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FIELD TESTING OF WEIGHING RAIN GAUGE

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PREFACE

There is an increasing need for detailed time resolution of rainfall measurements, and also for rainfall recordings from remote areas. This not only requires specially trained people, but also suitable equipment for use under difficult terrain conditions, often from remote areas. For an integrated development of water resources, data from automated rain gauges is useful in collecting information related to precipitation and streamflow. Due to limited after-sales maintenance facilities, fully imported field equipment cannot be generally relied upon and, therefore, it is necessary that equipment with indigenous technology are developed within the country.

The National Institute of Hydrology, Roorkee, has taken up the development of simple electronic field instruments for hydrological measurements using components available indigenously. Since rainfall is considered a basic parameter in hydrology, among the first instruments to be developed in this series at the National Institute of Hydrology was an electronic rain gauge. The report presents the field-testing of the weighing-type rain gauge, developed at the Institute using components and systems available indigenously. The report has been prepared by Dr V C Goyal, Scientist 'E', and the staff members, Messrs Raju Juyal, Sonia Mehta, Vishal Gupta, and Satya Prakash, under general guidance of Mrs Deepa Chalisgaonkar, Scientist 'E'.

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DIRECTOR

ABSTRACT

Reliable and accurate measurement of rainfall is an essential requirement in hydrological studies. For automated recording of rainfall data, tipping bucket rain gauges are generally used. It has been reported that the tipping bucket mechanism of such rain gauges frequently malfunctions and gives erroneous data, especially during high intensity rainstorms. Weighing type rain gauges are considered worldwide as accurate and reliable. With the weighing rain gauges, the ability to measure rainfall over very short time intervals (e.g. minutes) offers an advantage not generally available with conventional rain gauges.

Development and testing of a weighing rain gauge, using components and systems available indigenously, is reported. With the reported rain gauge, the total amount of rainfall can be measured continuously, and the rainfall intensity can be derived. Rainfall observations from the reported WRG were compared with that of the other standard rain gauges, e.g. SRRG and ORG, at a site in Roorkee (India). The instrument would require further field testing under different rain spells of sizeable magnitudes and duration. The results of the limited field testing carried out during 1999-2000 are presented in the report.

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1.0 INTRODUCTION

In India, the major contribution of water is through rainfall, so it is the most important and variable hydrological parameter. It is imperative to have reliable rainfall estimates, as they represent the upper bound on available water resources. A particular feature of rainfall is its extremely wide variation in time and space, and for this reason it will always be a significant component of any hydrological data collection and analysis system.

The magnitude of rainfall varies with space and time. Rainfall generally describes that form of the precipitation where the size of water droplets is larger than 0.5 mm. The raindrops are rarely above 6mm size, as they tend to breakup into smaller drops during their fall from the clouds.

The Rainfall is termed as light when its intensity is less than 2.5 mm./Hr, moderate between 2.5 and 7.5 mm./Hr and heavy when the intensity is more than 7.5 mm./Hr (Bras, 1990). Drizzle is a form of a rain with numerous droplets of size less than 0.5mm with intensity less than 1mm/Hr. Hailstorm is a form of a precipitation in the form of irregular pellets or lumps of frozen rain of size greater than 8 mm.

Study of rainfall is very essentials for human life, plant and animal life. It is also required for climatological analysis. Adequate data on rainfall of an area provide the basic information required for land and measurement. Some of the important parameters are intensity and duration, rainfall frequency and amount of rainfall.

2.0 RAINFALL MEASUREMENT

There is considerable variation existing annual rainfall among different areas in India. At any given station, there may be varied rainfall. This variation can be defined by coefficient of variation, which is the ratio of standard deviation of the year-to-year rainfall to the mean amount. The coefficient variation varies between 10 to 60 % in different regions of the country (Kumar B,1994-95). Precise and accurate measurement of rainfall is necessary for estimation of runoff and effective planning for integrated watershed development.

2.1 Limitations of Various Types of Rain Gauges

Symon's rain gauge is a non-recording type rain gauge. It main disadvantage is the manpower required to continuously monitor/ collect data. Tipping Bucket Rain

Gauge is a recording type rain gauge. Its limitation is that in light rainfall or drizzle the tip will not occur and the water may also be evaporated so beginning or ending of rainfall can not be defined. In this the tipping would also be effected during heavy intensity of rainfall.

The other type of rain gauge is Siphon Type or Float Type Rain Gauge. It has two limitations. It is unable to account for the rainfall that is received in the float chamber during the siphoning period. Another source of error is generated when there is sufficient time gap between two consecutive rains as little amount of water is initially required to uplift the float, which gets evaporated. Hence initial amount of rainfall is used to uplift the float, thus creating error in initial measurement.

3.0 DEVELOPMENT OF WEIGHING TYPE RAIN GAUGE

NIH has developed a Weighing Type Rain Gauge. The development of weighing type of rain gauge has been considered for its reliability, accuracy, and simplicity of design, convenience of operation and maintenance and strength of construction (Goyal, 1994-95). Weighing type rain gauge works on the principal of converting the weight of collected precipitation into equivalent depth of accumulated water in mm. It is simple in construction and has high degree of accuracy. This method measures both intensity and total rainfall.

3.1 Description of the Equipment

The instrument developed is based on a weighing mechanism. A strain gauge based load cell is used to weigh the accumulated rain. The rainfall is measured by the weight of accumulated water, every increase in weight corresponds to a certain volume of water. The accumulated rain after a preset level is drained out using a siphon arrangement. A collector rim of 205mm diameter is used on an outer container from which the water is collected through a funnel into an inner container. The inner container rests on the load cell and has been designed to store 10 cm of rainfall. A data logger (CR10X of Campbell, U.S.A.) has been used with the load cell sensor for measuring and recording the rainfall data.

The plan view of the equipment is shown in figure 1. It consists of an outer container with 205 mm diameter and 500 mm height, an inner container of 175 mm diameter and 195 mm height, and a load cell of 10 kg capacity. The load cell has been fixed below the inner container and 25mm above the base plate. It is fixed through a specific fixing arrangement so that load is uniformly transmitted to the center of the load cell. An aluminum base plate with suitable mounting and leveling arrangement has been used for mounting the outer container. For siphoning a U-shape glass tube with inner diameter of 7 mm and height of 190 mm. has been used.

3.1.1 Load Cell

The load cell used for the measurement is of 10 kg capacity with 1.9071 mV/V rated output and a non linearity of 0.025 % of FSO (model 60510 of ADI TECH, BARODA) and hysterisis of 0.02% of FSO. The excitation voltage of up to 10V can be used. The stainless steel load cell is hermetically sealed and is corrosion resistant for use in outdoor environment. The excitation voltage and output of load cell is provided through four-conductor cable. The error characteristics associated with the load cell are temperature effects on output Zero is 0.0020/C of FSO: non-linearity is 0.025 % of FSO, hysterisis is 0.2 % of FSO.

3.1.2 Data Logger

A Campbell scientific Inc. data logger (model CR10X) has been used to measure the weight of rainfall using load cell. It has a capacity to make multiple measurements through 6 differential channels or 12 single ended channels. The standard CR10X has 128 K of flash electrically erasable programmable read only memory (EEPROM) which stores the operating system and user programs and 128 K of Static Random Access Memory (SRAM) which is used for data and running the programs. CR10X is powered by 12 volt DC source. It has 9-pin serial I/O port for serial communication with external devices. It also has 3-switched excitation out put which are active during measurement with one out put active at a time. Its range is ± 2.5 volt. CR 10 X has been designed to operate reliably from –25 degree centigrade to +50 degree centigrade.

