SPECIAL MOBILITY STRAND

MAINTENANCE AS AN IMPORTANT ACTIVITY IN FIRE PROTECTION

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1. MAINTENANCE OF EQUIPMENT
2. EQUIPMENT FOR FIRE PROTECTION
3. TECHNICAL DIAGNOSTIC
4. MODEL AND SOFTWARE DEVELOPMENT FOR EARLY FAILURE DETECTION
5. APPLICATION ON AUTOMATIC SYSTEMS FOR EARLY DETECTION OF FIRES AND ALARMING

1. MAINTENANCE OF EQUIPMENT

- There are fields where the systems are not allowed to fail.
- Application of these systems is aviation, military industry, fire protection and more.
- These systems must have a great readiness and reliability.
- The technical diagnosis is the study of readiness and reliability.

1. MAINTENANCE OF EQUIPMENT

- MAS flight Boeing 737 left KLIA at 2:00 pm
- All two engines, hydraulic systems working
- 2:22 pm explosion shook plane
- Number 2 engine torn apart, 2 separate hydraulic lines ceased to work
- In spite of maintenance work, engine still failed
- Imagine having no maintenance systems.

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1. MAINTENANCE OF EQUIPMENT

Maintenance and reliability is important

Maintenance and product quality

Maintenance and productivity

Maintenance and safety

Maintenance and supply chain, JIT

Failure cause disruption, waste, accident, inconvenience and expensive, and somebody can lost life.

1. MAINTENANCE OF EQUIPMENT

The term “ **maintenance**“ covers many activities including:

1. inspection
2. testing
3. measurement
4. replacement and adjustment.

Maintenance is carried out in all sectors and workplaces.

1. MAINTENANCE OF EQUIPMENT

Maintenance in service industry	Maintenance in manufacturing companies
Hospital	Electronic
Restaurants	Automotive
Transport companies	Petrochemicals
Banks	Refinery
Hotels and resorts	Furniture
Shopping malls / retail	Ceramics
Gas station	Food and beverages
Fire protection	

1. MAINTENANCE OF EQUIPMENT

- Operators less able to do repairs themselves,
- Machine and product failure can have effect on company’s operation and profitability,
- Idle workers, facility,
- Losses due to breakdown.

1. MAINTENANCE OF EQUIPMENT

Failure

Failure – inability to produce work in appropriate manner.

Equipment/machine failure on production floor – worn out bearing, pump, pressure leaks, broken shaft, overheated machine, equipment for fire protection etc.

Equipment failure in office – failure of power supply, air-conditioned system, computer network, photocopy machine.

Vehicle failure – brake, transmission, engine, cooling system.

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1. MAINTENANCE OF EQUIPMENT

Question?

- Why do we need maintenance?
- What are the costs of doing maintenance?
- What are the costs of not doing maintenance?
- What are the benefits of maintenance?
- How can maintenance increase profitability of company?

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1. MAINTENANCE OF EQUIPMENT

Purpose

- Attempt to maximize performance of production equipment efficiently and regularly
- Prevent breakdown or failures
- Minimize production loss from failures
- Increase reliability of the operating systems.

1. MAINTENANCE OF EQUIPMENT

Principle Objectives in Maintenance

- To achieve product quality and customer satisfaction through adjusted and serviced equipment.
- Maximize useful life of equipment, and life of people.
- Keep equipment safe and prevent safety hazards.
- Minimize frequency and severity of interruptions.
- Maximize production capacity – through high utilization of facility.

1. MAINTENANCE OF EQUIPMENT

Problems in Maintenance

- Lack of management attention to maintenance.
- Little participation by accounting in analyzing and reporting costs.
- Difficulties in applying quantitative analysis.
- Difficulties in obtaining time and cost estimates for maintenance works.
- Difficulties in measuring performance.

1. MAINTENANCE OF EQUIPMENT

Problems in Maintenance

Problems in Maintenance Exist Due To:

- Failure to develop written objectives and policy,
- Inadequate budgetary control,
- Inadequate control procedures for work order, service requests etc.,
- Infrequent use of standards,
- To control maintenance work,
- Absence of cost reports to aid maintenance planning and control system.

1. MAINTENANCE OF EQUIPMENT

Maintenance Objectives

- Must be consistent with the goals of production (cost, quality, delivery, safety).
- Must be comprehensive and include specific responsibilities.

1. MAINTENANCE OF EQUIPMENT

TYPES OF MAINTENANCE

Maintenance may be classified into **four categories**:

- **Corrective or Breakdown maintenance**
- **Scheduled maintenance**
- **Preventive maintenance**
- **Predictive (Condition-based) maintenance**

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1. MAINTENANCE OF EQUIPMENT

1. Corrective or Breakdown Maintenance

Corrective or Breakdown maintenance implies that repairs are made after the equipment is failed and can not perform its normal function anymore.

Quite justified in small factories where:

- Down times are non-critical and repair costs are less than other type of maintenance.
- Financial justification for scheduling are not felt.

1. MAINTENANCE OF EQUIPMENT

Disadvantages of Corrective Maintenance

- Breakdown generally occurs inappropriate times leading to poor and hurried maintenance.
- Excessive delay in production & reduces output
- Faster plant deterioration
- Increases chances of accidents and less safety for both workers and machines
- More spoilt materials
- Direct loss of profit
- Can not be employed for equipment regulated by statutory provisions e.g. cranes, lift and hoists etc.

1. MAINTENANCE OF EQUIPMENT

2. Scheduled Maintenance

- Scheduled maintenance is a stitch-in-time procedure and incorporates
  - inspection
  - lubrication
  - repair and overhaul of equipment.
- If neglected can result in breakdown
- Generally followed for:
  - overhauling of machines
  - changing of heavy equipment oils
  - cleaning of water and other tanks etc.

1. MAINTENANCE OF EQUIPMENT

3. Preventive Maintenance (PM)

- Procedure - Stitch-in-time
- Locates weak spots of machinery and equipments provides them periodic/scheduled inspections and minor repairs to reduce the danger of unanticipated breakdowns.

Principle – "Prevention is better than cure"

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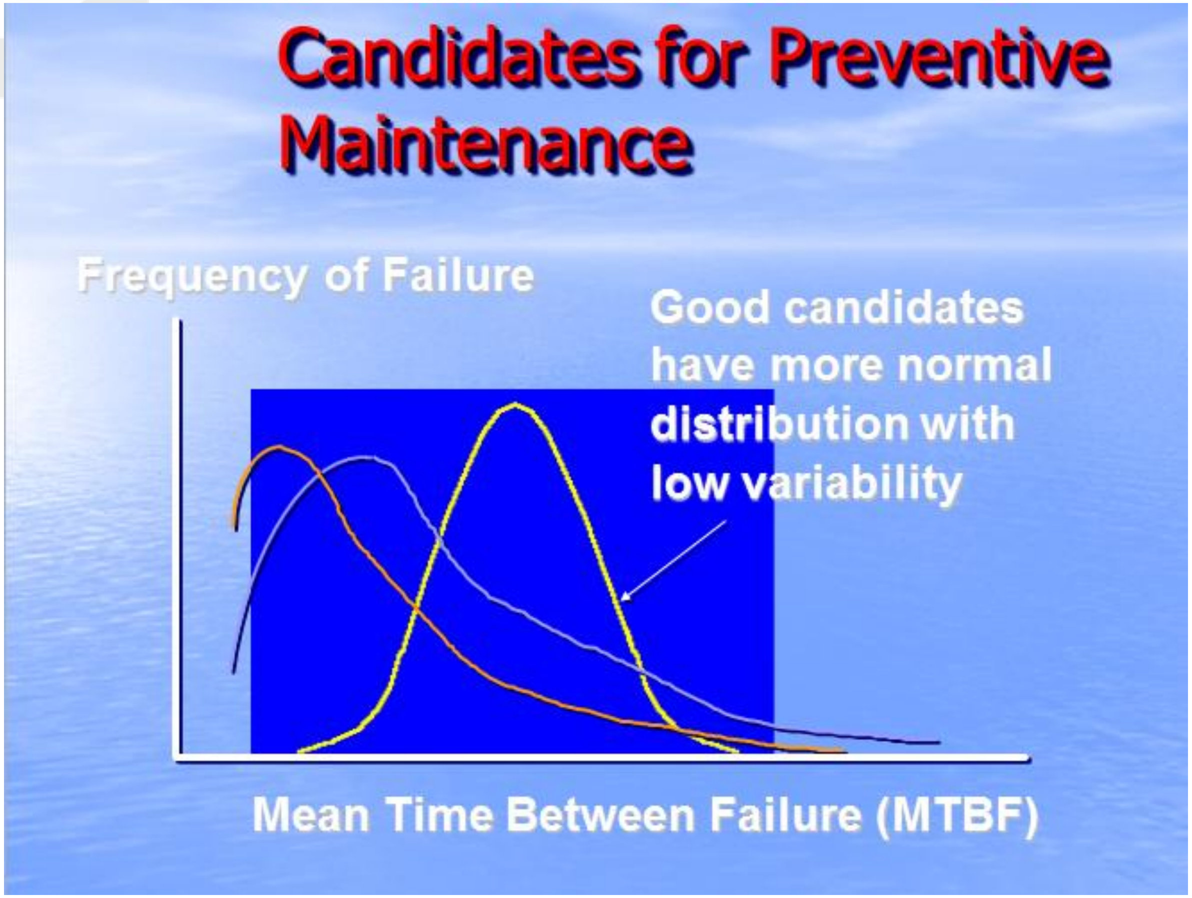
1. MAINTENANCE OF EQUIPMENT



1. MAINTENANCE OF EQUIPMENT

Advantages of Preventive Maintenance :

- Reduces break down and thereby down time
- Lass odd-time repair and reduces over time of crews
- Greater safety of workers
- Lower maintenance and repair costs
- Less stand-by equipments and spare parts
- Better product quality and fewer reworks and scraps
- Increases plant life
- Increases chances to get production incentive bonus

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1. MAINTENANCE OF EQUIPMENT

4. Predictive (Condition-based) Maintenance

In predictive maintenance, machinery conditions are periodically monitored and this enables the maintenance crews to take timely actions, such as machine adjustment, repair or overhaul

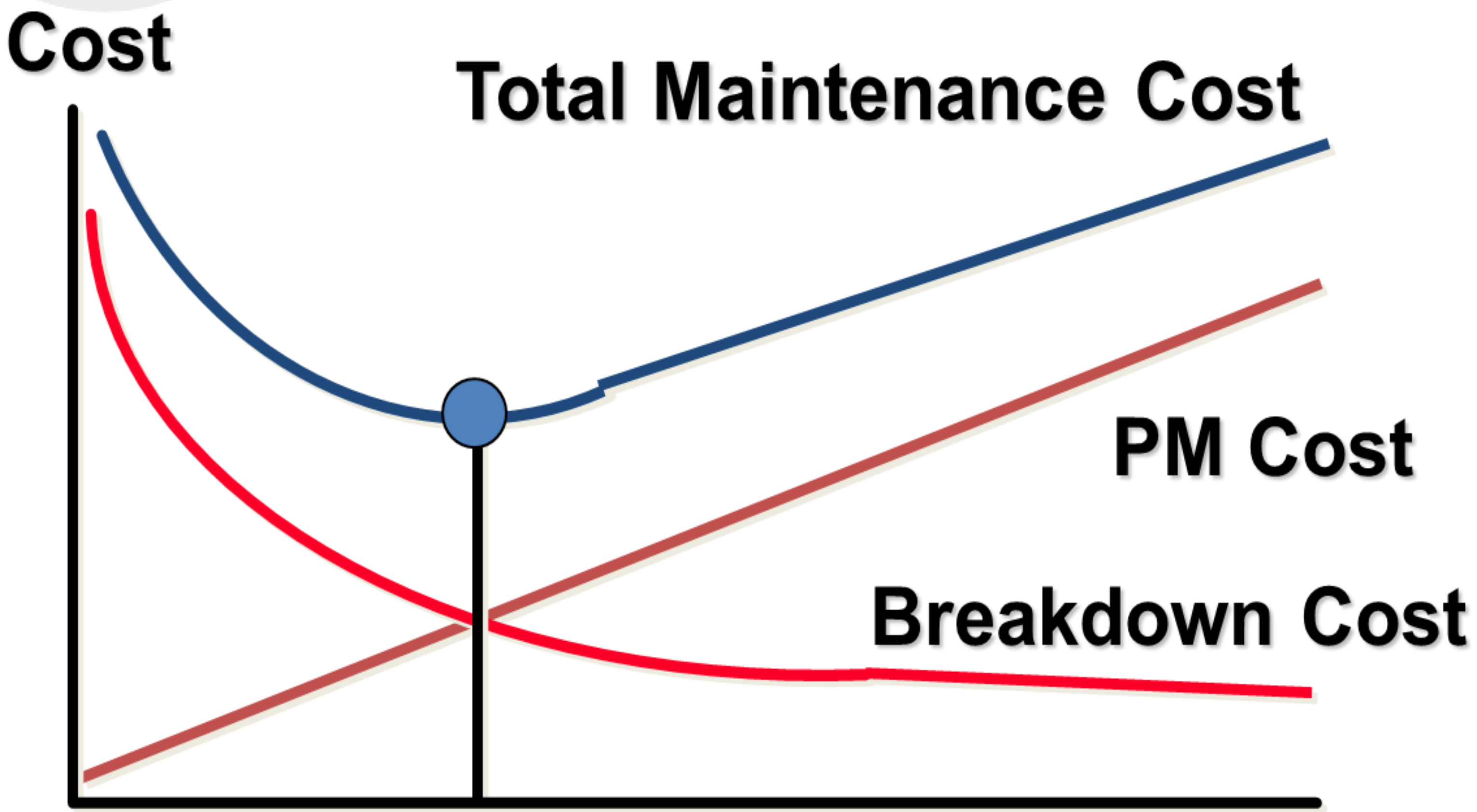
It makes use of human sense and other sensitive instruments, such as
audio gauge, vibration analyzer, amplitude meter, pressure, temperature and resistance strain gauges etc.

