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# EVALUATION OF THE COMMON EMITTERS RECENTLY USED IN EGYPT

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**ABSTRACT** Emitter is the main device of a drip irrigation system. The study was conducted to assess the performance of emitters recently used in Egypt. Drip irrigation systems required adequate uniform distribution of emitters discharge over the irrigated area. The manufacturing variation in emission devices (C_V) is play avital factor influencing the flow uniformity among emitters of a drip irrigation system. C_V is a dimensionless value calculated by dividing the standard deviation of the flow rates of a suitable sample of emitters by the mean flow rate of the sample tested. Emitter manufacturing uniformity must be measured when choosing an emitter for a system, and when designing the system to meet predetermined efficiency aims.The main purpose of this paper was to determine typical coefficient of manufacturing variation values for emitters commonly used in Egypt. Experiments were conducted to determine the emitter discharge-pressure relationship. These results will allow designers and operators of drip irrigation systems to be more aware of the capabilities and limitations in their systems.The pressure of 0. 5, 1.00, and 1.50 bar was set turn wise and the discharge rates were calculated separately for all set pressures. The C_V ranged from 0.031 to 0.045with an average of 0.038 for the model tested. The discharge - pressure relationship, emitter discharge exponent, was tested. A correlation was evident between C_V and the operating pressure.

**KEYWORDS :** Drip irrigation, Emitters, Manufacturing Variation.

## INTRODUCTION

The growing population of Egypt and related activities have increased the demand for water to a level that reaches the limits of the available supply. Up till now, the water availability from the Nile River is not increasing and possibilities for additional supply are of the present use of the current water resources. Agriculture is a major water consumer, especially in arid country as Egypt where nearly all agriculture depends on irrigation water. According to National Water Resources Plan Egypt [2],Agriculture accounts for about 95% of the total net demand in Egypt (with 4% for municipal and industrial and 1% for fish ponds). The water use efficiency in agriculture can be improved by using the drip irrigation method in both new and old lands. In the drip irrigation system, losses by deep percolation and evaporation are minimized. Presently it is the most efficient method of irrigation with typically 90 % efficiency, while sprinkler systems are around 75-85 % efficient.

The efficiency of drip irrigation systems is directly related to the uniformity at which water is discharged from emitters in the system. Accurate evaluation of drip irrigation system is necessary for maximum economy at chosen uniformity of application. Water enters the dripper emitters at approximately 1.0 bar and is delivered at zero pressure in the form of continuous droplets at low rates.

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Factors which may affect the uniformity of discharges from emitters include pressure differences within the system due to head losses from friction, local lead loss and elevation changes, inherent emitter characteristics due to their design, or the unit-to-unit variation of emitters during manufacture. The purpose of drip irrigation is to apply water relatively frequently at low application rates. It is therefore essential that the emitter flow variation be minimal and the uniformity of water distribution be maximum.

Nakayama, et al.[9] proposed a method of selecting the required number of drip emitters per plant based on the desired application uniformity and on the manufacturing coefficient of variation. Bralts et al. [4]statistically used $C_V$ in the uniformity calculations of single chamber drip irrigation lateral lines. Irrigation design standards generally specify a maximum allowable variation of discharge within a block irrigated at the same time. These variations result from pressure and flow differences within the distribution

### Manufacturing Variation

A drip irrigation system device is designed to discharge water at a very low flow rate. Hence, the critical dimensions of the device tend to be small and difficult to manufacture precisely. Variations, which do occur, while small in absolute magnitude, represent a relatively large percentage variation. The unit-to-unit emitters out of the same molding machine, tested at the same conditions, temperature and pressure, may have different flow rates. The amount of difference to be expected from one model of emitter to another, depending on the emitter's design, the materials used in its construction, and the care with which it is manufactured. The value of ($C_v$) should be available from the manufacturer. It can be estimated for point source emitters from the measured discharges.

According to Solomon and Keller [13], Solomon [12], and National Engineering Handbook [10], it is impossible to manufacture any two emitters exactly alike. Some variation always exists between supposedly "identical" objects. The small differences between the identical emitters cause significant discharge variations.