An external device is connected via a serial I/O port to communicate with the CR10 X. This may be either Campbell scientific CR10KD keyboard display or a computer / terminal. CR10X is connected through SC32A, an optically isolated RS 232 interface, to the serial port of computer. The CR 10 X must be programmed before it will make any measurements. The Block diagram of rainfall measurement using WRG is shown in figure 2.

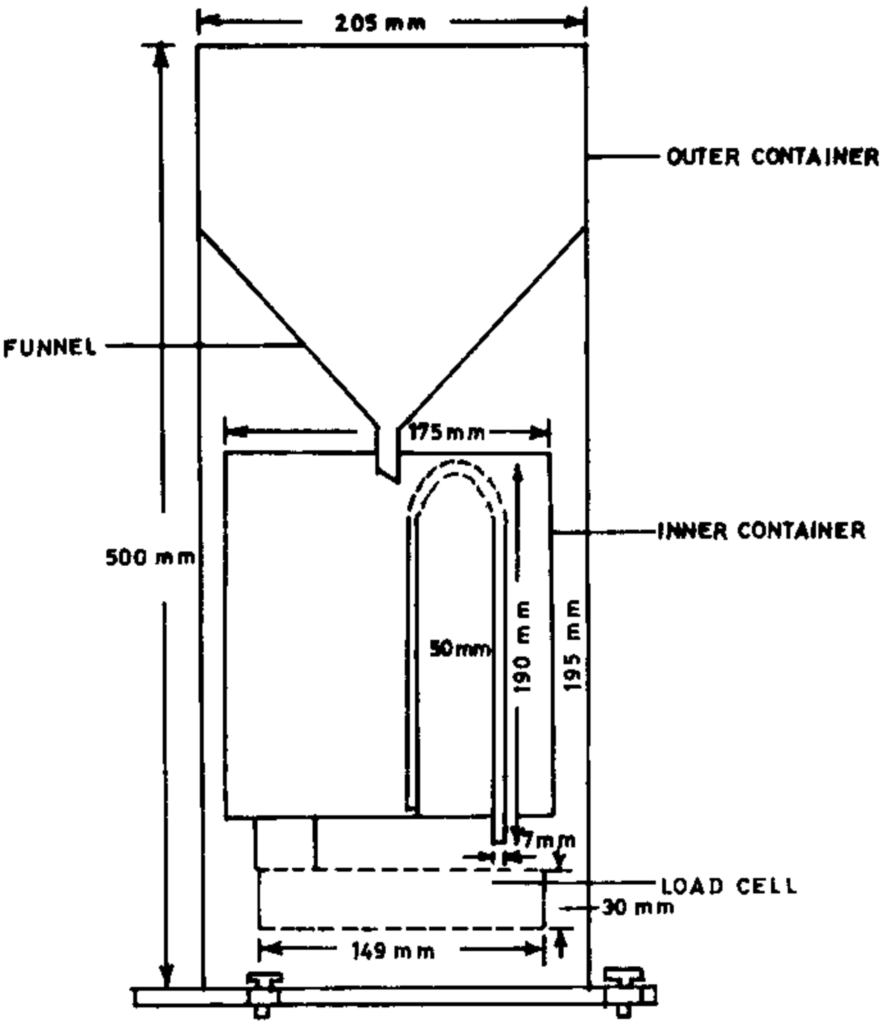


Fig. 1: Plan view of WRG

3.1.3 Battery

CR10 X is powered by 12 volt DC source. It is continuously monitored though program in data logger which stores battery voltage along with rainfall data. Below 9.6 volt and above 18 volts the CR10X does not operate properly; for longer unmanned periods, solar panel power can be connected to the data logger.

3.1.4 Software

The CR 10 X is programmed before it will record any measurements. The CR10 X based software PC 208 E and editor EDLOG have been used to write instructions. PC 208- E is Window based software through which several operations can be performed like set clock, down loading program, collecting data and monitor measurements etc.

3.2 Description of Program

The flow chart of rainfall measurement process in the WRG is shown in Fig.3. The program consists of a group of instructions entered into a program table. The program table is given an execution interval, which determines how frequently that table is executed. The execution interval determines the interval at which the sensors are measured. The interval at which data are stored is separate from how often the table is executed. The storage interval may be hourly / daily or longer periods. Under no rainfall conditions the data is stored daily, but during rainy periods the program stores data every 30 minutes, correspondingly maximum rainfall is recorded for the previous fifteen minutes. The format in which the final data has been stored is as follows:

(i) Station code
(ii) Julian Day
(iii) Time
(iv) Weight of Rainfall (Kg)
(v) Rainfall (mm)
(vi) Maximum rainfall (mm)
(vii) Battery voltage
(viii) Internal temperature of CR10