1. MAINTENANCE OF EQUIPMENT

- Unusual sounds coming out of a rotating equipment predicts a trouble.
- An excessively hot electric cable predicts a trouble.
- Simple hand touch can point out many unusual equipment conditions and thus predicts a trouble.

1. MAINTENANCE OF EQUIPMENT

Maintenance Costs



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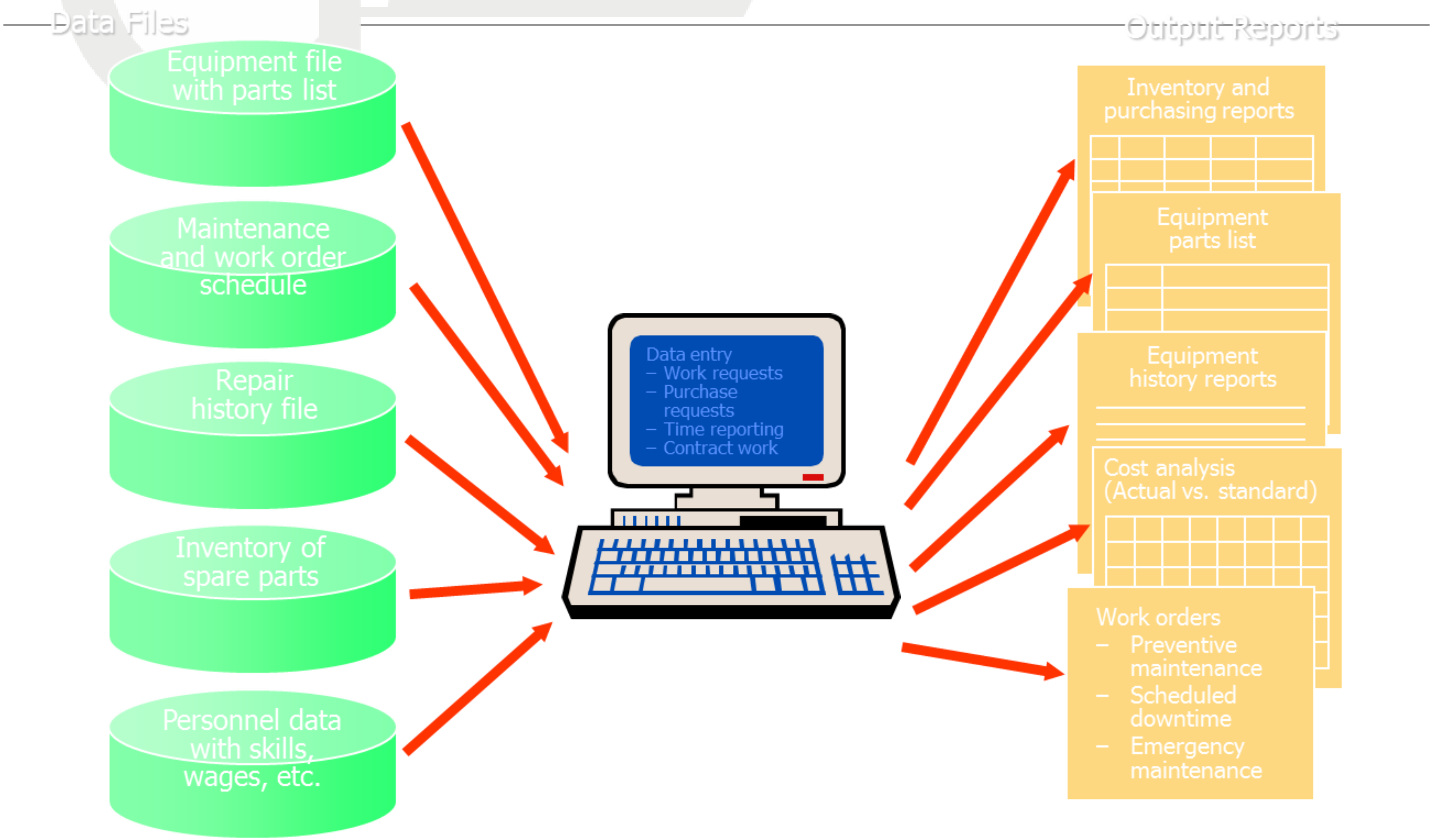
1. MAINTENANCE OF EQUIPMENT

Computerized Maintenance System



1. MAINTENANCE OF EQUIPMENT

THE EIGHT-STEP DIAGNOSTIC PROCEDURE

Step 1 Verify the Problem
Step 2 Perform a Thorough Visual Inspection and Basic Tests
Step 3 Retrieve the Diagnostic Trouble Codes (DTCs)
Step 4 Check for Technical Service Bulletins (TSBs)
Step 5 Look Carefully at Scan Tool Data
Step 6 Narrow the Problem to a System or Cylinder
Step 7 Repair the Problem and Determine the Root Cause
Step 8 Verify the Repair and Clear Any Stored DTCs

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ENGINE PERFORMANCE DIAGNOSIS WORKSHEET

(To Be Filled Out By the Vehicle Owner)

Name: ______________________ Mileage: ______________ Date: ______________

Make: ______________ Model: ______________ Year: ______________ Engine: ______________

(Please Circle All That Apply in All Categories)	
Describe Problem:	
When Did the Problem First Occur?	• Just Started • Last Week • Last Month • Other ______________
List Previous Repairs in the Last 6 Months:	
Starting Problems	• Will Not Crank • Cranks, but Will Not Start • Starts, but Takes a Long Time
Engine Quits or Stalls	• Right after Starting • When Put into Gear • During Steady Speed Driving • Right after Vehicle Comes to a Stop • While Idling • During Acceleration • When Parking
Poor Idling Conditions	• Is Too Slow at All Times • Is Too Fast • Intermittently Too Fast or Too Slow • Is Rough or Uneven • Fluctuates Up and Down
Poor Running Conditions	• Runs Rough • Lacks Power • Bucks and Jerks • Poor Fuel Economy • Hesitates or Stumbles on Acceleration • Backfires • Misfires or Cuts Out • Engine Knocks, Pings, Rattles • Surges • Dieseling or Run-On
Auto. Transmission Problems	• Improper Shifting (Early/Late) • Changes Gear Incorrectly • Vehicle Does Not Move When in Gear • Jerks or Bucks
Usually Occurs	• Morning • Afternoon • Anytime
Engine Temperature	• Cold • Warm • Hot
Driving Conditions During Occurrence	• Short—Less Than 2 Miles • 2–10 Miles • Long—More Than 10 Miles • Stop and Go • While Turning • While Braking • At Gear Engagement • With A/C Operating • With Headlights On • During Acceleration • During Deceleration • Mostly Downhill • Mostly Uphill • Mostly Level • Mostly Curvy • Rough Road
Driving Habits	• Mostly City Driving • Highway • Park Vehicle Inside • Park Vehicle Outside **Drive Per Day:** • Less Than 10 Miles • 10–50 • More Than 50
Gasoline Used	**Fuel Octane:** • 87 • 89 • 91 • More Than 91 **Brand:** ______________
Temperature When Problem Occurs	• 32–55° F • Below Freezing (32° F) • Above 55° F
Check Engine Light/ Dash Warning Light	• Light on Sometimes • Light on Always • Light Never on
Smells	• "Hot" • Gasoline • Oil Burning • Electrical
Noises	• Rattle • Knock • Squeak • Other

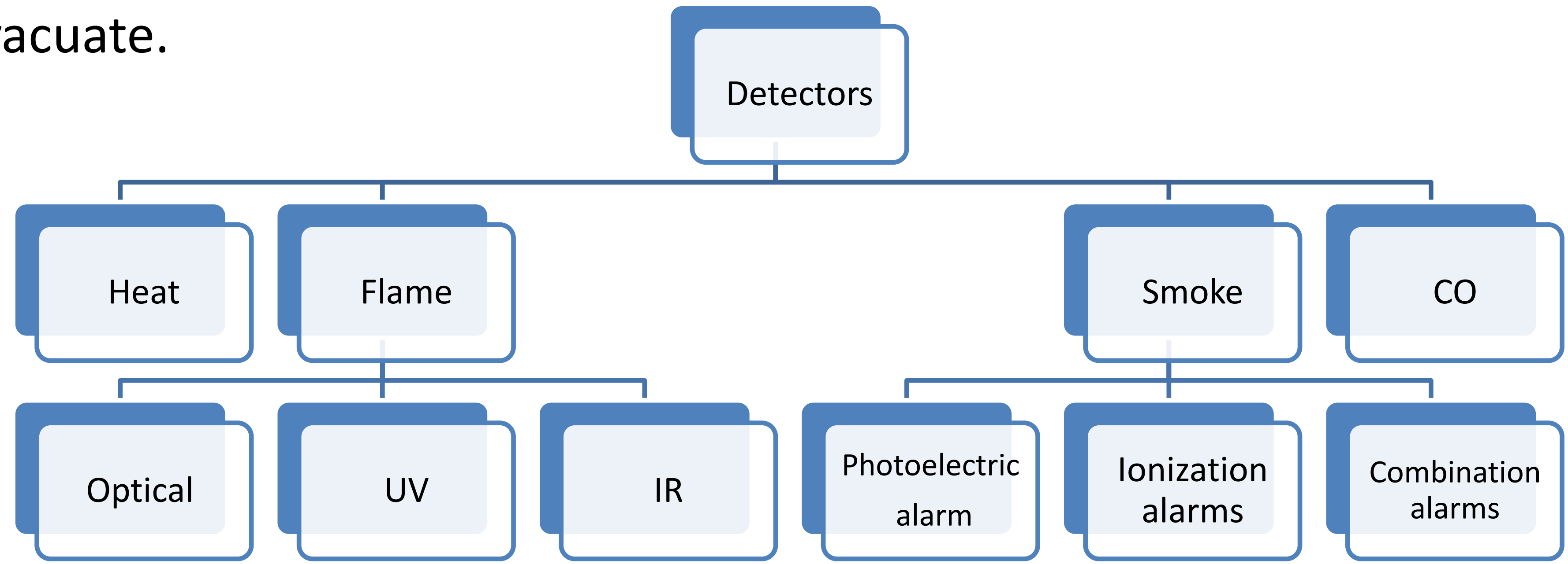
2. EQUIPMENT FOR FIRE PROTECTION

1. EQUIPMENT FOR FIRE DETECTION AND SIGNALING

2. EQUIPMENT FOR FIRE SUPPRESSION

1. EQUIPMENT FOR FIRE DETECTION AND SIGNALING

Smoke and fire detection equipment is an integral part of any building's safety. When working properly, they alert the occupants in a building of a fire before it spreads, giving them enough time to evacuate.



Type of equipment

2. EQUIPMENT FOR FIRE PROTECTION

Heat detectors

- Unlike other types of alarm systems, heat detectors are not early warning devices.
- These devices are typically found in spots with fixed temperature, including heater closets, small rooms, and kitchen facilities.
- Heat detectors is intended for use with ionization and/or photoelectric smoke detectors. The heat detector by itself does not provide life safety protection.

2. EQUIPMENT FOR FIRE PROTECTION

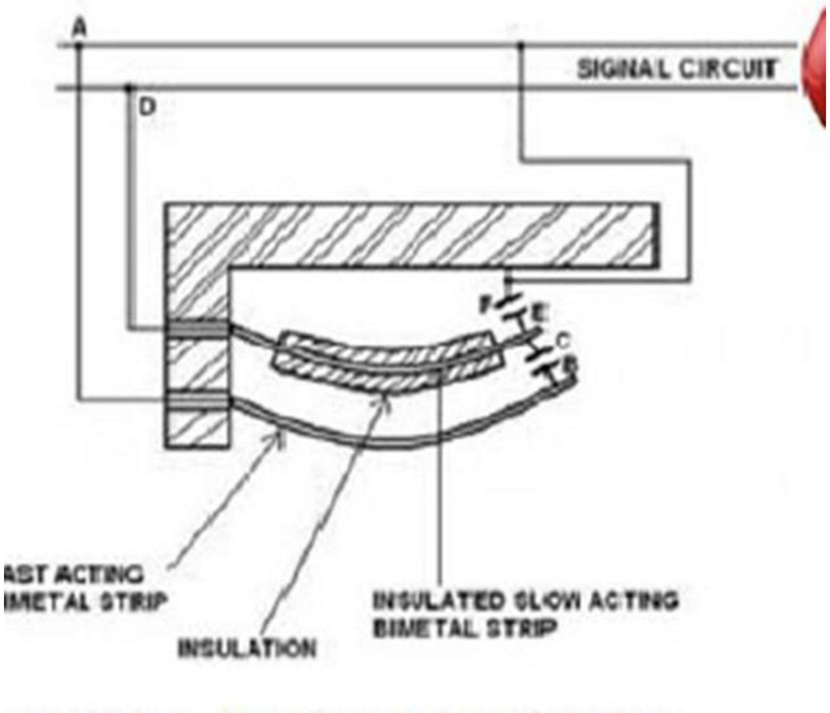
Heat detectors

Heat detectors sense a change in air temperature and initiate alarms based on a fixed-temperature point, rate of temperature rise, or amount of temperature rise above ambient condition.

Spot type heat detectors should be selected so that the rating is at least 11°C above maximum expected ceiling temperature.

Ceiling height, construction, and ventilation play significant roles in detector performance and must be considered when determining detector placement.

Heat detectors



1) Fixed-temperature type: This sensor consists of normally open contact held by bimetallic elements that will close the contacts when the ambient temperature reaches a fixed setting. The setting is generally designed for operation at 57°C, 88°C, or 94°C.

