Ministry of education and science of the Russian Federation
Federal state budget higher education institution
«Astrakhan state university»

Faculty of physics, mathematics and engineering technologies
Department of theoretical physics and methods of teaching physics

Direction of training
«44.06.01 Education and pedagogical sciences»
Directivity (profile)
«Theory and methodology of teaching and education
(physics; levels of general and vocational education)»

AUTHOR'S ABSTRACT

On the topic: « Physical principles for optimal workload of Sensabot Mark 2 robot»

The work of the graduate student:
Gainedenov Nariman, 1 course

Astrakhan, 2020

CONTENTS

Introduction

Urgency of an issue. Oil and gas production will continue to grow up taking into account the growing demands of oil and gas industry in the next few years. However, oilrecovery and gas production from traditional and non-conventional resources will become more and more challenging task. This is going to be applying quitesign if i cant are quirement for level of man power specialization, levelof economic and technological capability. Also process requirements for field production and recovery tools will be increased resulting in exaggeration of conditions for plant and equipment operation in particular for offshore oil industry. The result leads to rise in price of oil and gas technologies (equipment) [1]. Oil and gas field operation on off shoresite is complicated by inflammability hazards and sulphide-dust explosion which greatly increases risk of production leads to essential emissions of Sulphur dioxide gas into atmosphere, makes winding and finally discourage productivity.

The study and commercial exploitation of sea bottom resources is not conceivable without special technical devices. The important role among equipment absorption of sea bottom is allocated for mud linessystems, equipped winning and geological survey working element in the type of detacher, buckets, pick-ups, collectors, shellboards, soil pumps etc.

Here is an example of fact that further execution of oil production without robotics is almost impossible. In April 22, 2010 the Deep Water Horizon offshore platform went to the bottom of the coast ofLousiana US state resulting in largest oil spills in USA history. The massive explosion of gas has thundered at the wells after which fire started on the offshore unit and effort to extinguish it was fallen flat. The offshore platform had gone to the bottom after 36 hour fires. The result is that pipeline was injured upon which the oil flowed from sea bottom to the board of offshore platform. InJune, 3 2010underwaterrobotsatadepthof 1.5 kilometers cut off the drilling pipes issued from the emergency wells above blow out preventer.

Survey of leading countries state polices in the field of robotics suggests that challenging trend is making program for the development of robotics. Such kind of programs is accepted in Great Britain, France, the USA, Japan and South Korea.

The goal of our study is physical principles of robotics, identifying potentially – enable fields of their application in the oil and gas production. Conferring mobile and robotics system greater flexibility and sustainability in the search for ways to the achieve goals isoccurred due to on the one hand with development of an apparatus for the formation of algorithms to the proposed problems on the other part with increasing the capabilities to perception current information i.e. awareness of environment. Changeable external environment of work process leads to the fact that for implementation its system function must promptly monitor its work. The robotic system have to equipped with sensing devices sets and adaptive control system. Therefore, creation of various physical nature sensory - based systems with special properties, sensibility, and small size is important task for further execution of robots.

The sensory robotic system intended to service on extreme conditions characterized by high ranking of electromagnetic interferences, strong radiation, explosion risks, gas contamination gas – polluted air, high temperatures and high pressures. In such cases special requirements are applied to robotic systems in whole and to sensors. The sensors must effectively work for extreme conditions.

Surveyed “Sensabot” robot within this paper is represented remotely operated vehicle intended to inspection of production facilities (units) within oil and gas industry under the most adverse conditions of environments. The robotic system allows protecting staff from source of danger. The robot intended to use in explosive atmospheres in the capacity primary equipment for responding in emergency situation in industrial facilities.

Thesensoryrobotissurveillancetools. It has few sensors which assisted to operator of remote control unit can receive the same information as for operator of onsite of production unit. These sensors include the following gauges:

1. H2S Sensors for measuring current concentration of hydrogen sulfide in environmental air:
2. Hydrocarbon sensors for measuring hydrocarbons content in atmospheric air for the purpose of finding explosive air – gas mixtures;
3. Thermal camera for supplying information (data) about ambient temperature distinguishing of locations with high or low temperature to point at rejection of processing equipment [2].

The Master decree dissertation materials are indicated to research optimally uses of sensory robots in explosive atmospheres on itex protection insuring to safe operation in relevant in explosion hazard zonas from physical standpoint for the first time ever. There fore the subject of dissertation appears to beactual.

Hypothesis: if infrared sensors for wavelength range 8 – 12 μm with controlled characteristics as gas analyzer that application of sensory robots for operation in explosive atmospheres is the best optimum.

Object of research: sensory robot designed for work in explosive atmospheres within oil and gas fields in Kazakhstan.

Research subject: Infrared sensors on the basis of semiconductorfor sensory robot intended to use in explosive environments of oil and gas field in Kazakhstan.

Scientific novelty: investigate possibilities of optimally application of the robot in various oil and gas fields in Kazakhstan. To conduct comparative analysis of limitary directivity detection of various types of H2S and hydrocarbon infrared sensors with controlled spectral characteristics.

The goal of work isto study the threshold characteristics of various types of photoelectric sensor with long line infrared region which controlled by spectral characteristics. Such kind of sensors may include owned robotic sensors on the basis of semiconductor.

The following tasks shall be resolved to achieve goals:

1.The literature review of the paper related to theoretical basis of photo sensitivity transducers and investigational study of appearance.

2.Analysis of mathematical model for critical parameters of sensors within sensory robots.

3. Research of the optical detectors of sensory robot with higher operating temperature for wavelength ranges 8 – 12 µm.

Research methods:

1. The literature review of emergency situations and use of robotin this case.

2. Evaluation of the testing results of sensory robot.

3. Justification from physical standpoint optimum conditions of using sensory robot for oil and gas field in Kazakhstan.

Scientific and practical significance concludes the following:

1.Comparative analysis of limitary directivity detection of various types of infrared sensors for wavelength ranges 8 – 12 µm with controlled characteristics for the purpose of using in explosive environments.

2. Theoretically – investigated possibility of increasing energy efficiency sensors from hydrogen sulphide (H2S) influences.

3. the most optimal sensors for sensory robot intended to the extremally explosion hazardous zonashas been identified.

Three academic papers were published in peer reviewed journals based on the results ofcompleted research, conceptual issues of paper has presented in V International Scientific – Theoretical Conference “The role of Physics and Mathematical Sciences in the Modern Educational System”.

Structure and scope of work:master degree work consists of the introduction, three chapters, conclusions, list of reference links from 31native and foreign sources.

The total volume master degree dissertation 51 pages, of which 2 pages list of references, 16 pictures (figures) and 6 tables.

1. Industrial robots in modern industry

1.1. Industrial robots

The robotics technologies appeared on bases of cybernetics and mechanics, in turn promoted to a new departure of development and these sciences themselves. It is associated with intelligent control and bionics in cybernetics, mechanics with multiple devices as manipulator mechanisms.

Consequently, robotics sciences tasks - its development and creation of mechanics and cybernetics with a view to developing and purpose of robots based on their employment of robotic system various application. The role of robotics in this systems and complexes may vary from basic, when robots perform the main functions to additional, when robots perform the main or ancillary equipment carrying on these functions. Systems and complexes automated by robotically it is usually called robotized. The robotized systems and complexes in which carried out the basic functions are called robotics.

The important part is allocated to robots which replaced human while performing different tasks in extreme conditions: off soundings, in vacuum, in space, at the radiological, fire hazardous labor conditions sites.

The industrial robot is self-contained operational intelligent machine (stationary or mobile), consisting of manipulator which has several degree of freedom, and program control unit and intended to perform the main or auxiliary operation of production cycles without human involvement.

Researchers still have a lot of problems, but some areas are significantly progressing. A hazardous environment createsspecial problems for implementation targeted concerns depending on principles and magnitude of the danger. The danger can be presented as radiological or toxicity hazardous for potential explosion. The technologies that specialized engineering companies can develop and sell without active assistance of researcher are feasibility boundary.

In this regard special popularity are captured by automation solution of production passed on industrial robots which allowing make provision full circle processing with high rate of productivity and accuracy to avoid pauses and operational errors to human [3].

Robot automation of oil and gas fields’ facility is associated with a variety of difficulty. Except but this difficulty are carried not only technically character but also have an impact on general aspects including man power. Although robotic technician gives a good account of oneself in other industrial settings, it has to be adapted to specific conditions of oil and gas recovery. In oil and gas industry commands are performed in extremal climatic conditions and at great distance which require managing remote control. Telecommuting allows connecting operator in line control patch and using high level of trades to manage activity of the robot.

Therefore in contradistinction from traditionally robot operation for implementation a single monotonous and long – duration operation true to form for multiple conveyer system, in oil and gas industry will be applied for implementation sundries commands (operations) each of which shall be executed immaculately and upon fist request. The robots need to handle different level of automation from fully automatic mode without the need for human intervention to fully manual regulation. In between this extreme case any and all possible semi automation operations varying degrees demanding human intervention are situated. It goes to show departure from traditional principles of industrial robot application and agglomeration of operator in control path for interaction between robotic and controlling system. Understanding the computer based automated system “human-machine” type is automation in oil and gas industry rely on seamless integration of human, technology and organization. Oil and gas production presents different design requirements and robotic system capabilities. Apart from endurance to unfavorable weather conditions of robot has to explosion – proof[4]. The robots for offshore platform must stand extreme temperatures, strong breeze, impact of salty water and even snow and glacier covering. Robots for land purposes must stand sandstorm, direct sunlight, direst solar radiation, rain, and high humidity, extreme temperatures and effect of toxic gas such as H_2S. Such a specific requirements are not exercised to robots in usual production conditions.

The following important perspectives in the area of robotic consist of development of the apportioned multiples sensory devices (system) among others in sensory touch screen ensuring millirobot system and its collective intellect. The sensor system is organic functional component of robotic technician. The knowledge their possibility characteristics and development perspectives, statement of skills and technology requirements to sensory system picked up their availabilities and development of their contributions must have robotic designers.

Other and invariable development trends of the sensory robotic system is miniaturization of the in the first instance the main working sensors.

We educed robot sensory system parameters and properties are divisible into following groups:

1. Draw up the balance sheet of system environment attended by discharges and its separate objects;
2. The coordination system of robot location and parameters its movement including coordinates with regard to environment external entity objects;
3. The systems determination of the separate physic – chemical properties of the external environments and its concrete objects.

The robotic device cannot be in operation without entrance necessary information regarding environment location orientation with whom it should be cooperated. The source of information is multifarious sensors transferring data to controller which is “robot brain” that handles an incoming signal an “make decision” on further actions.

A description of the proposal, suggests some possible applications for such robot:

1. The robot could serve in supporting role as a part of oil and gas production facilities;
2. It can be used to prepare normally unmanned topside offshore facilities before the arrival of maintenance crew, by performing safety inspections;

3. Allow personnel to perform remote inspection audits and maintenance via telepresence;

1.2 Technical description of sensory robotic system

The sensor robot is a remote operated vehicle that is designed to perform daily inspections of offshore oil and gas plants. It has been developed with specific reference to the challenges faced in the Kashagan oil-gas industrial field in Caspian Sea, which has a high sour gas content, extreme climatic conditions and remote, normally unmanned islands that can be difficult to access at certain times of the year.

It has ex protection for Zona 1 and intended to operate as a being primary equipment of response in emergency situation in Kashagan production facility. During alarm actuation on the island operated automatically Sensabot robot can be directed to plant for checking reasons of alarm and diagnosticating problems in industrial island D. Duetothefactthat it has wheeled mover, the robot cannot independently move between islands. It will stay in the ready mode to one of islands in case may become necessary.

The robot Sensabot is rated for exercising watch over environment, therefore at this moment the robot is unequipped handling aids. Nevertheless monitoring software it has several sensors which operator of remote control unit can receive the same information as for operator at the industrial site.

The robot is equipped with sensors that replicate human senses:

- H_2S Sensors for measuring current concentration of hydrogen sulfide in environmental air;
- Hydrocarbon sensors for measuring hydrocarbons content in atmospheric air for the purpose of finding explosive air – gas mixtures;
- Thermal camera for supplying information (data) about ambient temperature distinguishing of locations with high or low temperature to point at rejection of processing equipment;
- Miltiple cameras and lights provide forward and backwards visibility when driving. Boom cameras and pan / tilt / zoom camera enable close checking / inspection of equipment;
- A vibration detector and a heat sensitive camera on the boom provide a sense of touch i.e. vibration probe as a contact sensor allow the operator find out harmfull level of vibrations e.g. upon inspection of rotating equipment for detecting their pre-accident condition;
- Stereo camera in the first instance will be used in navigation in environment status with operator. The robot also has depth function for obstacle detection and stop molding of door way to avoid collision;
- A microphone on the boom provides a sense of hearing;
- Hydrocarbon and hydrogen sulphide gas detectors on the boom provide a sense of smell;
- A speaker on the body provides the ability to speak. This implies that the operator can speak through the robot. Perhaps we can reword this slightly.

The sensor reading and steering signal of robot is processed by microcomputers set at robot working in Linux operational system. The computer data serves as control center of robot.They reply for data communication between different hardware system and user. As well as computers have algorithms allows detecting blocks and avoid to run inspection the system status of robot and give support during control.

The interchanging data with robot Sensabot is implemented with wireless telecommunication line assisted by user facility for 4G/LTE network based in frequency content Band 7. As well as in the capacity as reserve communication technology is allowed Wi-Fi hotspot 802.11n Wi-Fi, working site development conditions or some little distance during repair.

The sensabot robot equipped intrinsic accumulator battery which provides battery life about 4 hours typical bundle of workunder conditions. The battery produced on basis of hermetically sealed of acid accumulator and mounted within special designed cabinet which protected battery from environmental ingress of contamination. During installation of battery in station of robot battery charging circuit is released automatically.

The unique trait of Sensabot is the fact that it is designed for service on oil and gas industry due to this it is engineered in light of the requirement to pass ex testing certification for Zona 1. Accordingly all equipment of robot for Zona 1 was installed in special designed units which insuring sufficient level of protection in accordance with standards.

