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Chapter 33. Analysis of Engineering Systems

Practice Problems

1.

What type of signal is indicated by this line symbol on a piping and instrumentation diagram (P&ID)?

(A)

pneumatic signal

(B)

hydraulic signal

(C)

electromagnetic signal

(D)

sonic signal

2.

Which of these statements about piping and instrumentation diagram (P&ID) documents is NOT correct?

(A)

Issue for construction (IFC) revisions can include sizes of control valves and pressure safety valves as well as HAZOP actions.

(B)

Equipment is drawn to scale except for pumps and valves.

(C)

An instrumentation line is nearly always represented by a plain, solid line.

(D)

An instrument that is visible on a shared video display as part of a distributed control system is represented by a circle inscribed in a square.

3.

To assign a robustness indicator figure (RIF) for durability testing, the Arrhenius model can be applied. The Arrhenius model is usually applicable when high temperature tests or lifetime tests with constant temperature are conducted (see *NCEES Handbook:* Temperature Dependence).

A device under test (DUT) is required to work at a maximum temperature of 87°C for 1600 hr. When the DUT is tested at 98°C, the failure at accelerated conditions occurs after 1950 hr. From the Arrhenius model, the acceleration factor is

$$\pi_B = e^{E_A(\mathrm{TF})}$$

The Arrhenius activation energy, E_A, is 0.45 eV. The temperature factor, TF, is defined as

$$\mathrm{TF} = \frac{1}{k}\left(\frac{1}{T_{\max}} - \frac{1}{T_{\text{test}}}\right)$$

The Boltzmann constant, k, is 8.617×10^{-5} eV/K. Most nearly, the RIF is

(A)

1.9

(B)

2.2

(C)

2.5

(D)

3.0

Solutions

1.

Pneumatic signals are represented by lines with only TWO axial traversing line segments as represented by the spring-opposed single-acting, double-acting, and I/P actuator symbols in the *NCEES Handbook*. The line symbol shown represents a pneumatic signal. Standard symbols on P&IDs are defined by ANSI/ISA Standard S5.1.

The answer is (A).

2.

On process flow drawings (PFDs), which are the simplest P&ID documents, instrumentation lines are represented only by plain, solid lines. On other kinds of P&ID documents, however, instrumentation lines may be dashed, dotted, or marked with other patterns, mainly to indicate the type of signal (pneumatic, sonic, electrical, and so on) that each line transmits.

The answer is (C).

3.

The maximum absolute temperature is 87°C + 273° = 360K. The absolute testing temperature is 98°C + 273° = 371K. The temperature factor is

$$\begin{aligned}\mathrm{TF} &= \frac{1}{k}\left(\frac{1}{T_{\max}} - \frac{1}{T_{\text{test}}}\right)\\ &= \left(\frac{1}{8.617\times10^{-5}\ \frac{\mathrm{eV}}{\mathrm{K}}}\right)\left(\frac{1}{360\mathrm{K}} - \frac{1}{371\mathrm{K}}\right)\\ &= 0.96\ 1/\mathrm{eV}\end{aligned}$$

From the Arrhenius model, the acceleration factor is

$$\begin{aligned}\pi_B &= e^{E_A(\mathrm{TF})} \\ &= e^{(0.45\ \mathrm{eV})(0.96\ 1/\mathrm{eV})} \\ &= 1.54\end{aligned}$$

Robustness is defined as the difference between the limits of the design or the product and the specification requirement. The RIF for the device under test is

$$\mathrm{RIF} = \frac{\tau_2 \pi_B}{\tau_1} = \frac{(1950\ \mathrm{hr})\,(1.54)}{1600\ \mathrm{hr}} = 1.88 \quad (1.9)$$

The answer is (A).