2) Rate-of-rise (ROR) type: This sensor reacts to the rate at which the temperature rises. It contains a sealed but slightly vented air chamber which expands quickly when the temperature near the device rises quickly. When the air chamber expands faster than it can be vented, electrical contacts attached to the chamber begin to close and thus initiate an alarm.

3) Combination type: This device reacts to both a fixed temperature and a rate of rise.

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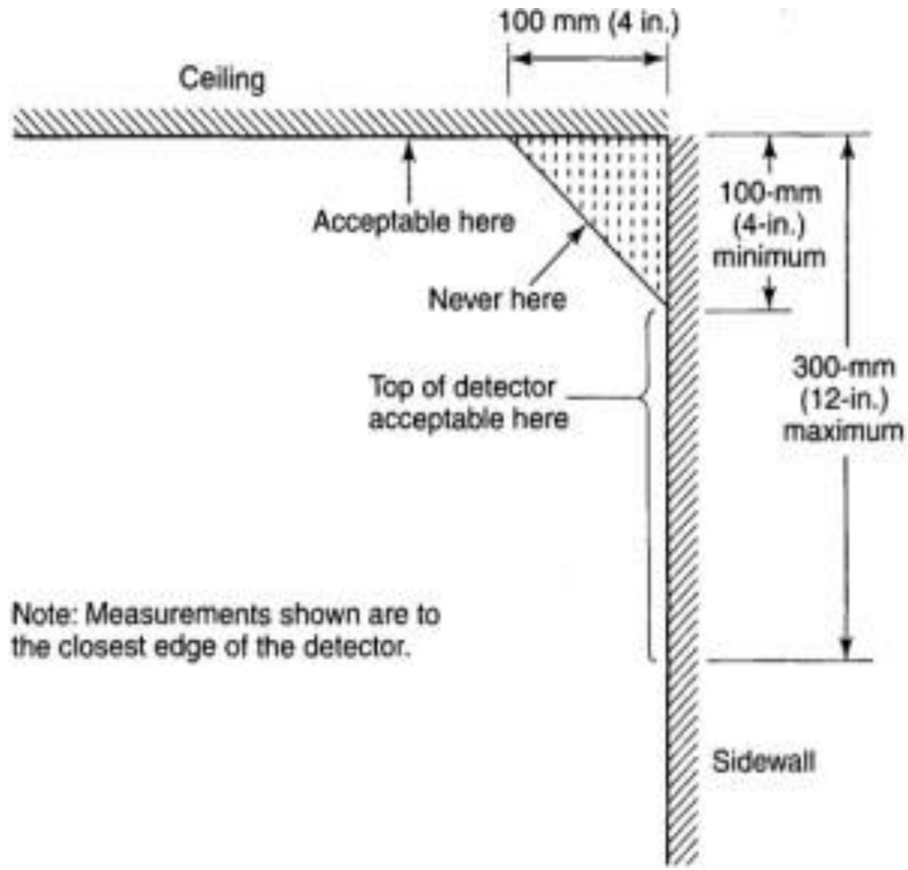
2. EQUIPMENT FOR FIRE PROTECTION

Heat detectors

Spacing of heat detectors

- Ceiling mounted heat detector shall be located not less than 4 inch from side wall.

- Sidewall mounted heat detector shall be located between 4 and 12 inches from the ceiling.



Smoke detectors

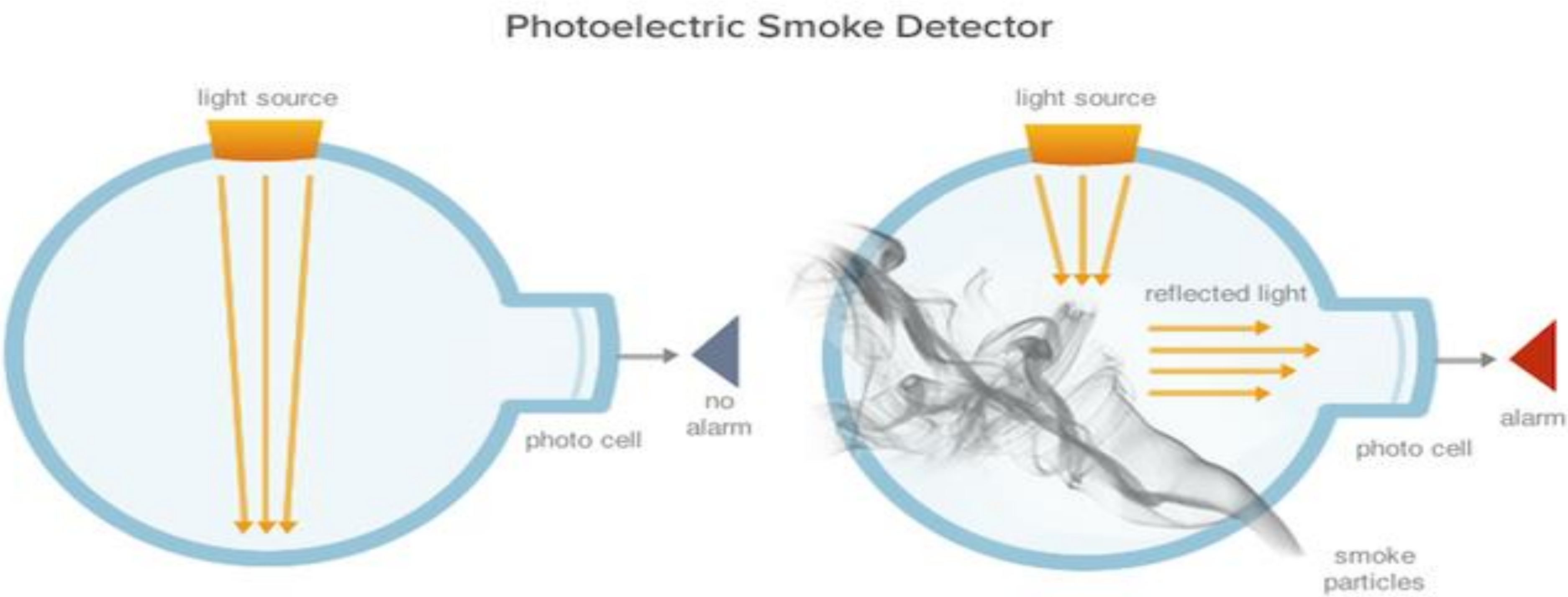
- Smoke alarms are designed to detect fires quickly.

Smoke detectors

- Photoelectric alarms
- Ionization alarms
- Combination alarms

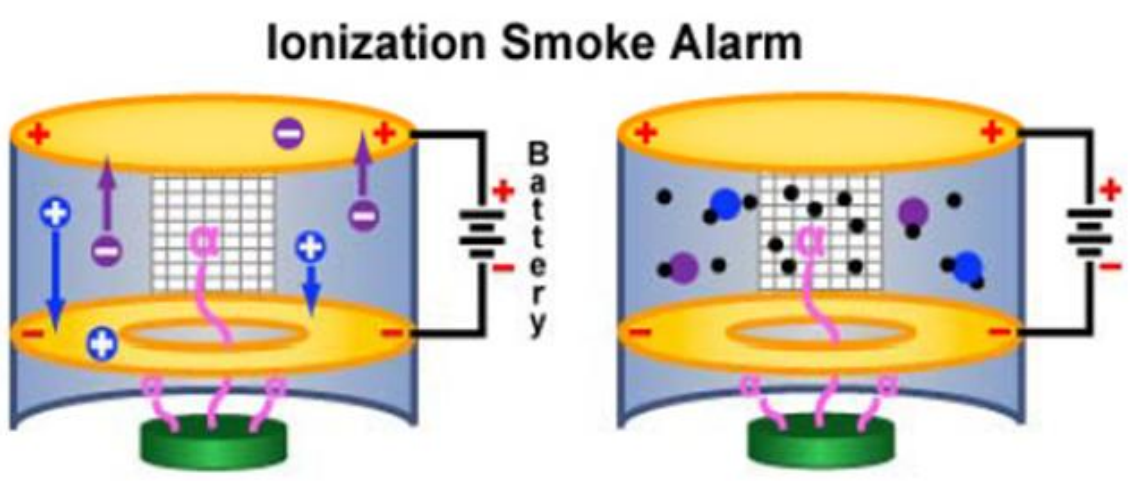
Photoelectric type

- Photoelectric detectors operate with the use of a light source and beam collimating system. When smoke begins to enter the optical chamber, it crosses the light beam path. This results in light being scattered by the particles in the smoke. The scattered light is then directed to the sensor, after which the alarm is activated and sounded.
- A photodiode or photo detector, usually placed 90 degrees to the beam, will sense the scattered infrared light and when a preset amount of light is detected, the alarm will sound. Photoelectric detectors are not as sensitive and are designed to detect cool or slow moving (smoldering) fires that



Ionization type

This type operates on the principle of changing conductivity of air within the detector chamber. The ionization detector uses a small amount of radioactive material to make the air within a sensing chamber conduct electricity. When smoke particles or combustion gases enter the sensing chamber they interfere with the conduction of electricity, reducing the current and triggering an alarm. The ionization detector can detect even invisible combustion gases produced by an open flame and will therefore respond slightly faster to an open flame fire than a photo-electric detector.



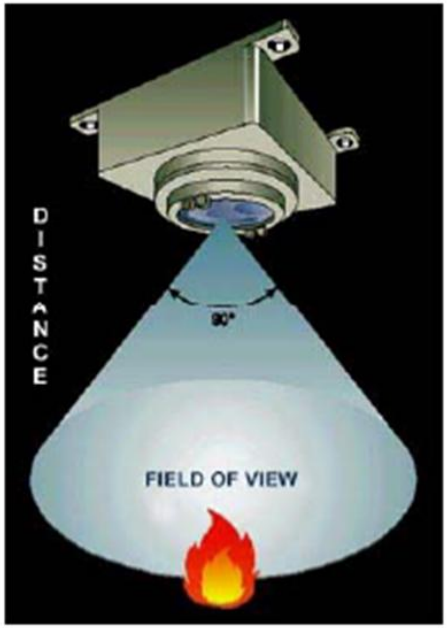
Combination type

- These have the features of both ionization and photoelectric alarm technologies.

- The photoelectric function responds to low energy smoldering fires, and the ionization function responds to rapid, high-energy fires.

Flame detectors

Flame detectors are used to detect the direct radiation of a flame in the visible, infrared, and ultraviolet ranges of the spectrum. When working properly, they detect fire nearly at the point of ignition.



They are very useful for buildings involving with hazardous processes, as well as gas and oil refineries and manufacturing industries.

Flame detectors

1. **Optical detectors:** The most commonly used, these feature optical sensors for detecting flames.

2. **UV detectors:** These work very quickly. They can detect open flames, explosions, and fires within four milliseconds, due to the UV radiation emitted at the instant of ignition. However, to prevent accidental triggers, some UV detectors are designed to integrate a three second time delay.

3. **IR detectors:** monitor the head radiation that is generated by open flames and fire. They have a response time of three to five seconds. Accidental triggers can be caused by nearby hot surfaces and background thermal radiation.

Manual Alarm Station

A fire alarm notification appliance is an active fire protection component.

A notification appliance may use audible, visible, or other stimuli to alert the occupants of a fire or other emergency condition requiring action.

Manual Alarm Station

- Alerting methods include:
- Sound (audible signals)

  ~3 kHz / ~3100 Hz tone (high frequency). Used in many current notification devices.

  520 Hz (low frequency). Used in newer notification devices.

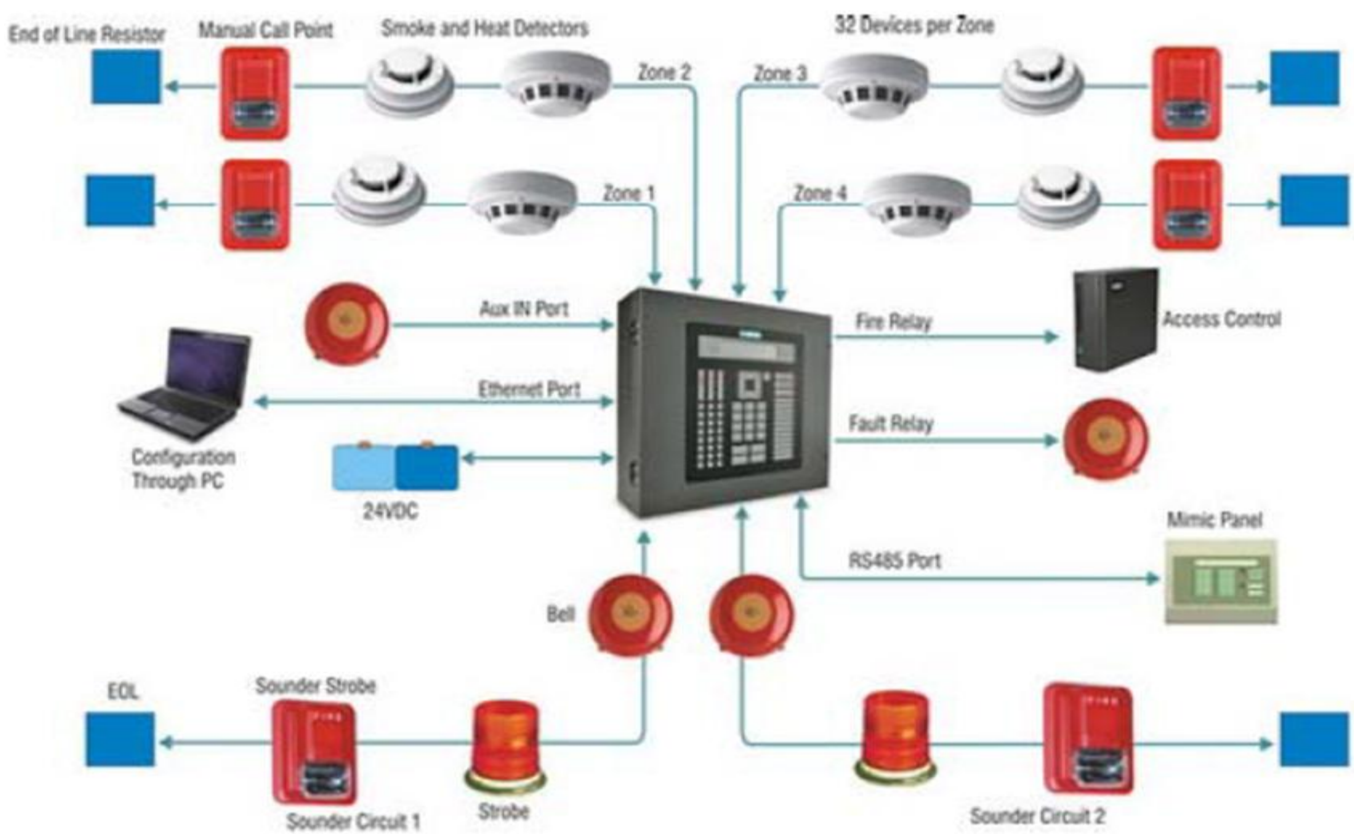
  45 dB to 120 dB A weighted for human hearing (higher decibels, in the 100 to 120 dB range, were common with older fire alarm horns)
- Light (visible signals)

