Failure Finding Intervals Protective Devices

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Failure Finding Intervals (FFIs) for Single Protective Devices

Your Protective Device

What is a protective device?

- It protects another function (protected function) and its Failure is hidden (or not self-announced)

- Hidden failure may (with a significant possibility) cause severe consequences, or major disaster if the main function (protected function) fails too

From: Moubray. J.M., Reliability - centred Maintenance II, 1999, page 172

"Failure-finding applies only to hidden or unrevealed failures. Hidden failures in turn only affect protective devices.

If RCM is correctly applied to almost any modern, complex industrial system, it is not unusual to find that up to 40% of failure modes fall into the hidden category. Furthermore, up to 80% of these failure modes require failure finding, so up to one third of the tasks generated by comprehensive, correctly applied maintenance strategy development programs are failure –finding tasks.

A more troubling finding is that at the time of writing, many existing maintenance programs provide for fewer than one third of protective devices to receive attention at all (and then at inappropriate intervals)".....

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"This lack of awareness and attention means that most of the protective devices in industry-our last line of protection when things go wrong- are maintained poorly or not at all.

This situation is completely untenable"

F.F. Interval vs. Availability: Moubray (Horton) Model

$$I = 2(1-A)M$$

Where:

A = Availability

M = MTBF

I = Failure Finding Interval

Source: Moubray, *RCM II,* pp. 177

An Example Using the Moubray Model

Problem: Brake lights on motorcycles

- MTBF = 10 years
- FFI = 10% of MTBF of 10 years = 1 year

Result: Availability = 95.0%

Problem source : Moubray, RCM II., 1999, pp. 175-176

Example for FFI (Failure Finding Interval) for a Protective Device

Pressure safety valve

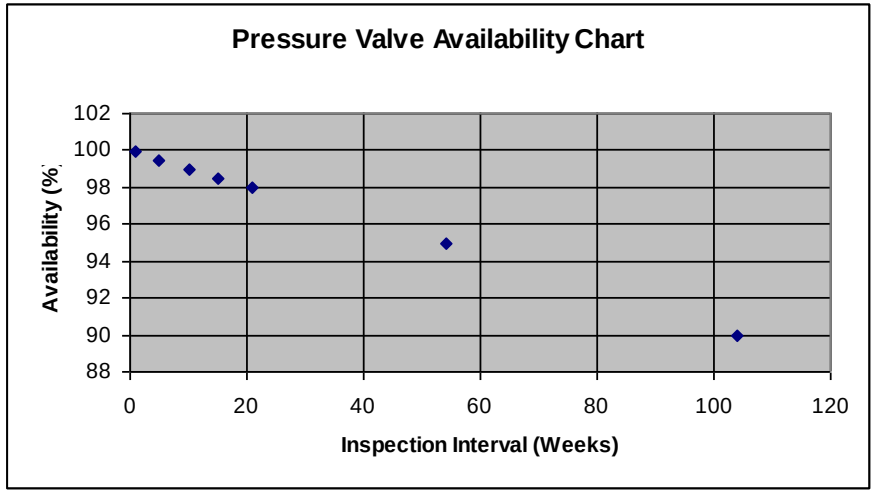
- 1000 valves in service
- Current inspection interval = 12 months
- Time to inspect = 1 hour
- Time to replace a defective valve = 1 hours
- 10% of valves found defective at inspection, therefore

  MTTF = (1000 x 1) /100 = 10 years

What is valve availability for the current inspection interval?

Answer

Failure Finding Interval (Weeks)	Pressure Valve Availability (%)
1	99.9
5	99.5
10	99.0
15	98.5
21	98.0
54	95.0
104	90.0



Optimum Inspection Interval: Safety/Environmental Consequences

$P_{inc} \leq P_{max}$, $P_{inc} = P_{ted} \times (1\text{-}A) = P_{ted} \times I/(2M)$

$P_{ted} \times I/(2M) \leq P_{max}$

$$I \leq \frac{2MP_{max}}{P_{ted}}$$

P_{inc}= probability of the catastrophic incident (failure of both protected function and protective device)

P_{max}= Maximum Tolerable Probability for catastrophic incident

P_{ted} is the probability/frequency of failure of the protected function in one unit of time

