# Exam – TPK4140 – 2022

We will consider the maintenance strategy for a pump in a process plant. The following parameters are of interest:

| Parameter | Value | Explanation |
| --- | --- | --- |
| MTTF | 13 140 | Average time to failure (in hours). Time-to-failure is assumed to be Weibull-distributed. |
|  | 3 | Aging parameter in the Weibull distribution |
| *C*PM | 8 000 | Cost of carrying out preventive maintenance, NOK |
| *C*CM | 15 000 | Cost of carrying out corrective maintenance, NOK |
| CU | 10 000 | Unavailability cost per hour (in case of pump failure), NOK |
| *C*T | 75 000 | Extra cost if we lose capacity, regardless of downtime, NOK |
| MDT | 16 | Men downtime (in hours) |

We assume that the dominant cause of failure is wear/defective impellers. We disregard other failure mechanisms. A preventive maintenance activity is to change the impeller.

Write down the cost equation required to find the optimal interval for preventive maintenance. Describe three ways we can find the optimal interval. Hint: The effective failure rate is given by . Write down you answer on paper for scanning.

1. Find the optimal interval when
2. By changing the design of production, we can reduce vulnerability. Instead of having the pump to feed the process directly, we will consider pumping the process medium into a storage vessel, and then feeding the process medium from the storage vessel. The capacity of the storage vessel should be determined. Let be the storage tank capacity. Find the probability that the vessel will run out in case of a pump failure when  = **20** hours. If the storage vessel runs out before the repair of the pump is finished, we will have downtime. Find expected downtime given that the storage vessel runs out. Hint: You can assume that the downtime, *D*, after a pump failure is *exponentially* distributed. In the exponential distribution where  where is the rate/intensity in the distribution.
3. The *annual* cost of production and operation of the storage vessel consists of a fixed amount of NOK **1,000** and an amount of NOK **250** per hour capacity installed, i.e., the larger the vessel is, the more expensive it is. Derive the cost function to minimize the expected cost per unit of time as a function of both the maintenance interval and the capacity of storage vessel . Find the optimal PM interval for  = 20 hours and 30 hours respectively, and determine which of these two alternatives is the best. Write your answer on paper for scanning.