  15 cd to 1000 cd candela output

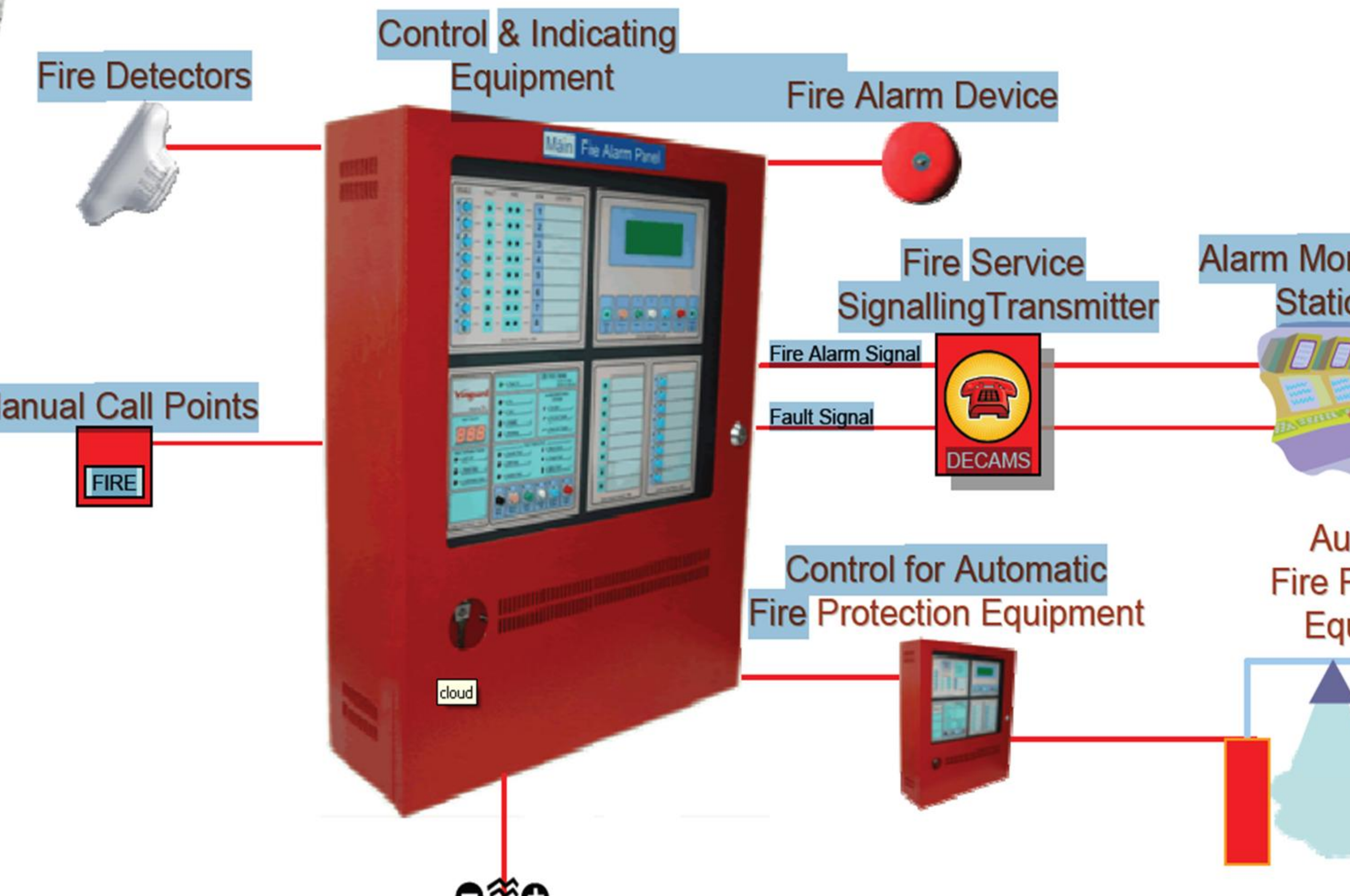
  1 to 2 flashes per second

Fire Alarm Systems

A fire alarm system has a number of devices working together to detect and warn people through visual and audio appliances when smoke, fire, carbon monoxide or other emergencies are present.

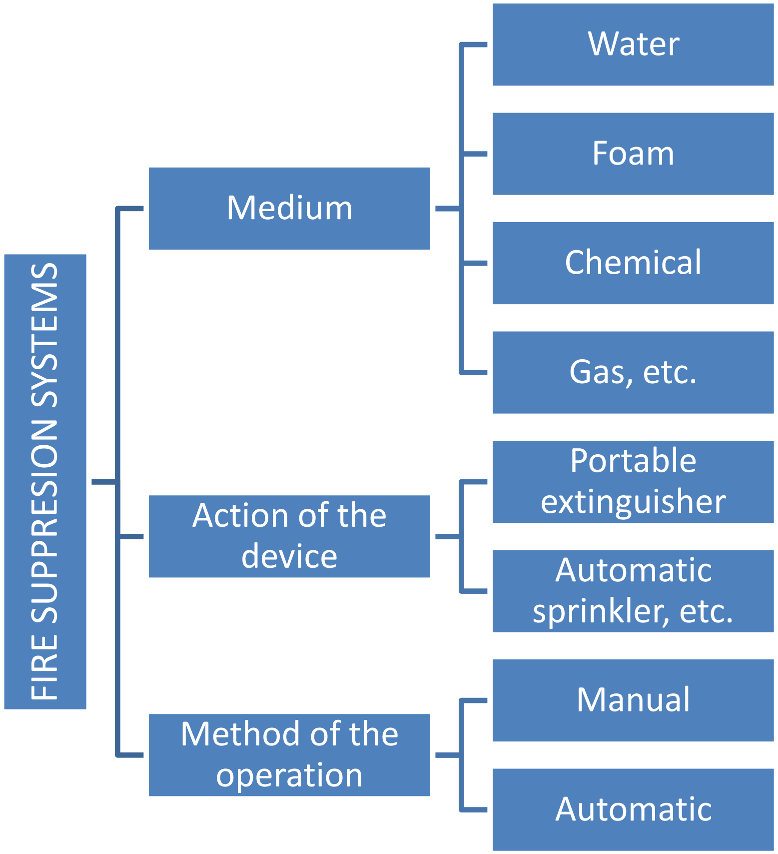


hat is a Fire Alarm System made up o



2. EQUIPMENT FOR FIRE SUPPRESSION SYSTEMS

Fire suppression systems are used to extinguish or prevent the spread of fire in a building.



Type of fire suppression systems

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STANDPIPE-AND– HOSE SYSTEMS (STANDPIPE SYSTEMS)

- Standpipe systems are a serious of pipe which connects a water supply to hose connections that are intended for fire department or trained occupant use.

- Consist of piping, valves, hose connections, and nozzles.

- Standpipe systems vary in design, use, and location.

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STANDPIPE-AND– HOSE SYSTEMS (STANDPIPE SYSTEMS)

Standpipes have three major classifications:

Class I standpipes serve a 2.5-inch fire hose connection for fire department use. These connections must match the hose thread utilized by the fire department and are typically found in stairwells of buildings.

Class II standpipes serve a 1.5-inch fire hose connection and are typically found in cabinets. These are intended for trained occupant use and are spaced according to the hose length. The hose length and connection spacing is intended for all spaces of the building.

Class III standpipes have both connections of Class I and II. Many times these connections will include a 2.5-inch reducer to a 1.5-inch connection.

STANDPIPE-AND– HOSE SYSTEMS (STANDPIPE SYSTEMS)

Class I **Class II** **Class III**

STANDPIPE-AND– HOSE SYSTEMS (STANDPIPE SYSTEMS)

NFPA 14 is the standard which the system shall be designed, installed, and maintained to.

The types of standpipe:

Automatic Standpipe systems are designed to provided the need pressure and water supply when the valve is opened.

Automatic Dry Standpipe system is only designed to have water in the system piping when the system is in use.

Manual Dry Standpipe system are exclusively for fire department use and require a fire department pumper to supply the need pressure and water supply through a fire department connection.

Semi-Automatic Standpipe System are capable of providing the need pressure and water supply, after the activation of a control device or fire pump.

Wet Standpipe systems are wet at all times.

Wet system

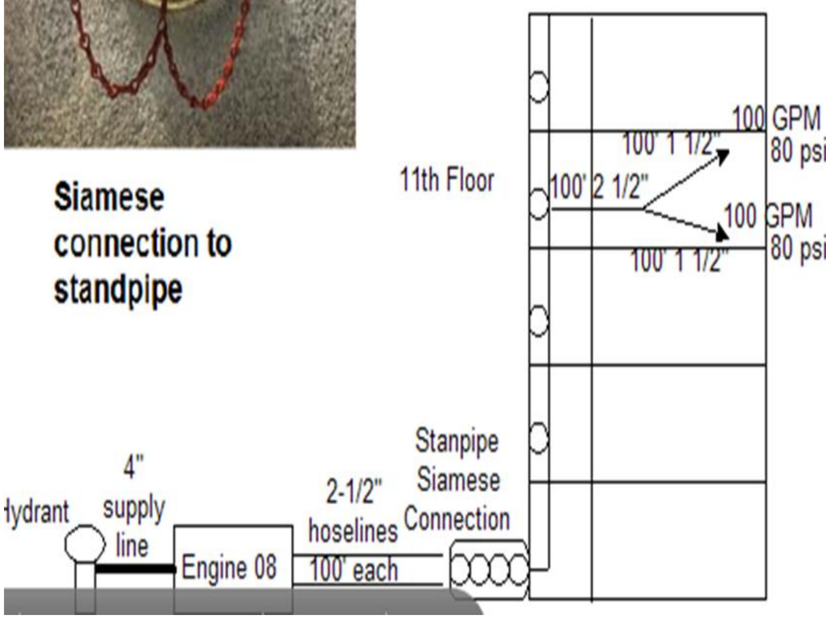
A "wet" standpipe is filled with water and is pressurized at all times.

▪ Whenever the system is activated, water will charge into the connected hose immediately.

▪ Wet standpipes can be used by building occupants.

Dry system

Siamese connection to standpipe



A "Dry" standpipe is NOT filled with water.

- The intakes of dry standpipes are usually located near a road or driveway so that a fire engine can supply water to the system.
- This system can be used only by firefighters.
- Regulations in many countries require that standpipe systems be charged by hoses from two different pump trucks, which can be accomplished by using both sides of a Siamese connection.

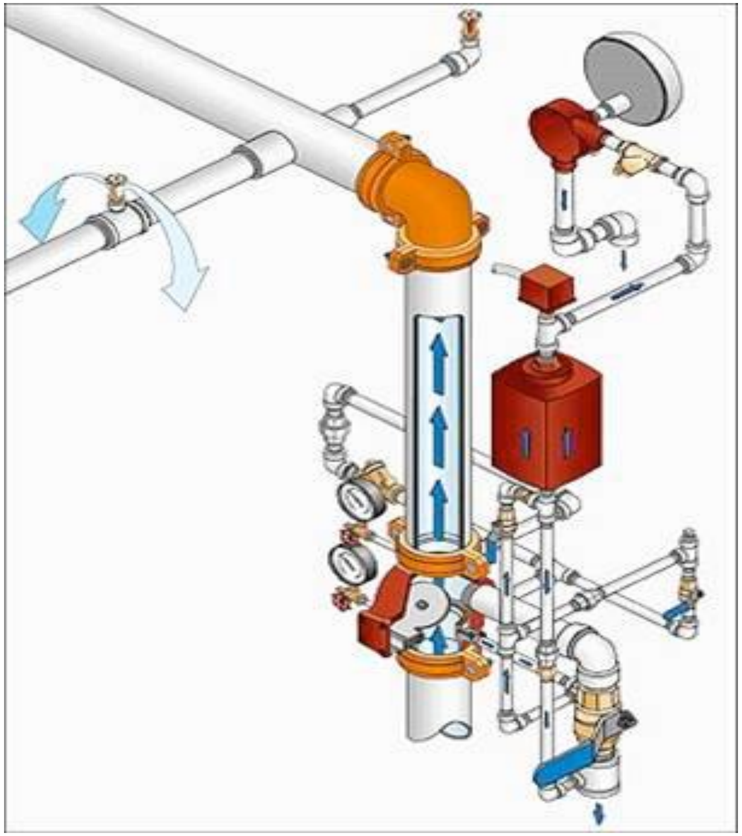
AUTOMATIC SPRINKLER SYSTEMS

- Installing a sprinkler system is a good preventative measure to take in commercial buildings in case of fire or smoke.