Optimum Inspection Interval: Safety/Environmental Consequences

For a system with n fully redundant protective devices:

$$I \leq M \left(\frac{(n+1)P_{max}}{P_{ted}} \right)^{\frac{1}{n}}$$

Adopted from RCM II book by John Moubray

Factors that Influence Tolerance Regarding Safety

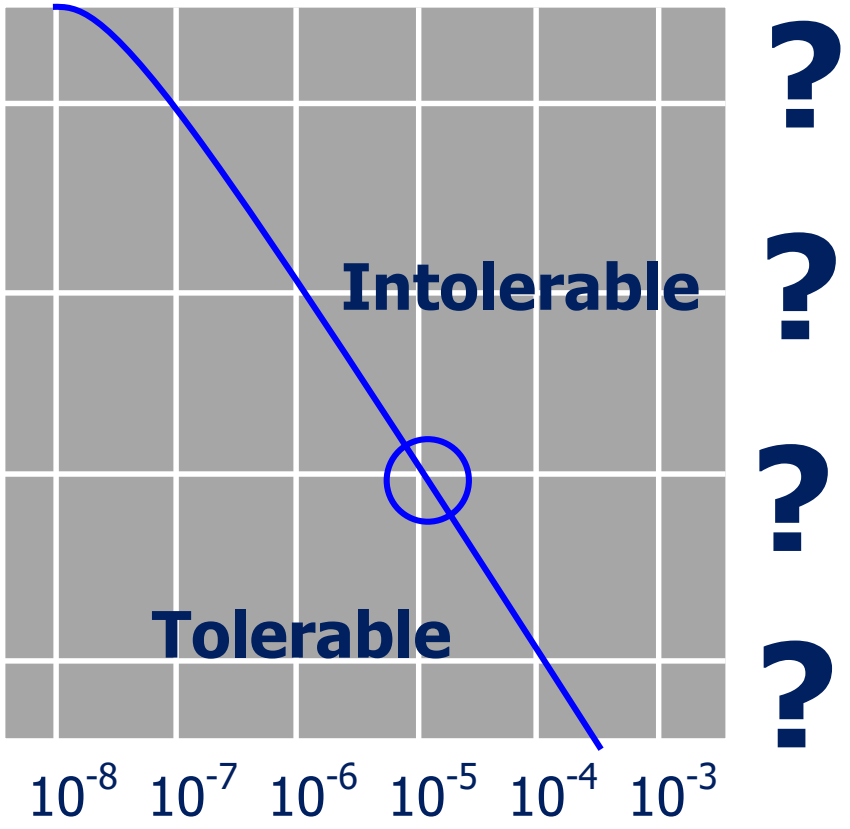
In any one year, what probability do ***you*** tolerate of being killed by any event in each situation?

I have no control and no choice about exposure *(off-site exposure to industrial accident)*

I believe I have no control but I have some choice about exposure *(in a passenger plane)*

I believe I have some control and have some choice about exposure *(at work)*

I believe I am in control and I have complete choice *(in my car or home workshop)*



Adopted from RCM II book by John Moubray

How Determine P_{max}

Assume that on average there are around 10 failure modes that can affect one person in a typical work environment. Therefore to achieve probability of fatality of less than 10^{-5}, probability of happening each failure mode needs to be less than 10^{-6}.
However, when a failure mode happens, it does not usually cause exactly one person to be killed. It could kill several people or kill a person with a probability less than 100%, so P_{max} should be adjusted accordingly, so:

$$P_{max} = \frac{10^{-6}}{chance\ of\ causing\ fatality\ if\ the\ failure\ happens}$$

$$P_{max} = \frac{10^{-6}}{expected\ number\ of\ fatalities\ if\ the\ failure\ happens}$$

Example

There are 50 pressure safety valves on 50 tanks (each tank has one) which are inspected annually. Over the last 10 years, 5 of them have been found defective. If the pressure in the tank exceeds 500 psi, the valve on the tank will release the additional pressure. If the valve does not work then there would be an explosion.

Example

The tanks are not close to any staff cabins, however if a tank explodes there is a 10% chance that somebody would be close enough to get killed.

Over the last 10 years, there has been 2 incidents that a pressure relief valve has released extra pressure.

What would be the optimum inspection interval?

