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TECHNICAL SPECIFICATION FOR DESIGN PHILOSOPHY OF FIREFIGHTING SYSTEM FIRE & GAS DETECTION SYSTEMS

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SUMMARY

ATTACHMENTS

1 INTRODUCTION AND SCOPE

Scope of this document is to define the general fire protection philosophy and to identify the minimum requirements of the fire protection devices to be applicable to ORC plants whatsoever they are configured.

The present document represents an internal EXERGY Technical Specification that is applicable to all ORC plants developed by the Company either its Clients have specified or either not fire concept (or philosophy) or technical requirements for the fire protection measures.

Philosophy describes fire fighting and fire proofing systems – in term of active/passive measures - as well as flammable gas detection ; combination of such systems, following an integrated approach to safety, has the following objectives :

a. to reduce the probability of occurrence of significant fires
b. to limit the escalation of them (“domino” effect reduction)
c. to limit the hazards for operators and properties related to flammable clouds diffusing throughout the plant and the surrounding areas where is ha been built

The definition of fire fighting / fire proofing systems and fire&gas detection systems described in the present Technical Specification is based on a fire zones analysis.

Specific issues that can affect the fire philosophy must be taken into account time by time for each single project during its development and this fire fighting concept review should be responsibility of EXERGY in conjunction with the ORC plant End-user ; the meaning of “specific issues” refer to following elements (but not limited to them):

- internal escape routes, accessibility to site (gates) and to ORC plant
- buildings present in ORC area (offices, Control Room)
- technical area / buildings (transformers, high/low voltage rooms, PLC Room, warehouses, etc.) and their ventilation systems
- classification of areas surrounding the ORC plant
- further process areas or sections not related to ORC plant but that can interfere and impact with ORC and its safe operability, including existing facilities (if any)

According to this last issue, it must be clearly highlighted that, if ORC plant is installed beside other existing factories, a comprehensive integrated risk assessment between the ORC plant and the existing process sections may be performed in order to evaluate eventual further hazards which can require specific protection devices ; this means that, for each ORC project, the Basic Design and the Detailed Engineering of the Fire Fighting / Fire & Gas Detection Systems can be different from Job to Job and they must have a dedicated design for each project.

Fire system and gas detection shall be checked, tested and in working condition before the ORC plant and the other related systems are commissioned or working fluid is introduced into the ORC plant.

Further specific Fire Fighting / Fire & Gas Detection Systems requirements should be issued by the Insurance Company ; because of these requirements could not be defined from the beginning of the ORC project development, as soon as the Fire Fighting / Fire & Gas Detection Systems concept will be considered in the project development, these requirements must be inserted and applied together with the Standard and Codes listed in next Paragraph 2.

1.1 Abbreviations

FFS : Fire Fighting System

FDS : Fire Detection System

GDS : Gas Detection System

F&GDS : Fire & Gas Detection System

1.2 ORC plant general description

The ORC process is based on ORC-Cycle performed by a process Unit which in general consists of :

- heat exchangers
- working fluid expander with generator
- feed pumps
- air (or liquid) cooled condenser
- auxiliary equipments

Plant is managed by an automatic PCS (Plant Control System) installed in a Central Control Room (CCR) with constant surveillance from operators ; normal operation and transient modes (start-up, shut down, trips) are also controlled by the PCS.

The ORC process can be formed by a single ORC Unit or, in some cases, by two identical Units working in parallel with two different pressure levels ; moreover, the ORC Unit can be built in an open area or in a dedicated building and the plant can be realized in site exclusively dedicated to ORC plant or inside an another industrial site.

All these possible ORC Plant / Units have been considered for the development of present Technical Specification for the fire fighting systems, the Fire& Gas detections systems and the other safety devices necessary to fight a fire or reduce the occurrence of vapours explosion or a fire spreading outside the ORC fence plant.

1.3 ORC hazardous chemicals

All ORC plants have Isopentane or n-Pentane or Cyclopentane, as working fluids, while for

the heat transfer fluids it should have two different main configurations :

a. heat to ORC process provided by geothermal vapors and brine or
b. by hot oils such as Dowtherm Oil or Therminol Oil or similar heat transfer medium

In the following Table 1, for each chemicals taken as key hazardous fluid, the main fire hazards properties and preferred extinguishing agents have been indicated (refer to attached MSDS in Annex 1 for further details or specific data from manufacturer).