Sprinkler	Wet
	Dry
	Pre-action and Deluge

Wet sprinkler systems

- Wet type systems are the most common type of sprinkler system that is installed.
- A wet pipe system has water in the pipes in the ambient or normal condition and has heat responsive elements on all sprinklers.



Dry sprinkler systems

- In areas where low temperatures could cause a wet pipe system to freeze, a dry pipe system is intended for use.

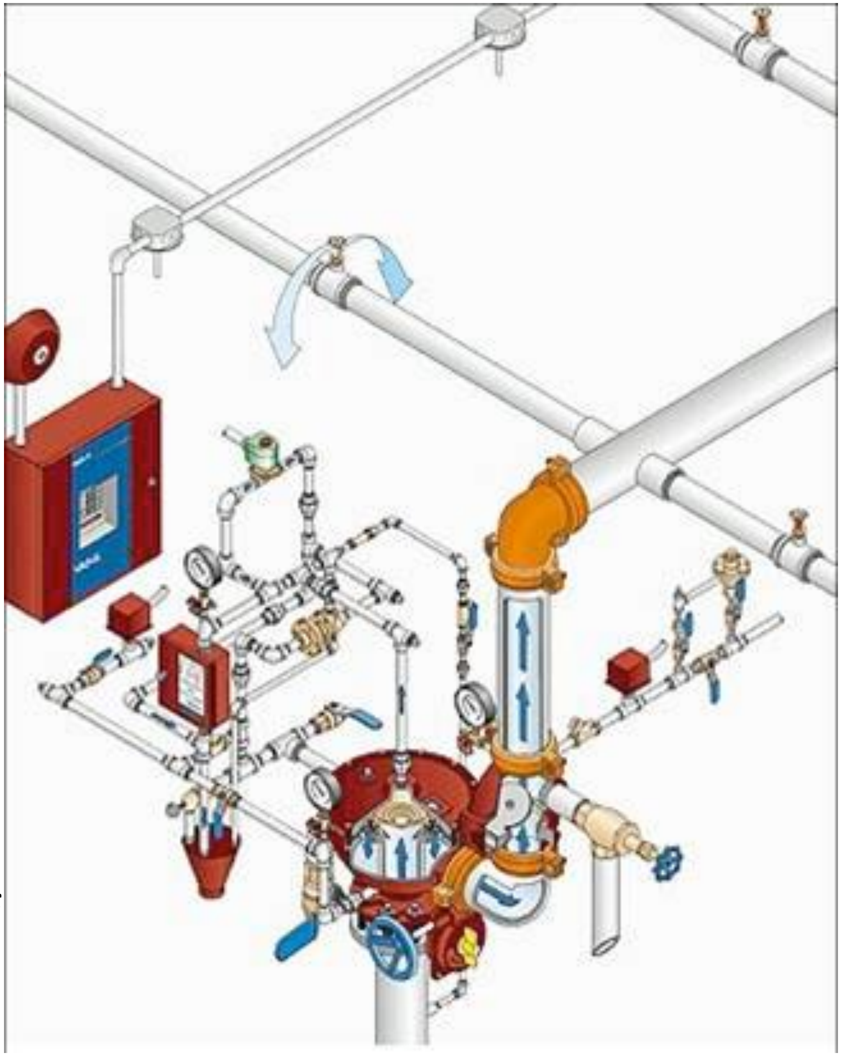
- Dry pipe systems are pressurized with air in the ambient condition and experience an inherent delay in the discharge of water to allow the pressurized air in the system to escape.
- When a sprinkler actuates, air is released through the sprinkler, allowing water to flow into the piping system through the dry pipe valve. The time for the water to reach the most remote sprinkler be no longer than 60 seconds.

- A quick opening device, such as an accelerator or an exhauster, is installed to rapidly remove air from the system and speed the operation of the dry pipe valve.

Pre-action and Deluge

- Pre-action systems and deluge systems **required fire detectors (smoke, heat, etc.) for the actuation of the system**. A deluge system uses open sprinklers or nozzles, so that all flow water is discharged when the deluge valve actuates.

- Pre-action system have closed heads and pipes filled with pressurized air that supervise a piping system, and can be considered for the protection of valuable assets or irreplaceable property. The detection system for a pre-action system can be designed to prevent water discharge in cases of a false alarm from the detection system, or in case of a sprinkler whose element has encountered mechanical damage.



Sprinkler Head Types

				
Pendant Head	**Upright Head**	**Sidewall head**	**Concealed Head**	**Dry Pendant Head**

Sprinkler Head Types

Spray sprinklers are manufactured in three basic styles.

- **Pendant sprinkler** - is mounted below the branch line, usually mounted at or below the surface of a suspended ceiling and is characterized by a flat deflector.

- **Upright sprinkler -** is mounted on upright above a branch line pipe, usually in a room with exposed structural elements, and has a deflector, a metal plate whose edge is distinctively bent to deflect water downward from the sprinkler.

- **Sidewall sprinklers** - have a specifically designed deflector that allows the sprinkler to discharge water from a wall-mounted position.

Variations on upright, pendant, and sidewall sprinkler are the dry upright, dry pendant, and dry sidewall sprinklers. These special sprinklers are manufactured with a seal at the inlet that prevents water from entering the nipple until the sprinkler actuates.

3. TECHNICAL DIAGNOSTIC

- *Technical diagnostics presents all the activities that are performed over a particular technical system for the purpose of* ***assessing the current state*** *or* ***giving a prognosis of the behavior of the system over a certain period of time****.*
- There are fields where the systems are not allowed to fail.
- Application of these systems is aviation, military industry, fire protection and more.
- These systems must have a great readiness and reliability.
- The technical diagnosis is the study of readiness and reliability.

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3. TECHNICAL DIAGNOSTIC

Various National Fire Protection Association (NFPA) fire codes provide good references and guidelines in this area.

- Government-legislated fire codes normally reference NFPA compliance as minimum requirements.
- Insurance companies also reference NFPA for minimum inspection, testing and maintenance requirements.

Some insurance companies recommend inspections and/or testing stricter than that required by NFPA codes.

NFPA 25 Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

Table 5.1.1.2 Summary of Sprinkler System Inspection, Testing, and Maintenance

Item	Frequency	Reference
Inspection		
Gauges (dry, preaction, and deluge systems)	Weekly/quarterly	5.2.4.2, 5.2.4.3, 5.2.4.4
Control valves		Table 13.1.1.2
Waterflow alarm devices	Quarterly	5.2.5
Valve supervisory signal devices	Quarterly	5.2.5
Supervisory signal devices (except valve supervisory switches)	Quarterly	5.2.5
Gauges (wet pipe systems)	Quarterly	5.2.4.1
Hydraulic nameplate	Quarterly	5.2.6
Buildings	Annually (prior to freezing weather)	4.1.1.1
Hanger/seismic bracing	Annually	5.2.3
Pipe and fittings	Annually	5.2.2
Sprinklers	Annually	5.2.1
Spare sprinklers	Annually	5.2.1.4
Information sign	Annually	5.2.8
Fire department connections		Table 13.1.1.2
Valves (all types)		Table 13.1.1.2
Obstruction, internal inspection of piping	5 years	14.2
Heat trace	Per manufacturer's requirements	5.2.7

Test		
Waterflow alarm devices		
Mechanical devices	Quarterly	5.3.3.1
Vane and pressure switch–type devices	Semiannually	5.3.3.2
Valve supervisory signal devices		Table 13.1.1.2
Supervisory signal devices (except valve supervisory switches)		Table 13.1.1.2
Main drain		Table 13.1.1.2
Antifreeze solution	Annually	5.3.4
Gauges	5 years	5.3.2
Sprinklers (extra-high or greater temperature solder type)	5 years	5.3.1.1.1.4
Sprinklers (fast-response)	At 20 years and every 10 years thereafter	5.3.1.1.1.3
Sprinklers	At 50 years and every 10 years thereafter	5.3.1.1.1
Sprinklers	At 75 years and every 5 years thereafter	5.3.1.1.1.5
Sprinklers (dry)	At 10 years and every 10 years thereafter	5.3.1.1.1.6
Sprinklers (in harsh environments)	5 years	5.3.1.1.2
Valves (all types)		Table 13.1.1.2
Valve status test		13.3.1.2.1

Maintenance

Valves (all types)		Table 13.1.1.2
Low-point drains (dry pipe system)		13.4.4.3.2
Sprinklers and automatic spray nozzles protecting commercial cooking equipment and ventilation systems	Annually	5.4.1.9

Daily Checks	• Check to ensure system is operating normally • Rectify and record any faults found
Weekly Tests	• Checks to ensure signal to monitoring station are functioning • Check battery and voltage conditions • Rectify and record any faults
Monthly Tests	• Simulate fire and foult conditions on all zones • Check that power supply, indicator, alarm outputs etc are operating correctly • Rectify and record any faults
Yearly Tests	• All monthly tests • Test 20% of all detectors over as many zones as possible such that all detectors will be check over a 5 year period • Test inerlocking circuits to ancillary equipment • Check and cleaning of dirty detectors

✔	EQUIPMENT TYPE	ACTION REQUIRED
	Portable fire extinguishers	*inspect monthly*
	Fire alarms and voice communication systems for life safety	*inspect and test annually (portions of systems require weekly/monthly testing)*
	Emergency power systems – emergency electrical power systems for critical equipment	*monthly testing*
	Special fire suppression systems – low-medium-high expansion foam, carbon dioxide, halon, clean agent, dry/wet chemical, deluge, etc.	*annual and/or semi-annual testing required*
	Smoke/heat detectors and carbon dioxide detectors	*inspect/test annually*
	Manual fire alarm pull stations	*test annually*
	Fire doors	*visual weekly inspection and annual testing*
	Water suction tanks and reservoirs	*visual weekly inspections and monthly/annual maintenance*

Probability

- An analysis of the contribution of a particular fire protection system to the achievement of specified objectives should include an assessment of the effectiveness and reliability of the proposed fire protection systems.

- “Reliability” is defined as the probability that a product or system will operate under designated operating conditions for a designated period of time or number of cycles.

- "Effectiveness” refers to the ability of a system to achieve desired objectives.

Probability

- Reliability data may be derived from fire incident statistics considering the entire fire protection system to be a single entity. Alternatively, the reliability of a system may be determined from an engineering analysis based on failure and repair rates of the components of the system, accounting for any redundancy in system components.

- The effectiveness of sprinkler systems in U.S. fire incidents is summarized in Figure 1. As indicated in the figure, when sprinklers operate in fire incidents, only one sprinkler operates in almost 70% of all fires and that one sprinkler is effective in 98% of the incidents. An interesting trend indicated in the figure is that the effectiveness of sprinklers declines with an increasing number of operating sprinklers.

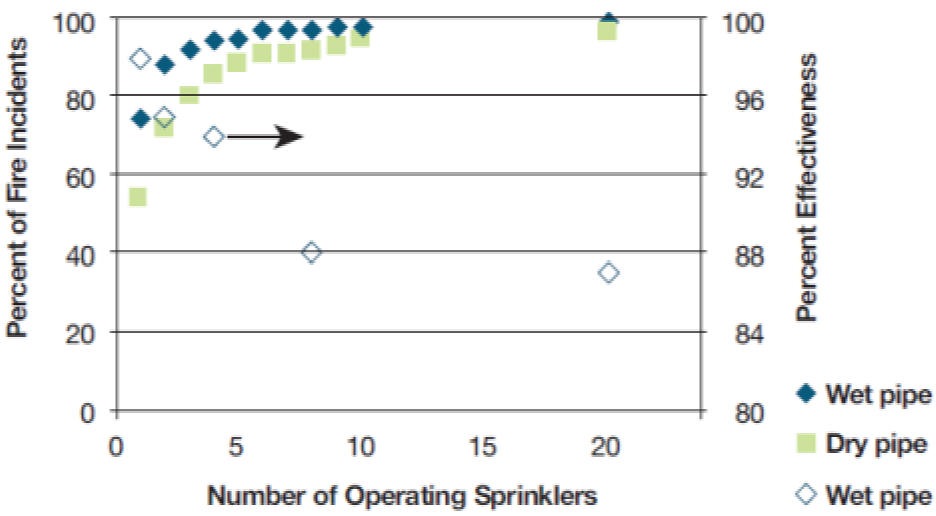


Figure 1: Effectiveness of Sprinklers in U.S. Fire Incidents

Probability

Table 1. Fire Death rates with and without sprinklers

Occupancy	Fire death rate* without auto extinguishing system	Fire death rate* with wet pipe sprinkler	Percent reduction
All public assembly	0.4	0.0	100%
Residential	7.4	1.2	84%
Store/Office	1.2	0.2	81%
Manufacturing	1.8	0.3	84%
Warehouse	1.2	2.0	-67%
Total	6.2	0.9	85%

The reasons for sprinklers to be ineffective are indicated in Table 2. As indicated in the table, the dominant cause for ineffectiveness is the system being turned off.