Example: Solution

- $P_{inc} \leq P_{max}=10^{-6}/0.10=10^{-5}$
- $P_{ted}=2/(10*50)=0.004$
- M= 50*10/5=100 years

$$I \leq \frac{2MP_{max}}{P_{ted}} = \frac{2 \times 100 \times 10^{-5}}{0.004}$$
$$= 0.5\ year = 6\ months$$

Quantitative Risk Assessment

- Number of PSVs
  =176
- Inspection Time Interval for PSV
  =3 years
- No. of Defective PSVs within this inspection time =1
- How many PSV activation over the Inspection Period =0.5
- Chances of someone being killed from explosion =90%

Suncor Risk Matrix Residual Risk Level	III	II	II	I
Inspection Interval (year)	0.5	3	6	10

Blast Resistant Trailers Case Study

- Currently 4 sets of H2S and LEL detectors are installed per 30’ X 15’ Blast Resistant Trailers. One set of Gas detectors has to be located close to the intake duct of HVAC unit and a second set of Gas Detectors to be located at the top outside surface of the BRT.

- Gas Detectors provide detection of flammable hydrocarbon gas and is capable of detecting hundreds of flammable hydrocarbon vapors such as methane ,ethane, propane, butane, ethylene and propylene.

- Numerous additional operating parameters are programmable via digital communications or the optional handheld communicator.

Reliability Engineering- Electrical & Control Systems
Infrastructure and Shared Assets (ISA)

Introduction

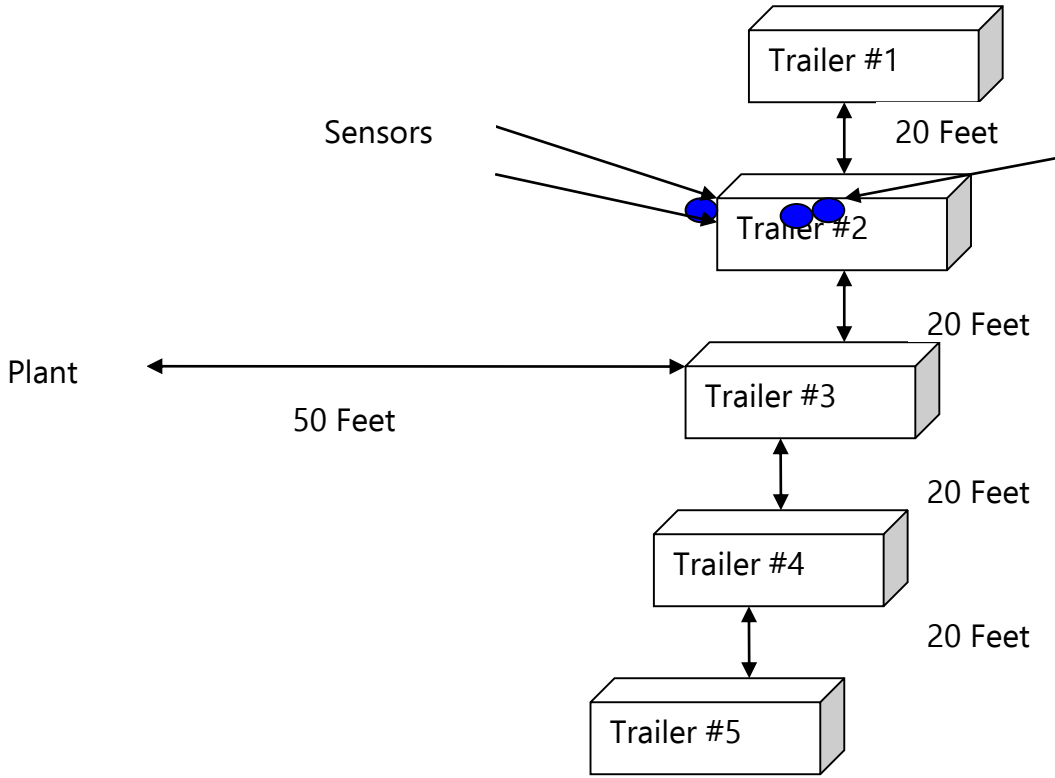
Infrared Hydrocarbon Gas Detector

It is a diffusion-based, infrared combustible gas detector that provides continuous, fixed monitoring of flammable hydrocarbon gases from 0 to 100% Lower Flammable Limit (LFL).