Table 1 – List of flammable / combustible ORC chemicals

Chemical	Hazard	Properties	Prevention	Exting. medium
Isopentane	Extremely Flammable	Boiling point : 28 °C Flash point : < -35 °C LEL - UEL : 1.3% - 7.6 % Autoign. temp. : 420 °C Vapour density : 2.185 (air = 1)	No open flames, no sparks, no electrostatic discharge and no smoking	Water spray, foam alcohol resistant, CO2, powder
n-pentane	Extremely Flammable	Boiling point : 36.2 °C Flash point : < -40 °C LEL - UEL : 1.4% - 7.8 % Autoign. temp. : 285 °C Vapour density : 1.873 (air = 1)	No open flames, no sparks, no electrostatic discharge and no smoking	Water spray, foam alcohol resistant, CO2, powder
Cyclopentane	Flammable	Boiling point : 49.2 °C Flash point : < -37.2 °C LEL - UEL : 1.1% - 8.7 % Autoign. temp. : 361 °C Vapour density : NA (air = 1)	No open flames, no sparks, no electrostatic discharge and no smoking	Water spray, foam alcohol resistant, CO2, powder
Dowtherm oil (*)	Combustible	Boiling point : 257 °C Flash point : 113 °C LEL - UEL : 0.5% - 6.2% (at 260 °C) Autoign. temp. : 599 °C Vapour density : 3.44 kg/mc (at 250 °C)	No open flames, no sparks and no smoking	Water, foam, CO2, dry chemical
Therminol oil (§)	Combustible	Boiling point : 359 °C Flash point : 170 °C LEL - UEL : NA Autoign. temp. : 399 °C Vapour density : NA	No open flames, no sparks and no smoking ; avoid contact with strong oxidizing agents	Water, foam, CO2, dry chemical
Delco Term SolarE15	Combustible	Boiling point : NA Flash point : 200 °C LEL - UEL : 0.9% - 7.0% Autoign. temp. : >300 °C Vapour density : NA	No open flames, no sparks and no smoking, no electrostatic discharge; avoid contact with oxidizing agents	Foam, CO2, dry chemical
Delco Term SDBT	Combustible	Boiling point : NA Flash point : 200 °C LEL - UEL : NA Autoign. temp. : 470 °C Vapour density : NA	No open flames, no sparks and no smoking, no electrostatic discharge; avoid contact with strong oxidizing agents	Foam, CO2, dry chemical

(*) The physical properties refers to Dowtherm A ; in case of different Dowtherm oil, these data must be modified and considered in developing the fire fighting systems

(§) The physical properties refers to Therminol 66 ; in case of different Therminol oil, these data must be modified and considered in developing the fire fighting systems
NA : Not Available

1.4 Ambient conditions

During firefighting and fire&gas detection systems design, the environmental conditions can greatly affect the design and lay-out of these systems ; therefore, the following environment aspects must be considered:

- presence of possible inhibitors and/ or poisoning pollutants for gas detectors, in particular for catalytic detectors (such as H2S or chlorides in the atmosphere)
- dust and/or salty fogs or particulates that can affect the flames or gas detection
- wind strength and direction (rose wind for ORC site must be available) for the gas detection system design
- freezing and snow conditions

2 APPLICABLE CODES AND STANDARD

The concept design of FFS and F&GDS must be developed in compliance with the local Laws and Regulations of the country where the ORC plant will be built ; nevertheless, the minimum requirements for the FFS and FGDS of the ORC plants must those here below described in :

- Paragraph 4 – Sub-parts 4.1 / 4.2 / 4.3 / 4.6
- Paragraph 5 – Sub-parts 5.1 / 5.2 / 5.3
- Paragraph 7 – Sub-parts 7.1 / 7.3
- Paragraph 8

even if the national Laws / Regulations requires a less protection level for the fire fighting systems.

As soon as the concept design FFS and F&GDS has been developed, the firefighting system and the fire&gas detection systems should be designed in accordance with the major Standards well-recognized internationally such as the NFPA Standard or the European Standard EN ; at least, the following Standards must considered in the project :

NFPA Standards

NFPA 1 – Fire Prevention Code

NFPA 10 – Standard for Portable Fire Extinguishers

NFPA 14 – Standard the Installation of Standpipe, Private Hydrants and Hose Systems

NFPA 20 – Standard the Installation of Stationary Pumps for Fire Protection

NFPA 25 – Standard for the Inspection, Testing and Maintenance of Water-based Fire Protection System

NFPA 30 – Flammable & Combustible Liquids Code

NFPA 72 – National Fire Alarm Code

UNI and EN Standards

UNI 10779 – Impianti di estinzione incendi - Reti di idranti - Progettazione, installazione ed esercizio