Table 2. Reasons for sprinkler ineffectiveness

Reason for failure	All	wet pipe	Dry pipe
System shut off	65%	61%	74%
Manual intervention defeated system	16%	19%	8%
Lack of maintenance	7%	8%	4%
System component damaged	7%	6%	10%
Inappropriate system for type of fire	5%	6%	3%
Total fires per year	738	564	130

Probability

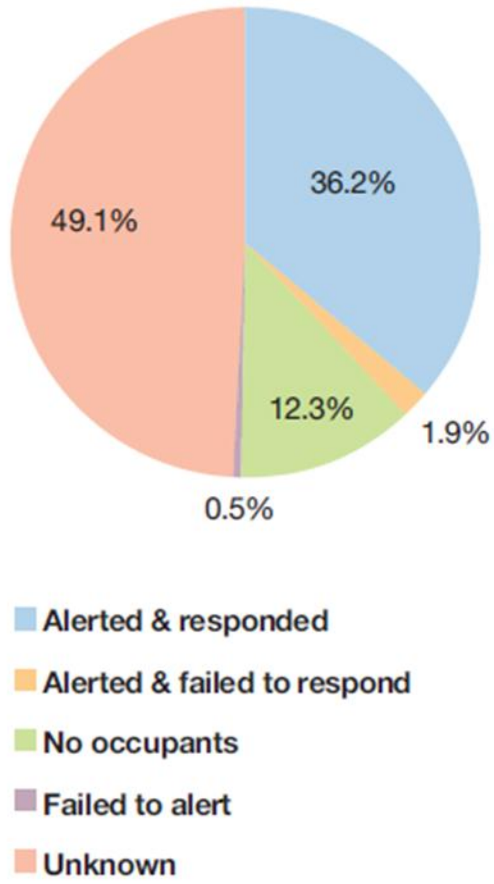
Fire Alarm Systems

The effectiveness of sprinklers and smoke detectors was assessed via an analysis of approximately 200,000 U.S. fire incidents that occurred from 2003 to 2007 in residential, commercial residential, and health-care facilities.

The casualty rate (including both fatal and non-fatal casualties) was substantially less in residences with operating sprinklers (2.06 casualties per 100 fire incidents) than operating smoke detectors (3.17 casualties per 100 fire incidents).

Probability

The response of individuals to the operation of smoke detectors in U.S. fire incidents in commercial occupancies is indicated in Figure. This study included 30,900 fire incidents that occurred from 2003-2010. As indicated in Figure, occupants responded in only 36% of the fire incidents where an audible alarm was produced as a result of an operating smoke detector.



Probability

- Based on data from U.S fire incidents that occurred from 1989-1994 the reliability of fire-resistant-rated construction in commercial occupancies was estimated to be 70% (as compared to reliabilities of 95% for sprinklers and 75% for smoke detectors).

4. DEVELOPMENT MODEL AND SOFTWARE FOR EARLY FAILURE DETECTION AND ITS APPLICATION ON AUTOMATIC SYSTEMS FOR EARLY DETECTION OF FIRES AND ALARMING

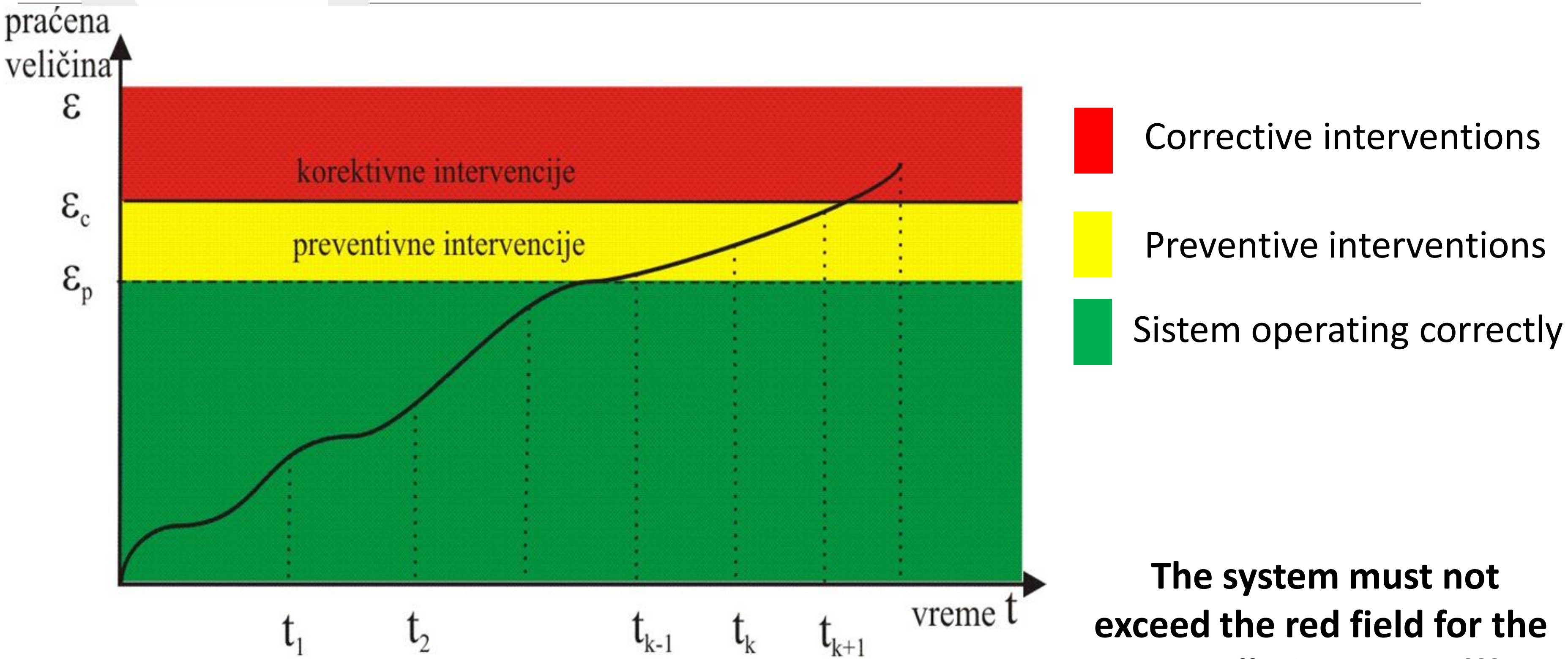
HIGHER EDUCATION TECHNICAL SCHOOL OF PROFESSIONAL STUDIES
Novi Sad

Co-funded by the Erasmus+ Programme of the European Union

Model of technical diagnostics

- Models of technical diagnostics can point to **the possibility of failure**.
- Complex models are complicated to use.
- Simple models do not give reliable results.

SETTING MODEL



The system must not exceed the red field for the cancellation occurs!!!

- ε_p border on which are performed prevention interventions
- ε_c limit where the running corrective intervention
- t – time moments in which to perform diagnostics

Probability

"Reliability" is defined as the probability that a product or system will operate under designated operating conditions for a designated period of time or number of cycles.

$$P_i = \int_0^{\varepsilon_c} \varphi(\varepsilon) d\varepsilon \quad P_c = \int_{\varepsilon_c}^{\infty} \varphi(\varepsilon) d\varepsilon \quad P_p = \int_{\varepsilon_p}^{\varepsilon_c} \varphi(\varepsilon) d\varepsilon \quad P_o = \int_{\varepsilon_c}^{\infty} \varphi(\varepsilon) d\varepsilon \quad P_i = 1 - \int f(t) dt$$

Where is:

φ(ε) file system state change ,

***f(t)* density function of occurrence of system failure**

Total cost equation

$$C_u = \sum_{k=0}^{\infty}\left(\left(C_i(k+1)(1-\int_{t_k}^{t_{k+1}} f(t)dt)\right)+C_c\int_{t_k}^{t_{k+1}} f(t)dt + C_o(t_{k+1}-t)\int_{t_k}^{t_{k+1}} f(t)dt + C_p\int_{t_k}^{t_{k+1}}\int_{\varepsilon_p}^{\varepsilon_c}\varphi(\varepsilon,t)d\varepsilon dt\right)$$

$$\frac{\partial C_u}{\partial t_k} = \left(C_i\cdot k\cdot f(t_k)+C_c\cdot f(t_k)+C_o\left(\int_{t_{k-1}}^{t_k} f(t)dt - t_k\cdot f(t_k)-t_k\cdot f(t_k)\right)+C_p\int_{\varepsilon_p}^{\varepsilon_c}\varphi(\varepsilon,t)d\varepsilon\right)+$$

$$+\left(C_i(k+1)f(t_k)-C_c\cdot f(t_k)+C_o\left(-t_{k+1}\cdot f(t_k)+t_k\cdot f(t_k)\right)-C_p\int_{\varepsilon_p}^{\varepsilon_c}\varphi(\varepsilon,t)d\varepsilon\right).$$

Computational methods

- Electronic components used in fire protection have Weibul's law distribution, with density function of failure state:

$$f(t) = \frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^{\beta}}$$

- The general model developed by the assessment of the optimal moment is obtained

$$t_{k+1} - t_k = \frac{\frac{\beta}{\eta}\int_0^{t_k}\left(\frac{t}{\eta}\right)^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^{\beta}} - \frac{\beta}{\eta}\int_0^{t_{k-1}}\left(\frac{t}{\eta}\right)^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^{\beta}}}{\frac{\beta}{\eta}\left(\frac{t_k}{\eta}\right)^{\beta-1} e^{-\left(\frac{t_k}{\eta}\right)^{\beta}}} + \frac{C_i}{C_o}$$

Practical application of model

Table 1: The moment of breakdown, reliability, the function of breakdown density and intensity of breakdown [hour]

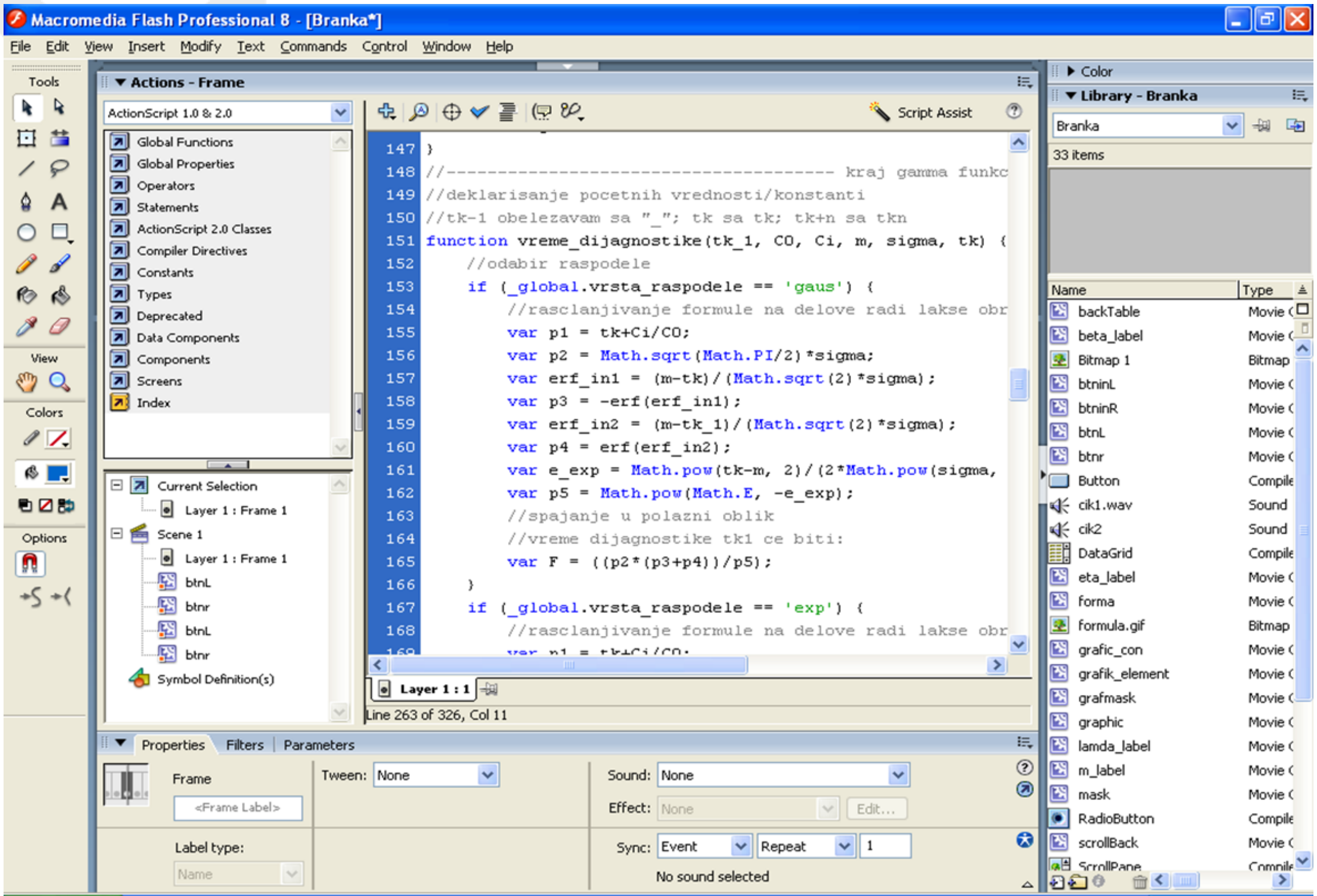
i	t_o	R(t)	F(t)	$f(t)\cdot 10^{-4}$	$\lambda(t)\cdot 10^{-5}$
1.	365	0,918	0,082	2,161	23,537
2.	1095	0,773	0,227	1,819	23,537
3.	1825	0,651	0,349	1,532	23,537
4.	2555	0,548	0,452	1,290	23,537
5.	3285	0,462	0,538	1,087	23,537
6.	4015	0,389	0,611	0,916	23,537
7.	4745	0,327	0,673	0,770	23,537
8.	5475	0,276	0,724	0,650	23,537
9.	6205	0,232	0,768	0,546	23,537
10.	6935	0,195	0,805	0,459	23,537
11.	7665	0,165	0,835	0,388	23,537
12.	8395	0,139	0,861	0,327	23,537