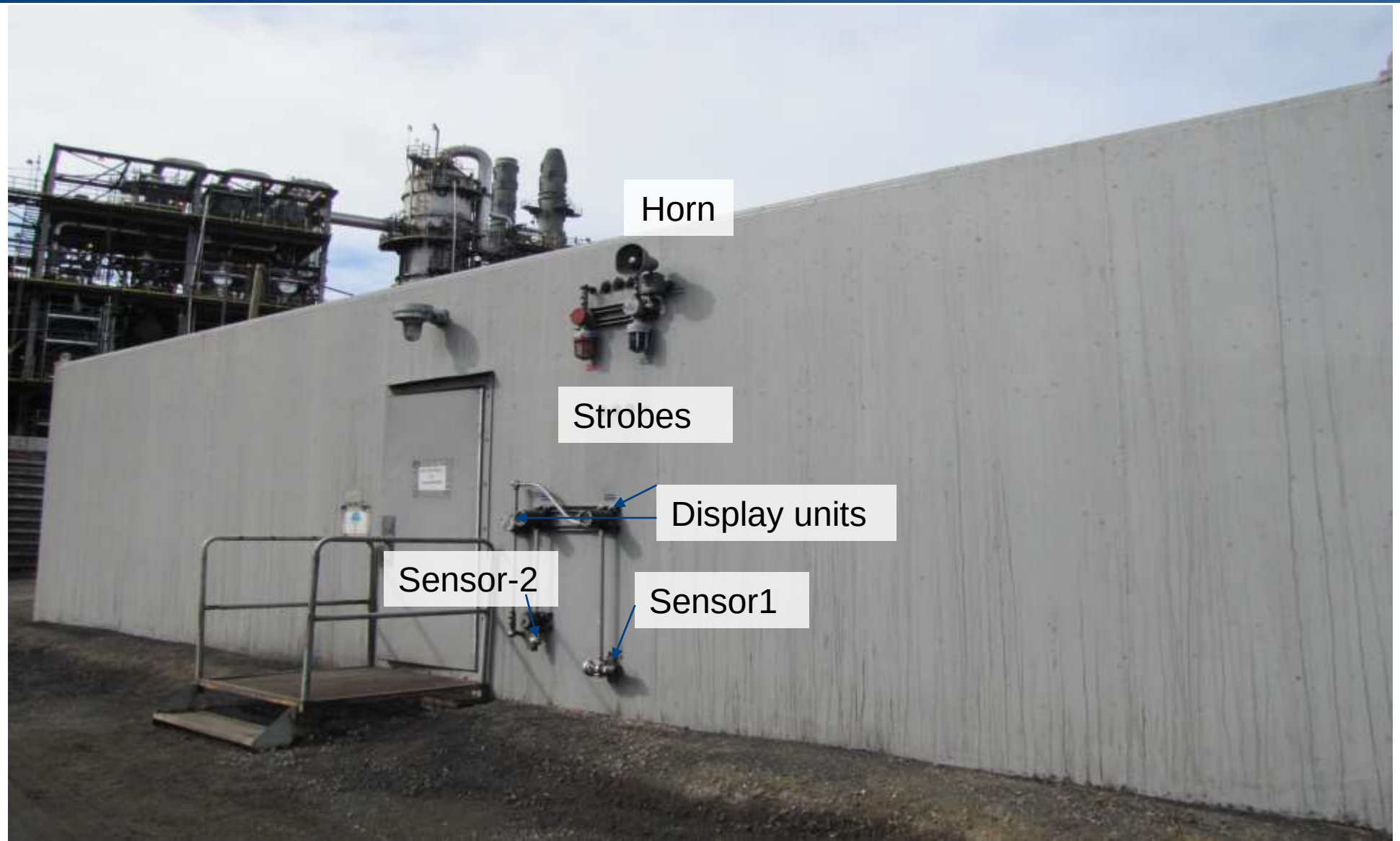
Explosion-Proof Universal Display Unit

The display unit is designed and approved as a 'stand alone' device and performs all the functions of a gas controller.