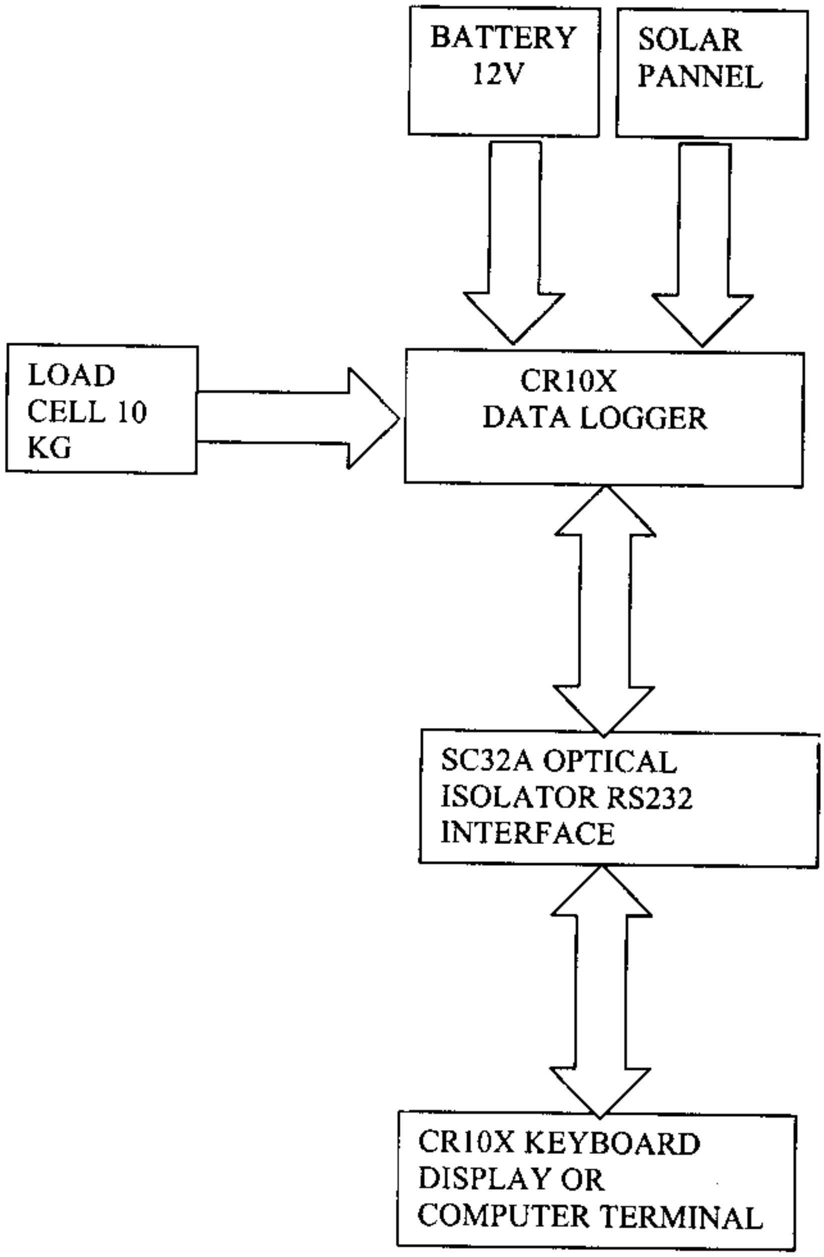


Fig.2 Block Diagram of Weighing Type Rain Gauge

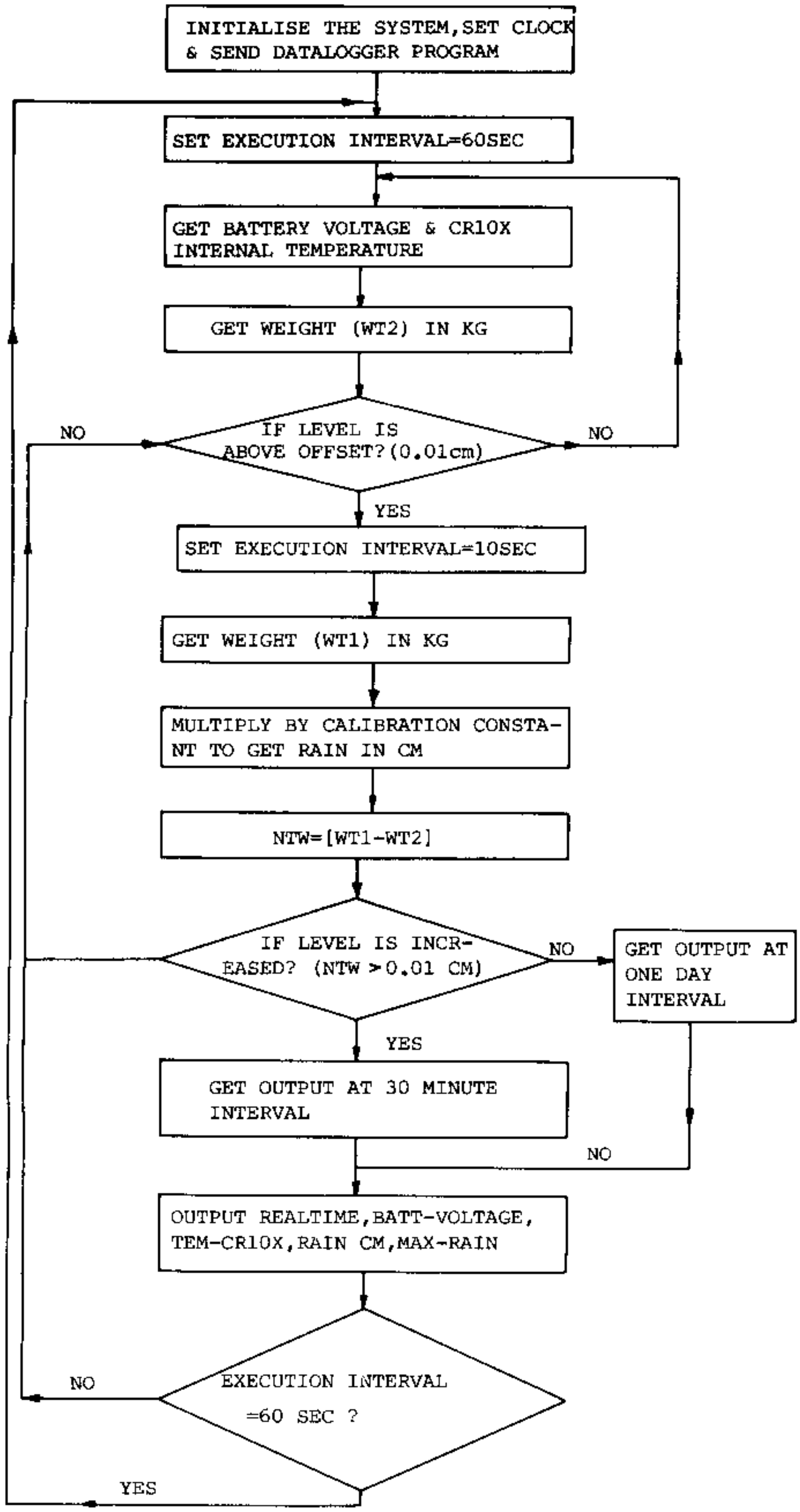


FIG.3 FLOW CHART OF WEIGHING TYPE RAIN GAUGE PROGRAM

The Data has been stored in 128 K of Static Random Access Memory (SRAM) of CR10X data logger which is used for data and running the programs. The system has been designed so that data can be stored up to three months duration unmanned (without downloading). For data retrieval an external device must be connected to CR10X serial I/O port to communicate with the CR10 X. This may be either Campbell scientific CR10KD keyboard display or a computer / terminal. CR10X has been connected through SC32A, an optically isolated RS 232 interface, to the serial port of computer. The CR10 X based software PC208E has been used through which off loading of data is done.

3.2.1 Execution Interval

Table 1 and Table 2 have independent execution interval entered in units of seconds with allowable range of 1/64 to 8191 seconds. The execution interval of 60 seconds has been used in table 1 and 10 seconds in table 2. When the table is executed the instructions are executed in sequence from beginning to end. After executing the table, the CR10X goes to a wait state, after which it executes the table again from the beginning.

3.2.2 Loop (P 87)

Instructions included between the loop instruction and the End (95) instruction are repeated the number of times specified by the iteration count or until a program executes an Exit loop command with the loop. For count 0 the loop is repeated until an Exit loop command is executed. The first parameter, delay, controls how frequently passes through the loop are made. It units are multiple of table execution interval. A delay of '0' means that there is no delay between passes through the loop.

Parameter Number	Data Type	Description
01	00	Delay
02	00	Iteration Count

3.2.3 Full Bridge

This instruction is used to apply an excitation voltage to a full bridge and make a differential voltage measurement of the bridge output. The measurement is made with the polarity of the excitation voltage; both positive and negative. The result is 1000 times the ratio of the measurement to the excitation voltage.

Parameter Number	Data Type	Description
01	01	Repetition
02	33	Range code
03	01	Input Channel No.
04	01	Excitation Channel No.
05	2500	Excitation Voltage(mV)
06	03	Input Location for 1st Measurement
07	5.192	Multiplier
08	-1.50725	Offset

3.2.4 Battery Voltage (10)

This instruction reads the battery voltage and writes it to an input location. If the battery voltage is approximately 9.6 volts, the CR 10 X suspends measurements.

Parameter Number	Data Type	Description
01	01	Input location for Battery voltage

3.2.5 Internal Temperature

This instruction measures the temperature (°C) of a thermister on the CR10 X analogue board.

Parameter Number	Data Type	Description
01	01	Input location for Temperature

3.2.6. If Time (92)

The user specifies the number of minutes or seconds into an interval, the duration of the interval and a command. The command is executed each time the real time is the specified time into the interval. The IF condition will always be false, if 0000 is entered the time interval. As 60 minutes time interval is specified the command will be executed each hour synchronized with real time. The maximum interval that can be specified is 1440 minutes.

Parameter Number	Data Type	Description
01	0000	Time into Interval
02	60	Time in minutes
03	10	Set output flag high

3.2.7 Real Time (P 77)

This instruction stores the current time in final storage. At midnight the clock rolls from 23:59 to 00:00. The day also changes.