Practical application of model

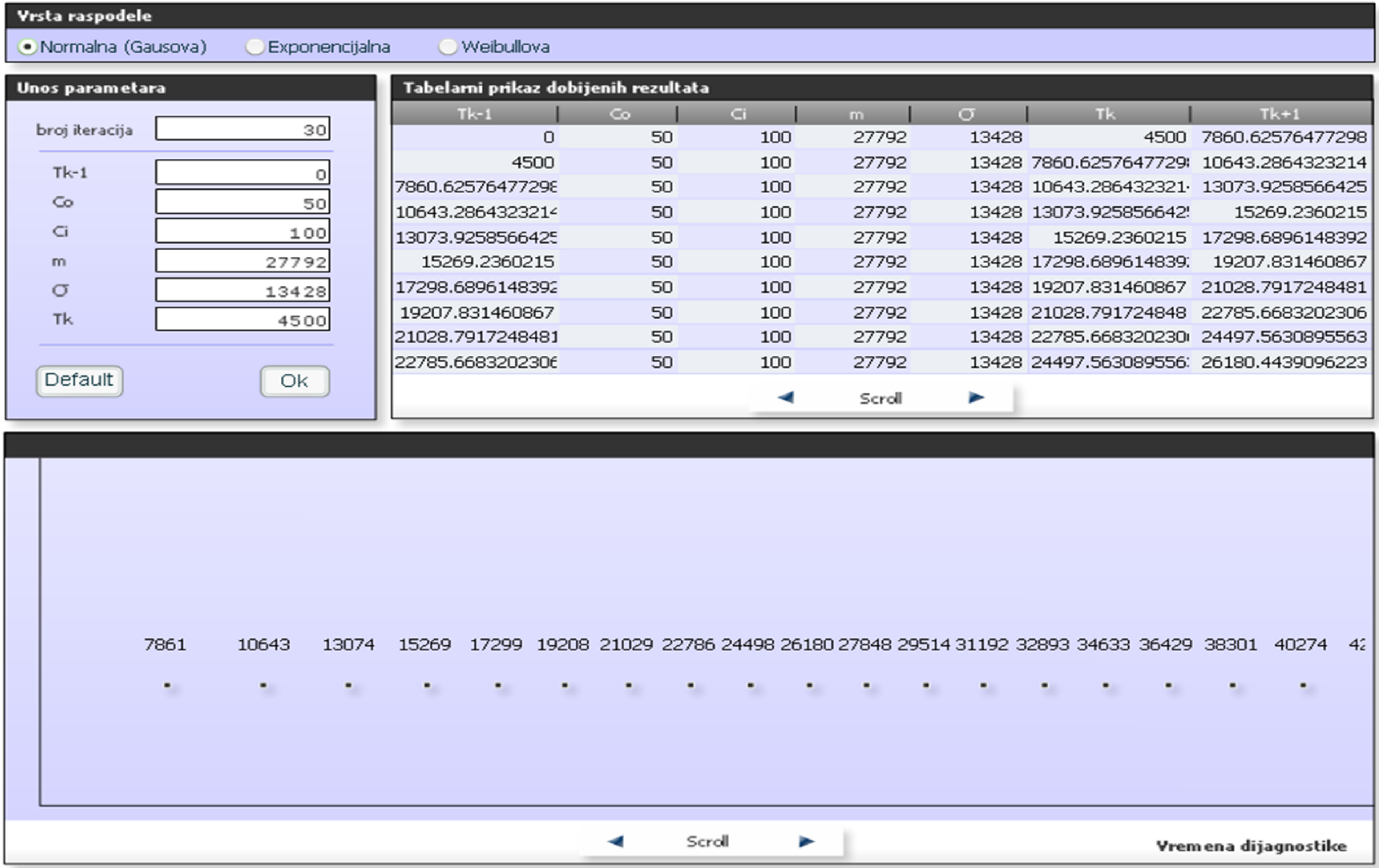
Table 2:The calculated optimal moments for carrying out diagnoses of automatic systems for early fire detection and alarming

Moment of execution	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}
Time of execution	350	1071	1819	2517	3244	4012	4717	5471	6150	6801	7450	8201

Software Development



The software was developed with **Macromedia Flash Professional 8**.



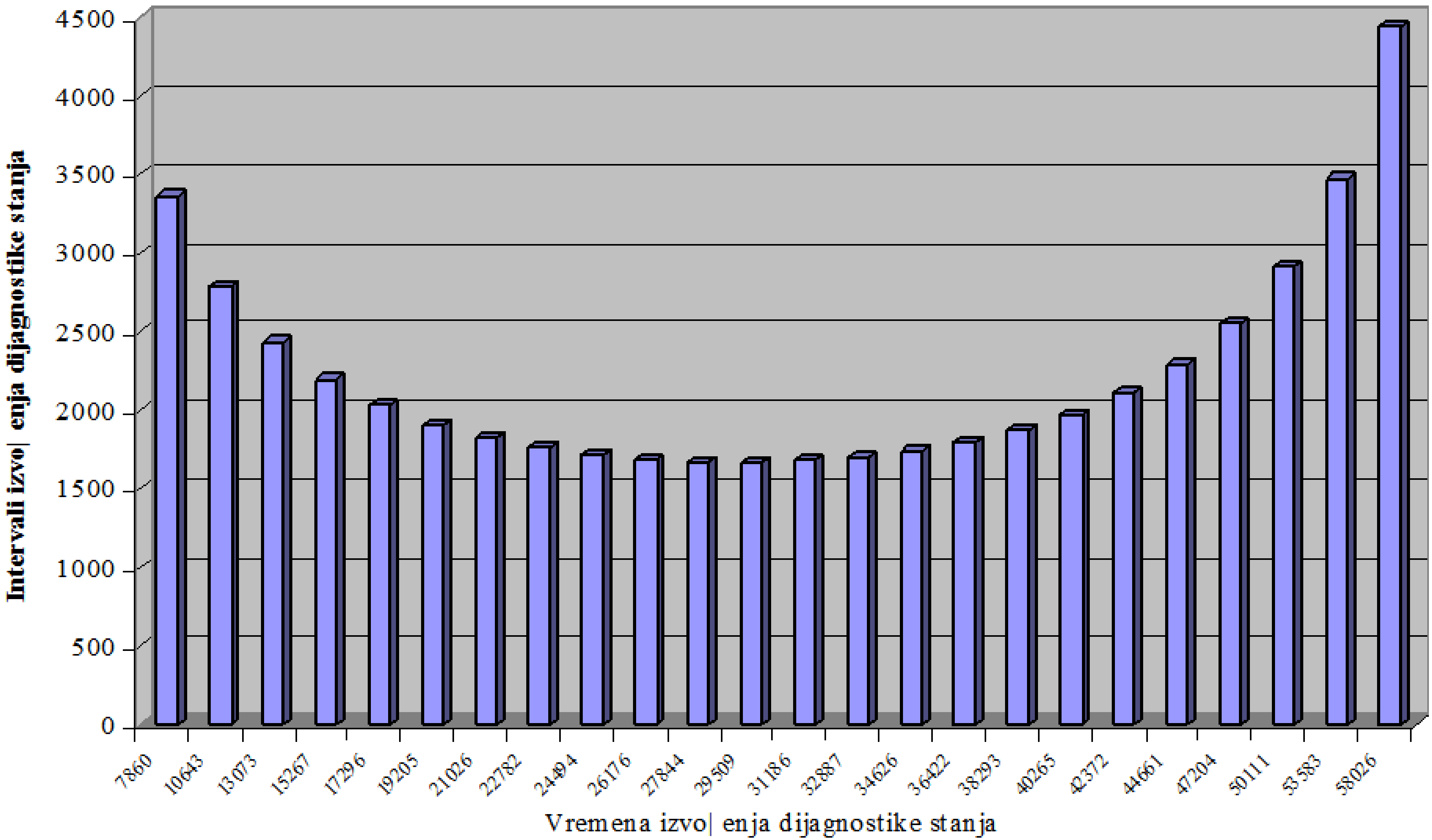
Tk-1	Co	Ci	m	σ	Tk	Tk+1
0	50	100	27792	13428	4500	7860.62576477298
4500	50	100	27792	13428	7860.6257647729	10643.2864323214
7860.6257647729	50	100	27792	13428	10643.286432321	13073.9258566425
10643.286432321	50	100	27792	13428	13073.925856642	15269.2360215
13073.925856642	50	100	27792	13428	15269.2360215	17298.6896148392
15269.2360215	50	100	27792	13428	17298.689614839	19207.831460867
17298.689614839	50	100	27792	13428	19207.831460867	21028.7917248481
19207.831460867	50	100	27792	13428	21028.791724848	22785.6683202306
21028.7917248481	50	100	27792	13428	22785.668320230	24497.5630895563
22785.668320230	50	100	27792	13428	24497.563089556	26180.4439096223

Program in execution

The following table were calculated: Optimum moments of diagnosis Tk
Possible moments of failure Tk+1

Tabelarni prikaz dobijenih rezultata

Tk-1	Co	Ci	m	σ	Tk	Tk+1
0	50	100	27792	13428	4500	7860.62576477298
4500	50	100	27792	13428	7860.6257647729	10643.2864323214
7860.6257647729	50	100	27792	13428	10643.286432321	13073.9258566425
10643.286432321	50	100	27792	13428	13073.925856642	15269.2360215
13073.925856642	50	100	27792	13428	15269.2360215	17298.6896148392
15269.2360215	50	100	27792	13428	17298.689614839	19207.831460867
17298.689614839	50	100	27792	13428	19207.831460867	21028.7917248481
19207.831460867	50	100	27792	13428	21028.791724848	22785.6683202306
21028.7917248481	50	100	27792	13428	22785.668320230	24497.5630895563
22785.668320230	50	100	27792	13428	24497.563089556	26180.4439096223
24497.563089556	50	100	27792	13428	26180.443909622	27848.3860778787
26180.443909622	50	100	27792	13428	27848.386077878	29514.4824196633
27848.386077878	50	100	27792	13428	29514.482419663	31191.5918522043
29514.482419663	50	100	27792	13428	31191.591852204	32893.0437978325
31191.591852204	50	100	27792	13428	32893.043797832	34633.4009352883
32893.043797832	50	100	27792	13428	34633.400935288	36429.3972117498
34633.400935288	50	100	27792	13428	36429.397211749	38301.2180494055
36429.397211749	50	100	27792	13428	38301.218049405	40274.3992869785
38301.218049405	50	100	27792	13428	40274.399286978	42382.8535201528
40274.399286978	50	100	27792	13428	42382.853520152	44674.0428253257
42382.853520152	50	100	27792	13428	44674.042825325	47218.5280875683
44674.042825325	50	100	27792	13428	47218.528087568	50129.3398885309
47218.528087568	50	100	27792	13428	50129.339888530	53606.4413466582
50129.339888530	50	100	27792	13428	53606.441346658	58058.3077095646
53606.441346658	50	100	27792	13428	58058.307709564	64538.669888719
58058.307709564	50	100	27792	13428	64538.669888719	77342.5065499108
64538.669888719	50	100	27792	13428	77342.506549910	168527.524762024
77342.506549910	50	100	27792	13428	168527.52476202	2.68811213752293e
168527.52476202	50	100	27792	13428	2.6881121375229	NaN
2.6881121375229	50	100	27792	13428	NaN	NaN


4500
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3500
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Intervali izvo| enja dijagnostike stanja
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13073
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17296
19205
21026
22782
24494
26176
27844
29509
31186
32887
34626
36422
38293
40265
42372
44661
47204
50111
53583
58026
Vremena izvo| enja dijagnostike stanja

3. CONCLUSIONS

- Developed a new model for determining optimal time performance of system diagnostics.
- The model provides optimal results for diagnosis of this Weibull distribution and prevents the occurrence of failure. Developed software for early detection of opportunities for failure. Software more quickly determine the moment of possible failure.
- The assessment of the performance of the specified times, there is no cancellation of the observed elements of the system. In this way, it produces substantial savings in maintenance process. By applying the sistem in a fire protection can be saved and human lives.

Fires caused by computer systems

- Computer systems, especially those who work continuously, can be the cause of the fire.
- The aim of the paper is to analyze the computer system, to determine the potential causes of the fire.
- Practically check the possible causes and give suggestions for improving the condition.

