ANNEX 2: HEIGHTS OF BALLOON BURST USING PAWAN BALLOON IN MILLIBARS DURING THE YEAR 2003 AT HOUR: 2300 GMT

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	78.7	45.4	41.2	37.8	78.3	58.5	49.5	50.7	81.5	47.6	68.3	86.5
2	63.7	38.5	53.2	73.7	75.3	97.9		70.2	57.5	62.1	53.5	106.8
3	76.6	62.6	46.6	50.2		52.6	66.1	43.8	48.2	76.3	57.7	47.4
4	76.2	82.8	74.6	73.5	79.1	79.7	40.2	50.7		76.9		60.1
5	73.7	47.3	59.2	73	78	53.1	49.1	75.3	62.7	77.8	60.5	
6	66.1	37.8	64.5	48.5		46.1		54.2	46.1	51.8	37.9	46.2
7	65.3	60.6	40	60.4	77.4	_	48.9	56.5	49.6	52.3	60.4	62.7
8	71.2	84	91.9	57.6	_	42	53	45.2	133.1	39.8	147	68.1
9	83.4	84.9	39.8	88.6	89.3	38	40.4	60.4	62	54.2	55.2	57.6
10	75.6	78.8	46.1	48.5	55.5	52.5	41.4	49.1	67.1	103.8	48	48.4
11	92.4	89.5	57.9	48.3	46.8	56.9	45.4	51.4	44.9	62.3	42.8	87.4
12	82.3	87.2	33.8	61.3	49.8	53.3	36.8	44.4	56.6	78.3	35	56.8
13	73.7	70.9	49.4	82.8	_	36.8	30.2	35.7	58.8	54.5	66.8	78
14	79.5	42.1	_	80.1	93.6	40.6	55.4	45.7	55.8	51.1	50.9	68.1
15	79.1	72.2	77	_	70.1	57.7	47.2	_	64.8	34.8	47.6	61.3
16	89.3	22.4	43.5	_	_	38.9	_	50.6	36.2	42	64.5	64.8
17	77.9	41.1	237.6	43.1	185.2	57.6	44.1	41.1	42.2	73.8	52.9	39
18	45	78.6	34.9	101.3	_	54.4	59.4	69.7	83.3	52.9	83.6	97.2
19	57.4	61.5	57.4	76.1	40.7	40.5	44.2	65.3	41.8	40.2	69.6	73.3
20	_	62	54.1	88.2	45.7	60.5	39.2	65	63.1	47.3	89.7	38.1
21	60.1	76	59.9	84.6	63.6	47.6	45.6	52.1	67.4	49.1	49.5	69.3
22	45.2	48.2	95.3	63.6	44.1	46.6	57.5	95.3	69.3	49.3	64.9	59.2
23	45	62.3	95.2	54.6	_	40.5	64.2	54.2	53.3	89.2	58.3	48.9
24	44.4	55.4	58	77.3	51.2	46.9	66.1	73.1	73.3	51.9	45.2	51.2
25	66.6	37.7	47.8	44.4	_	57.9	50.9	68.8		199	48.2	_
26	66.3	64.7	57.3	66.7	48.8	43.8	55.4	53.8	66.3	54.4	44.5	70.5
27	53	45.9	_	74.9	40.4	39.4	55.2	64	49.3	44.4	73.3	56.1
28	41.4	49.8	48.4	88	65.5	53.9	43	65.2	47	57.8	77.5	56.9
29	60.7	_	50.5	94.2	81.1	41.5	60.2	53.6	64.3	62.7	_	53
30	63.5	_	64.3	74.2	47.2	46.6	_	_	_	60.3	64.2	66.1
31	46.4	_	71.3	_	_	_	41.4	37.8	_	73	_	73.2
TOTAL	**1999.7**	**1690.2**	**1850.7**	**1915.5**	**1506.7**	**1482.3**	**1330**	**1642.9**	**1645.5**	**1970.9**	**1717.5**	**1852.2**
MEAN HEIGHT OF BALLOON BURST	**66.7**	**60.4**	**63.8**	**68.4**	**68.5**	**51.1**	**49.3**	**56.7**	**60.9**	**63.6**	**61.3**	**63.9**
HIGHEST HEIGTH OF BALLOON BURST	**41.4**	**22.4**	**33.8**	**37.8**	**40.4**	**36.8**	**30.2**	**35.7**	**36.2**	**34.8**	**35**	**38.1**
LOWEST HEIGHT OF BALLOON BURST	**92.4**	**89.5**	**237.6**	**101.3**	**185.2**	**97.9**	**66.1**	**95.3**	**133.1**	**199.0**	**147.0**	**106.8**
MEAN HEIGHEST HEIHGT OF BALLOON BURST	**35.216667**											
MEAN LOWEST HEIGHT OF BALLOON BURST	**129.26667**											
AVERAGE MEAN HEIGHT OF BALLOON BURST	**61.207514**											