Parameter Number	Data Type	Description
01	110	Day, Hour/minutes

3.2.8 Sample (P 70)

This instruction stores the value from each specified input location. The values stored are those in the input locations when instruction 70 is executed with output flag set high. The sampling is done on following parameters: Battery voltage, Temperature, Rainfall (mm) and Maximum Rainfall (mm).

Parameter Number	Data Type	Description
01	01	Repetitions
02	01	Input locations

3.2.9 Maximize (73)

This instruction stores the maximum value taken over 10 minutes interval. An internal flag is set whenever a new maximum value is seen. Time of maximum value can also be stored, if required.

Parameter Number	Data Type	Description
01	00	Repetitions
02	00	Time Option
03	05	I/P location for maximum

4.0 INSTALLATION

For accurate data collection, the site selection for installation of rain gauge is very important. The gauge should not be located near an elevated object such as tree, buildings, fence, etc. as eddies are set up which will have negative effect on the rainfall catch. The gauge should be exactly vertical with receiver edge horizontal. The level of gauge is checked with the help of sprit level. A masonry platform with suitable depth of foundation supports the gauge. In general, objects should not be closer to the gauge than a distance twice their height above the gauge orifice. Sites on a slope or on the roof of a building should be avoided. The surface surrounding the precipitation gauge can be covered with short grass or gravel or shingle, but hard, flat surfaces such as concrete should be avoided to prevent excessive in-splashing. The best sites are often found in clearings within forests or orchards, among trees, in scrub or shrub forests, or where other objects act as an effective wind - break for winds from all directions.

The rainfall measurement setup, consisting of weighing type rain gauge, was installed at NIH campus, Roorkee. A brick masonry platform of 18inches x 18 inches with height of 10 inches foundation supports the gauge.

4.1 Consideration of Errors : There are two types of error associated with rainfall measurement: Systematic error and Random error.

4.1.1 Systematic Error

Systematic error is caused by several components, the largest is due to systematic horizontal and vertical average acceleration of the wind just above the orifice of elevated gauges, which prevents some rainfall particles from entering the gauge. Thus, the amount of the rainfall caught by the gauge is smaller than the amount of incident rainfall. The errors due to other components are wetting of internal walls of the gauge, the collector and the container, evaporation of some of the water accumulated in the container and splashing of raindrops from or into the gauge.

For adjustment of systematic error it is necessary first to make adjustment to the data in order to allow for this condition prior to making calculations. The adjustment cannot, of course, be exact. Thus the original data should always be kept as the basic archive, both to maintain continuity and to serve as the best base for future improve adjustment if and when they become possible.

As the true amount of rainfall reaching the ground is not known, except in rare instances in which all the other items of the water balance are accurately known, the true amount of rainfall must be estimated. The general model for adjusting the data from most gauges takes the following form(WMO 1985):

$$p_k = K{=}K\, p_c = (\, p_g + \Delta\, p_1 + \Delta p_2 + \Delta\, p_3\,)$$

Where,

p_k = adjusted rainfall amount;

K = adjusted factor for the effects of wind field deformation;

p_c = the amount of rainfall caught by the gauge collector;

p_g = the measured amount of rainfall in the gauge;

Δp_1 = adjustment for the wetting loss in the internal walls of the collector

Δp_2 = adjustment for wetting loss in the container after emptying;

Δp_3 = adjustment for evaporation from the container.

4.1.2 Random Errors

Random errors are likely to arise from the use of inaccurate dip-rod measures, spilling of water when transferring it to the measure, leakage into or out of the gauge, observational errors, deformation or damage of the gauge or its rim, deviations of the orifice position from the horizontal, etc. The size of random errors can be reduced by frequently and regularly checking the gauge and the measured values and by taking appropriate corrective action. In contrast, the components of systematic error are inherent in the method of measurement of rainfall; their individual magnitudes vary, depending on instrumental and meteorological conditions, from very small to significant values.

5.0 DISCUSSION OF RESULTS

The instrument was tested in NIH campus during Sept 1999 and Jan-Feb, 2000. Rainfall measured from WRG was compared with Ordinary Non-recording Rain gauge (ORG) and Self-Recording Rain Gauge (SRRG), available in the Institute's campus. Total daily rainfall as recorded by the three rain gauges for selected events is given in Table 1.

Table: 1 Rainfall Data (mm) From Three Rain Gauges at NIH Campus

DATE 8:30 Hrs	WRG	ORG	WRG-ORG	%ERROR WRG Vs ORG	SRRG	WRG-SRRG	%ERROR WRG Vs SRRG	ORG-SRRG	%ERROR ORG Vs SRR
19/9/99	38.13	32.73	5.39	16.47					
23/9/99	24.05	24.68	-0.63	-2.55					
26/1/00	20.21	19.80	0.43	2.07	20.00	0.21	1.05	-0.20	-1.00
11/2/00	19.69	20.20	-0.51	-2.52	19.8	-0.11	-0.56	0.40	2.02
12/2/00	5.8	6.0	-0.20	-3.33	6.0	-0.20	-3.33	0.00	0.00

For the purpose of evaluation, the WRG was operated at different storage intervals –1min, 15 min and 30 min 24 hrs, but the analysis reported here has been done on 30 minute data. The data shown in this study is not corrected for any losses.

For comparison purpose, 5 events were selected (Table 1) for which data from all the three rain gauges were available, four events were with rainfall above 10 mm and one event below 10mm. The comparative performance of WRG with respect to ORG and SRRG is shown in Fig.4.

Since Ordinary non-recording rain gauge (ORG) has no moving parts and collects the total rain poured during a defined interval (e.g. a day), thus minimising the chances of error in measurement, it is usually considered the standard gauge for comparing measurements from the other rain gauges (WMO, 1994). Rainfall data recorded by WRG was compared with those recorded by ORG and SRRG. Comparative performances of SRRG was also evaluated with respect to ORG. Percent error in the data observed by different gauges is calculated as (Goyal,1996-97):

$$\% \text{ Error in "X" gauge} = \frac{100 \text{ "X" gauge - ORG}}{\text{ORG}}$$

The observations specific to three rain gauges are given in Table 1. Out of 5 observations the percent error of WRG Vs ORG is less than 3.5% for four events while in one case error is 16.5%. Correspondingly the error in three observations of WRG Vs SRRG is also less than 3.5%. The percent error of WRG Vs ORG and WRG Vs SRRG is shown in Fig.5.

On January 25-26, 2000 and February 10-11, 2000, rainfall of 20.21 mm and 25.29 mm was recorded by WRG. The rainfall measured by SRRG for these two rainstorms were 20 mm and 24.8 mm (Table 2 & Table 3). The results of these two rainstorms for WRG and SRRG are shown in Figure 6(a) & 6(b).

Results of regression analysis between rainfall values measured by WRG and ORG with a correlation coefficient of 0.97 are shown in Fig.7. Similarly coefficient of 0.99 was obtained between WRG and SRRG values as shown in Fig.8

The possible errors occurred in WRG are due to the following reasons:

(i) The source of error in weighing type of arrangement is its inability to account for the rainfall that is received in the collection chamber during the siphoning period. The duration for siphoning is 2.5 min, which may create error during heavy rainfall conditions.

