

Degree of utilisation – The reciprocal of the peak factor. Its application in the operation of a water supply and distribution system

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Abstract

The degree of utilisation provides both a technical and economic connotation to the analysis of peak (load) factors. It is the reciprocal of the peak factor and should be measured within specified time-intervals that will provide realistic values for the specific purposes of a particular analysis of a water supply and distribution system. This paper briefly reviews some previous studies on peak factors and suggests a method of examining peak factors and their associated degree of utilisation in terms of probability theory in an attempt to provide greater insight when analysing the optimal investment level required in water infrastructure. The application of this concept is specifically relevant, although not restricted to, the operation of water supply and distribution systems for short time horizons.

Low degrees of utilisation indicate the uneconomical practice of maintaining excess capacity to accommodate a short interval of peak demand. The application of probability theory is used to indicate the recurrence interval of peak events as well as to provide a useful intuitive method for improving a water system's degree of utilisation through operation and control procedures.

Introduction

The shortcoming of most water demand forecasts is that they produce average consumption values. However, it is the maximum or peak load (flows) which is used in the application of fundamental hydraulic sizing and design techniques for water engineering infrastructure.

The simplest form of the peak factor is a ratio of maximum or peak flow to average flow. A more comprehensive method is to express the peak factor as a function of average flow in the form of a linear or logarithmic expression. Tessendorff (1972) considered that a peak value which occurs only very seldom and which is only of very short duration provides no useful basis for hydraulic design. Therefore the duration and the frequency of peak-flow intervals must be taken into account in addition to the peak flow rate and the period of observation. The magnitude, duration and frequency of flow peaks are not amenable to theoretical predictions and must therefore be assessed by field measurements.

Tessendorff (1972) recommended different time-intervals for the various sections of the pipe network where the load should be considered constant. These time-intervals are:

For consumer installation lines	: 15 s
For service lines	: 2 min
For supply lines (and distribution systems)	: 15 min
For mains and feeders	: 30 min

Due to the technical limitations of the chart-scanning equipment used for Tessendorff's project, the limit of accuracy of the flow interval was 20 s. However, the use of a shorter time-interval would result in unrealistically high values being determined.

The consequences of design flows being exceeded are generally not catastrophic for the water network as a whole, but occurrences such as a drop in supply pressure may prevail for a short period whilst the peak flow for a particular pipeline is being exceeded or the reserve storage of a service reservoir is encroached upon (Johnson, 1987). In the United Kingdom, however, it is a requirement that the number of failures (i.e. below a particular specified pressure threshold) occurring in the supply pressure must be recorded (Newsome, 1991). Cognisance should be taken of the possibility that smaller items within the water network, such as water meters, can be damaged when design flows are exceeded.

The degree of utilisation is determined by dividing the average flow (load) during a certain period by the maximum flow (load) for which the installation (i.e. pipe, pump station, etc.) was designed or can accommodate and expressing it as a percentage.

The reciprocal of the peak factor is therefore the degree of utilisation and it is important to know this degree of utilisation when the economic use of the distribution network is to be determined. The closer the degree of utilisation is to unity (or 100%), the lower is the excess capacity that needs to be maintained just to accommodate short intervals of peak demand and therefore the more profitable is the installation (Tessendorff, 1972).

It would appear from some literature that most water supply and distribution systems have a low degree of utilisation in the order of 30 to 50% (Tessendorff, 1972) (Johnson, 1987).

This paper provides a brief review of some previous studies on peak factors, and suggests a method of examining peak flows and their associated degree of utilisation in terms of probability theory in an attempt to provide greater insight when analysing the optimal investment level in water infrastructure. The application of this concept is specifically relevant in the operation of water supply and distribution systems for short time horizons, although it can also be applied in the planning stage of projects to establish the effect on existing water infrastructure of delaying the installation of new water infrastructure.