The emitter coefficient of manufacturing variation ($C_V$) is used as a measure of anticipated variations in flow rate in a sample of new emitters. It is actually caused by the non-uniform production from the manufacturer. Coefficient of variation was calculated using the following statistical equation, Solomon[12]:

$$C_V = \frac{S}{\bar{q}}$$

$$S = \frac{\sqrt{q_1^2 + q_2^2 .... + q_n^2 - n(\bar{q}}}{\sqrt{n-1}}$$

where S represents the standard deviation of emitter discharges of a sample, q is the average emitter flow rate of the emitters sampled, n is the number of emitters in sample, and $q_1, q_2 ......\ q_n$ are the emitters discharge values operated at the recommended operating pressure.

The American Society of Agricultural Engineers (ASAE) [1], Practice standard concerning performance of trickle irrigation systems was adopted and recommended the following $C_V$ range classifications: <0.05 as good, 0.05 to 0.10 as average, 0.10 to 0.15 as marginal, and >0.15 as unacceptable.

Often more than one emitter or emitter outlet is used per plant. In such an instance, the tendency is for the variation in flow rate from each emitter around the plant to partially compensate for one another. The variation in the total flow rate delivered to each plant is less than might be expected from considering $C_V$ alone. The variation in flow rate to each plant may be characterized by the system coefficient of manufacturing variation, Solomon [11]. Howell and Hiller [6], Keller and Karmeli, [8],and Solomon and Keller [13],computed the distribution of emitter rates within trickle irrigation systems under various circumstances. Assuming a flat field, they first developed a general expression for the pressure available at any point within the systems pipe network. This allowed the calculation of the emitter flow rate to be expected at any point, based on the assumed.

$$C_{VS} = \frac{C_V}{\sqrt{N_e}}$$

where $C_v$s is the system coefficient of manufacturing variation, $C_V$ is the emitter coefficient of manufacturing variation, and Ne is the number of emitters per plant.

Emitter flow rate variation, $q_{var}$ was determined using the equation:

$$q_{var} = \frac{q_{max} - q_{min}}{q_{max}}$$

where $q_{max}$ is the maximum emitter flow rate, and q_min is the minimum emitter flow rate.

## MATERIALS AND METHODS

The experiments were conducted at Higher Institute of Engineering and Technology- King Marriott, Alexandria. It is located at 31 1 N latitude and 29 46 E longitude

### System measurements

The manufacturing variations were determined in laboratory flow rate tests.Twenty-five segmentsof a most common drip line, each containing one emitter only, to ensure that all emitters operate at identical pressure and water temperature. This drip tube, GR, is available on the irrigation markets. The pressure in the water supply is adjustable by using an elevated tank and automatically controlled at pre-set values. The digital pressure gauge of accuracy of 0.001 bar was fitted on the PE line betweenthe regulated valve and the tested emitter. The discharge from each emitter in the sample was measured individually by collecting the water discharged from it,the emitters are flagged, (total of 25 randomly selected emitters for every type).Emitter discharge was measured over a range of three pressures of 0.5, 1.0 and 1.5 bar (Fig. 1, 2, 3 and 4).Stopwatch was used to measure the flow times for a period of 5 min for each test. The volume of water dripped out from each emitter was collected separately and the discharge rates were calculated separately for all set pressures. Each test was repeated three times for each emitter at each executed pressure.