Figure 4 DAILY RAINFALL VALUES MEASURED AT NIH CAMPUS

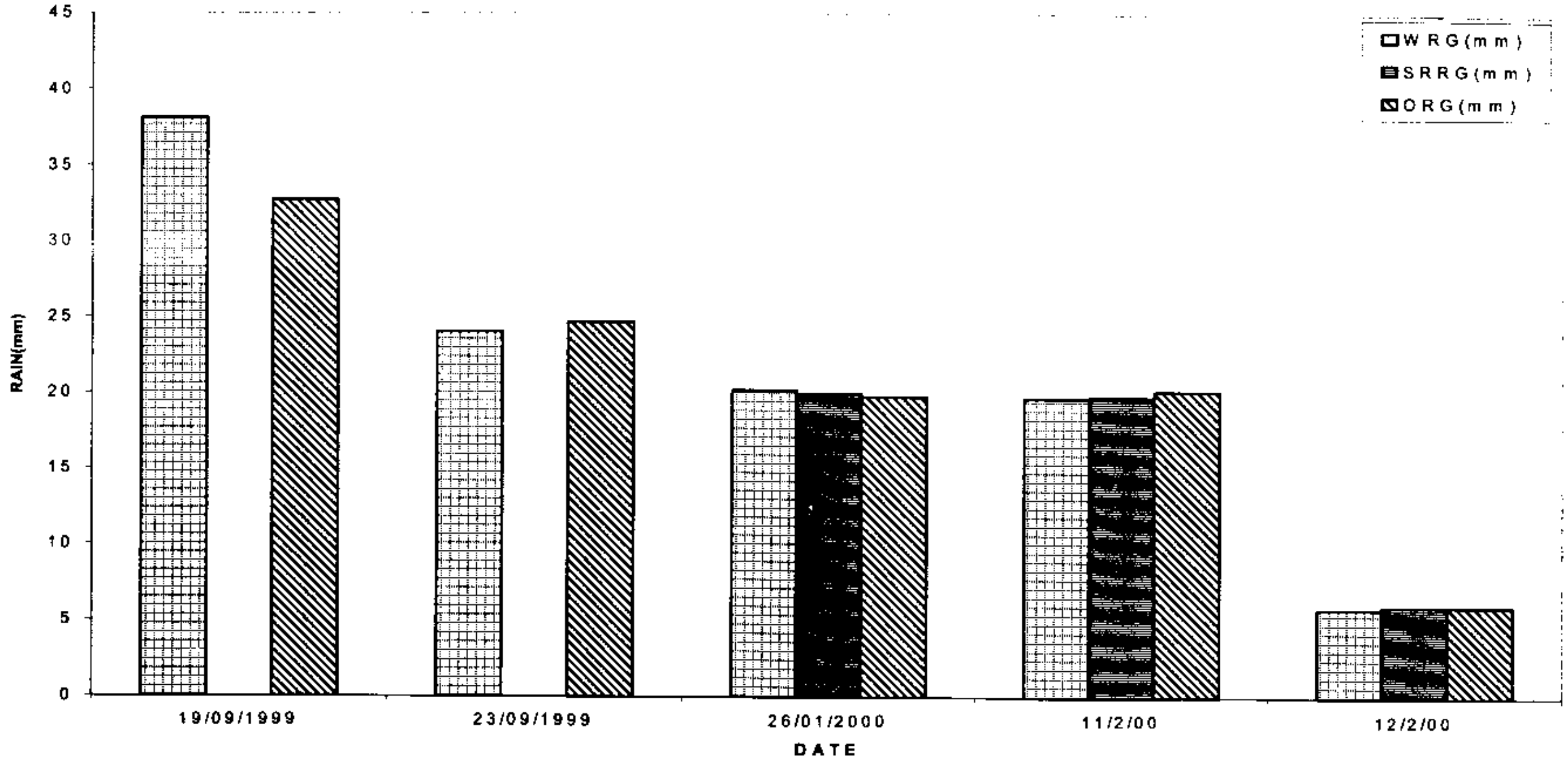
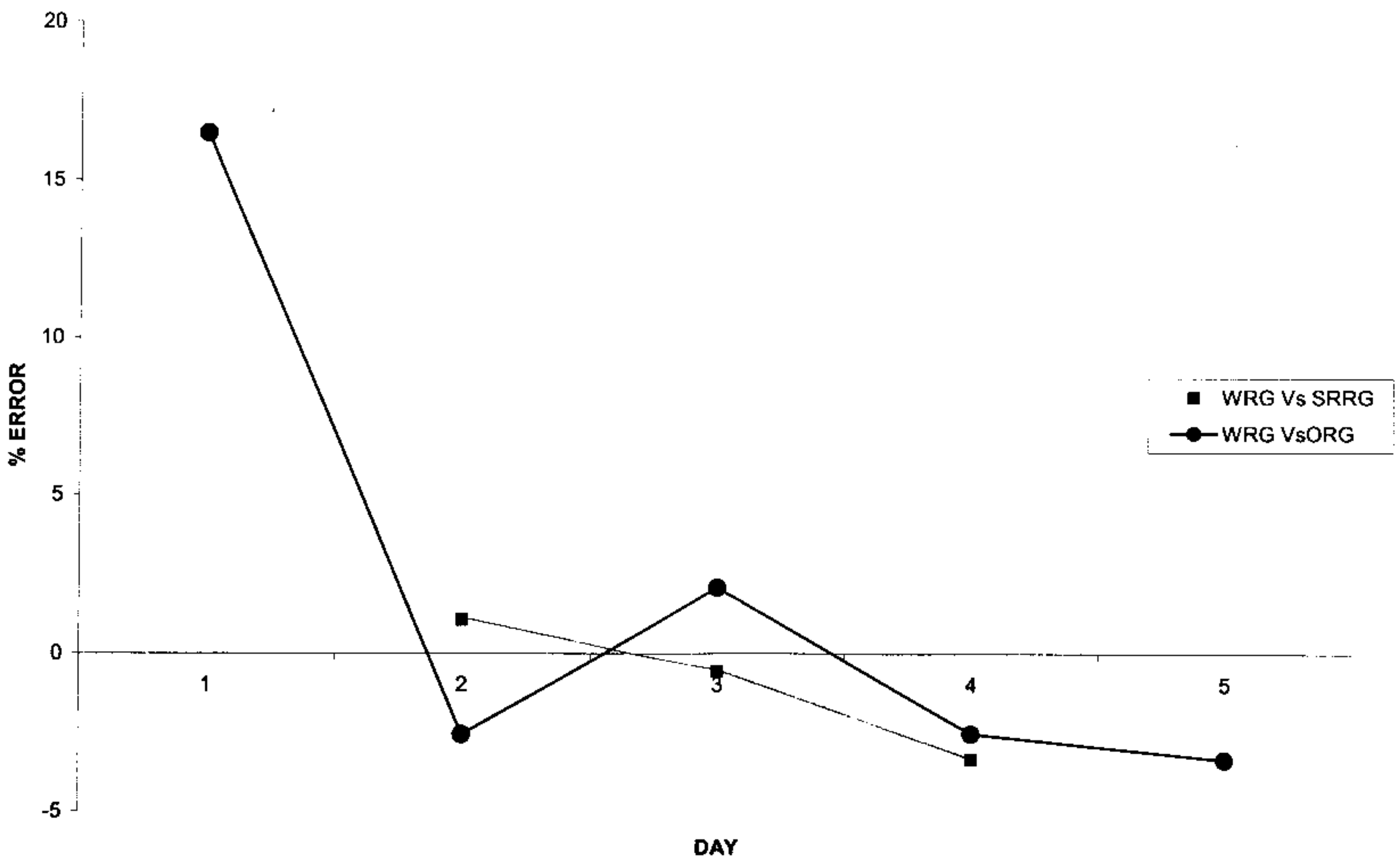


Figure 5 Percentage Error WRG Vs ORG , WRG Vs SRRG



(ii) After the siphon action has occurred a little amount of water is left in the collection chamber so initially a little amount of water is required to set the offset.