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Fires caused by computer systems

Classification of computer systems according to

- Type
- Time of work
- Built-in components

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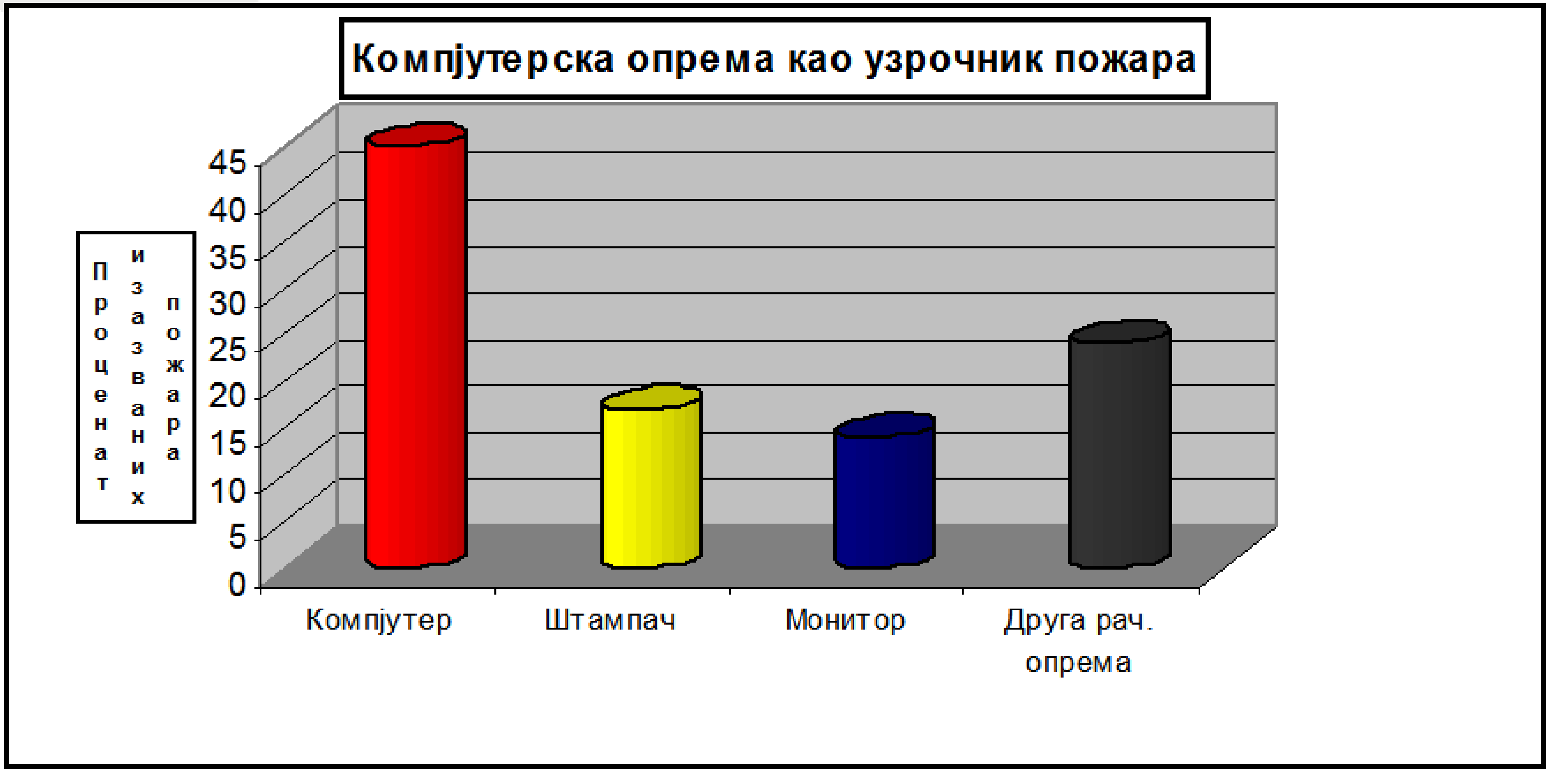
Fires caused by computer systems



Percentage of caused fire due to ignition of different computer equipment

The cause of the fire

Percentage of caused fires due to certain activities or condition of computer equipment

Place of origin and extent of fire

- The computer system has electronic components that can overheat in case of failure.
- Extensive cables, battery adapters, cathode ray tube monitors and so on as a potential cause of fire.

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Possible causes of fire on laptop computers

- The laptop has its own electronic components as well as desktop computers.
- The cooling system for lap top computers is very important.
- The batteries used in them are potential fire triggers, if they are not treated according to regulations.

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Possible causes of fire on laptop computers

- Adapters that convert 220V alternating current, to the most common 19V DCs, are very heated and potential are the cause of the fire.
- Insulation damage on the cable that connects the adapter with the lap top, because it often bends when packing, may result in short circuit, sparking and causing fire.

Thermography of computer system

By monitoring the temperature is enabled:

- to control the proper control of the temperature,
- to detect a change in temperature due to malfunction of the system component and
- to detect a change in the conduct of heat through or outside of it, caused by the incorrect operation of a component.

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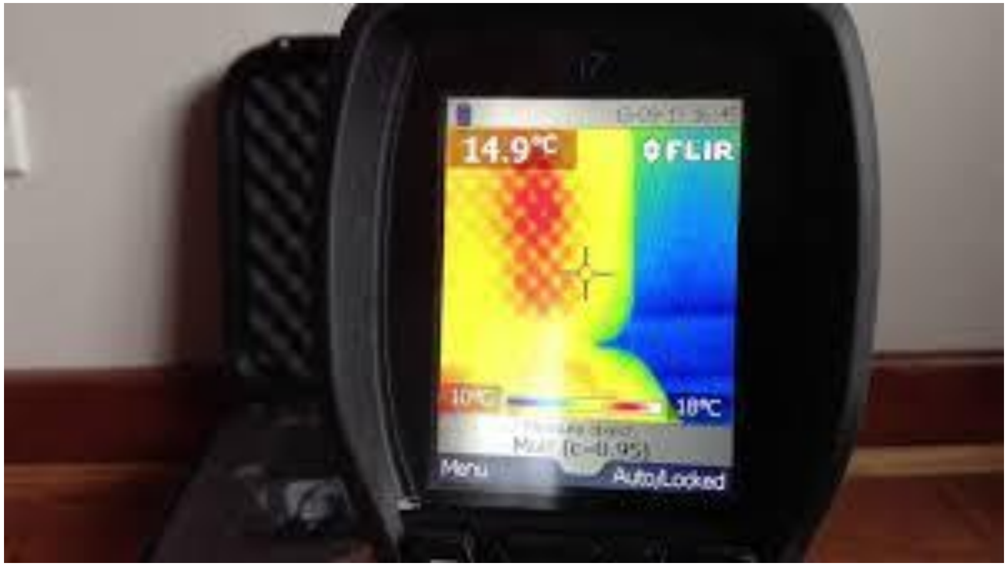
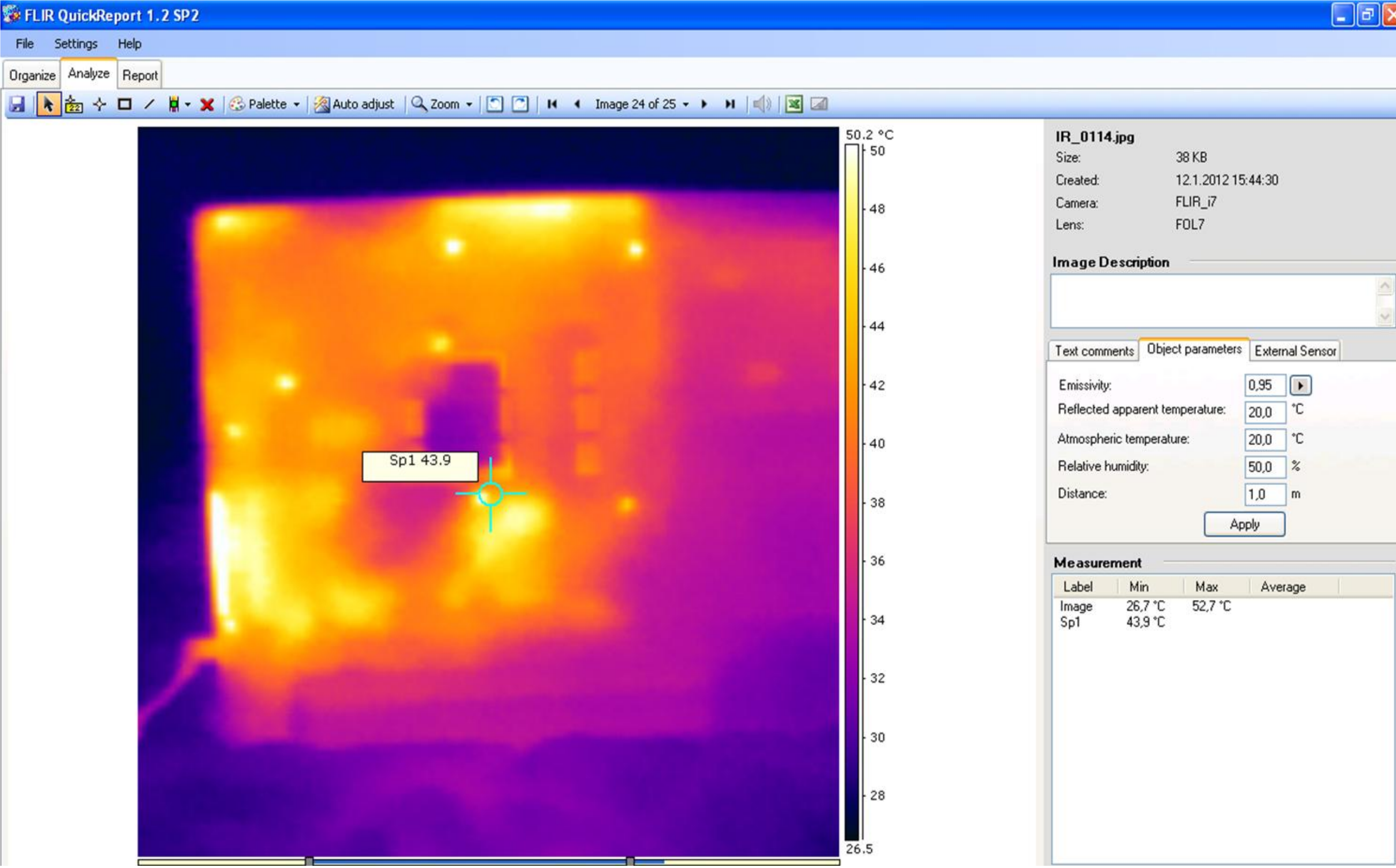
Thermography of computer system

Infrared camera i7, the world's leading manufacturer of FLIR, was used for testing.




FLIR QuickReport 1.2 SP2
File
Settings
Help
Organize
Analyze
Report
Palette
Auto adjust
Zoom
Image 24 of 25
50.2 °C
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IR_0114.jpg
Size: 38 KB
Created: 12.1.2012 15:44:30
Camera: FLIR_i7
Lens: FOL7
Image Description
Text comments
Object parameters
External Sensor
Emissivity: 0,95
Reflected apparent temperature: 20,0 °C
Atmospheric temperature: 20,0 °C
Relative humidity: 50,0 %
Distance: 1,0 m
Apply
Measurement
Label
Min
Max
Average
Image 26,7 °C 52,7 °C
Sp1 43,9 °C

Thermography of computer system

Слика 8: Лап топ у раду на подлози која затвара вентилационе изводе и температурна слика електронских компоненти при таквом раду

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Thermography of computer system

Слика 9: Додатни хладњак за лап топ и температурна слика електронских компоненти при таквом раду

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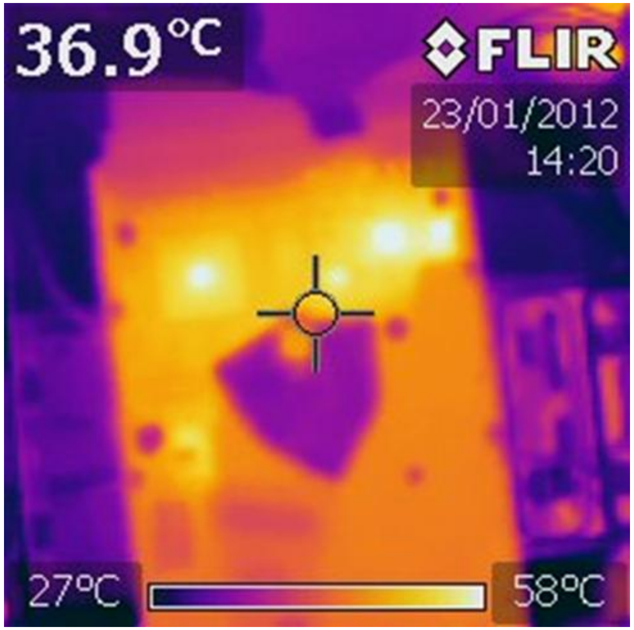
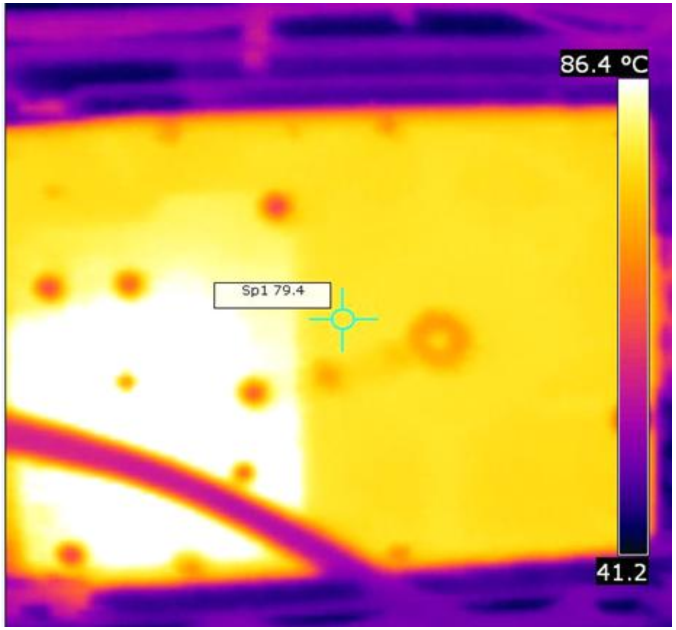
Directions for further research

Thermovision can be monitored and detected by a change in the temperature of a component. The temperature change usually leads to a pre-fault condition, after which a failure occurs.

$$t_{k+1} - t_k = \frac{F(t_k) - F(t_{k-1})}{f(t_k)} + \frac{C_i}{C_o}$$





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CONCLUSION

- Computer systems are more prevalent in developed countries, hence the number of fires caused by computer systems in these countries is higher.
- The largest number of fires arises on the computer itself with the corresponding components, in the workplace by offices.
- These fires are not fatal and most are localized on the computer itself, 40% are localized in the area of the room, and only 10% of the fire is expanding.
- In the case of laptop computers, the temperature of the computer can climb up to 80°C in the case of fan drains, which can easily lead to the cancellation of a component and the outbreak of the fire. Also, attention must be paid to the adapters because the temperature they reach is high and in the event of damage to the insulation, fire may occur.
- Termovision is a newer diagnostic method with a wide range of applications.

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K-FORCE

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Thank you
for your attention

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Knowledge FOr Resilient soCiEty