UNI 11224 – Controllo iniziale e manutenzione dei sistemi di rivelazione incendi

UNI 11280 – Controllo iniziale e manutenzione dei sistemi di rivelazione incendi

UNI 11292 – Locali destinati ad ospitare gruppi di pompaggio per impianti antincendio - Caratteristiche costruttive e funzionali

UNI 9795 – Sistemi fissi automatici di rivelazione e di segnalazione allarme d'incendio - Progettazione, installazione ed esercizio

UNI EN 15004 – Installazioni fisse antincendio - Sistemi a estinguenti gassosi, Parti 1 ÷ 10

UNI EN 54 – Sistemi di rivelazione e di segnalazione d'incendio, Parti 1 / 2 / 3 / 4 / 5 / 10 / 11 / 14 / 23

UNI EN 671– Sistemi fissi di estinzione incendi – Naspi, Idranti e manutenzione, Parti 1 / 2 / 3

CEI EN 60079-29-1 : Atmosfere esplosive, Parte 29-1: Rilevatori di gas infiammabili - Requisiti generali e di prestazione

CEI EN 60079-29-2 : Atmosfere esplosive, Parte 29-2: Rilevatori di gas infiammabili - Scelta, installazione, uso e manutenzione dei rilevatori di gas infiammabili e ossigeno

3 FIRE PROTECTION SYSTEM – GENERAL CRITERIA

Mitigation measures in term of Active Fire Protection (AFP) and Passive Fire Protection (PFP) must be adopted to reduce or delay the potential escalation and consequences of a developed fire or a potential situation in which a fire can occur or flammable vapors can be burst.

Active Fire Protection (AFP) systems must be provided in defined zones of ORC plant and must be appropriate to hazards connected with the area characteristics (lay-out, other facilities, etc.) and/or possible domino effects ; Active Fire Protection (AFP) objectives are :

- ❖ to control and extinguish a fire within an area and limit it to this area
- ❖ to maintain structural integrity to enable evacuation to take place
- ❖ to reduce damage for the environment
- ❖ to reduce damage to installation and surrounding equipment, installation

The installed systems shall be actuated primarily from a manual intervention on an alarm activated by means of a fire or a gas detection systems ; Active Fire Protection (AFP) fixed systems must be also supported by mobile and portable fire fighting equipment to enable intervention in a early phase of fire development.

Passive Fire Protection (PFP) should be installed to mitigate the possible damages caused by fire by preventing the escalation of a fire for a limited period of time until full fire fighting capabilities can be deployed in order to extinguish the fire itself or to put the accident under control ; Passive Fire Protection (PFP) must not be considered as a replacement of AFP means.

In the definition of AFP / PFP systems and detection systems for the potential fire hazards related to ORC process and plant, the following considerations have been taken into account and appropriate methods of fire control and extinguishing actions have been selected :

- ➢ health care and life safety for the operators and people in general
- ➢ predominant flammable and combustible materials present in ORC plant
- ➢ avoidance of a fire spreading to all ORC plant and, if possible, extending to other areas outside the ORC plant

3.1 Extinguishing agents

The permanent fire fighting systems will be designed considering the effectiveness of the two usable agents ; compatibility and performance of a different extinguishing agent for a specific chemical must be verified carefully with the use of MSDS and available literature.

Water

Water must be used as the primary agent for fire protection ; nevertheless, its use must be considered with the following aims :

- to cool metal by applying water directly on the protected surfaces to prevent thermal damages and rupture from flame exposure or radiant heat
- to prevent ignition by cooling potential ignition sources and by quenching vapors released from equipment and / or piping damaged by flame exposure
- to control fire intensity by spraying water on equipment or area where a fire is likely to originate from leakage or where fire fighting would be unusually difficult in order to control the burning rate and thereby limit the release of heat from the fire until the combustible is eliminated or extinguishment provided.

Water must not be used on electrical installations with execution less than IP55.

With all chemicals listed in Table 1, It must be avoided the direct water flow (high volume water jet) in order to reduce the risk of scatter and spread fire ; if strictly necessary, it must be used a fine spray water jet.

Foam

For large fires involving one or more of flammable / combustible chemicals of Table 1, the suitable extinguishing agent is a mixture of water and foam ; the Isopentane and other kind or working fluids, Dowtherm Oils (or other heat transfer medium) require an alcohol resistant foam while for Therminol Oils no specific indications are provided by the manufacturer.

Owing to this, the appropriate foam for the use with Isopentane and heat transfer oils is a film-forming fuoroprotein FFFP foam, for instance such as HYDREX-AR, or fluorosynthetic AFFF foam (HYDRAL-AR), both at concentration of 6% with water.