As well as all materials whereof robot – manufactured shape up in light of the requirements to production activity (operation) in the presence of hydrogen sulfide that on an emergency basis the robot can work under the influence of gaseous hydrogen sulfide over a protracted period.

The docking station is made as module which encompasses the robot Sensabot within the period when it is not used upon the operation. In the period down time this module is employed as master container for robot, but in the time of expansion it serves heating docking station insuring as well recharging of electric batteries of robot.

The docking system presents thermally – insulated stained steel container with door at the front which in hanging down conditions is operable in the capacity footlight. In the work presented configuration the docking station is fixed inside of rapid deployable container,however in case of need it can be extracted from container.

Data communication network 4G/LTE

The equipment 4G/LTE allows starting up private high – bandwidth data network by which can be carried out controlling a sensor robot. Operating equipment represents commercially available system non requiring entering of updating according to the requirements of customer. The equipment will be hardwired and installed to inside of cabinet with protection from environmental hazard.

General processor unit LTE: General processor unit is computer center any cellular network. It replies for user authorizations and traffic distribution inter-place.

Base station: in elected configuration of base station contains all equipment which is a part of square knot of cellular network including radio station.

Network Control System: server with specially designed software for the monitoring over the technical states of network.

Barrier layer: device acting in the capacity of interface between base stations adjusted inside of container aerial wire outline of container. It provides protection from explosive air – gas mixture and limit output capacity of radio transmitter.

Aerial wire: one or two aerial wire (depending on final project configuration) is set to inside of container for securing omnidirectional radio ranges covers.

The system intended to services in frequency content BAND 7, its output power limited degree 3.5 W in accordance with IEC Ex Starndart.

Sensabot operator station. Operator station is designed as computer which is used in controlling a robot Sensabot. It represents conventional commercially – available PC with operating system Linux, fit up two joysticks and two monitor unit. Operator station coming with pre – installed software required for controlling a robot.

The operator station can be fixed for a table inside of container in order to provide safety handling. The point to note is that this control station has to moved certain distance from container before use in explosive conditions of environment. The rapidly deployable container is designed for sensor robot arrangement and all required supporting machinery allowing within short timeframes involving robot at minimum exposure to working production facility. It represents standard shipping container (2.5 x 2.5 m) adapted for placement several robot components which consider herein as well as for electric power supply this element.

As well as contained equipped with power backup from accumulator battery which in the event of malfunction of electric power supply will support telecommunication equipment in robot at least throughout the period of autonomous operation of sensory robot from accumulator battery.

The sensory robot Sensabot is represented remotely operated vehicle intended to inspection of production facilities in oil and gas industry under the most adverse conditions of environment. It removes humans from harm's way.

The sensory robot's operator uses a control station that is connected to Sensabot by a wireless network. This station is designed for traffic control of robot and to observe the indications of its sensors. The control station will be located in a safe area, comfortable environment away from facilities. Typically, this is the facility's control unit since this enables Sensabot's Operator to work closely with the facility's operator.

The sensory robot is equipped with sensor that replicates human senses:

- Multiple cameras and lights provide forward and backwards visibility when driving. Boom cameras and a pan/tilt/zoom camera enable close inspection of unit / equipment;
- A vibration detector (and heat sensitive camera if fitted) on the boom provides a sense of touch;
- A microphone on the boom provides a sense of hearing;

- Hydrocarbon and hydrogen sulphide gas detectors on the boom camera provide a sense of smell.

Sensory robot's dimensions and manoeuvrability allow it to navigate walkways that were designed for human operators. Ramps or rails can be installed where it needs to change height. The sensors can be positioned in a wide range of orientations by using Sensabot's ability to spin on the spot and the multiple joints on its boom camera.

The sensory robot is designed to base on following requirements:

- Feasibility of application in explosive hazard area relating to Zona 1;
- Operation feasibility within the range temperature from – 20^{0}C to + 40^{0}C and extreme weather conditions (sun, snow, rain and wind);
- Resist corrosive environments;
- Havemaintenanceintervalof 6 month. It is removed to a safe environment for any significant maintenance.

The robot is an intricate, integrated system and it will not be modified in any way since this could compromise its safety.

Figure1 –Thesen sory robot system

The sensory robot and its associated equipment (control station, kenels/containers, ramps/gates, wireless networks) are illustrated in Figure 1 and are referred to jointly as the "Sensory robot Sensabot system".

The sensory robot is a 570 kg industrial type vehicle driven by a remote operator so it represents a significant crush and impact hazards areas. When the warning beacon flashes of Sensabot is enabled to drive. Even if it is stationary it could move at any time when the light is flashing and audible alert may sound when motion is started as well [4].

Although the sensory robot is rated at severe service conditions (this applies especially aerial of network and rotating beacon), it can be affected if handled incorrectly. Holding and transportation for robot it should be used its container unit. If this is not possible to provide it must prepared and realized execute plan for managing.

Key external features on Sensabot are shown in figures 2 and 3. Operation of these features is described in later sections.

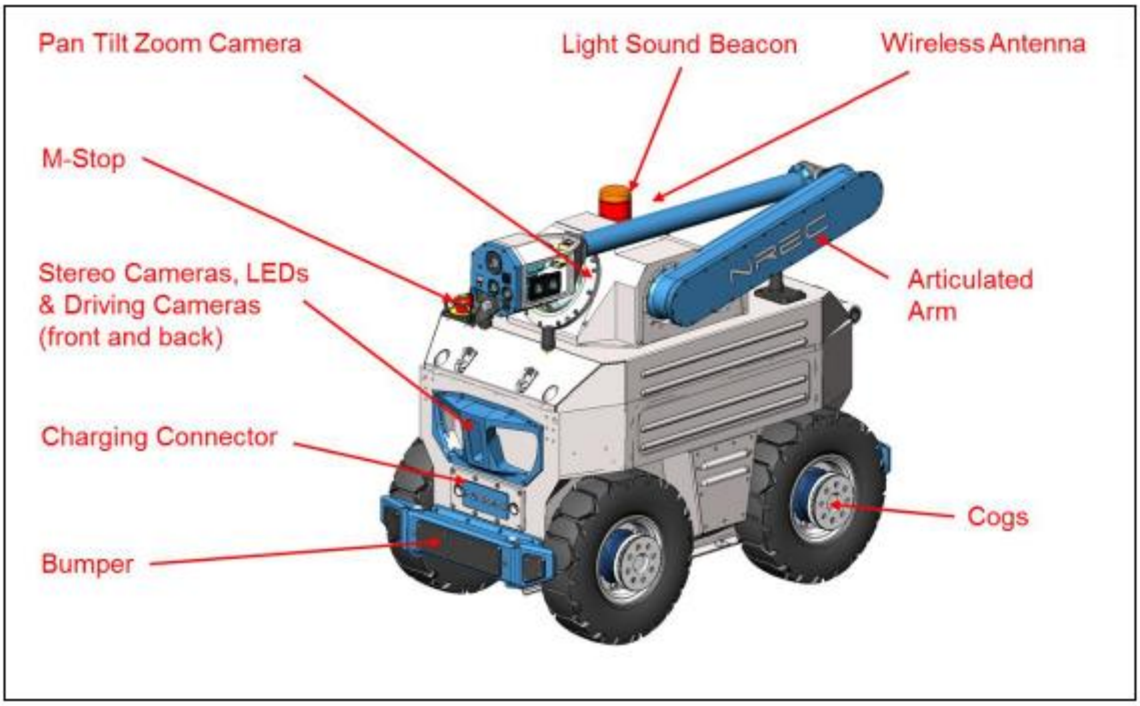


Figure 2 –ExternalSensors and Equipment of Sensory robot

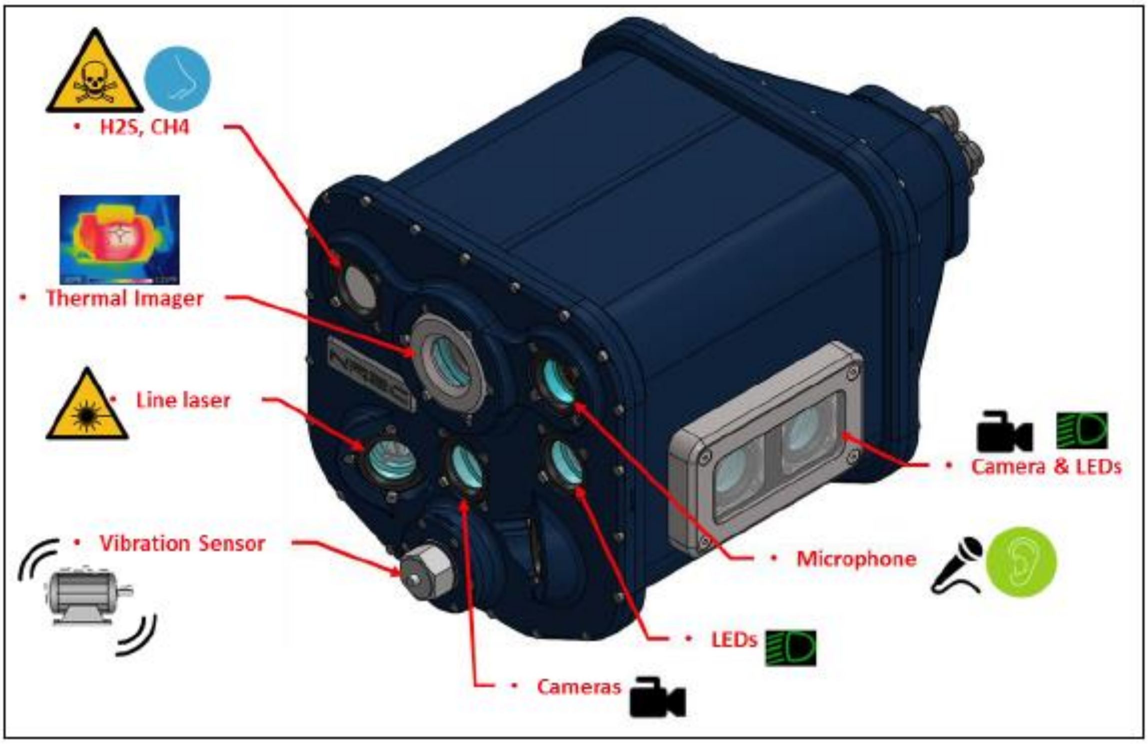


Figure 3 –Sensor head Sensors and Equipment

It is important to understand the impact of temperature to protectabilty of robots for use on explosion hazard Zona 1. If the temperature of the critical equipment to be colder or hotter above rating value the sensory robot loses its protection for use in in explosive hazard zona 1 and can activates explosion upon contact with inflammable gas.

The temperature value within electronics box at the top of the control station screens is displayed:

- The sensory robot will trip when the temperature display is at 58^0C. if the robot is it risk of reaching this temperature it will be docked in the kennel as quickly as practical. If the robot trips before reaching the kennel it will be left until the internal temperatures falls and the robot will be reactivated by pressing the green button on the input/output terminal;
- The temperature inside the electronics box in unlikely to fall below 0^0C when it is in use due to the heat generated by its electrical circuits. However, the robot will trip if the temperature inside the electronics box reached - 19^0C.
- The battery enclosure heats up during and charging and the performance of the batteries can be affected if they overheat. To avoid this issue when the ambient temperature outside of the kennel exceeds 20^0C the robot will enter the kennel but will not be fully docked until 6 hours after returning to the kennel. This allows the battery enclosure to cool before charging commences. At the end of this period the robot will be fully docked and charging will commence. It should be fully charged within 2 hours.
- The only exception to the previous paragraph is if the battery charge indicator on the control station drops to 0%. Then the robot will be docked immediately so that it is not stranded without power. In this situation the total elapsed time between the robot entering the kennel and the start of the next mission will be not less than 8 hours.

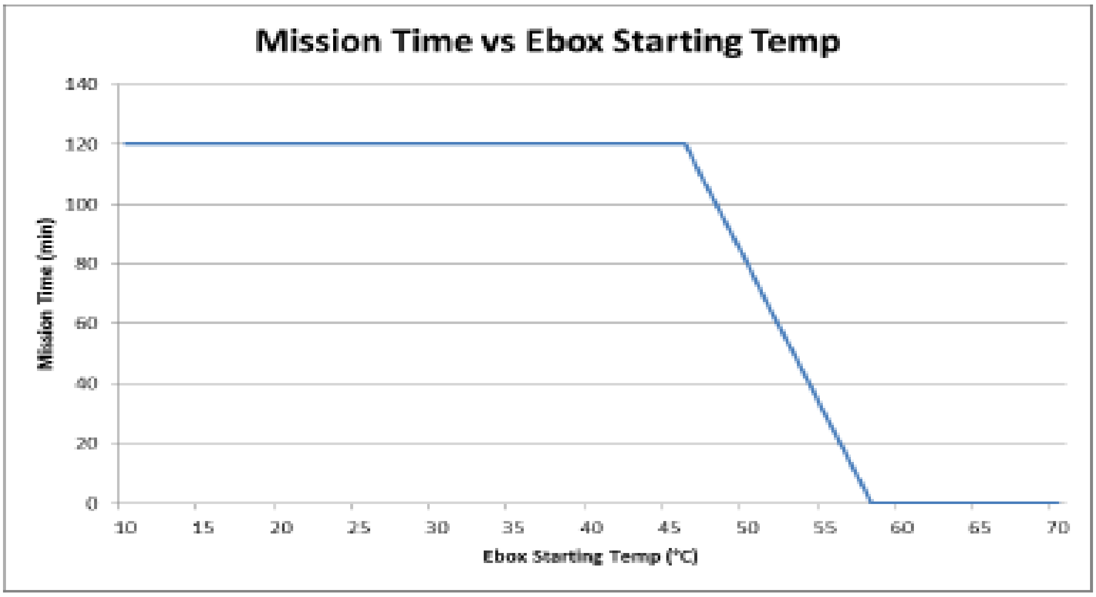


Figure 4 – Sensoryrobot mission time versus electronics box starting temperature

The sensors on board Sensabot will be used screening and inspection in the same manner as they would be used by operator in the production facilities [5]-. Therefore for implementation problem data should be applied conventional working practices. The vibration sensors will not be used in explosive gas environments to avoid the risk of static sparks.