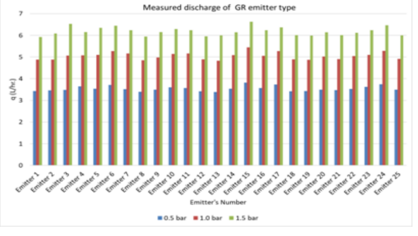


**Figure (1): Measured discharge of GR emitter type**

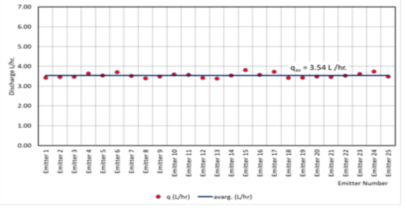


**Figure (2): Measured discharge of GR emitter type P= 0.5 bar**

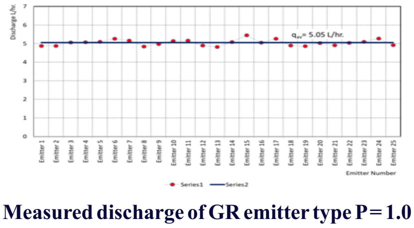


**Figure (3): Measured discharge of GR emitter type P= 1.0 bar**

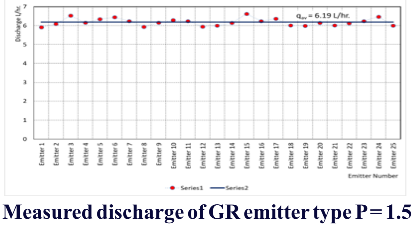


**Figure (4): Measured discharge of GR emitter type P= 1.5 bar**

### Pressure Discharge Relationship

The relation between changes in pressure head and discharge is a most important characteristic of emitters behavior. The discharge rates at various operating pressures, 0.5, 1.0, and 1.5 bar, were measured and the fixed time, 5 min for each set, was noted. The discharges were calculated by following formula:

$$Q = V/t$$

Where, Q is the emitter flow rate (L/hr.), V is the volume of water collected in glass graduated cylinder (L), and t is the fixed timetaken to collect emitted water (hr.) The mathematical and graphical relationship developed using collected data on pressure-discharge. According to, Wu and Gitlin [14], Howell and Hiler [6] and Karmeli [7], emitters flow rates expressed as a function of executed pressure as the following:

$$q = k_d H^x$$

Where: q is the emitter flow rate, $k_d$ is the emitter discharge coefficient, H is the operating pressure available at the emitter, and x is the emitter discharge exponent measures the flatness of the discharge-pressure curve. The observed data of Q and P was plotted through Excel and the best fitted model with highest $R^2$ was determined, as shown in Fig. (5).The lower the value of (x) the less discharge will be affected by variation in pressure, for fully compensating emitters x = 0.0, the exponent x for experimental emitters is 0.5067.

### Manufacturing variation

According to the classification of American Society of Agricultural Engineering (ASAE) [1], the tested emitters are classified as listed in Table (1). Based on Eq. (2-12), the coefficient of manufacturing variation was calculated for emitter GR type under operating pressure 0.5, 1.0, and 1.5 bar. A summary of  values is listed in Table (1).

**Table (1): Average coefficients of manufacturing variation**

| Operating pressure | 0.5 bar | 1.0 bar | 1.50 bar |
|---|---|---|---|
| $C_v$ | 0.033 | 0.031 | 0.045 |
| Classification | Good | Good | Good |

According to ASAE classification, it can be noticed that the manufacture quality of studied emitter is considered acceptable. Correlation was evident between $C_v$ and pressure, the manufacturing variation alternate with the applied pressure and the ultimate value at nominal pressure, 1 bar.

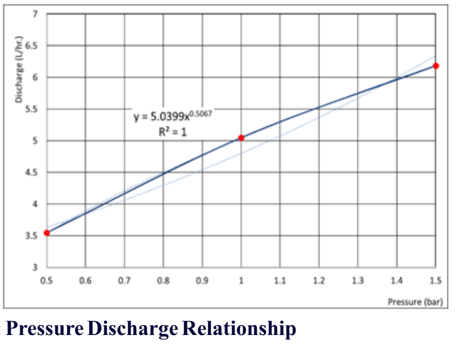


**Fig. (5): Pressure Discharge Relationship**

### Statistical analysis of the manufacturing variation

The physical significance of $C_v$ can be obtained from the above experimental tests using a statistical analysis. According to Bralts and Kesner [3], the procedure of analysis is summarized by assuming that the distribution of emission rates for a given emitter at normal operating pressure follows a normal distribution. Then, essentially all of the observed flow rates will fall within three standard deviations of the mean flow rate. Firstly, about 95 percent of the observed flow rates will fall within two standard deviations of the mean discharge. Secondly, 68 percent will fall within one standard deviation of the mean discharge. Thirdly, all of the flow rates are expected to be within three standard deviations of the mean discharge. Lastly, mean for lower quarter emitters discharge approximately equals (1-1.27 ) mean discharge.