3.2 Fire Zones and fire protection

The philosophy described in the present Technical Specification for the fire protection requirements for the ORC plant is based on a fire zones analysis ; fire zones are defined for the ORC facilities on the concept that a fire within on fire zone should be prevented from affecting other fire zones.

In each fire zone, the type of fire protection provided must be appropriate for the type of fire hazards identified which have been identified also in HAZOP analysis of ORC process.

Based on a typical ORC lay-out and P&ID scheme, the following fire zones can be identified :

Fire Zone 1 *Working Fluid Cooling Condenser*

Release of liquid working fluid at temperature below boiling point and low pressure, due to

rupture of a condenser pipe – ***Pool Fire hazard***

Fire Zone 2 *Filters and Working Fluid pumps*

Release of liquid working fluid at temperature below boiling point and high pressure, due to leak from pumps or rupture of process line – ***Pool Fire hazard***

Fire Zone 3 *Working Fluid Pre-Heaters*

Release of liquid working fluid at higher temperature and high pressure, due to overheating or overpressure of equipment – ***Pool Fire hazard and Flash-fire or UVCE***

Release of Heat Transfer Medium (such as Dowtherm / Therminol Oils) at higher temperature and high pressure, due to a rupture of a heaters pipe – ***Pool Fire hazard***

Fire Zone 4 *Working Fluid Evaporator*

Release of bi-phase working fluid at higher temperature and high pressure, due to overheating or overpressure of equipment – ***Flash-fire or UVCE hazard, possible Pool Fire***

Release of Heat Transfer Medium (such as Dowtherm / Therminol Oils) at higher temperature and high pressure, due to a rupture of a heaters pipe – ***Pool Fire hazard***

Fire Zone 5 *Turboexpander and Lube Oil System*

Release of working fluid vapours at higher temperature and high / low pressures, due to overheating or overpressure of equipment – ***Flash-fire or UVCE hazard***

Release of Lube Oil at ambient or higher temperature and low pressure, due to a rupture of a Lube Oil skid pipe – ***Pool Fire hazard***

Fire Zone 6 *Working Fluid Recuperator*

Release of liquid of working fluid or its vapours at higher temperature or at temperature below boiling point and low pressures, due to overpressure of equipment or rupture of a pipe – ***Pool Fire hazard and Flash-fire or UVCE***

Fire Zone 7 *Working Fluid Loading / Unloading Station*

Release of liquid working fluid at temperature below boiling point and low pressure, due to rupture of a condenser pipe or from a flexhose – ***Pool Fire hazard***

Fire Zone 8 *CCR, Electrical Room, MCC Room, PLC Room*

Electrical equipment, cabinets at medium-low voltage – ***Combustible Fire hazard with presence of electrical equipment in operation***

According to these identified Fire Zones, the following Table 2 lists the applicable relevant Fire Protection Systems / Means / Devices.

Tab. 2 – List of Fire Protection Systems / Means / Devices

Fire Zone	Fire Fighting Systems	F&G Detection System	Passive Protection
1 - Cooling Condenser	Water / foam Monitors, Hydrants for cooling	Thermal Firewires [§]	Thermal protection to metallic (or concrete) frames
2 - Filters and pumps	Water / foam Monitors, Hydrants for cooling	IR/UV fire detectors Gas detectors (SP or OP)	==
3 - Pre-Heaters	Water / foam Monitors, Hydrants for cooling	IR/UV fire detectors Gas detectors (SP or OP)	==
4 - Evaporator	Water / foam Monitors, Hydrants for cooling	IR/UV fire detectors Gas detectors (SP or OP)	Thermal protection to concrete (or metallic) frames
5 - Turboexpander and Lube Oil System	Water / foam Monitors, Hydrants for cooling	IR/UV fire detectors Gas detectors (SP or OP)	==
6 - Recuperator	Water / foam Monitors, Hydrants for cooling	IR/UV fire detectors Gas detectors (SP or OP)	Thermal protection to metallic (or concrete) frames
7 - WF Loading / Unloading Station	Hydrants for cooling Water / foam deluge system (if mixer station present)	==	==
8 - CCR, Electrical Room, MCC Room, PLC Room	Gas Extinguishing System	Smoke detectors	==

SP : Single Point detectors

OP : Open Path Detectors

[§] In case of small area covered by the condenser (for instance, in case of liquid condensers) the thermal firewires can be substituted by IR/UV flame detectors

4 ACTIVE FIRE PROTECTION SYSTEMS

The Active Fire Protection systems (AFP) should be designed according to US or UE Codes and Standards as indicated at Paragraph 2 and to good engineering practice ; the objective of these AFP systems must be the extinguishing and control of fires or provide exposure protection to prevent a fire spreading (avoidance of domino effects).