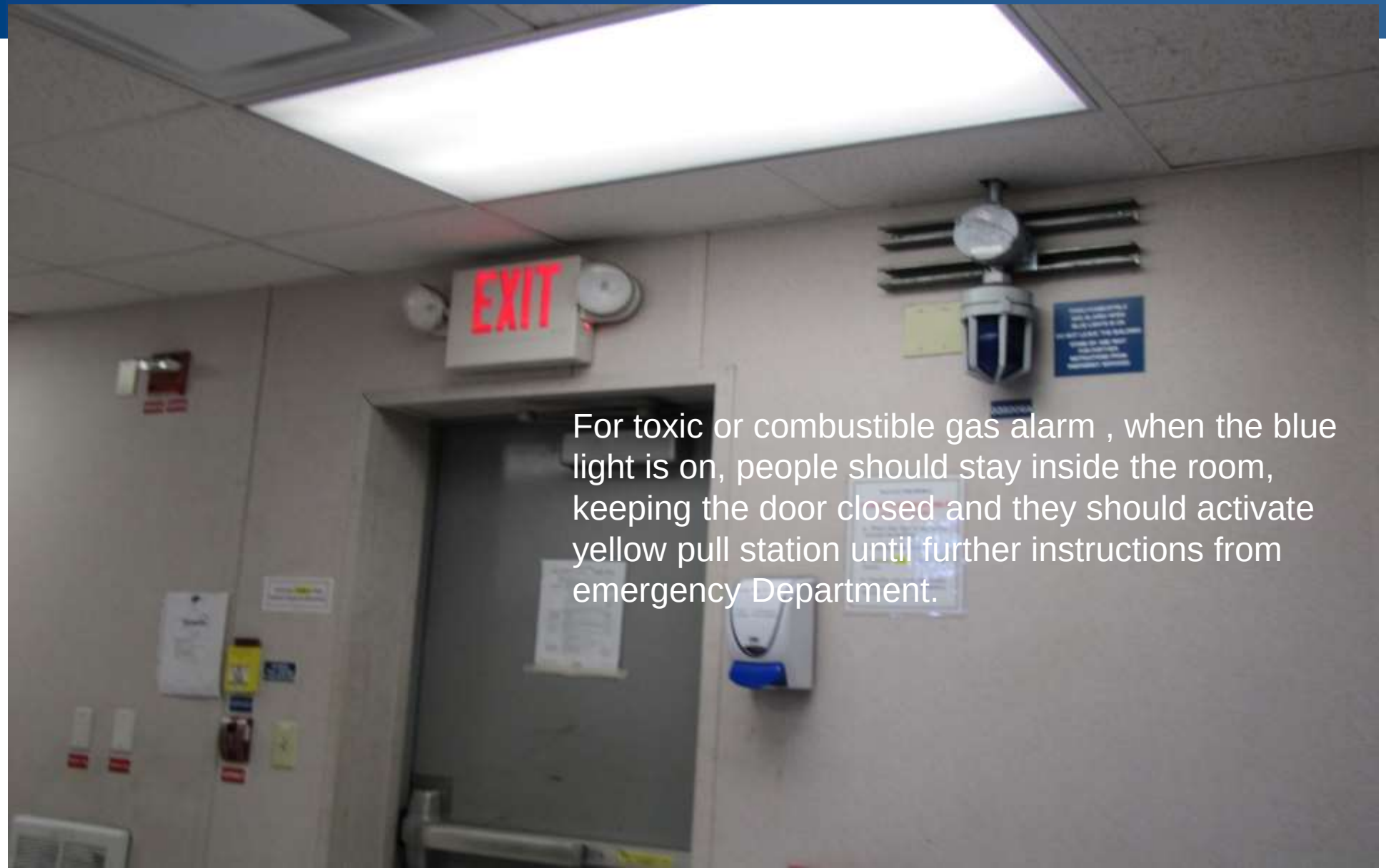
5 Blast resistant trailers location



Distance between plant and trailer-1 is 50 Feet



Strobe Location inside trailer



For toxic or combustible gas alarm , when the blue light is on, people should stay inside the room, keeping the door closed and they should activate yellow pull station until further instructions from emergency Department.

Location of the other two sets of Gas detectors

Outside strobe and horn location

- Current Inspection Intervals: 3 months
- Current no of sensors: 3 or 4
- Detectors MTTF: 10 years (manufacturers data)
- Gas release frequency: every 1-10 years (estimates)
- Estimated fatality in case of multiple failure: 5 persons
- Should the current inspection interval change?
- Can no of sensors reduced to save costs?

Optimum Inspection Interval: Safety/Environmental Consequences

For a system with ***n*** fully redundant protective devices:

$$I \leq M \left(\frac{(n+1)P_{max}}{P_{ted}} \right)^{\frac{1}{n}}$$

- If n=4 then Inspection Interval: 3 months
- If n=3 then Inspection Interval: every months
- If n=2 then Inspection Interval: every 3 days (NOT FEASIBLE)

Thank You