The sensory robot structure calculated as at that provide protection in conditions for high concentration of gas hydrocarbons and hydrogen sulphide, so in the unlikely event of a major gas leak the sensory robot can be safely used to access the extent of any gas plume provided:

- Power is still available to the kennel. Otherwise sensory robot can only use until its batteries discharge at which point it will automatically shut down.
- The wireless network is still active. They shall be the case if power is still available to the equipment rooms in which the wireless units are located.
- It is not being deployed using the containerized system of sensory robot.

In this case sensory robot can traverse the gas plume recording gas concentrations. The hydrocarbon gas sensors should be used as primary source of information since it has no upper gas detection limit. The heat sensitive camera can be used to detect the source of the leak which will be very cold due to Joule – Thomson coaling. As well as the microphone might detect the sounds of gas release. The hydrogen sulphide detector may be of limited value because it cannot distinguish between concentrations 4200 ppm. In actual fact, its behavior and recovery after influence to concentration above 5000 ppm is less than fully explored, therefore all data which can be collected and must be analyzed for future reference.

1.3 Kashagan projects. Characteristics of Marine Natural Environmental conditions. Physical Marine environments.

The greatest depths in the North Caspian reach 25 m, while the average is 4.4 m. Depths of 0-1 m occupy approximately 21% of the area of the North Caspian and depths of 0-5 m account for 67%. 10% of the area has depths of over 10 m. ongoing fluctuations in the level of the Caspian Sea have resulted in changes to bathymetric values. The average multi-year seasonal change in sea level in the North Caspian amounts to 40 sm. The maximum increase in depth was 72 sm, while the maximum decrease was 64 sm, recorded at Seal Island.

The background level of the Caspian Sea is subject to significant variation. Last century, the background sea level generally fell up until the end of the 1970s. The overall constant falling in levels observed during 1930-1977, amounted to 3.2 m with an average intensity of approximately 4 sm per year.

Starting in 1978 Caspian Sea levels began to increase rapidly, and this continued via 1995. Over this time the level rose by 2.5 m and by 1996 reacheda level of minus 26.6 m [7].

The Kashagan East oil field is located offshore in the Caspian Sea in the Kazakhstan, approximately 40 km from land and approximately south of the town of Atyrau. Th the south – west of Kashagan East lies the Kashagan South west and Kalamkas Sea fields and to the east the Kairan and Aktobe fields.

The maximum sea depth surrounding the Kashagan development is very shallow approximately up to 4 m. there are seasonal and annual water level changes in the Caspian sea and the sea is also ice bound during the winter season (frozen to a depth of up to 2 m). The Caspian sea is an environmentally sensitive area and the entire north coast of the Caspian sea has been declared a special Ecological Region.

Diverse water temperatures are typical of the eastern waters of the North Caspian during transition periods, i.e. during the period of active warming of the seawater (April – May) and its cooling (September) and similar temperatures are found via the area during the period with ice cover and period when water temperatures are at their highest (July). The temperature regime depends on the sea level and to a great degree on depth distribution. Spring time warming begins in the northeastern shallow – water areas, before spreading west and south. In the northeastern part of the North Caspian, water temperatures reach their maximum in late July, heating evenly throughout the waters to 25 – 27^{0}C. In August the cooling period begins. First, the waters of the northeastern shallows cool followed by more western waters and in November the water temperature in coastal areas approach freezing.

The North Caspian is known for its low levels of transparency, caused by the large influx of river water rich with organic and non – organic suspended substances, high aquatic biological productivity, and shallow depths. The distribution of transparency agrees well with the depth at the location and hydro meteorological conditions.

Under calm conditions, when water transparency is at its peak, it increases in direct proportion to the depth at the location from the seaward edge boundaries of the Volga and Ural River Deltas (0.3-0.5 m) toward the boundary with the Middle Caspian (10-15 m), which is connected to the gradual precipitation of suspended matter arriving with the river runoff onto the seabed.

As the wind strengthens and wave – formation intensifies, transparency decreases due to the suspension of the fine fraction of bottom sediments and in zones with depths of less than 4 – 5m during storms transparency equals 0.2 – 0.3 m. during this period, the water her acquires slivery white coloration.

The sediments accumulating on the Caspian Sea bed are made up of carbonate materials of Terri genic, biogenic and chemo genic origin.

Within the territory under discussion all types of hazardous phenomena and natural hydro meteorological disasters occur (strong winds, inversions, blizzards, dust storms, high and low temperatures, etc.) which may have a significant impact on the work conducted in the waters of the Caspian. Special attention should be paid to the following amount the – storms, fogs and vessel icing.

Storms from northwesterly and northerly wind directions are most often short-lasting but intense. In the winter they can be accompanied by blizzards, icing and shifting of the ice cover. Storms with winds of a southeasterly direction have a greater duration and last100–120 hours.

Fog is the most hazardous meteorological phenomenon, especially during offshore operations. Fog in the northern part of the Caspian is most often seen during the cold period of the year. The frequency of fogs is fairly high 31 – 34% with visibility worsening down to 50 – 200 m.

Vessel icing is a rare but hazardous phenomenon in the North Caspian. Icing is most typical for the northern parts of the northeastern region and may occur starting in October through April [8].

2. Specific parameters of explosion hazard zonas and indexes responsible for explosive safety of equipment.

2.1 Physical characteristics of explosive environments

Explosive environments – it is chemically active media based under such conditions when can arise explosion. Explosion fast exothermic chemical conversions of explosive atmosphere followed by release of energy and formation of stored gas for conducting process.

Explosion hazardous zone is divided onto classes in dependence on periodicity rise of explosive environments and its duration. Protection from risks o rise of explosive environments are important wherefore explosion sends for uncontrolled flaming formation of hazardous substance, pressure effect, oxygen deficiency in atmosphere that threaten life and health of human. Timely risk assessments of explosion hazards allow for degrade danger and its rise in industrial facilities as well as evaluate damages if any in environments and life hazard & human health.

Advantages which provide assessment of explosive environments:

1) Assessment of equipment and facilities related states;
2) Evaluation of hazardous zones in industrial facilities;
3) Evaluation of every potentially dangerous work location, subsystem with graphical display, blocking;
4) Assessment of selected equipment in accordance with the legislation requirements;
5) Independent expert appraisement of hazardous areas in accordance with regulatory documents requirements;
6) Possibility assessment the risk of dangerous and select necessary protective measures to prevent and decrees risks raising explosion.

An explosion hazard environment marks the following key parameters:

- Flash point and auto – ignition temperature;
- Flammability range (thermic and explosion limit);
- Full speed of flame spreading;
- Minimum explosive oxygen concentration;
- Minimum ignition energy;
- Propensity to explosive and detonation;
- Sensitivity to mechanical effect (impact and friction).

Exude during production activities the dust can be detectable for explosive and fire. The dust mineral (aerogel) subsided from air cannot able to explode, but it can form punky or flammable mixture [9]. The practice shows to the fact that explosion – fire attitude dust is unprofitable product of which it received.

The dust as well as mixture of gaseous fuel and vapor with air can be ale to explode if their airborne concentration resides in gas ignition area. The dust concentration appears usually in industrial facility and factory close to lower concentration limit of explosion when concentration eligible to maximum limit of explosion educated in reducing machines and apparatus.

The dust which has lower ignition concentration limit until 65 g/m^3 is sangerously explosion – protected, large concentration limit is inflammable.

One of key element aerosol explosion, gas and air – steam mixture is non combustion efficiency that conditioned burning only gaseous product, the dust have no time to burn during explosion of carbon residual. It is commonly supposed that the dust is able to explode in which contaminating gas is composed more than 10% of dust weight. Explosive hazardous from the mineral dust is coaling, sulphuric and sulphidic dusts.

The aerosolized sulphuric dust is highly explosive. It's limit of inflammability is 275 – 350 ^{0}C, low explosion concentration limit is 5 g/m^3 for comic sulfur, 15 g/m^3 for crystal sulfur.

Thesulfidedustwith coarseness fraction 0.1 mm is able to form explosive the dust cloud about consistence 250 – 1490 g/m^3, expect but the most dangerous is 286 g/m^3 concentration. The temperature of inflammation of sulfide dust is 435 – 450^{0}C. during explosion of sulfide and sulphur dust arise sulfur dioxide gas and hydrogen sulfide that may cause personal toxication.

The carbon dust is as during production of coal and during processing, warehousing and practice. Explosion characteristic of coal dust depend essentially from following factors:

- Fromdustconcentrationinair. Aerosol containing a lot of quantity of volatile component has lower concentration limit 16 – 21 g/m^3, upper concentration limit of explosive – 1500 – 2000 g/m^3. The most explosive powerful is feasible with coal udst concentration in air 300 – 600 g/m^3. Temperatureinflammationofcoaldust 750 – 800^{0}C;
- Fromcoalconcentrationpremisesisvolatilecomponent (methane, hydrogen, carbonicoxide, ethane, heavyhydrocarbon). Coal aerosol containing more 10% of volatile concentration fall in the category dangerous under explosion. The most explosive coal dust containing from 17 to 32% volatile component;
- From dust dispensability. The most explosive coal dust with molecule size 10 – 75 µm, however after creation of explosion therein can take part and more macro aggregate size of 0.75 – 1.0 mm.
- It depends from dust content. Whereof air content of coal dust far less their explosive properties. The coal aerosol concentration 10% and more air the coal dust is no longer explosive.

The reason of dust explosive in industrial sites isgas steam and air steam mixtures of free fire of shot operations. The most frequently vapor explosion, dust, mixed gas is raised from sparkle in electrical facilities and power supply utilities [10].

Every production sites should follow with classificationfor the selection of explosion proof electrical equipment, for development of activities in explosion safety and explosive protection. Theclassificationbasedoncategories (GOSTK 12.1.011-78) is set value of maximum experimental safe gap (MESG) – maximum backlash clearance between spherical cap flanges where through be absent explosion delivery from jackets in environment whatever concentration gasoline in air conventional camera.

2.2. Classification of indexes analyzing explosive safety of equipment

Explosion hazard zona classification has application to equipment selection targets on it explosive level which ensuring safety operation of such equipment in the relevant explosion hazard sites. Depending on frequency and presence of explosive gas and dust environments explosive hazard zone are divide into the following classes:

1) For explosive gas environments – 0, 1 and 2 classes;
2) For explosive dust environments – 20, 21 and 22 classes.

Depending on sphere of equipment application is divided into for following groups:

1) I equipment group – equipment intended to use for application underground workings of mines and land constructions, dangerous mine gas or combustible dust. Depending on equipment construction group I has one of the ex-protection level;
2) II equipment group –equipment intended to use in locations (except underground mine working and their land structures) dangerous under explosive gas atmospheres. Depending on equipment design the equipment II group is entitled to one or the three ex protection level, Equipment II group is divided into sublines IIA, IIB, IIC depending on gas groups for which intended;
3) III equipment group – equipment intended to use in locations (except underground mine working and their land structures) dangerous under explosive dust atmospheres. Depending on construction is entitled to one of the three ex-protection level. Equipment III group is divided into sublines IIIA, IIIB, IIIC depending on explosive environments specification (characteristics) for which intended [11].

Equipment depending on danger set up ignition source and conditions for explosive environments application is classified by ex – protection:

1) Extra explosion – proof (very high);
2) Explosion – proof (high);
3) Advanced reliability vs explosion (advanced).

Depending on maximum permissible temperature equipment superficies II group equipment is divided to for following temperature classes:

1) T1 – 450 degree Celsius;
2) T2 – 300 degree Celsius;
3) T3 – 200 degree Celsius;
4) T4 – 135 degree Celsius;
5) T5 – 100 degree Celsius;

6)T6–85degreeCelsius.

Explosive characteristics of explosion - proof equipment:

- Physical aspects: give perspective range of use in terms of which it may be used;
- Detonation properties: this ability used to describe activity of explosion – proof equipment

- Safety properties: this character describes handling rules for various (different) products.

All properties and characteristics are important when making a selection of explosive items.

The equipment physical properties:

- Density of load;
- Waterproof;
- Chemical proof;
- Fume characteristics;
- Activateintheprescribedtime.

Equipment apparent density:

- An important properties for explosive selection;
- Density below 1.0 g/cm^3 means explosive may float in water:
  Highviscosityproductssuchahomogenizedemulsion
  Loadingprocesssuchasre-pumpemulsion
- Increasing density leads for increasing Detonation Velocity up towards critical density
- Increasing density leads to increasing detonation pressure;
- Higher density for non-ideal explosives risks dead pressing;
- Determine loading density (kg/m or Ib/ft).
  Resistance of water: ability of explosive ability to with stand exposure to water losing sensitivity of efficiencies
- Wide variation
- **Water Resistance**
  Abilityofexplosiveabilitytowithstandexposuretowaterlosingsensitivityorefficiency

- Widevariation:
  - ANFOhasnone
  - Emulsionisexcellent
- Dependentonwaterconditions
  - Staticor dynamicwater
  - pH willbe affectedemulsionsleeptime
- FumespostblastOrange-Brown Nitrousoxidesisindicationofwaterdamagetoexplosive
- Waterresistanceofexplosivescanbeearly improvedbyuseofwholeliners,butusuallyattheriskofreducedchargepermeterofblastholes

Chemical Stability

Definedastheabilitytoremainchemicallyunchanged,whenstoredcorrectly based.Itisakeyparameterinshelflifeofmanyproducts it means ex-rated items.