The philosophy of protection in cases of fire can require different types of actions, depending on the hazardous scenario occurring ; nevertheless, for the ORC the AFP must be guaranteed by manual operations combining the intervention of trained operators with hydrants and water / foam monitors.

At the present, the basic AFP systems does not include fixed spraying water / foam systems such as sprinkler or deluge systems ; these systems should be mandatory fire fighting equipment only if National Authorities require them. In this case, a dedicated specification shall be issued for the design of sprinkler / deluge systems.

This Paragraph will describe :

- ❖ the fire water supply and distribution system
- ❖ the water hydrants and hose cabinets
- ❖ the water / foam monitors
- ❖ gas extinguishing system for enclosed area
- ❖ portable and mobile extinguishing devices

4.1 Firefighting Main System

The water supply to AFP systems could be provided in two different way : by means of a direct connection with the public water net or with a dedicated Fire Main System.

In the first case, the public net can supply water only to feed hydrants, monitors and hose reels ; in case of sprinkler / deluge systems this water supply system can not be applicable.

The public water net must guarantee a residual pressure of at least 3 bar at the most unfavorable point of firefighting net and the flow rate must be sized for the worst fire scenario ; if one of these two requirement is not satisfied, this type of water supply system can not be applicable.

In case of a Fire Main System, this system is devoted to supply the necessary water to all AFP systems ; this Fire Main System comprises :

- a water storage tank
- a water pumps station
- a water distribution net

The water storage tank must be sized for a minimum intervention time of 60 min considering the contemporary actions of hydrants and monitors ; as minimum, it must be dimensioned for feeding four hydrants, with a flow rate of 300 lt/min, and two monitors of 800 lt/min (even the intervention should allow less equipment in use during an emergency operation).

In any case, the water storage volume must be assessed during the design of fire fighting systems and, more important, according to Standards used for the design development and to applicable local rules / laws of the country where the ORC plant has to be built.

The firefighting water pumping station must be configured as follow :

- an electrical main fire pump, delivering the nominal water flow rate required by the fire fighting means that shall be in use contemporary (worst case scenario)
- a spare fire pump, driven by a diesel engine or by an electrical motor ; this pump must deliver the same water nominal flow of the main fire pump
- an electrical jockey pump for water distribution net pressurization

The pumps station must be complete of necessary accessories and control such as pressure switches for automatic pumps start (stop only for jockey pump), isolating valves, testing line, etc.

The fire water net must be a closed ring and installed underground, with a minimum depth of 1 mt ; the ring shall be divided into sections by post indicator valves for isolation and the pipes material must be HDPE, with a nominal pressure design equal to PN16.
To this fire water distribution net shall be installed the hydrants, hose houses/hose reels, hose cabinets in buildings, and monitors.

4.2 Water hydrants with hose cabinet

Firewater hydrants shall be positioned in external locations throughout the facilities ; they shall be located with a maximum separation distance of 50 mt such that two hoses streams connected to separate hydrant stations can be brought to bear any part of the ORC facility.

Hydrants shall be provided along the roads at a distance of not over 2.5 mt from the edge of roadway and no closer than 5 mt from building walls.

The hydrants will be head type above ground level each connected to double valves of 2 ½ “ instantaneous connection to BS 336 (or similar connection) ; hydrants equipment storage cabinets shall contain 2 x 20 mt length of hose and two standard discharge nozzles.

The indicative water flow rate shall be equal to 300 lt/min at a residual pressure of 4 bar and a contemporary operation of six hydrants shall be foreseen ; nevertheless, these parameters must be adjusted according to Standard applied for the fire fighting design (see Paragraph 2)

Internal to buildings (Control Room, offices) hose reels shall be placed.

4.3 Water / Foam Monitors

Fixed manual monitors shall be installed for the protection of the following plant sections and equipment :

- Evaporators and Pre-heaters
- Isopentane pumps, with filters, and recuperators
- Lube oil for turbine seals and bearings lubrication
- Surface below the air coolers

The coverage of the ORC plant must be provided with five (5) monitors manually operated, with adjustable nozzles (three functions : straight, spray and shut-off) ; the foam will be provided by mobile drums or IBC or portable tank. The working pressure of monitors shall be at around 5 bar and the nominal water / foam flow rate shall be equal to 800 lt / min.