(iii) When there is sufficent time gap between two consecutive rains little amount of water gets evaporated. As it is a cumulative collection process, needs to be suitably corrected during data processing.

6.0 CONCLUSION

Weighing Rain Gauge, developed at the National Institute of Hydrology, was tested under field conditions at NIH Campus. The results obtained from the field testing during September 1999 – February, 2000 are reported and discussed.

Results of a comparative and regression analysis of weighing rain gauge vs ordinary rain gauge and weighing rain gauge vs self recording rain gauge are also reported.

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Table-2 Rainstorm Of January 25-26, 2000

Time	SRRG(mm)	WRG(mm)
14:30	0.50	0.00
15:00	1.00	0.40
15:30	1.25	1.04
16:00	1.25	1.26
16:30	2.00	1.43
17:00	2.00	1.59
17:30	2.50	1.59
18:30	2.50	1.59
18:30	3.75	2.67
19:00	8.00	6.88
19:30	8.75	8.60
20:00	8.75	8.66
20:30	10.00	9.58
21:00	10.00	9.90
21:30	10.30	10.06
22:00	12.50	11.00
22:30	13.00	12.65
23:00	13.50	13.68
23:30	15.25	14.54
00:00	15.40	15.08
0:30	15.40	15.02
1:00	15.40	15.24
1:30	15.65	15.35
2:00	15.65	15.35
2:30	15.65	15.40
3:00	15.65	15.40
3:30	17.50	16.97
4:00	17.50	17.27
4:30	18.50	17.35
5:00	18.50	18.05
5:30	18.50	18.05
6:00	18.50	19.99
6:30	18.50	17.99
7:00	18.50	17.99
7:30	18.75	18.37
8:00	19.20	18.96
8:30	20.00	20.21

Table 3 Rainstorm Of Feburary 10-11, 2000

Time	SRRG(mm)	WRG(mm)
18:00	0.025	0.00
18:30	0.620	0.44
19:00	1.250	1.10
19:30	2.000	1.75
20:00	3.500	2.83
20:30	4.500	4.56
21:00	5.000	5.05
21:30	5.000	5.43
22:00	5.250	5.50
22:30	5.500	5.77
23:00	5.800	5.93
23:30	6.250	6.31
00:00	6.750	6.60
0:30	7.500	7.28
1:00	8.250	8.10
1:30	9.000	8.84
2:00	10.000	9.76
2:30	11.250	10.99
3:00	13.000	12.49
3:30	15.000	14.29
4:00	16.750	15.99
4:30	17.500	17.29
5:00	18.500	18.39
5:30	18.750	18.59
6:00	19.250	19.29
6:30	19.250	19.29
7:00	19.250	19.29
7:30	19.250	19.29
8:00	19.250	19.49
8:30	19.800	19.69
9:00	19.800	19.69
9:30	19.800	19.89
10:00	19.900	19.89
10:30	20.300	19.89
11:00	22.050	20.19
11:30	23.300	22.29
12:00	23.550	23.39
12:30	23.550	23.39
13:00	23.550	23.39
13:30	23.550	23.39
14:00	23.550	23.39

14:30	23.800	23.39
15:00	24.300	24.19
15:30	24.300	24.19
16:00	24.300	24.19
16:30	24.300	24.59
17:00	24.800	24.59
17:30	24.800	25.29