Factorsaffecting to item shelflifeinclude:

- Formulation and Rawmaterialquality concentration
- Packaging list

- Temperature and humidity of storage environment concentration of the hazardous area
- Contamination area

Characteristic signs of deterioration in clude the following steps:

- Crystallization type
- Increasedviscosityand/ordensity of hazardous areas explosive electrical items
- Colorchange(e.g.bulkmaterials emulsionsgocloudyascrystallizationincreases)
- Poorfieldperformance charchetristics

Fume Characteristics

- Oxygenbalancedexplosivesyieldnontoxicgases in hazardous facilities
  - CO_2,N_2andH_2O (H_2S)

Minorquantitiesoftoxicgasesalsoprocured by:

- The oxidesofnitrogen(NO_x)resultfromanexcessofoxygen (O_2)intheformulation(oxygenpositive)
- The carbonmonoxide(CO)resultsfromadeficiencyofoxygenintheexplosive environments(oxygennegative)

Sleep Time

- Wetordryground type
- Productselection type
- Groundtype:
  - The reactivematerialto the explosivematerial (hazardous material)
  - The exposuretothereactivematerialaswithbulkproducts it means piping materials, compressors, oil tanks etc.
  - Intended to use in hottemperatureground items (150^0C)

Detonation Properties

- Velocityofdetonation of chemical activites (VoD)
- Detonationpressure of the energyandstrength
- Criticaldiameter of piping bulks
- Confinement of chemical element

VelocityofDetonation(VoD) of the materials

Speedthatthedetonationwave lenghttravelsviatheexplosive,usuallyexpressedinmeterspersecond(m/S)orfeetsecond(ft/s);

- Influencedby:Rocktype,the chargediameter of ball,explosivedensity,explosiveformulation,particlesize of ball,degreeofconfinement,perimeter(sizeandtype);
- VoDwillinfluencehowtheenergyisreleasedfromtheexplosive hazardous zona(i.e.thepartitionofenergyintoshockandheave type)

Velocityofdetonation(VoD)

VoDisguide toolstodeterminingtheefficiencyoftheexplosive environments

- ComparisonofVoDresultsshallbedonewithinthecontextoftheparticularblastingsituation(i.e.samemine,samerocktype).Forexample,“anfo”VoDsvaryfrom2300to4400m/s(8100-14600ft/s)dependingonthe wholediameter of the items and materialsinthesamerock.
- VoDdatashouldbeseenasastatisticalvariable(i.e.getmultipledatawhereverpossible)toallowfor following states:
  - Roktype of variation
  - Chargingvariation type
  - Datacaptures system (DT)

Detonation Pressure P_d

Pressureinthedetonationof the reactionzone i.e. hazardous zona,asitprogressesalongthe charge,expressedinMPa.Thisiswhatgeneratestheshockpulseinrock

$P_d$estimationforcommercialexplosives areas:

$$P_d = 0.25xVoD^2x\rho$$

Eg.“ANFO”at$\rho = \frac{0.85g}{cc} andVOS = 4000m/s(13123\ ft/s$

$$P_d = 0.25\ x\ 4000^2\ x\ 0.85 = 3400MPa = 34Kbars = 499.800psi$$

Available Explosives Energy

Theenergythatanexplosivecandelivertodousefulwork:

- Energydeliveredtotherockmassbeforethegassesventstotheatmosphere environments(calculatedusingthermodynamiccodes)
- Effectiveenergyistheenergytransformedontousefulrockfragmentationandrockdisplacement again explosive environments material
- Actualamountofenergydeliveredinanyblastisunknownastomanyvariablesexists
- Onecriticalfactors arethecutoffpressureassumedby anyenergycalculation
  - Changingthecutofpressurewillbe changedtheenergyattributedtoanexplosive

Absolute Weight Strength(AWS)

This is the theoretical absolute energyis available, basedontheingredientsof the explosive environments (100 k)

- Energy calculatedby the thermodynamic codes(ideal gas) (i.e.computer models of the detonation chemistry and energy of there actions)
- Usually quoted in MJ / kg of explosive steam or vapor
- AWSofANFOis880cal/gfor94%ANand6%FuelOil gas
- Explosiveefficiencyof the hazardous environments variesfrom35%to90%ofmaximumenergy(thisistheactualenergydeliveredinablastis35%to90%oftheoreticalmaximum)

Relative Weight Strength (RWS)

Thisistheratioofenergiesofaunitweightofexplosivecomparedtoanequalweightof“anfo”

- RVSforanexplosivesaretheAVSoftheexplosivedividebytheAVSofANFO,expressedasapercentage:

$$RVS_{explosive} = \frac{AVS_{explosive} \times 100}{AVS_{ANFO}}$$

Absolute Bulk Strenght(ABS)

Theenergyavailableinaskidvolumeofthe explosive

- ABCforthe explosiveisitsAWSmultipliedbyitsdensity status

$$ABC_{explosive} = AWC_{explosive} \times \rho_{explosive}$$

Where$\rho_{explosive}$isthehigh densityoftheexplosiveandABCunitisareincal/cc

Relative Bulk Strength (RBS)

Ther atiooftheenergiesavailableinagivenvolumeofexplosivecomparedtoanequalvolumeofANFO [12]

- RBS forane xplosive is the ABS of the explosivedi vided by the ABS of NAFO, expres sedasapercentage:

$$RBS_{explosive} = \frac{ABS_{explosive} \times 100}{ABS_{ANFO}}$$

2.3 Calculation of parameters for explosion proof equipment

Physical aspects of development explosive crashes and mathematical model fir to dynamics formation of explosive load is described in hand. Crash explosion inside of building and rooms are characterized by not detonation but deflagration type of explosion transformation (fig. 5).

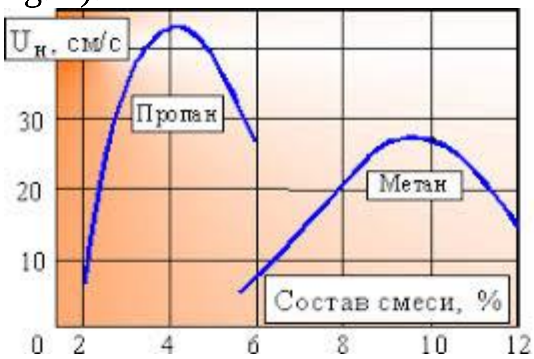


Figure 5 – Dependenceof speed normal combustion from gasoline mixture concentration

Maximum rating of speed normal combustion U_h presented by stated percentage content of gas fuel in mixture, but speed flame spreading essentially not so much as acoustic speed under deflagration explosion is implemented by cvazistatic module of blast pressure which consist of independence if blast load from space coordinates.

When calculating required area of passage explosive for pressure relieving device explosion carried out following steps: rise of pressure in protected volume in combustion of environment should be fully compensated pressure reduction in consequences of gas escapes via spout. It is required to take per unit time from quantity of gas volume:

$$G = Svr(e-1) \tag{1}$$

WhereS – flamefrontface; v – normal velocity of flamefront propagation; r – eliminate gas density; e – ratio of expansion for firing.

S, r and e values during firing process and pressure changes as well as varied, but let’s change these values for most hazardous events marking these values with index “m”.

Level change value of gas density can be expressed with following formula:

$$G_m = S_m v r_m (e_m - 1) \quad (2)$$

also

$$r_m = r_0 (\frac{P_m}{P_0})^{1/g} \quad (3)$$

Where P – pressure absolute valuein protectedvalue; g $=C_P/C_V$ – adiabatic exponent; C_P and C_V – meanheatcapacityproperlywhenthepressureiskeptconstantandconstantvolume; “o” index means initial parameters.

Atdetermining $r_m$acceptedthatthrough spout flow out cold gas fuel other than burned gas. Spoutsquaremust have calculatedinsuchawaythatinsevereenvironmentsthe pressure in protected volume was not exceeded pre – determined value P_m.

The ratio of expansion during firing vary depending on their temperature. During adiabatic compression of fuel gas in the making explosion $e_m$value can be shown depending on pressure in accordance with equation:

$$e_m = 1 + (e_0 - 1)(\frac{P_m}{P_0})^{(1-g)/g} \quad (4)$$

It is necessary for effective explosion any plant conditioned by pressure relieving of explosive the protection device can make provision of gas rates minimum:

$$G_m = S_m v r_0 (e_0 - 1)({}^{P_0}/_{P_0})^{(2-g)/g} \quad (5)$$

Asisknowningeodynamicsthatgas – weightfloatationunderthepressure P_m viainletcanbeexpressedfollowingmanner:

- Under critical conditions effusion, when$b > (2/(g+1)^{g/(g-1)}$

$$G_m = \propto SP_m \sqrt{\frac{2M}{RT}\frac{\gamma}{\gamma-1}} \quad (6)$$

- Under above critical conditions, when$b \in (2/(g+1)^{g/(g-1)}$.

$$G_m = \alpha SP_m \sqrt{\frac{\gamma M}{RT}} \sqrt{\frac{2}{\gamma+1})^{(\gamma+1)(\gamma-1)}} \quad (7)$$

Where, $\alpha -$ effluxcoefficientforrobotforinlet; $S -$ areaofpassageforinlet; $b = P_c/P_m -$ maximumrelativepressuredifferentialacrossininlet; $P_c -$ absolutepressureinspaceinwhichtakeplacegasefflux (ifventingofgascarriedoutinatmospherethat$P_c = 0.1\ Mpa$; M – gas molecular mass; T – absolute temperature of venting gas; $R -$ absolute (molar) gas constant.

The value P_m as mentioned above fixed by durability of protected object and presents maximal pressure which can be accepted from strength conditions of object. Maintains this value in formula (6) and (7) intrinsically amount to condition for maximum of mass flow G_m .

Compare with ride side of formulas (5), (6) and (7) and may be collected proportion for area of passage explosion pressure relief device:

- Subcritical conditions inlet for case, when$b > 2/(g+1)^{g/(g-1)}$

$$1.\ S \geq \frac{F_m u \rho_0 (\varepsilon_0 - 1)(\frac{P_m}{P_0})^{(2-\gamma)/\gamma}}{\alpha P_m \sqrt{(\frac{2M}{RT}\frac{\gamma}{\gamma-1})(\beta^{\frac{2}{\gamma}} - \beta^{\frac{\gamma+1}{\gamma}})}} \quad (8)$$

- above critically conditions for case, when$b \in (2/(g+1)^{g/(g-1)}$

$$\frac{F_m u \rho_0 (\varepsilon_0 - 1)(\frac{P_m}{P_0})^{(2-\gamma)/\gamma}}{\alpha P_m \sqrt{\frac{\gamma M}{RT}(\frac{2}{\gamma=1})^{(\gamma+1)(\gamma-1)}}} \quad (9)$$

whereF_m – flame front maximum space$F_m = cF_m^0$;
F_m^0 – maximum flamespacegeometricallymeasuredon the theoryatfistapproximation from point flamefireraising expandedat the whole horizon with equal speed and has spherical shape;c – flame front crocking coefficient.

This section describes calculation method of explosive loading to process equipment on exposure to external and internal emergency explosive factor. Developed construction tools for ensuring explosion proof operation of equipment is listed for present day production [13]. The offered construction of explosion proof sensory robot parameters is analyzed.

3. Compare of sensors for detection of hydrocarbon and hydrogen sulphide

3.1 The sensor for intended to use in explosive environments

The sensors within the robots play one of the critical role. Various of robot sensors find itself and visual environment. This is sensory organ: eye, ear, skin for robot.

So what is the sensors? Thesensors are device which issue stated signal subject to occurrence any specific event. This is to say sensor under specific conditions are activated and on this output analog proportional input actions or quantified (proportional input actions) or digital (binary, discretionary i.e. two eventual level) signal [14].

The sensors are divided to:

- for the purposes: measurement of efforts temperature, humidity, speeds etc;
- under the activity principles – electrical, mechanical, infrared, optical etc;
- under the transformation purposes: nonelectric quantity to electrical; thermoelectric to photoelectric; radioactive, active resistnace (potentiometer type, strange gauge type etc);

The sensory device occurs:

- contact (immediately touch);
- non – contacting (non – touch: photoelectric, ultrasonic, radioactive, optical)

Fromtheaboveweconsideronlyopticalsensors. Opticalsensors is small size electronic device able to affected by electromagnetic emissions seeing infrared and ultraviolet range gives singular or total input signals recording or controlling system. Opticalsensorsrespondtocloudyandtransduceditems, vapor, smoke, aerosol.

Optical sensor is variety of noncontact sensors since mechanical contact between active area of sensor transducer and actor to object is missing. This character of optical sensor stipulated their common use in automated control system [15]. Range of action optical sensors vastly large than with alternative type of noncontact transducer.

According to the working principles optical sensors are divided for three groups:

T type – barrier type of sensor (reception of a beam from a separate radiator);

R type - reflex type of sensor (reception of a beam reflected retroreflector)

D type – diffusive type of sensor (reception of a beam abstractedly reflexed object).

Barrier type of sensors is transmitter and receiving set reside in annex which set in opposite one another in axial alignment. The distance diversity of cases can amount to 100 meters. The items captured by active section of optical sensor breaks ray propagation. The changes are recorded by receiving set signal after treatment fed to controlled device.

Refectory type of sensor contains in their case and transmitter of optical signal and their receiving set. Areflectorisusedtoreflecttheray. The sensors of this type are actively used on the conveyor to calculate the quantity of products. To detect item with mirror reflecting metal surface in the sensor of the reflex type a polarization filter is used. The range for reflex type of sensor can reach 8 meters.

In diffuse reflection sensor the source of the optical and its receiver are in the same case. The receiver takes into account the intensity of the beam reflected by the controlled item [16]. For accuracy of operation in the sensor the background suppression function can be activated. The range of action depends on the reflective properties of the item can be determined using correction factor and with the standard target can reach 2 meters.

3.2 Electrocatalytic technology

The basis element sensors with electrocatalytic or catalytically touch control areplatinum coil coated with catalytic converter. This sensing element is heated and presence of gaseous fuel thereon the space passed reaction with ambient oxygen as a result of which take place heating catalitical element.