The position of monitors shall achieve complete coverage of the hazardous equipment above mentioned using maximum 2 monitors contemporary ; according to this, an indicative positioning of the five monitors should be the following (at around 15 mt from the protected equipment) :

- two monitors must be placed in front of the evaporators / preheaters and turboexpander
- three monitors around the air (or liquid) cooler along the free sides

4.4 Working Fluid Loading Station

The working fluid fill station is designed to receive working fluid by truck (unloading operations) for filling the ORC plant or for downloading the ORC plant, in case of maintenance, and filling truck with it for transportation outside the ORC plant.

Due to these operations performed in Loading / Unloading working fluid station, it should be included provisions for fire control.

The provision applicable for this area should be a system working with foam (see the considerations on working fluid for its extinguishment) ; owing to this, this coverage system should be installed only in case to have a foam premixing station made by a foam storage vessel and a displacement liquid premixer system to dilute the foam into water at a specific ratio.

If this foam premixing station is not realized, this system can not be provided.

The fire protection of the Loading / Unloading working fluid station should be provided by means of a deluge system with nozzles for generating foam at low or medium expansion ratios (1:6 or 1 60 respectively) ; the indicating hydraulic working parameters of this system should be : water / foam flowrate of 90 ÷ 100 lt / min at 5 bar.

The activation of this deluge system should manually by means of the operator intervention which supervises the loading / unloading operations.

4.5 Gas Extinguishing System for enclosed spaces

The gas extinguishing configuration shall eb designed to be a total flooding system plus extended discharge and shall consists in high pressure vertical cylinders complete with hand wheels valves, electric actuators (pilot), pneumatic connections, discharge and pneumatic actuation pipes.

The extinguishing agent shall be INERGEN (first choice) or other inert gas mixture and halogenated mixture (as second choice).

The areas that should be protected shall be the following :

- Medium – Low voltage cable cellars
- Low voltage switchgear room
- PLC Room

4.6 Portable and mobile equipment

Fire extinguishers shall be provided at every ORC plant section in fixed systems and at such locations that at least one extinguishers is readily accessible from any part of the area.

Portable extinguishers are intended to provide a “first-aid” or “incipient” fire fighting facility for dealing with small outbreaks of fire ; mobile larger wheeled extinguishers shall be provided too in order to deal with mid-size operators controlled fires.

The portable fire extinguishers that should be used in the plant include :

- Carbon dioxide CO2
- Dry chemical powder
- Twin agent

All of these agents are adequate for the flammable liquids and combustible oils present in ORC plant and process ; CO2 extinguisher shall be available for electrical equipment, electrical room and enclosed spaces in general while dry powder can be used in open area.

Portable fire extinguishers distribution shall be logical and practical so that extinguishers can be available along the escape routes and / or near emergency exits (for building or enclosed spaces) ; the following minimum quantities shall be foreseen :

- N. 6 powder extinguishers, weight 9 kg, distributed in external area where air / liquid coolers, recuperators, turboexpanders are present
- N. 2 powder wheeled extinguishers, weight 50 kg, distributed in the same previous external areas
- N. 1 powder wheeled extinguisher, weight 50 kg, in Isopentane truck unloading area
- N. 1 powder extinguisher, weight 9 kg, in the same above area

- N. 2 powder extinguishers, weight 9 kg, in Control Room
- N. 1 CO2 extinguishers, weight 5 kg, in each electrical room (PLC Room or MCC or similar areas)
- N. 1 powder extinguisher, weight 9 kg, in fire pumps station (if present a diesel pump)

5 FIRE & GAS DETECTION SYSTEM AND MANUAL ALARMS

Fire and Gas Detection Systems (FDS – GDS, F&GDS) are necessary to detect releases of dangerous chemicals (liquids of vapors) with a potential to create hazards and prevent escalation of initial accidents that might occur.

All F&GDS panels / cabinets shall be centralized and located, when possible, in PLC Room and repeated in the 24 hours manned area of ORC plant (or connected areas to this plant such as Central Control Room – CCR).

Loops fault and supervision systems shall be identified, designed and developed according to NFPA 72C Standard or EN 54 and EN 60079-29 Parts 1/2.

With the installation divided into fire and / or gas zones, the design of Fire & Gas Detection Systems shall presume the more critical areas shall be covered by a sufficient number of detectors suitable for detection of likely fire development or flammable gas leakage in the ORC area.

The gas detection system shall have in particular detectors for Isopentane vapours, i.e. heavy hydrocarbons, in relevant areas of ORC plant where this vapours can be released.

As a general rule, the F&GDS shall be designed so that the maintenance, function testing etc. can be carried out without disabling the system.

In next sub-Paragraphs details are provided for FD and GD systems, manual Alarm Call Points and acoustic / optical signals.

