# Statistical Analysis of Water Pipeline Failures

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**Abstract**: In this study, influence of parameters such as material type, sizes, lengths and climates were investigated. The two models (time dependent exponential model and nonhomogeneous passion model) were proposed to include those parameters. The predicted results were in good agreement with the historical data. Those models could be used in the future prediction and thus help the pipeline system management in the future.

## 1. Introduction:

1.1.1 Multi-variate exponential model (Rajani(2000))

$$N(x_t) = N(x_{t0})e^{a_1x_1+a_2x_2+\ldots+a_nx_n} = N(x_{t0})e^{ax_t^T} \quad (1)$$

Where $x_t$ =vector of time-dependent covariates prevailing at time t;
$N(x_t)$ =number of breaks per unit length of pipe resulting from $x_t$
$a_i$= vector of parameters corresponding to the covariates x, i=1,2,...n
$x_{t0}$=vector of baseline x values at year of reference to

1.1.2 Possible time dependent variables

1) **Temperature** (cumulative average daily temperature below a threshold temperature during a given period) (accounting the breaks in cold winter)

$$T^w = \sum_{T_i \le \tau} \tau - T_i \quad (2)$$

2) **Rain deficit**(accounting the breaks in dry summer)
The thornmwaite method quantifies the moisture depletion in the ground as a function of temperature, precipitation and geographical latitude.

$$PET = 1.6(\frac{L}{20})(\frac{N}{30})(\frac{10T_a}{I})^{\alpha}$$ (Thornmwaite equation (1948)

PET is the estimated potential evapotranspiration

1.2 Nonhomgeneous Poisson Process (reliability analysis)

$$f(t,\beta,z_i) = \lambda_0(t)c(z_i'\beta) \quad (3)$$

$$\lambda_0(t) = \lambda\delta t^{\delta-1}$$ (weibull distribution) (4)

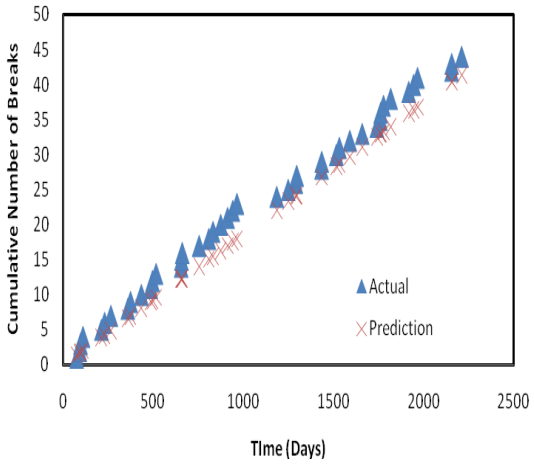
$$E(N(t)) = \int_0^t f(u,\beta,z_i)du \quad (5)$$

Where t = failure time
$E(N(t))$ =expect number of breaks with time
λ, δ, = weibull distribution parameters
zi= covariates affecting the pipe failure time
β =vector of parameters corresponding to the covariates z

## 2. Objectives:

The objectives of this study are as follows: (1) identify the causes of water pipeline failures; (2) Investigate the applicable of the proposed models.

### 3. Results for CI pipes in City of Houston between 2004 and 2008:



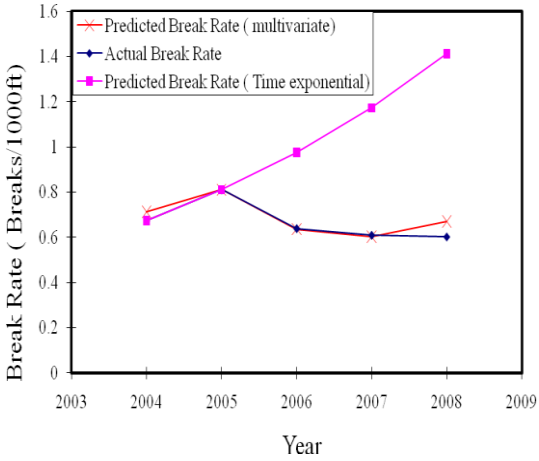




**Figure 1 Nonhomogeneous Model(Eq. (5)) Figure 2 Multi- variate exponential Model(Eq. (1))**

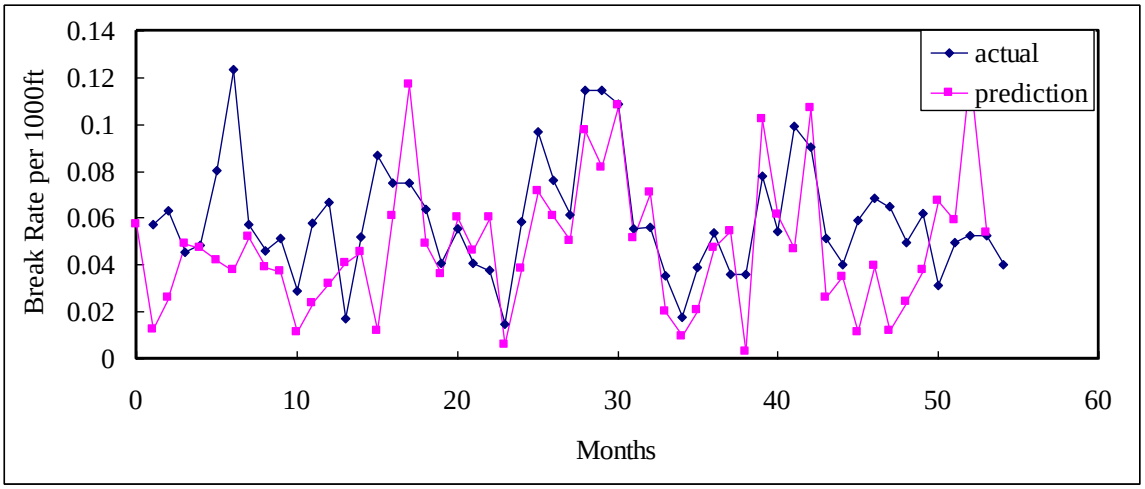



**Figure 3 Multi-variate exponential model by monthly (Eq.(1))(Covariates (x): Temperature, Rain deficit, Abanded Length of pipes and time)**

### 4. Conclusion:

Both models matched the historical data well. Time-exponential model could include the effects of climate factors but the prediction is only good for year scale and not very good for month scale. Nohomogeneous possion model could not include the time dependent variables but it predicted well in the day scale. Based on these models, it can be concluded that time, length, material, rain deficit, cold temperatures are important parameters influencing the pipe failures.

### 5. Acknowledgements:

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### 7. References:

Balvant Rajani (2001), “Comprehensive review of structural deterioration of water mains: statistical based models”, Urban Water, No.3, 2001, pages 151-164.