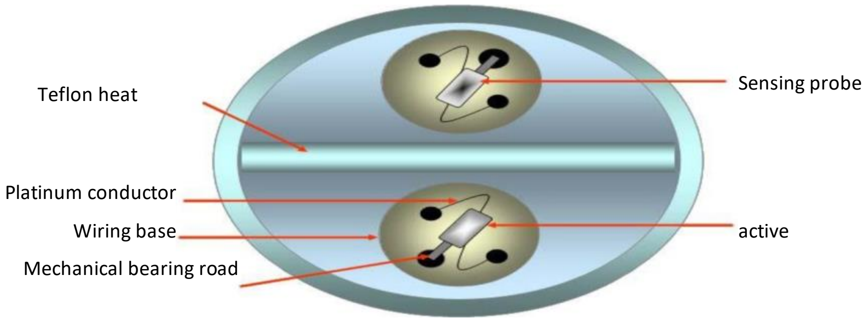


Figure7 –Transducer with catalytic sensor

This lead to changes of electrical resistance built into coil which checked in and controlled. This transducer is also used for sensor cooperation passivated glass coating. It is designed to temperature motion compensation, relative humidity and ambient air pressure without reaction to gaseous fuel which does not work way via cover. Catalyst element applied in this sensor exercises a decisive influence for accuracy and instrument service life, and also to nomenclature of gaseous fuel to detect sensor. Although catalytically sensors are used in over a period several decades for this actual technology has some defects. One of critical limitation is incapacity for working in environment with oxygen deficient since the sensor requires effective corrosion of gas hydrocarbons; oxygen concentration impact to effectiveness of oxidation, therefore it is impacted to sensor accuracy. The drawback is the possibility of sensor intoxication by chemical mixture such as organosilicon material and sulfur compounds that leading to decrease in catalytic effect [17]. Also it is possible to contamination of sensor for example, in consequence of dust arresting flow arrestor or influence heavy oil product and lubricants. Effects of pollution can appear during the system engineering services in terms of response time increment when calibrating time increment recovery after exposure, and sensitivity loss.

Considering that the operator need not know about formation such condition of electro catalytic hydrocarbon sensors are not fail – operational. The fail – operational in this instant case is regarded to the sensor capacity report to operator data on nonservice availability with different failure mode. Forexample, operatormaynotknow about toxic exposure of catalytic sensor until required calibrating gas. This lead to increase of recalibration intervals in the section where availability of catalyzer poison.

3.3 Infrared technology

Due to continuous improvement if infrared technologies Infrared hydrocarbon sensors have been created safety point detectors intended to ongoing monitoring of fuel gas and vapor convention in order to control over limits of low explosion level and emitting an alarm signal. The sensitivity of detectors is operation feasibility imstruments intended to use in zona with insufficient or excess density of oxygen, absence of necessity in current calibration for nun susceptibility to catalyst poison existence of interface to data exchange and input current 4 – 20 mA.

IR technologies also used for line of sight detectors which supply suggested point of detectors. In line system does not provide fixed capacity of ray patch at gas leakage measurement, therefore measurement results are expressed in concentration unit valued patch length. In line system has an advantages optical point detectors and designed to operate in two ranges: ppm/*meter for hydrocarbon small spills and Lower Explosive Limit * meter for more serious leakage [18].

Fuel gas catalytic sensor is widely used for detection potentially inflammable concentration at leakage and accumulation gas hydrocarbons, however its usual named disadvantages such as overexposure of sensor and its scrumming during operation in heavy conditions and oxygen demand for transducer maintenance accuracy. Due to achieved success during the last few years development of infrared technologies succeed have created sustainable at the same economy alternatives in the area of fuel gas sensors principles of operation which is based on infrared absorption.

Advanced reliability also promoted saving on cost due to reduction in requirement in engineering services in oil processing, petrochemical and gas production enterprise. As it is described in the master degree work technology of infrared absorption is active as dusting from passive technologies the most commonly encountered exercise for realization which it is reputed electro catalytic sensors.

Although infrared technology is described into master degree work step by step become preferred methods for gas detection catalytic sensors still stays the most relevant variant in case where sensor head must handle at the temperatures above 75^0C. This is due to these device fits for work at way over high temperatures (until 200^0C), which normally used devices based on infrared technologies. As well as during calibration in place of installation or on calibration using to other calibration gases in place of installation the calibration procedure of catalytic sensors may prove to be their linear characteristics [19].

The hydrocarbon sensors predicated on the principle of infrared absorption of infrared rays devoid of above described shortcomings of sensors with catalytic sensor. Due to it is stained advanced reliability and declined maintenance requirement monitoring system for many years. Infrared measuring quipment makes it possible to fall safe operation by activity of optical technologies as well as provides massage delivery about status or refusal information to operator. Gas hydrocarbon infrared detectors are divided to two categories: point type detectors and line of sight detectors.

Based on infrared gas concentration method rested infrared radiation absorption with fixed length of wave in his presence passing through gas space. The point detectors beam absorption path and it is determined by the instrument designed to be a few inches. For slight infrared detectors the beam absorption patch may be as long as 130 meters compared to several inches of point detectors. Based on infrared technology in measuring devices is used two wave length: one at the gas absorbing wave lengths are absorbed by other atmospheric constituents such as vapor, nitrogen, carbon dioxide and oxygen.

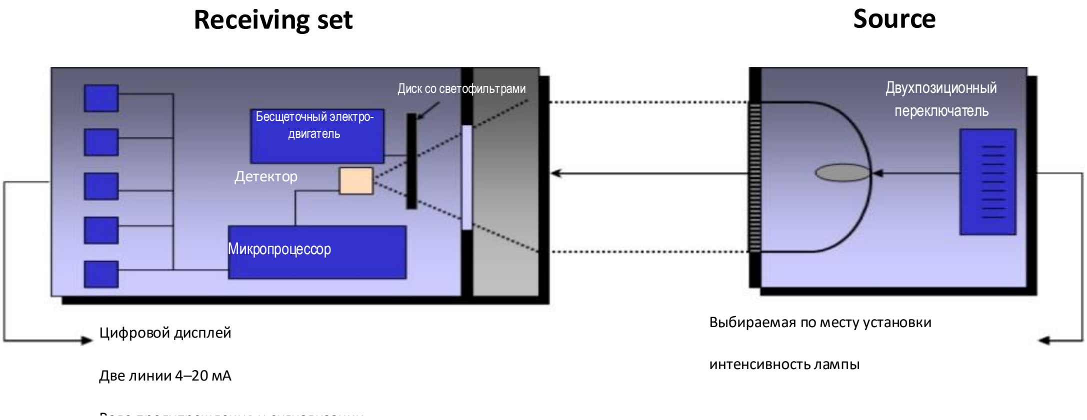


Figure8 – Patchinfrared system

Compared to electro catalytic device infrared gas detection technologies is described fail safe feature. Due to optical detection technologies are active and provide constant control with a view to sensor fault and informing users. This is goal attained for the most part through the use of the second wave length and cooperation of wave – length. As well as Infrared detectors insensible to intoxication catalyst poison, corrosion – resistance, ensure safe operation in disadvantage conditions or excess oxygen and not subject to service life decrees of sensor in case of multiple exposures. Through the use of modern high – technology optical and electric circuit of sensors are calibrated by manufacturer and little if any no require major servicing.

This is advantages of prime important is when sensors require set to in inaccessible areas where their periodic calibration is associated with complexity.

The main conclusion and findings received in this chapter is as follows:

1. Shows topicality and workability of hydrogen sulfide and hydrocarbon infrared sensors jointly with fiber – optic communication line for sensory robot operating in extreme conditions.

2. Analyzed familiar sensors for contact sensing with reference to which detected its merits and demerits as well as framed a requirements for H_2S and CO_2 sensors for sensory based system extremely robotic system.

3.4 Point infrared sensors

Gas fuel point type of detectors is used to monitoring of inflammable gaseous and vaporous hydrocarbon concentration in production sector, for example oil processing and chemical factory. If concentration of hydrocarbon gaseous and vaporous exceed lower explosive limits steam and gas mixture can fire followed by explosion. In this basis point type of detectors for fuel gas set in several tens point for monitoring gas leakage. The operation principles infrared point of sensors response on hydrocarbon gas concentration measurement in powers of infrared absorption in optical beam is named active rays / beam.

.

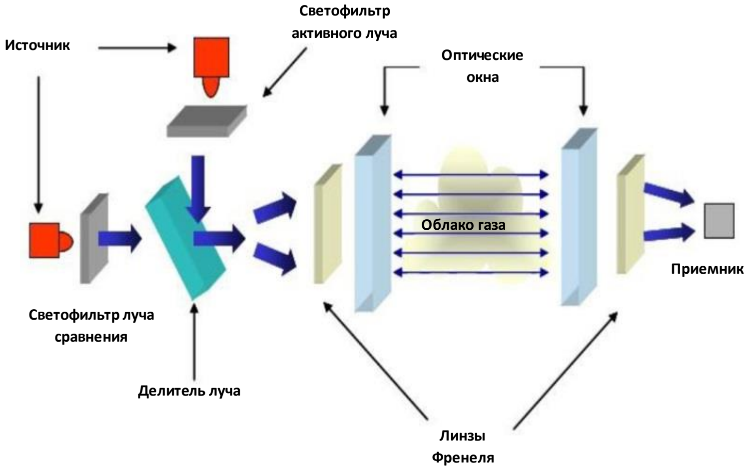


Figure 9 – Opticalschemes of point type of detector.

The second optical beam named by rays cooperation takes the same optical ways as in active beam, however its wave length is not absorbed by gas. This second beam is designed to securing fail – safe operation infrared point type of sensors in such factor which missing of electro cathodic technologies [20].

In the sensors related to use in explosive environments the two eave lengths are generated by two infrared sources which has active and reference filters included for them and pulsed alternately and guided by the optics on an optical patch. All the components of measuring sensors are installed inside of explosion proof casing with infrared optical window.

Maintains operation of infrared technology usually limited to periodic bases cleaning outside face of optical window and reflecting electrode with a view to ensuring reliable evidence. Due to availability of reliable and inexpensive electronic component and solid state infrared sensor succeed reduce the cost and ensuring economic feasibility of this technology in many area of business activities.

Typical controllable gas	Other controllable gas
• *methane*	• *isopropylamine*
• *ethane*	• *propylene*
• *propane*	• *ethylene epoxide*
• *High line gas butane*	• *Propylene epoxide*
	• *etanol*
• *pentane*	
• *Hexane*	• *methanol*
• *benzol*	

Figure 10 –Infraredgas point sensors and controlled gases.

Thesignalsfromtheinfraredsensorsareconvertedintodigitalformatandprocessed by microprocessor with assisted by gas concentration look up table and correction factor for ambient temperature variations.

The instrument has analug output 4 – 20 mA and interface signals as well as exchange data. Through the use of interface with report provided bilateral addressable data exchange suitable for data communication about signal status fail awarding and other information required for operation troubleshooting or the programming the device. As well as communication protocol allows successfully connect to 138 point sensor and when using assembler till 250 point sensor. Default configuration system connecting gas detectors with flame scanner shown in figure 11.

Локальная сеть Ethernet

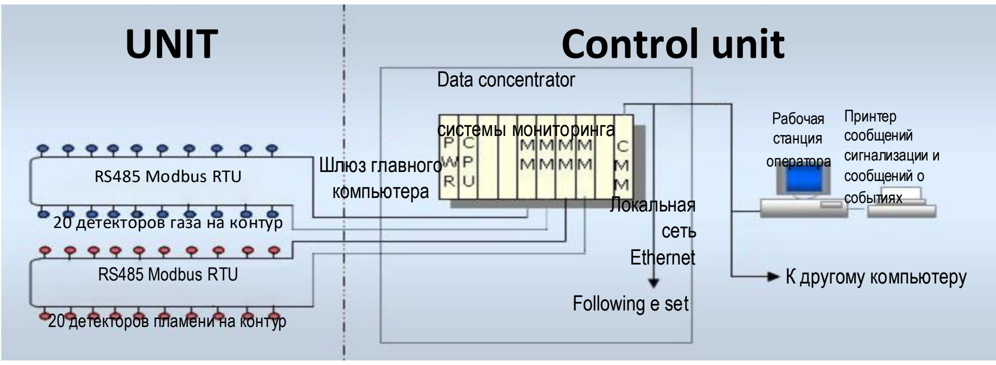


Figure 11 – Multipoint addressable system

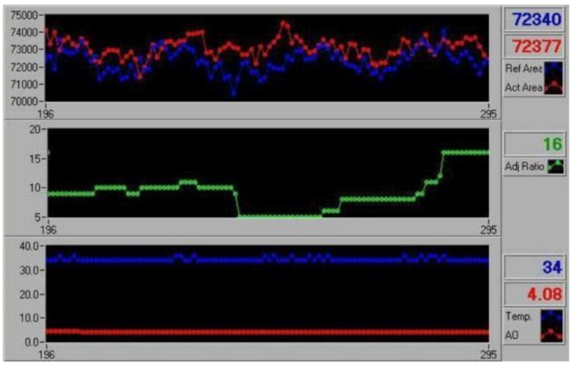
In memory of microprocessor can save look-up concentration tables with CD data of eight gases. Thegassesincluded hydrocarbon, methane, ethanoic and propanoic groups and also aromatic hydrocarbons such as benzol.

Detection of this and other gases (see the list of gases in figure 10) maybe within the limits from 0 to 100% lower explosive limit; as well as measuring instruments if required to able measure of concentration at the range from 0 to 100 vol.% . application of this infrared technologies closed due to the fact that controlled gas shall be active in relation to infrared radiation as in case hydrocarbon [21].

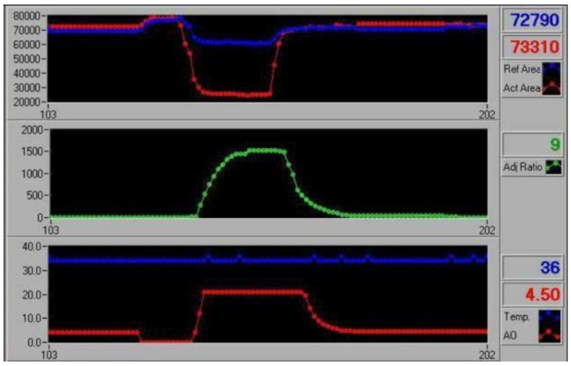
Infrared point type of detectors with design updated with the objective of ensuring in conditions absorbable wave length can also use for concentration controlling another gases except hydrocarbon.