5.1 Flammable Gas Detection System (GDS)

Release of flammable gases into atmosphere will generate a flammable or explosive hazard and for these situations it is possible to adopt explosion protection measures to keep the personnel and plant safe.

Depending on application, different measuring principles for the detection of gases and vapours can be used : catalytic bead sensors, point or open-path infrared IR sensors ; these sensors, connected with a central controller, allow to detect flammable gases / vapours at an early stage when concentrations are so low that a dangerous condition (and therefore a risk of explosion) can be reliably averted.

For the GDS, only a proper sensors positioning can guarantee and ensure a reliable GD system ; this can be performed according to IEC/EN 60079, Part 2 – Chapter 8 : Criteria for the placement of sensors and sampling points.

In designing a GD system it is essential to know (even if trivial) that a gas detector can detect a gas when it is close to it and enters into the sensor element.

Generally, the vapours from flammable liquid are heavier than air and therefore they spread across the floor or ground instead to rise up ; owing to this, gas detection sensors should be placed where the flammable substances can accumulate, i.e. at ground level or below the leak sources.

The following guidelines shall apply concerning detectors positioning and these strongly affect the strategies that could be applied in sensors placement :

- types of leak sources within a specific area (in term also of pressure release)
- gas density respect to air (how much heavier than air)
- presence of poisoning and inhibitors in the environment
- wind direction and velocity (for open areas)
- ventilation air patterns (if release is in closed spaces)
- critical reaction time / detector response time
- surface of the area to be covered by the GD system

According to these elements, the possible GDS configuration (or detectors placement strategies) should be selected among one of the following three (or a combination of them), each of them having a positive and negative effects on GD

1. *spot monitoring* : the potential leak sources are single points, well-known and locatable ; the sensors can be installed close to these single points
2. *area monitoring* : the potential leak sources are spread across a large area and are not completely locatable ; in this condition, the sensors can be positioned in a regular and equidistant shape across the whole area
3. *fence monitoring* : the potential leak sources are not locatable ; for this, the sensors can be positioned at the outer limit of the area to monitor gas concentrations crossing the fence of the area

The selected gas detectors must have the approval for application in ATEX zones and certified as SIL 2 equipment.

5.1.1 Configuration for the Gas Detectors System

The GD system must be designed with the aim to cover different types of plant / site areas which are identified in the following :

- ORC process area and equipment installed in outdoor area
- ORC process area and equipment installed in indoor building (if the plant has been developed with such lay-out solution)
- buildings where are located these plant functions : a) Control Room (CCR), electrical and MCC rooms, PLC Room, HVAC system

The gas detectors should be selected for providing a monitoring as “spot” or as “fence” or a combination of them; this allows the selection of single point sensors and of open-path sensors based mainly on IR technology instead of catalytic beads (considering the possibility to have presence of H_2S which is a poisoning for catalytic detectors).

ORC outdoor process area

The preferred solution for this lay-out is the adoption of open-path detectors because allow to have a complete coverage area of the plant ; in this case, the following sensors must be installed :

- three open-path detectors (formed each one by a transmitter and a receiver) surrounding the zone of evaporator, turboexpanders and the two lateral sides of evaporators / pre-heaters and Isopentane pumps
- one open-path detector along the air cooler, close to Isopentane pumps
- another open-path detector on the opposite side of air cooler

With these five detectors a fence-plant monitoring can be performed covering the whole process area ; these open-path detectors must be placed at ground level, at around 50-60 cm from the concrete quote.

If it is preferable to choose a spot monitoring solution, for the process area (LP or HP section, indifferently) fifteen single-point detectors should be displaced for covering the equipment (evaporators, turboexpanders, pre-heaters, pumsp and filters).

The area where air or liquid coolers are installed is so wide that should require a high number of detectors to have a good reliable coverage and, therefore, no sensors have been foreseen.

ORC indoor process area

For ORC plant installed inside a dedicated building, the numbers and positioning of gas detectors must be in accordance also to the hazardous classification area – ATEX zones.

For this type of ORC lay-out, the single-point detectors are adequate for the scope ; as basic requirement, the following sensors must be foreseen :

- one sensor close to turboexpander
- one sensor in evaporator zone
- one sensor in between the recuperator and heaters
- one sensor close to Isopentane pump

further detectors should be necessary in function of equipment lay-out.

Indoor working area and equipment

Where dedicated buildings are present for the CCR, offices, electrical rooms (High-Low voltage, MCC, PLC Room), single point sensors should be placed :

- outside the building (in particular where CCR is located and the electrical equipment)
- inside the same building

while it must be installed a sensor at the fresh HVAC system air intake of Central Control

Room.