Figure 6(a) RAINSTORM OF JANUARY 25-26,2000

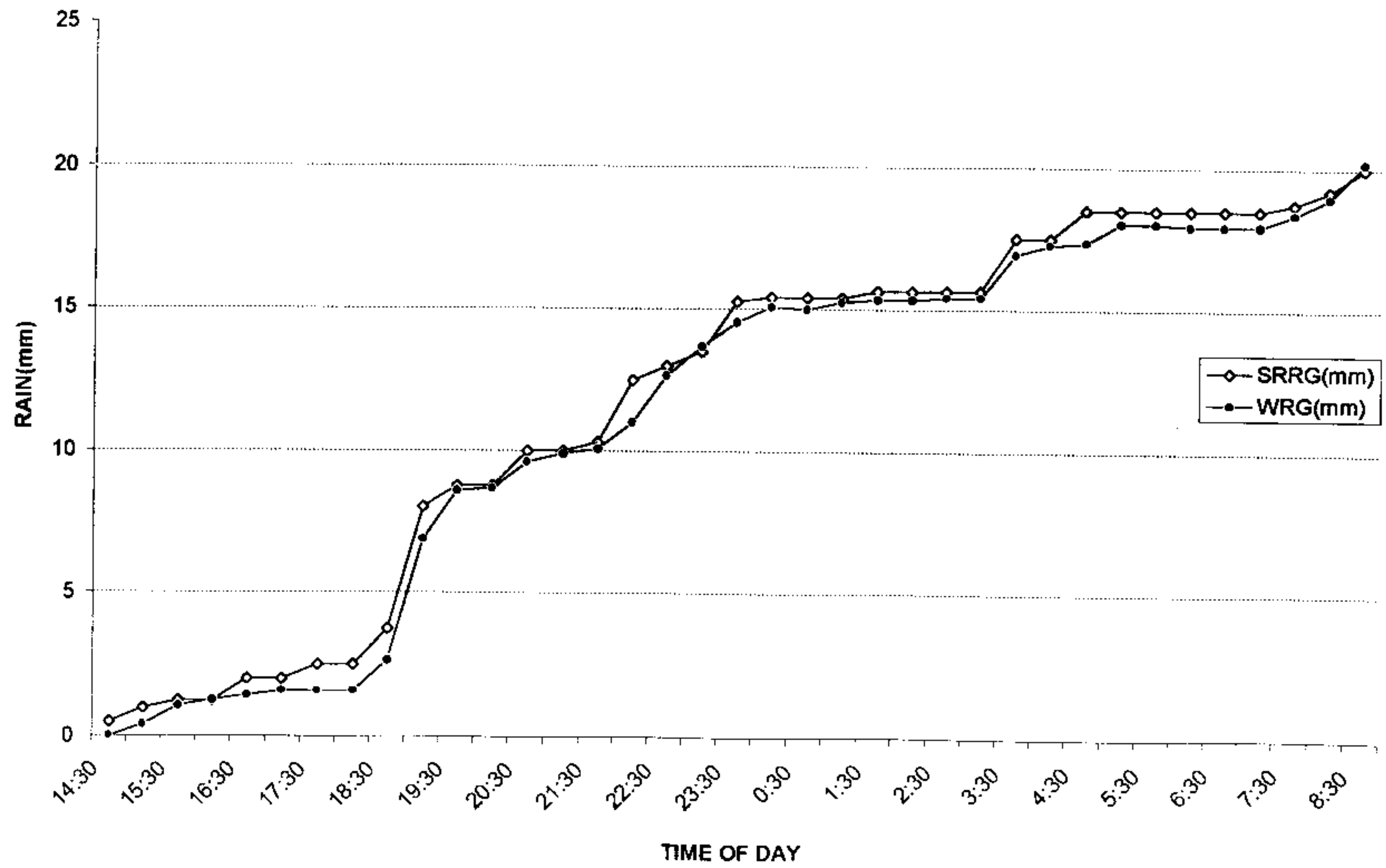


Figure 6(b) RAINSTORM OF FEBURARY 10-11,2000

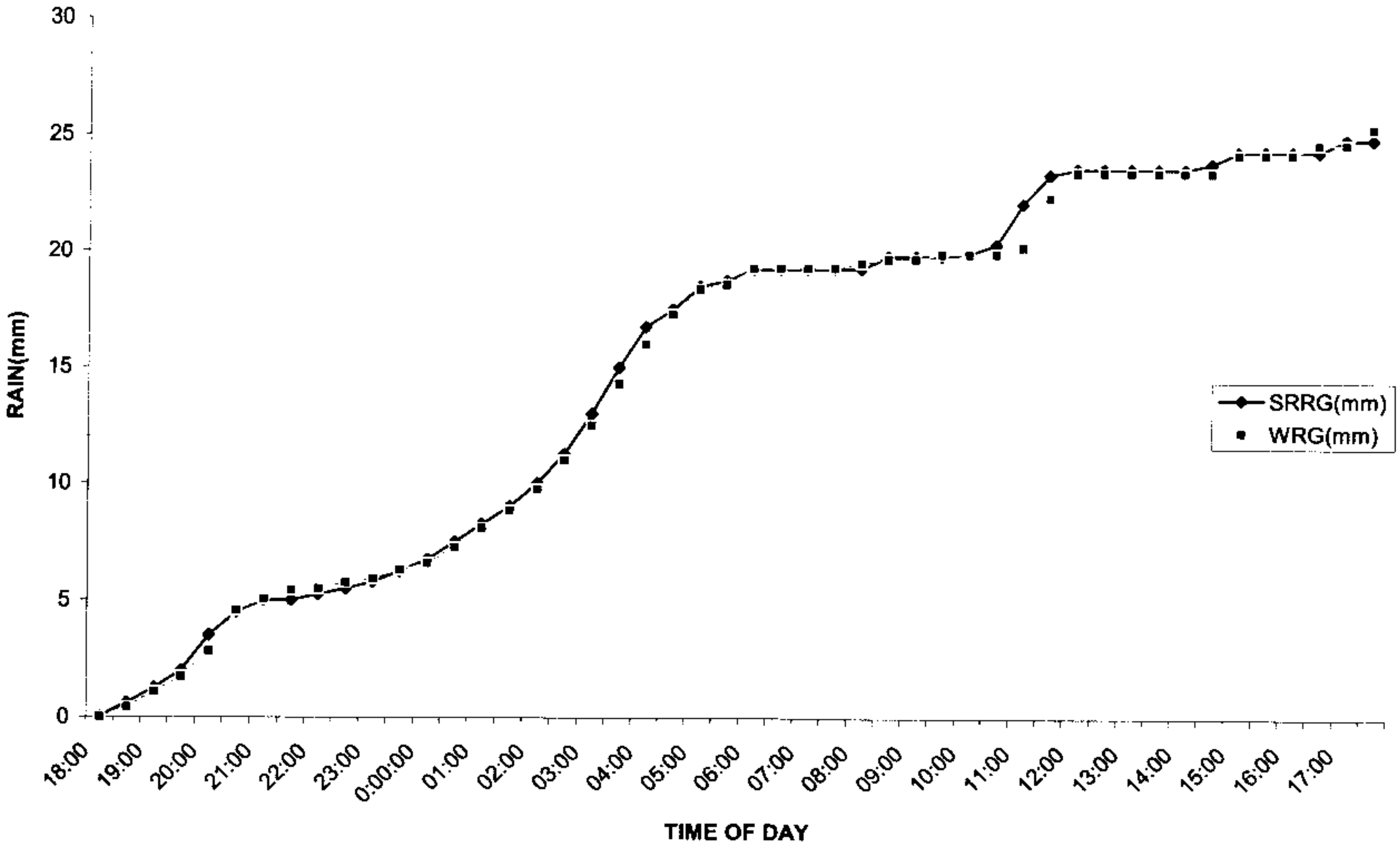


Figure 7 Testng of WRG Vs ORG at NIH Campus (1999-2000)