As example such device serves infrared point type of sensor to measure of carbon dioxide concentration in the range of 0 to 5000 parts per million (ppm). This measuring instrument is created based on standard type of IR 21/00 using to optical components and colour – filters is appropriate for absorption band of carbon dioxide with wave length 4.3 µm.

Infrared gas point type of sensors is coming with software for feasibility demonstration and alignment (figure 12), whereby on screen can on a real time basis take in actual level of signal and gas concentration evidence as well as temperature and analog output 4 – 25 mA. As well as potential control of fault conditions and alarm.



Usual terms



Alarm operation conditions

Figure 12 – Software diagnostic screen infrared point type of sensors.

3.5 Open patch infrared sensors.

Open patch infrared sensor applies that the same conception underlying infrared pont type of sensors technologies but open a gate for beam to measuring gas concentration, length to amount up 150 meters as compared to inch within measuring equipment for point type of sensors. In this system is usable as return reflecting electrode and certain infrared transmitter and receiving set installed in equipment cases in explosion – proof [19].

Although open patch infrared sensor cannot serve universal solutions, they provide alternative approach in complicated cases and it should be used combined with point type of gas sensor in view limited prospects to accurate determination gas point of leakage. Open patch infrared sensors used in open air plant for monitoring air environments during loading and unloading railroad tank car, and for controlling oil and gas storage tank. Point types of sensors have application to plant rooms and potential locations of leak, in an exposed position, for example, pumping units and tanks in plant [20].

Multiple – purpose gas sensor is appropriate for using as described below housing type and service temperature range which depend up type of in used in binding construction materials. Consequently this device should be used just while conditions that equipment housing style and surface temperature on target mounting conforms such as below value:

Table 1 – Physical characteristics of gas analyzer

Binder materials	Ambient temperature range	Enclosure type
2850	from – 40^0C to + 70^0C	The enclosure certified by the certification agency any in accordance with Directive requirements EN 60079-1 and European Directive 94/9/EC
2850FT	from – 40^0C to + 120^0C	The enclosure certified by the certification agency any in accordance with Directive requirements EN 60079-7 and European Directive 94/9/EC
2762	from – 40^0C to + 180^0C	The enclosure certified by the certification agency any in accordance with Directive requirements EN 60079-7 and European Directive 94/9/EC

Universal gas sensor testing in accordance with EN 60079-1 article 15.4.2.1 maximum rise of temperature surface consisted 26.3 K. This main value shall be accepted if equipped with this instrument within unit. Universal gas sensor with connecting type 2850 dispensed only in case of enclosure and calculated as at reference pressure not above 9.6 bar.

Implementation of safety system

Before switching gas analyzer hold a survey electric wiring of terminal connections assure one of looseness including all inside of safety devices:

- power supply;
- control unit;
- peripheral detector;
- signal and output device;
- Auxiliary device connected to peripheral and signaling unit.

After initializing potential input in safety system and rating warming up period input and output signals shall be verified in safety system. Primary calibration, verification and testing shall be performed in accordance with manufacturer’s instructions and recommendations.

There is a need to examine system availability through complex function test all lines of safety system with a view ensuring required levels of alarm actuation. As well as alarm signaling of contour should be checked for refusal characteristics.

Periodic testing and calibration of peripheral device

Periodic testing and calibration shall be required to execute in accordance with manufacturer's instructions and recommendation. The testing procedure of calibration shall include control operative conditions of all optical surface and devices. If the result does not correspond to the technical specifications specified by the manufacturer, then it is necessary to produce a rebuild calibration or repair of device and replace it with non-adjustable device. Calibration interval shall be included into procedure including calibration register which issued for company or governing sites.

For the purposes of this preliminary QRA, and since the design of the ISGS pipelines is only at concept phase, it is assumed that the ISGS pipelines will be of a similar construction to the EP Sour Oil Trunkline (SOL) since the pipelines are expected to be 28" in diameter and internally CRA-clad. Therefore, the release frequencies derived for the SOL in Review of Kashagan Pipeline Release Frequencies can be used to estimate the release frequencies of the ISGS pipelines, as presented in Table 2 [22].

Table 2 – The robots segments release rates and durations

No	Segment Start (s)	Segment Duration (s)	Release Rate (kg/s)	Mass Released (kg)	Total Mass Released (kg)
1	0	5.28	5.1267	27.0687	27.069
2	5.28	8.43	3.2110	27.0687	54.137
3	13.71	10.52	2.5731	27.0687	81.026
4	24.23	12.00	2.2557	27.0687	108.275
5	36.23	14.00	1.9335	27.0687	135.275
6	50.23	31.00	873.2	27.0687	162.412
7	81.23	38.00	712.3	27.0687	189.481
8	119.23	50.00	541.4	27.0687	216.530
9	169.23	79.00	342.6	27.0687	243.619
10	248.23	81.00	342.8	27.0687	270.687
11	280.23	89.00	350.12	27.0687	272.048
12	295.23	91.00	355.52	27.0687	274.647
13	302.03	93.00	357.81	27.0687	277.147
14	315.36	96.00	363.02	27.0687	280.008
15	340.25	99.96	365.02	27.0687	282.522
16	352.06	102.01	374.02	27.0687	286.012
17	361.12	105.62	377.07	27.0687	288.123
18	380.70	112.07	382.14	27.0687	290.004

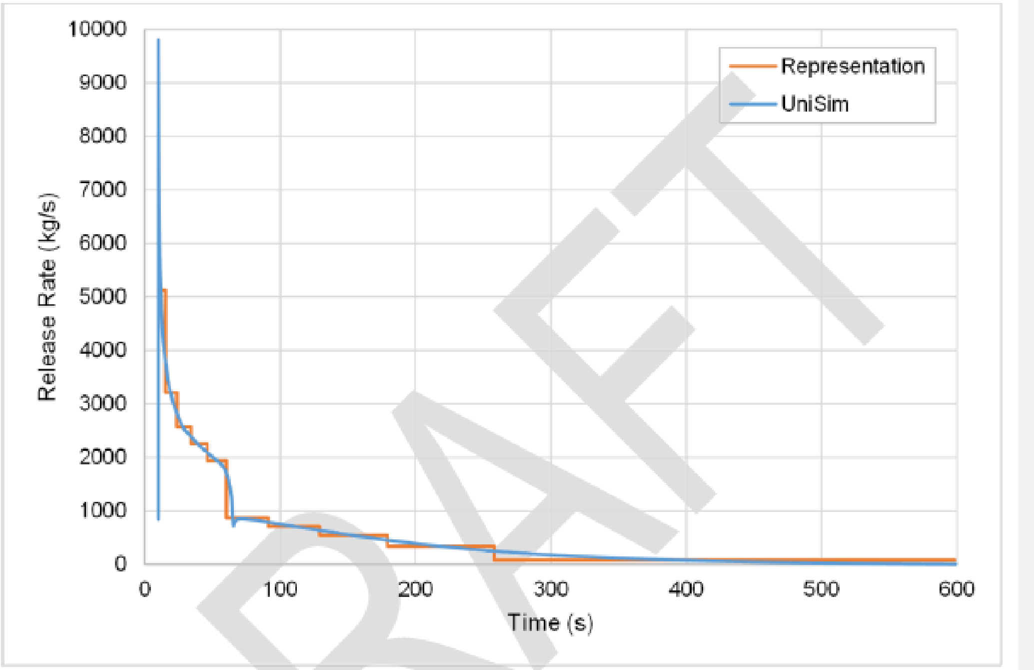


Figure 13 – Theresults and approximation with sensory robot segments

3.6 The smart sensors for detecting of hydrogen sulphide emission

In diverse fields of production sector exists performing technical control state of the environments for certain operating space, as well as large industrial facilities in whole. Important using of the individual control devices is expected for on-line monitoring at industrial projects will be growing up.

Hydrocarbon sulphide (H_2S) presents high toxic gas among the most commonly encountered pollutant in raw oil and conventional gas. Thisisnotsurprisingthatchemicalprocess and oil production sector are using control system for H_2S gas emission status for assured warning staff about dangerous emission or detecting and prevention a large emissions representative's significant hazard for staff, assets, environment and population beyond perimeter of manufactory. To eliminate probability such danger utilities operator which have in one's disposition wide variety of several sensing technologies. The electrochemical transducer, semiconductor sensor, impregnated paper and laser based patch detector are used for early warning and activate relevant automatic reactions to dangers gas leakages.

The electrochemical sensors generally is used to toxic gas detection at concentrations ranging about part per million (ppm). Electrode divided electrolyte intrinsic layer placed in small plastic case and connected with external electronic circuit. Gas makes it into sensor thorough permeable membrane at which point electrochemical reaction generated low-voltage current. As far as quantity of gas which make it into sensor / transducer take shaped gas diffusion through permeable membrane current proportional gas concentration [23].

Operating principles of solid state sensor based on changes electronic conduction on gas absorption on the semiconductor's space. In fact such sensor presents slim metallic-oxide layer supported on (spread on) silicon wafer. The production technologies of these similar intended to semiconductor manufacturing hence the name "metallic-oxide semiconductor" under which they are familiar. Gas absorption on the spot oxide followed by catholic corrosion as subsequently amended electric resistance of oxide material. The sensor face incessantly heated for rate increase reaction and minimization of the changes in ambient temperature. Thesensorfaceusually heated for increasing in speed reaction and minimizing change in ambient temperature. Resistance change morph into electrical signal proportional gas concentration.

However as such quantity of measuring controlling sensors for detecting harmful gas leakage become to identify such as to most closely correspond to uniquely requirements for each industrial consumer. A quite a bit operators pick up H_2S sensor based on only to sensibility or reaction rate on the assumption such as measuring instruments can detect few toxic gas emissions. Unfortunately such conclusion may cause to incorrect designing process safety. It is all about stationary gas detectors would be used only for maximization leakage probability of detection.

The weather conditions especially wind speed and direction nearness leakage to sensor as well as barrier or intersection their way to obstruct access to gas for sensor influence over detection efficiency. As well as volume of emission have influence with measurement results depending on type of gas detection. For example indicator paper is exact during long concentration but not suitable for determining quantitative analyzing of gas plume. Physically plant staff probably is amiss have the impression that protection level suggested by gas detection system conforms to requirements.

One of routine for H_2S detection method is solid state semiconductor sensor. The solid state sensors consist of one or more metal-oxide from transition metals such as tin oxide or tungstic oxide. This metal oxide prepares and reorganizes into paste for formation heavy gage film or heaped in the form of thin layer /films using vacuum deposition supported on silicon dioxide or aluminum oxide. This latest process similar such as are used for semiconductor fabrication consequently named by oxide semiconductor metal (MOS). That is these materials is the products of latest technological solutions can be prepared by customer required characteristics [24].

As affected by gas, gas molecules enter into reaction on the space of metallic oxide and fall into exploded ion or interhalogen compound which changes film resistance. This changes stand on physical properties of metal oxide film as well as from construction and geometrical adjectives sensory layer and temperature whereby reaction. Heater circuit raise temperature of film to diapason which provide effective sensibility and reaction time to detected gas. As well as sensor electrode beam or electrode mixture penetrate with metal oxide for measuring competence. This changes of sensor is caused by gas molecule cooperation with film is measured as signal and fully revertible. Then this signal morph into measuring instrument monitor on numerical value to displaying gas concentration.

Semiconductor devices (sensor) have the advantages in application of for safety for leaking industrial process. One of the advantages is such as parameters as reaction time and recovery. These parameters are most critical in actual practice since quick recovery detector sensibility play key role during fixation of amount of gas leaking acts and in which escape sequence it take place. Understanding danger of gas dispersion per second after emergency can assist in taking necessary solutions the staff emergency response which helps to save staff life in this sector and does not lead to aggravation of danger denervation of times safely become operational life-saver in defeat zona. In fact the sensor which rapidly renewed can provide entry for incident time referenced useful in recovery evidence during investigation. Specifically due to such properties semiconductor sensor often used in oil and gas and chemical facilities.

Theycontrolgasblastonpetroleumrefinery, offshore industrial sites, onshore assets, well injection plants many of which managing process steam containing appreciable quantity of hydrogen sulfide (H_2S). Due to rapid reaction and recovery of semiconductor sensors (solid state sensor) is well suited for plant meant to protect from large leakage in zona source with high potential emission.

Operational principle of gas sensors based on transformation measuredconcentration in electrical parameters sensor primary elements. Sensor current proportional to fractional pressure measurable air gas [25].

