Reactor System Technology 1D

Calculation and Application of Minimum Sump Volume

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CONTENTS

01 Introduction

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Minimum sump volume

- Most pumping systems that transfer liquid utilize some form of a pump sump including Kijang Research Reactor [1].
- It is important to calculate the **required minimum sump volume** for estimation of the volume of the sump room or entire volume of a reactor building.
- From the applicable Standard, it can be calculated but it is **important to know the methods** for diverse pump operation.
- In this study, **the equations of minimum sump volume are derived** and will be applied to other operation.

02
Methods and Results

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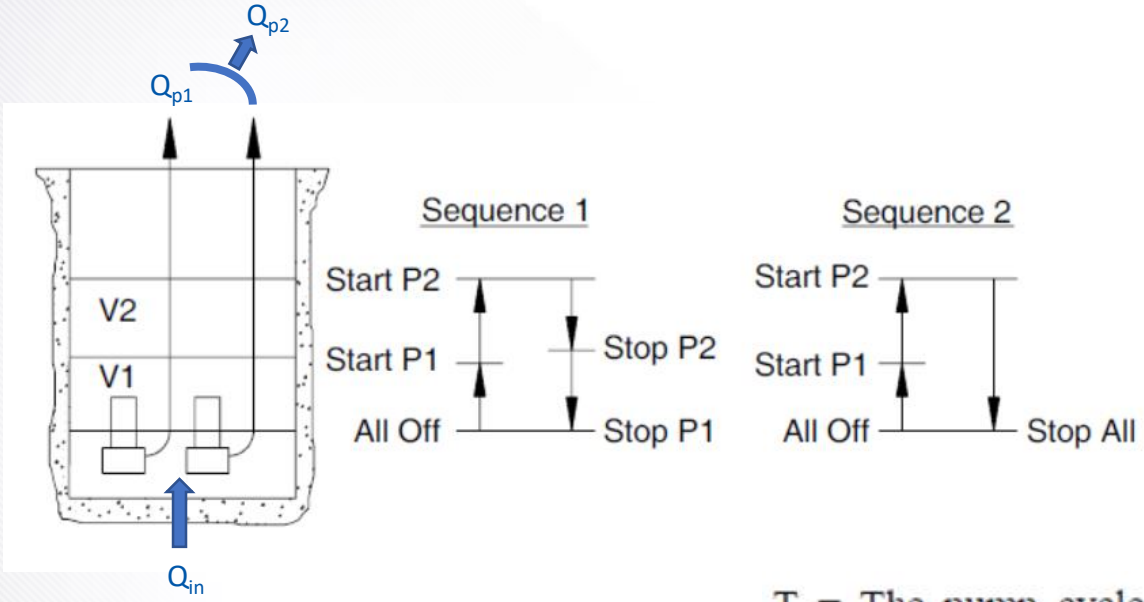
Operational sequences with descriptions for multi-pump stations



T = The pump cycle time in minutes, i.e., the time between two consecutive starts

Vol_x = The effective sump volume for pump x, i.e., the volume between the start level and the stop level in liters

Q_{in} = The inflow into the pump station in l/min

Q_{p1} = The flow rate of pump 1 in l/min

Q_{p2} = The combined flow rate with 2 pumps in l/min

02 Methods and Results

Minimum sump volume sequence 1

1. For Vol_1 (Stop P_1)

$$T = \frac{Vol_1}{Q_{in}} + \frac{Vol_1}{Q_{p1} - Q_{in}} \quad (1)$$

$$\Rightarrow Vol_1 = T\left(\frac{Q_{in}}{Q_{p1}}\right)(Q_{p1} - Q_{in}) \quad (2)$$

For minimum sump volume Vol_1, partially differentiate Vol_1 from Q_{in}.

$$\text{When } \frac{\partial Vol_1}{\partial Q_{in}} = \frac{-(2Q_{in} - Q_{p1})T}{Q_{p1}} = 0 \quad (3)$$

$$\text{then } Q_{in} = \frac{Q_{p1}}{2} \quad (4)$$

Substituting Eq. (4) in (2) gives

$$Vol_1 = \frac{Q_{p1}}{4}T \quad (5)$$

2. For Vol_2 (Stop P_2)

$$T = \frac{Vol_2}{Q_{in} - Q_{p1}} + \frac{Vol_2}{Q_{p2} - Q_{in}} \quad (6)$$

$$\Rightarrow Vol_2 = T(Q_{in} - Q_{p1})\left(\frac{Q_{p2} - Q_{in}}{Q_{p2} - Q_{p1}}\right) \quad (7)$$

For minimum sump volume Vol_2, partially differentiate Vol_2 from Q_{in}.

$$\text{When } \frac{\partial Vol_2}{\partial Q_{in}} = \frac{(2Q_{in} - Q_{p1} - Q_{p2})T}{Q_{p1} - Q_{p2}} = 0 \quad (8)$$

$$\text{then } Q_{in} = \frac{Q_{p1} + Q_{p2}}{2} \quad (9)$$

Substituting Eq. (9) in (7) gives

$$Vol_2 = \frac{(Q_{p2} - Q_{p1})}{4}T \quad (10)$$

Minimum sump volume sequence 2

1. For Vol_1 (Stop P_1)

It is the same as Sequence 1.

2. For Vol_2 (Stop All)

$$T = \left(\frac{Vol_1}{Q_{in}} + \frac{Vol_2}{Q_{in} - Q_{p1}} + \frac{Vol_1 + Vol_2}{Q_{p2} - Q_{in}}\right) \quad (11)$$

$$\Rightarrow Vol_2 = \frac{T(Q_{in} - Q_{p1})(Q_{p2} - Q_{in})}{Q_{p2} - Q_{p1}} - \frac{Vol_1 Q_{p2}(Q_{in} - Q_{p1})}{Q_{in}(Q_{p2} - Q_{p1})} \quad (12)$$

For minimum sump volume Vol_2, partially differentiate Vol_2 from Q_{in}.

$$\frac{\partial Vol_2}{\partial Q_{in}} = \frac{2Q_{in}^3 T - Q_{in}^2 T(Q_{p1} + Q_{p2}) + Q_{p1}Q_{p2}Vol_1}{Q_{in}^2(Q_{p1} - Q_{p2})} = 0 \quad (13)$$

02 Methods and Results

Comparison for validation

- Comparison of calculated results of Standard examples [1] and derived equations can be used to verify that the equations are correct.

- **The calculated results of the examples and equations:**

Sequence	Variable	Example	Equation
1	Q_{in} of Vol_1	75	75
	Q_{in} of Vol_2	200	200
2	Q_{in} of Vol_2	180	177.74

- The results of Sequence 1 are exactly the same.

- In the case of sequence 2, there is a slight difference, but it is the result of an iteration or trial error process as it appears in the Standard [1].

03
Conclusions

03 Conclusions

- In this study, the equations of minimum sump volume are derived from the Standard [1] and validated from the calculated results.
- From the results, we can understand the meaning and methodology of volume calculation.
- By knowing the process and methodology, rather than simply substituting values for the Standard, it can be applied to other operational sequences that are not in the Standard.

04
Acknowledgement & References

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Acknowledgements

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References

[1] American National Standard for Pump Intake Design, ANSI/HI 9.8, Hydraulic Institute, 1998.

THANK YOU