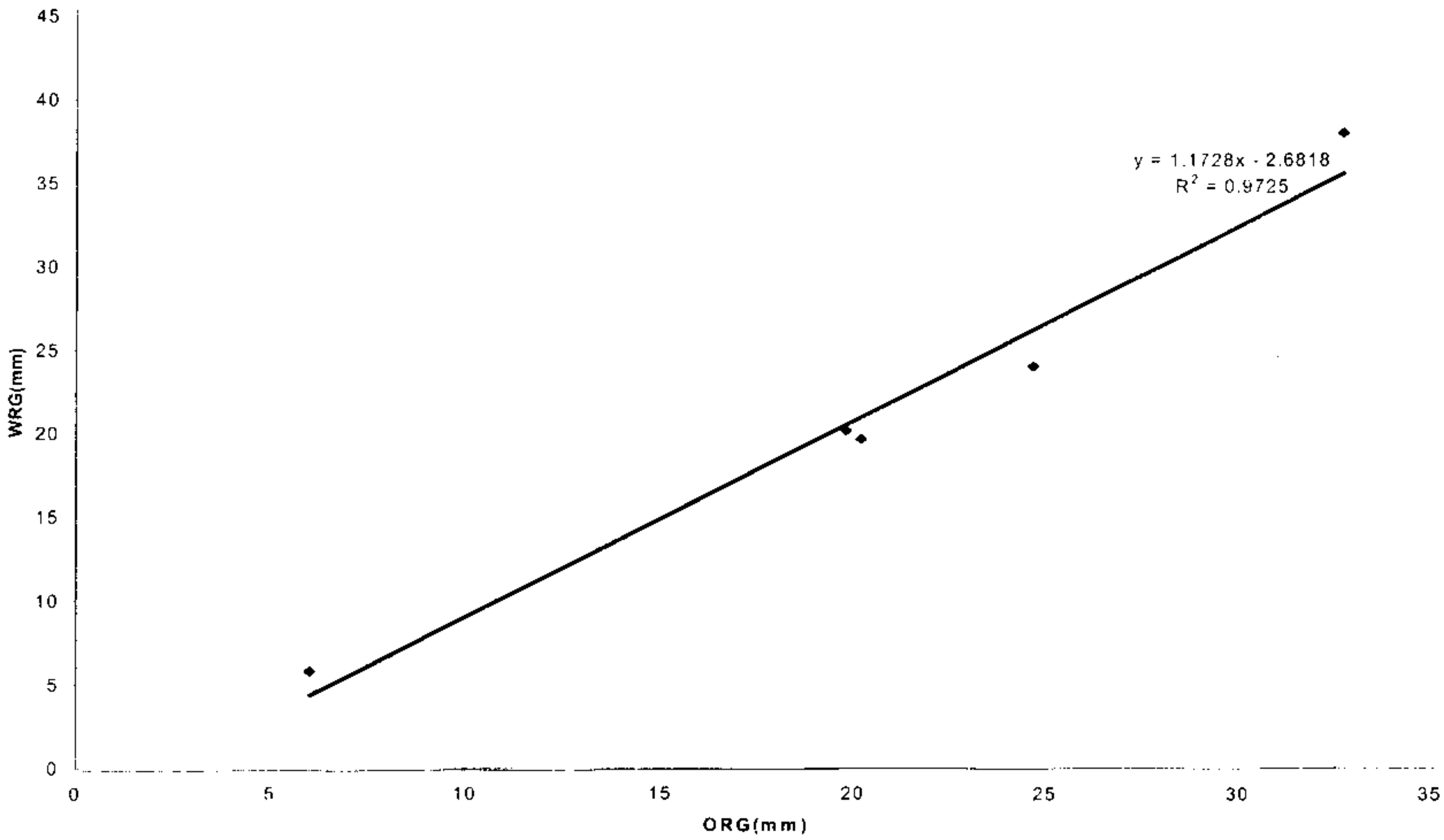
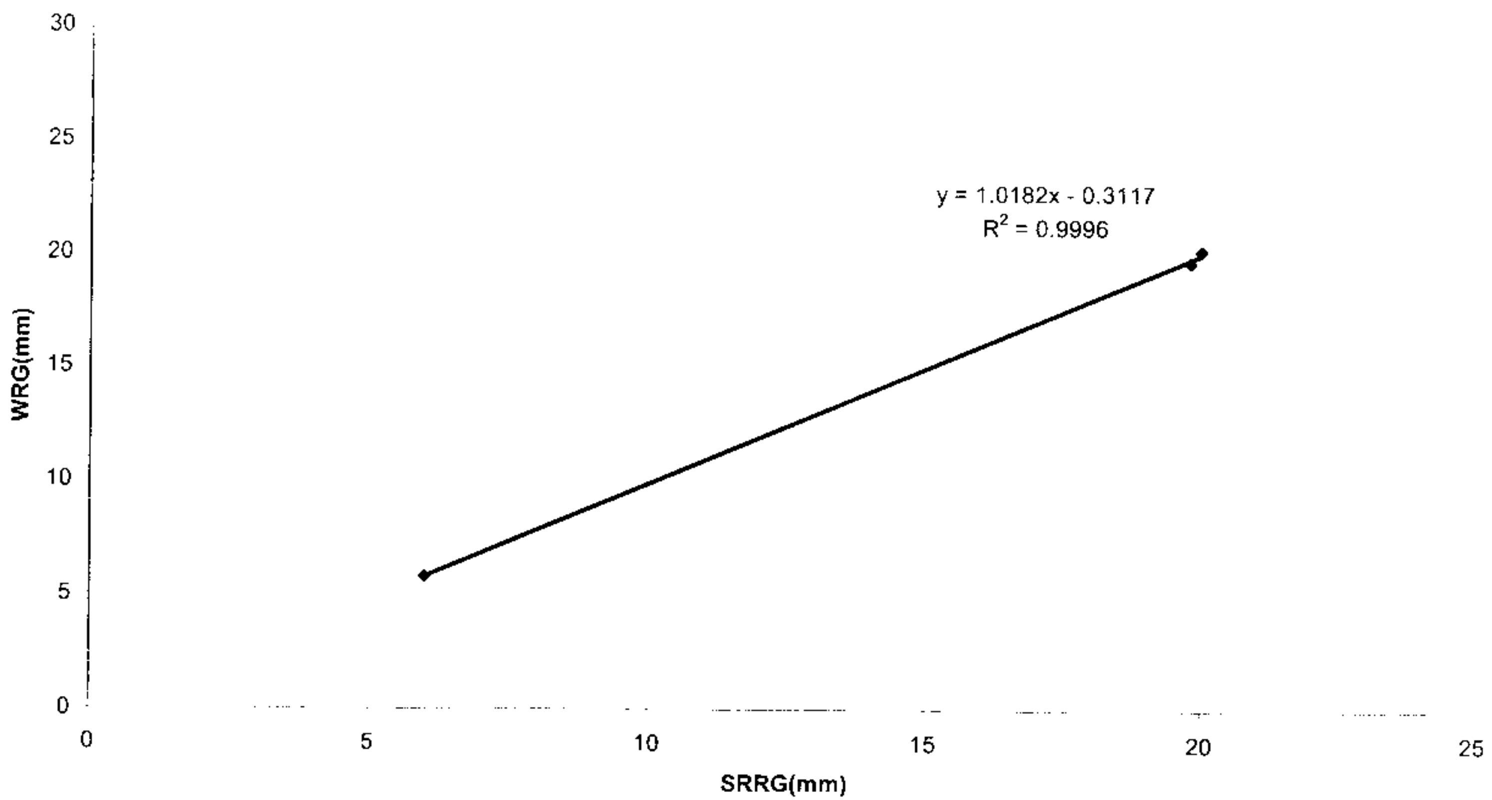


Figure 8 Testing of WRG Vs SRRG at NIH Campus (1999-2000)



APPENDIX-I

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*Table 1 Program
 01: 60.0         Execution Interval (seconds)

1: Beginning of Loop (P87)
 1: 0000         Delay
 2: 0000         Loop Count

2: Battery Voltage (P10)
 1: 1            Loc [ BATT_V  ]

3: Internal Temperature (P17)
 1: 2            Loc [ TEMP_CR10 ]

4: Full Bridge (P6)
 1: 1            Reps
 2: 33           25 mV 50 Hz Rejection Range
 3: 2            DIFF Channel
 4: 2            Excite all reps w/Exchan 1
 5: 2500         mV Excitation
 6: 3            Loc [ WT2_KG  ]
 7: 5.1922       Mult
 8: -1.50725     Offset

5: If (X<=>F) (P89)
 1: 3            X Loc [ WT2_KG  ]
 2: 3     >=
 3: 0.05         F
 4: 31           Exit Loop if True

6: End (P95)

*Table 2 Program
 02: 10.0        Execution Interval (seconds)

1: Full Bridge (P6)
 1: 1            Reps
 2: 33           25 mV 50 Hz Rejection Range
 3: 2            DIFF Channel
 4: 2            Excite all reps w/Exchan 1
 5: 2500         mV Excitation
 6: 4            Loc [ WT1_KG  ]
 7: 5.1922       Mult
 8: -1.50725     Offset

2: Z=X*F (P37)
```

```
 1: 4           X Loc [ WT1_KG   ]
 2: 31.23       F
 3: 5           Z Loc [ Rain_mm   ]

3: Z=X-Y (P35)
 1: 4           X Loc [ WT1_KG   ]
 2: 3           Y Loc [ WT2_KG   ]
 3: 6           Z Loc [ NWT_KG   ]

4: If (X<=>F) (P89)
 1: 6           X Loc [ NWT_KG   ]
 2: 3     >=
 3: .01         F
 4: 30          Then Do

5: Do (P86)
 1: 1           Call Subroutine 1

6: Else (P94)

7: If time is (P92)
 1: 0000        Minutes (Seconds --) into a
 2: 1440        Interval (same units as above)
 3: 10          Set Output Flag High (Flag 0)

8: Real Time (P77)
 1: 110         Day, Hour/Minute (midnight = 0000)

9: Sample (P70)
 1: 1           Reps
 2: 1           Loc [ BATT_V   ]

10: Sample (P70)
 1: 1           Reps
 2: 2           Loc [ TEMP_CR10 ]

11: Sample (P70)
 1: 1           Reps
 2: 5           Loc [ Rain mm ]

12: End (P95)

*Table 3 Subroutines

1: Beginning of Subroutine (P85)
 1: 1           Subroutine 1
```

```
2: If time is (P92)
 1: 0000        Minutes (Seconds --) into a
 2: 30          Interval (same units as above)
 3: 10          Set Output Flag High (Flag 0)

3: Real Time (P77)
 1: 110         Day, Hour/Minute (midnight = 0000)

4: Sample (P70)
 1: 1           Reps
 2: 1           Loc [ BATT_V  ]

5: Sample (P70)
 1: 1           Reps
 2: 2           Loc [ TEMP_CR10 ]

6: Sample (P70)
 1: 1           Reps
 2: 5           Loc [ Rain_mm  ]

7: Maximize (P73)
 1: 1           Reps
 2: 00          Time Option
 3: 5           Loc [ Rain_mm  ]

8: Sample on Max or Min (P79)
 1: 1           Reps
 2: 7           Loc [ MAXRAIN  ]

9: End (P95)

End Program
```

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