Central to this QRA is the assessment of the offsite toxic risk to the general public. Fatality risk due to H2S exposure is calculated using a Probit equation. Probit equations are based on dose related data and are commonly used to quantify the fatality rate for an exposed population. Probit equations are usually presented in the following format:

$$P(i) = a + bln(C \square t)$$

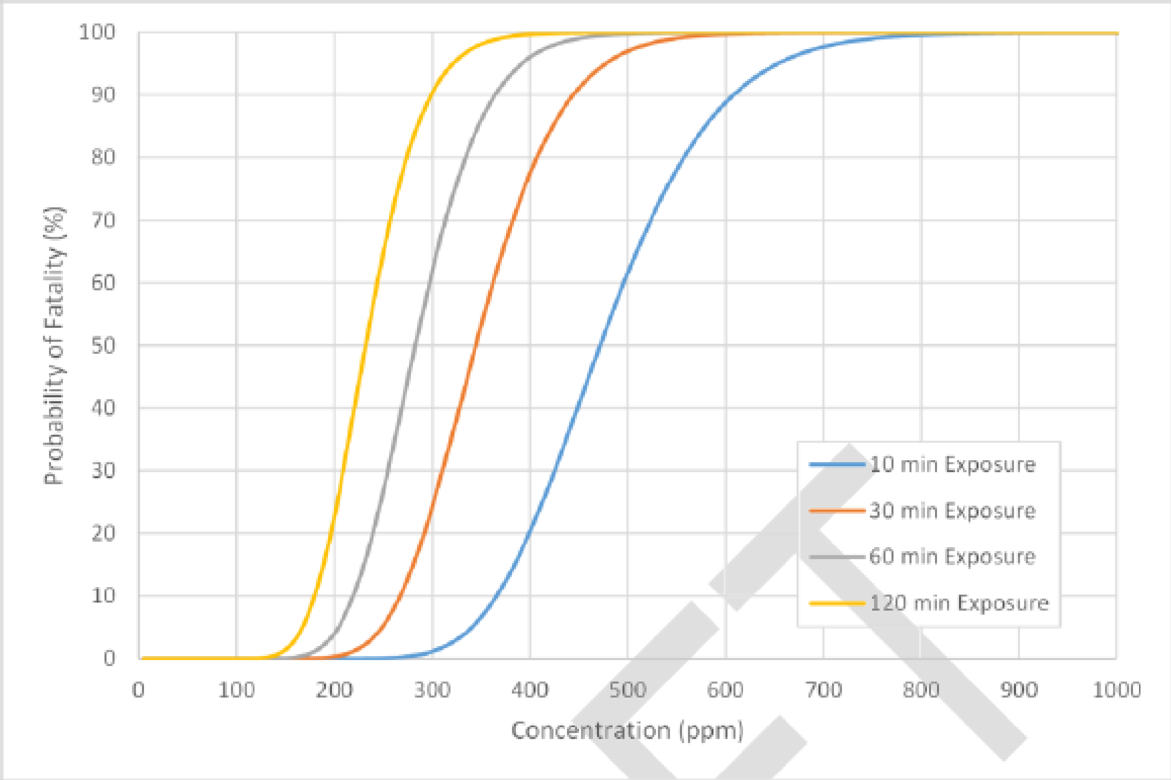


Figure 14 –Sensor response solid state condition after calibration per100ppmH_2S

When making a selection of sensor non latest role acted to fix maximum dose of gas in the standard opening mode. The semiconductor sensors as distinguished from electrochemical sensor resistant to batching high in content H_2S concentration. Consideredreactionof 4 tin oxide sensors (SnO_2) calibrate to 100 ppm, and affected to 100 – 1500 lined gas flooding and using in capacity of gas required for system charging (fig. 14). As is evident all sensors respond to incremental measurement gradually raised H_2S concentration. Readability od sensor consists 10% from enclosed gas but recovery period (T10) – 100 ppm and 1500 ppm 10 – 14 second.

Due to equal terms of using, recovery operative conditions of sensors not much varied when the sensors SnO_2 are affected H2S strong concentration within 5 minute till 20 minutes. Thefindingsofinvestigationaredescribedintable3. The table 3 is illustrated reaction time and recovery time for sensors calibrated till 25 ppm. All sensors recovered within 70 sec [26].

Table 3 – Responsetime and recovery till impact H_2S 1000 ppm

Time of exposure (min)	**Response time 50% measuring range**	**concentration,ppm**	**Recoverytimefromдo50% from starting**	**Recovery time 10%starting**	**Recovery tome from0%starting**
5	<2	0	10	15	40
20	<2	0	10	30	70

Accuracy of sensor H_2SMOSat25ppmare measured via 40 minute after H_2S filling . the different between measured evidence in a moment 40 minute and initial exploration composed 3 ppm or 12% of starting evidence.

Semiconductor sensor shows recovery properties from exposure to H_2S concentration, approached to easily inflaming layer (LEL – lower explosive limit) = 4.0% on volume). For example, while injecting 10000 ppm H_2S (25% LEL)minimumoperatingspeedofsensorrespondedwithunder 2 second exceeded range or alarm indexing when gas freeing restored about via 31 seconds. The recovery time essentially vary among sensors work for during 2 hours or less.

Table 4 – Responsetime and recovery time to impact of 10000ppmH_2S

Exposure time(min)	Response time(s) 50%measuring range	concentration,ppm	Recovery time50%starting time	Recovery time till10%starting time	Recovery time till 0%starting time
5	<2	0	35	105	240

Electrochemical element was explored for reference which exposed to 10000 ppm H_2S occupied 4 hours for recovery process. As well as within the first two hours after external actions evidence of electrochemical sensor was unstable. Device reflected a good accuracy and base line shift until after its recovery. Recovery time of electrochemical sensors shown in table 4 [27].

3.7Effective possibility of application in actual practice

The long term effects pointed stuffs can take a toll on analyzer labors. Duetohighconcentrationofthisstuffsintotheatmosphere sensitivity loss or corrosion can take place gradually whereas due to strong concentration of this process are speed up. As an illustration of this stuffs can be example:

- Organic silicone compound which frequently is contained in aluminum base grease and aerosol;
- Halogens: connection with containing fluoro, bromine, chloride and yod;
- Heavy metals, for example, tetraethyl lead;
- Acidic liquid and vapor;
- Glycol.

Availability in H_2S sensor unit zona pollution agent not always constitutes a bar to usage of smart transducers. Feasibility of using semiconductor sensors in such zona is necessary to identify evaluation path special factors in particular conditions.

Response time and recovery time is important guide for selection of hydro sulfide gas detectors. The block Sulphur recovery on petroleum refinery processed large volume flow of hydrogen sulfide. As a result these blocks have fixed hydrogen sulfide detectors with a view to ensuring required standards protection. These detectors install along the right of way access nearby potential leak source and places where can accumulate gas. Due to massive (high) concentration of hydrogen sulfide in process line even small localized leakages possessed high potential danger. As electrochemical and semiconductor sensors (transducers) connected with alarm system can assure speediest treatment of reporting production facility staff.

Defined processes improvement of crude oil production which uses carbon dioxide (CO_2) amenable MAC layer inflammation of hydrogen sulfide. In some Kazakhstan oil field $CO_2$and H_2S injection for production increase of oil, isolation of greenhouse gases and utilization H_2S. A CO2 unit processes improvement of crude oil production H_2S detectors installed nearby estuarine, well, manifold, and compressors. Whereas production module opens for environmental sectors, detectors generally are used for monitoring potentially sources with highly likely rejection or continued possibilities of larger gas emissions. Solid state detectors (sensor) are well suited to appliance due to its universality and quick recovery.

OnoffshoreindustrialfacilitiesH_2Sdetectionismostcriticalconcern. The big consideration during selection of gas detectors has to pay attention lots of parameters including H_2S concentration, process pressure, ventilation, and temperature and equipment location.

The best when electrochemical, semiconductor and laser – based sensors open loop set at the one platform for the preventing any variant if dangers leakage.

3.8 Photo electrical in frared sensors with operated current – wavelength characteristics

The mobile robotic technologies is in demandat the present time forusein differentarea essentially aligned with implementation various operations in extreme conditions presents substantive object from the management perspective. Analyzing sensory system be of some interest for creation of robots since it may be encountered necessarily as closely as fully simulate its function in automatic system.

Operational safety in chemical industry, comfortable atmosphere in production facility units leakage finding and gas compassions all of this feasible assisted by gas detectors. Accident free operation requirements and more high reliability levels production forces many users make a choice for gas infrared system. The sensors such as this type principles have impulsive energy source infrared radiation which are observed every type of gas proportionally length its wave and concentration. The wave-length of infrared radiation (IR) selected based on concrete type of gas, for example methane or carbon dioxide (CO_2). This method of detection sufficiently reliable and safe although the price of measuring instruments carried on thereon basis usually over than solution as part of pellistor. However as against pellistor infrared sensor has a certificate for operation in the midst of prompting intrinsically and explosion proof.

Operational safety in offshore installation and chemical industry it is leak detection and gas composition all of this feasible assisted by sensory robotic technician which have consisting of gas sensor. In this present work quoted the result analysis of suitable inspection tool sensory robotic regardless of physic technical and advantages this detector alternative style of sensor physically principles of operation in Infrared Detectors.

The requirements of accident-free work and more high – reliability forced several of users decide on gas infrared sensors. Such type of sensors has impulsive energy source infrared radiation which is absorbed each type gas proportionately length its wave and concentration. The wave length of infrared radiation makes it to concrete gas for example methane and carbon dioxide.

The primary advantages of Infrared gas sensors: explosion proof (explosive safety), no need oxygen availability, no need moving part, tolerance to vibration, , finding capability of concentration at ranges 0 – 100%, high quality accuracy of measurement , fine selectiveness of gases. Proposed for election type of sensory replays high level requirements applicable to modern infrared system as technologically these receiving sets realize on basis of compound semiconductor highly homogeneous characteristics in terms of area [28]. Energy diagram concerned semiconductor structure promote multispectral device electronically controlled its spectroscopic photosensitivity. In regard of integrity simplicity instrumentation and monitoring equipment infrared sensors also have advantages above pellistor as far as have no need of complicated technically diagrams high rates accuracy and for obtaining microprocessor of linearization and temperature compensating. Sensory robotics intended to environmental temperature range from – 20^0C to +40^0C. All components calculated at a minimum temperature – 20^0C and is used without exceed of relevant upper temperature limit.

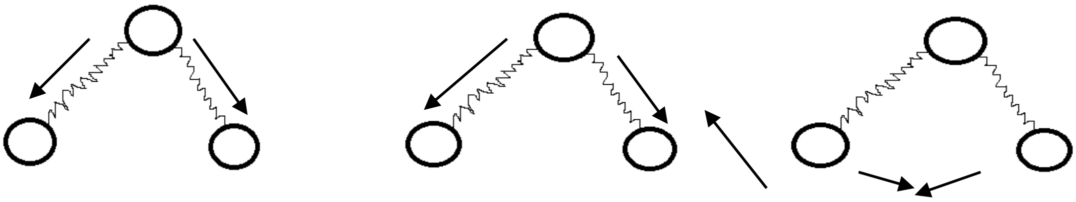
Sensory robot contains equipment emissive electromagnetic energy and radio – frequency radiation. The robot has infrared detectors hydrocarbon gas on basis of compound semiconductor. In used models is not considered noises related to generation through surface conditions, defect conditions, thermal generation in the area of space characteristics since contribution event data depend from fabrication technique of materials and device structure i.e. defect concentration of grate and surface state density at the density of dielectric and semiconducting materials. Infrared sensors for carbon dioxide detectionwith measuring range 0-5% and 0-100% find wide application in sensory robotic technician. The critical parameters responsible for directivity detection D_λ and temperature t are: phase generation rate $g_{th}$and effective collection efficiency η determination selected the materials n-type of conductivity:

$$g_{th} = \frac{n_{th}}{\tau} \quad (10)$$

$$\eta = \frac{(1-R)(1-\exp(-\alpha t))}{1-R\cdot\exp(-\alpha t)} = \alpha t, (\alpha t < 1) \quad (11)$$

where,n_{th}-carrier concentration subject to thermal generation;τ–filler carrier lifetime;t-photosensitive element thickness;α-material absorption coefficient.

Gas evaluation is measurement of the output signal formed by transformation gas absorption infrared radiation.Infrared radiation this is the part of electromagnetic spectrum usually absorbed by gas molecules (incident reactants). When emission wavelength alignswith natural frequency of vibration molecule its energetic rates are varied. In other words vibration amplitude of atom is accrued during absorption for emission with fixed length of wave. Absorption of infrared radiation intensifies gas heat. Infraredradiationisreactivewithdipolemoleculeofgas. Molecular dipole shaped when molecular vibrations non symmetric with respect to different atoms else situated non symmetrical ways. The atom deforms inter atomic bonding which forms dipole moment. It is shown in picture 15 for CO_2 molecules.



a) b) c)

Figure15 –Oscillation of the atoms in molecule CO_2:

a)symmetrical

b)asymmetrical

c)deformational

Thesymmetricalmoleculeisnotferment by infrared radiation, since it is not created dipole. Somedouble (binary) moleculesO_2,$H_2$and$N_2$is a primary examples with symmetrical molecules which has symmetrical (fig. 15 a) and asymmetrical (fig. 15 b) vibration direction. The radiation rate of gas molecules depending on wave length is absorption spectrum.

Application of the infrared radiation provides variety of advantages in cooperation catalyst method with identifying chemical constitution and gas concentration. The main key aspects of this methods was that narrow bandpass filter emission is used with certain infrared sensors for detecting several diapasons (ranges) gas absorption spectrum in specific range of wave length. In case of complex chemicaltreatment of molecule presents critical vibration series (sympathetic). Usual it is look like enlistment absorption peak on diagram built on extension ration length. It is called as absorption spectrum. Absorption gas spectrum is demonstrated in figure 16 which can be defined with infrared sensor of sensory robot. The reaction time and recovery time detectability detection of infrared sensors is shownin table 5

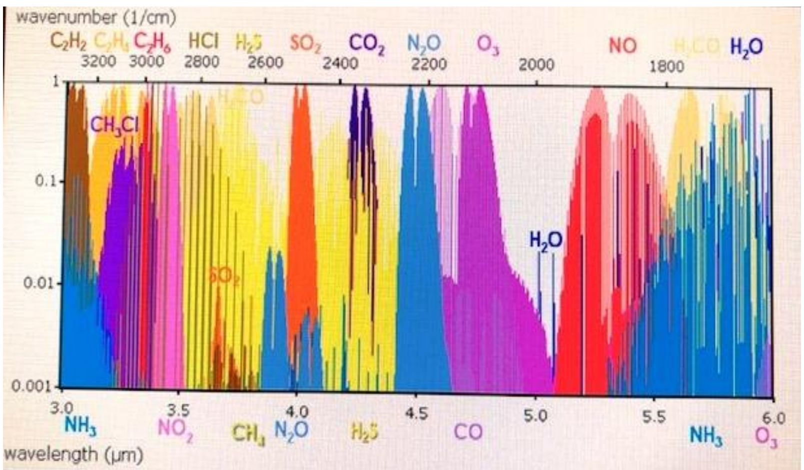


Figure16 – Infraredspectrogram of water vapor, nitrogen oxide vapor, hydrogen sulphide vapor, sulphur oxide vapor and carbon dioxide vapor

Selectionofwave – length for detecting o gases controlled by current output spectrum of the infrared emitter. Theabsorptionspectrum of water shown strong absorption at length waves less than 3.5 – 8 and after 16 μm. if spectral line definable of gas resides in this range then hindrance presents due to presence humidity. Consequently the best results of the work have on 8 – 16 and 3 – 5 μm, where spectral line of more quantity of the gas planted.