Table (2) demonstrates the theoretical and the corresponding calculated values of the standard normal distribution for the five tested emitter types.

| Operating pressure | | 0.5 bar | 1.0 bar | 1.50 bar |
|---|---|---|---|---|
| $C_v$ | | 0.033 | 0.031 | 0.045 |
| Percent fall within (1±$C_v$) $Q_{av}$ l/h | Theoretical | 68% | 68% | 68% |
| | Actual | 84% | 64% | 80% |
| | Dev. | 23.5% | 5.9% | 17.6% |
| Percent fall within (1± 2 $C_v$)$Q_{av}$ l/h | Theoretical | 95% | 95% | 95% |
| | Actual | 96% | 88% | 96% |
| | Dev. | 1.1% | 7.3% | 1 % |
| Percent fall within (1± 3 $C_v$ ) $Q_{av}$ l/h | Theoretical | 100% | 100% | 100% |
| | Actual | 100% | 100% | 96% |
| | Dev. | 0% | 0.00% | 4% |
| (1-1.27 $C_v$) $Q_{av}$ l/h | Theoretical | 3.39 | 4.84 | 5.79 |
| | Actual | 3.42 | 4.87 | 5.83 |
| | Dev. | 0.9% | 0.6% | 0.7% |

$$\text{Dev}^*. = \frac{|\text{theoretical - actual}|}{\text{theoretical}}$$

Noticed that the results of the emitter type(GR) operated under 1.0 bargreatly closed to the standard normal distribution. Meanwhile, emittersoperated under extremely pressures 0.5 and 1.5 bar are considered marginal.

**Manufacturing Variation and uniformity**

The water application uniformity is a measure of how evenly the volumes of water are applied from each emitter.For new emitters, the performance variation is due to manufacturing variation among emitters only if it is operated under identical pressure and water temperature. The standard statistical equation for the variance using new emitter flow as the random variable is, Bralts V. F., et al. [5],

$$S_q^2 = \frac{1}{n}\sum_{i=1}^{n}(q_i - \bar{q})^2$$

where $S_q^2$ is the variance of the random variable q, n is the total number of emitters, i is the subscript identifying a particular emitter,q_iis the emitter flow, q is the mean emitter flow.

The coefficient of variation of emitter flow due to emitter manufacturing

$$V_{ME} = \frac{\sqrt{S_q^2}}{\bar{q}}$$

**RESULTS AND DISCUSSION**

The experimental and analysis study for evaluating manufacturing variation, the emitter discharge exponent (x) and emission uniformity of common emitters recently usedis carried out. Based on this experimental study, it appears that the average value of the actual discharge (5.02 L/hr.), with nominal head equal 1 bar, is more above the nominal discharge (4 L/hr.). It makes an increase of measured discharge by about 26% more than the corresponding nominal discharge. It appears too, that the measured discharge is more sensitivity to operating pressure and manufacturer coefficient. Results indicated that discharge was unevenly at all operating pressures (x= 0.5083), average discharge was 3.54, 5.05 and 6.19 L/hr. at operating pressure equal 0.5, 1.0 and 1.5 bar respectively. Results indicated too, the random variable S_q^2 was 0.01, 0.02 and 0.04, and V_MEwas 0.032, 0.031 and 0.031at operating pressure equal 0.5, 1.0 and 1.5 bar respectively.

**Recommendations**

Based on the results of this study, the following recommendations can be provided:

An Egyptian standard specification to evaluate the production of emitter should be done.

The emitters manufacturing and production procedure must be done under quality control specification.

A field evaluation for different available types of emitters should be carried out in a small scale to select the most appropriate and efficient one.

A Field and laboratory evaluation for emitter flow rate and uniformity must be performed every season.

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