Table 5 – Responsetime and recovery before impact of the 10000 ppm CO_2 and CH_4

Detected gas	Response time of measured range 50%	Concentration, ppm	Recovery time before 50%from starting process	Recovery time before 10% from starting process	Recovery time before 0% from starting process
0-100%CH_4 0-50%CO_2	T90<30c T90<10c	5ppm (0-2000ppm) 10ppm (2000-5000ppm) 20ppm (5000-10000ppm)	35	105	240

The sensors installed within the sensory robot the spectrum ranges 3 – 5 μm is selected due to following reasons:

1. Large quantity of the absorption lines in the range of 3-3.5 μm spectrum for hydrocarbon and carbon dioxide (fig. 16).
2. Thestandardinfraredlampwithglasspackageemittedradiationspontaneouslywith wavelengththill 5 μm. The range above 8 μm is required for apply the most expensive infrared source. As well as rate accuracy the line of absorption is declined, therefore this range shall be used sparsely. Therange 5 – 8 μmdoesnotusedasperabovementionedprinciples.
3. Therearenogasabsorptionlinesatthewavelength 4 μm which makes it possible to reference signal herein spectrum.

Emission intensity after absorption (output wavelength) compare with intensity till absorption (reference signal) [28].

The frequency analysis combines parts counting with release frequencies per part per year to arrive at the total release frequency for each particular isolatable section of the pipeline or associated equipment. The event frequency of particular consequences (e.g. due to toxic gas, jet fire and flash fire) is then derived from the release frequency by application of event tree probabilities of, for example, ignited events (jet fire, pool fire, flash fire and explosion) and non-ignited events (toxic releases). It provides more detail on the event trees and how the frequency of release for each isolatable section has been determined in this study.

For most failure mechanisms, the apportioning between hole sizes (i.e. 22 mm, 70 mm and FBR) is completed based on historical data. However, for some failure mechanisms which cause sharp, crack-like defects, it is known that there is a maximum crack size which can be sustained before the crack propagates, resulting in a FBR. The length of such a crack will vary, depending on pipeline material, welding and operating pressure and temperature characteristics; values corresponding to the EP Sour Gas Trunkline (SGL) and EP SOL have been calculated in a separate study and were found to be equivalent to a hole of the order of 10 mm in diameter or less.

One important input to the event tree is probably of ignition since this governs the likelihood of thermal hazards and also whether toxic H_2S will be combusted to form SO_2 which is also toxic. The probably of ignition is calculated using the appropriate correction and the release rate, this is discussed in more detalils in the test report. It is noted that probability of ignition for offshore sections of pipeline is assumed to be zero since these are underwater.

The result in two separate toxic gas dispersion consequences for Offhsre plant of sour pipelines:

1. Dispersion of H_2S;
2. DispersionofCO_2asaresultofcombustionofH_2S.

Although in these cases there will also be a thermal radiation hazard from the fire, the effect of the toxic gas dispersion is much more onerous as this reaches a far greater downwind distance. Therefore for offshore plant only toxic gas consequences are included in the measuring instruments model.

The toxicity of the CO_2 and H_2S for unignited release and CO_2 for ignited release is assumed to be dominant, and therefore flammable effects are neglected. Flammableeffectsi.e. those due to thermal radiation form jet, pool, and flash fires, have a relatively localized effect whilst harmful concentration of toxic gases can persist a considerable distance from the release point. The probability of ignition of all other representatives'whole sizes is much smaller, and therefore all such releases are assumed unignited.

The release temperature will also vary considerably as a result of variations along the length of the pipelines of both operating pressure and operating temperature, so it is necessary to consider the full range of possible release temperatures and not just those corresponding to the locations modelled above. There will also be a variation in operating pressure and temperature due to seasonal variations in the ambient temperature and production flowrate.

The gas fraction of the FBR releases as modelled by UniSim is buoyant. However, for conservatism it is assumed that unignited releases are neutrally buoyant for the purposes of modelling FBRs with ADMS 5.1. For non-FBR releases modelled with PHAST, PHAST typically calculates very low temperatures for flashing releases, and therefore such releases are usually initially negatively buoyant resulting in larger consequence distances which is conservative.

For the proportion of FBRs that are assumed to ignite, H_2S will combust to produce SO_2, which is also toxic. Assuming complete combustion, it is possible to calculate the release rate of SO_2 as the release rate of H_2S multiplied by the ratio of molecular weights (64.066 / 34.0809 =1.8798) [27].

In this case the CO_2 emitted from the fire is not hot and has muchgreater buoyancy that the relatively cold H_2S release.

Therefore, the toxic consequences due to SO_2 for the proportion of ignited full bore releases from the sour gas and sour oil pipelines have been included in the risk calculation, for 10D conditions only. The toxic consequences for ignited events in all other weather conditions are assumed negligible.In the event of an ignited release from a pipeline carrying sour fluid, sulphur dioxide (SO_2) will be produced due to the combustion of H_2S.

The QRA Methodology and Ruleset [Ref. (5)] does not recommend a probit for SO_2, and for simplicity the TNO probit for SO_2 included in PHAST 7.11 has been adopted. The TNO probit for SO_2 has constants of a = -16.76, b = 1 and n = 2.4. The relationship between concentration, exposure time and probability of fatality for this probit is illustrated in Figure 4.9. In comparison with the H_2S probit shown in Figure 4.8 it can be seen that SO_2 is considered to be less toxic than H2S since a higher concentration and/or longer exposure time is required to achieve the same probability of fatality based on the probits used in this study.

The semiconductor equipment resistant to heighten an effect H_2S and recovered during 30 seconds with decreesing 100 times acceptance limit. Such universality makes a sensor ideal when making a selection for many units where potentially gas emissions are intiteled to wide range.

The sensors widely used in North America, in Middle East, and East Asia. In research report conducted by Canadian Association of Petroleum. Producers research workers find out that sensors H_2S with fixed square justify and exceed expectations on leak monitoring of gas 10 ppm and 15 ppm. Some direct commercial users mounted sensors fixed square in the first istance for worning operator about leakage and equipment hardware fault in industrial area which often kepp unoccupied.

At the daub sector of gas loss quick recovery of semiconductor detectors lead to safety system availability. The valves would be isolated earlier suction device for ventilation living quorters and control models would be automatically closed in time to prevent getting into and process increased, ventilation unaffected modules can be carried on more effective [30]. The system availability improves safety. A quick recovery also provide further insight into seriousness and scaling up danger as much as change a gas concentration con be controlled with the course of time.

Conclusion

Overthepastfewdecadesmodernrobottechnicianandsensortechnologiesconnectedwiththem developed with rush tempo, obtaining ever-greater potentially for use of robotic technician in diverse of the area in human activity. Therobotscienceisluckycombinationofpracticeandscience. Sensor packages of robots constitute the major position of information and measuring systems, the main function is issuing, providing and forming information, data on the status of the facilities and process activities in environment and performance of the required information of itself robot [31].

The sensitive device or transducers it is the primary measuring sensors which responding to the slated for exposure value (temperature, pressure, power current etc.) and modified to other value readily for further use, produce the signal and availability of the intensity. This signal can be either physical nature of definable mode of functioning sensitive device. Therefore this type of sensors was selected to analyzing major topics of this master degree dissertation.

The main results and conclusions received from dissertation paper are outlined as follows:

1. Shown the topicality and potentially for using infrared sensors of hydrocarbon and hydrogen sulfide in combination with fiber optic lines for sensory robots operated in extremal conditions. Carried out analyze of familiar sensors for contact sensing with reference to which detected their merits and demerits as well as stated requirements to H_2O and CO_2 sensors for sensory system of extremely robotic industry;
2. Investigated mathematical model of sensor (transducer), conducted comparative analysis consummate detectability of various type of infrared sensors (transducers) with controllable current wave length characteristics. Testify to the fact that proper sensors on semiconductor basis commands superior property for operating in spectral range 8 – 12 μm. Consequently, made it clear that advanced for new generation infrared system is detectors in terms of structures with variable spectrum response. This type of optical receiver is armed with higher operating temperature for wave length range 8 – 12 μm. investigated photovoltaic performance of transducers (sensor) on semiconductor helium, cadmium, titan bases. Made it clear that while using subsurface graded-gap base it is possible to prevent reduction of then volume lifetime due to influence (effect) wall (surface) recombination which resulting in raise directivity of sensors (transducers).
3. Define time parameters of mechanical effect response of mechanical effect for transducers on semiconductor bases. On a scale own activity of the many industrial facilities elaborates toxic materials in concentration in several occasions in excess of admissible exposure limits. For this reason it is conceivable that gas detection systems mounted for warning staff about dangerous of emissions will fall under high impact. In those circumstances, gas detection system should be quick reaction and quickly restored.

Semiconductor based measuring tools resistance to H_2S hazardous gas and recovered fewer than 30 seconds over rise 100 times doses (exposure) acceptable limits. This generality of these sensors shaped improvable during emissions for several units where potential gas emissions would have wide range.

The large scale of the field of application operating results depend on peak sensibility of the detectors (sensor) and speed work single photon sensors in terms of under consideration of this nano-structurer will achieve substantial advances in fiber optic technologies, quantum cryptography theory based, computer system, radio astronomy pharmacology, medicines, and safety – control system etc.

The practical relevance of this work semiconductor sensors mounted in sensory robot is as optimum tools for detecting H_2S and CO_2 gasses in oil and gas industry and chemical sector with Kazakhstan.

List of reference links

1. Солопчико Г.Н. Измерительные информационные системы / СПб.: изд. Политехнического университета, 2012 -17 с.
2. Sensabot Technical manual, 2017 – 7 p.
3. Каляев И.А., Мельник Э.В. Децентрализованные системы компьютерного управления / - Ростов на Дону: ЮНЦ РАН, 2013 – 32-33 с.
4. Попов А.В., Юревич Е.И. Роботы с силовым очувствлением, СПб. АСТЕРИОН, 2008 - 77 с.
5. Paul Smith, Ian Peerless, Berry Mulder, M.Nigmetov: Sensabot Mark II Operations and Maintenance Manual, Netherlands, 2018 – 7 – 41 p.
6. Berry Mulder, Adam Serblowski, M. Nigmetov:Sensabot project. Technical specification for implantation of LTE solution in a container, Netherlands, 2016 – 18-22 p.
7. Keaton Mowery, Sarah Meiklejohn Heat of the moment: Characterizing the efficacy of thermal camera based attacks./2008. – 8 – p.
8. Journal Akpar, Caspian SeaCharacteristics of Marine Natural Environmental conditions. 2017, 5 – 8 p.
9. Юревич Е.И. Сенсорные системы в робототехнике: учеб. пособие/ Е.И.Юревич. – СПб: Изд-во Политех. Ун-та, 2013 – 7 с.
10. Юревич Е.И. Основы робототехники: учеб. пособие. – 4-е изд., перераб. И лоп. – СПб: БХБ-Петербург, 2017. – 304 с.
11. ТР ТС 012/2011 О безопасности оборудования для работы во взрывоопасных средах: утв. 18 октября 2011 года, №825 // ИС ПАРАГРАФ.-2013, февраль -15.
12. ГОСТ Р 52350.29.4- 2011 (МЭК 60079-29- 4:2009) Взрывоопасные среды. Часть 29-4. Газоанализаторы. Общие технические требования и методы испытаний газоанализаторов горючих газов с открытым оптическим каналом. Введ. 05.10.2012 – М: Стандартинформ, 2012 – 11 – 17 с.
13. MSAThesafetycompany. Стационарные системы обнаружения газа и пламени. Обзор ассортиментов продукции. – 2018. №2 – с. 7-10
14. General Monitors. Intelligent Sensor for gas detection. – 2015. – с. 3-4
15. Offshore environmental survey annual report 2016 Rev. No. 1. – 370-374, 1050 с.
16. Anderson R. Why cryptosystem fail. In proceeding of CCS 2007, p. 215-217
17. Van Eck.W. Electromagnetic radiation from video display units: /Computers and Security 4, 4./2004. 269 p.
18. ТР ТС 010/2011 О безопасности машин и оборудования: утв. 18 октября 2011 года, № 823 // ИС ПАРАГРАФ.-2013,октябрь -18
19. Industrial automation and drive technologies. Products and system for use in hazardous area, SIEMENS AG Brochure, November, 2010: 12 p.
20. ГОСТ 12.1.072-98. Роботы промышленные. Роботизированные технологические комплексы. Требования безопасности и методы

испытаний. – взамен ГОСТ 12.2.072-82; введ. 20.07.2010 – Минск: МГС, 1998 – 6 с.
21. ГОСТ 26050-89. Роботы промышленные. Общие технические требования. – взамен ГОСТ 26050-84; введ. 01.01.1990 – ГОССТАНДАРТ: 2016 – 12 с.
22. General Monitors by MSA Intelligent gas sensors, General operation manual 10-16, 2016. - №10-16
23. Factory Acceptance Test Report//US/UL ExTR16.0034/00
24. Factory Acceptance Test Report//US/UL ExTR16.0021/00
25. Factory Acceptance Test Report//US/UL ExTR16.0022/00
26. Factory Acceptance Test Report//US/UL ExTR16.0031/00
27. Factory Acceptance Test Report//US/UL ExTR16.0019/00
28. Factory Acceptance Test Report//US/UL ExTR16.0028/00
29. Factory Acceptance Test Report//US/UL ExTR16.0030/00
30. Уэйн Р. Основы и применения фотохимии: - Мир, 2003 – 304 с
31. Стариков В.И. Столкновение спектральных линий поглащения молекул атмосферных газов: // Изд-во Института оптики атмосферы СО РАН, 2006. – 308 с.