Installation and control system

The detectors (open-path or single-point) must be connected to the Control Unit with a closed-loop for the power supply and the signals transmission (see second scheme below); this connection should be : an analog signal 0-20 mA or a digital signal via an HART protocol using the same wires of analog signal.

The Control Unit shall be placed in a substation room or in another room dedicated to instrumentation equipment and electrical panels ; this Control Unit shall be linked directly to DCS or to the fire controller via RS485 ModBus (this second configuration is represented in the third scheme attached below).

The system shall provide audible alarms inside and outside of the control room.

Detectors Calibration

In case of a gas detection, the detectors shall function in two ways according to gas concentration level detected ; the calibration threshold must be compliant also with the information provided bt the detector manufacturer.

A first threshold, set at 15 ÷ 20% of LEL, must activate an audible pre-alarm in all the site plant.

A second threshold, set at 30 ÷ 40% of LEL, must activate a second alarm and eventual emergency sequences with the aim of : a) eliminating or reducing the leak source, b) start a ventilation for diluting the gas concentration (for closed space) or stop the ventilation, for the air intake HVAC system, c) switch off the potential ignition sources represented by electrical equipment.

Nevertheless, these actions must be defined case by case according to plant lay-out and ORC process configuration.

5.2 Fire Detection System (FDS)

For the design of Fire Detection System (FDS) that should be installed in open areas, preliminary evaluation must be done in order to select the best performance technology in relation to the real fire hazard; these basic information and requirements to be followed for a good site design are mainly :

- gather all relevant information about the site, including the equipment lay-out, confinement (partial or whole), flammable materials, etc.
- verify the protection level required for the areas, i.e. standard fire detection, early warning fire detection or very early warning fire detection
- gather information on environmental conditions affecting the fire detection

The ORC lay-out considered for the FDS concept are two :

- ❖ all process equipment in outdoor area

- ❖ process equipment in enclosed space (indoor building)

The flammable chemicals play an important role for the definition of FDS system because the smoke emitted by the burning chemical can shield the flames and this affects strongly the choice of sensors technology that defines the FD system.

For present Technical Specification, the potential fire scenarios can involve as burning substances :

- o Isopentane, which is a light liquid hydrocarbon generating visible flames and small quantity of smoke
- o Dowtherm A Oil and Therminol 66 Oil ; these oils would generate in a fire huge quantity of smoke and so the flames are shielded by it reducing the capacity to detect the flames heat
- o Heat transfer oil, such as Delco Term, which should have same behavior of Dowtherm / Therminol Oils

The environmental conditions are other parameters that can affect the functionality of a FD system and so these environmental conditions should be well evaluated in order to avoid false fire detection (for high external temperature or sunlight) or the selection of some kind of sensors (due to presence of dust / sand in air or humidity or salt which may cause troubles to sensors operation).

Owing to this, it is important to assess :

- the maximum ambient temperature values, humidity and presence of sand
- the presence of “noise” sources like reflecting surfaces or hot surfaces
- obstacles and position of equipment

As well known, the available technologies for the sensors are the following :

1. flame detection : based on single sensors detecting the IR or IR/UV emitted by the flames
2. smoke detection : based on sucking air in a tube and a laser detector
3. thermal detection : made with a calibrated thermal wiring

Also for these detectors, they must have the approval for application in ATEX zones and certified as SIL 2 equipment.

5.2.1 Configuration for the Fire Detectors System

According to the fire zones identified in Paragraph 3.2, the areas that must be covered by the FD system are those where are present the ORC process equipment ; the Isopentane unloading area can not be covered by fire detectors because the operations require the presence of operators which can see a liquid release and activate immediately the emergency procedures.

Other areas with hazard of fire could be the buildings where the CCR and electrical / MCC / PLC rooms are present.

The FDS concept on which the design has to be developed is based on the following two major assumptions :

- a first fire system dedicated to detect small flammable liquid / combustible oil releases in areas where critical equipment are present (turboexpander or recuperators)
- a second fire system for medium / large fire hazard zones and bigger liquid release where huge flames are generated by the fire

Due to these assumptions, for the first fir scenario it is strictly required that the FDS detects as soon as possible such small pool fire and this can be provided only installing *flame detectors* ; among the different available technologies of sensors, the present design foresees the use of flame detectors IR/UV, combining in this way a solar blind UV sensor together with a high signal-to-noise ratio IR sensor, working at 4.1 μ – 4.6 μ spectral range which is the specific wavelength peak of CO_2 emitted by a fire.

For the second condition, in order to avoid a large numbers of single-point fire detectors for covering the zone, it is preferable and efficient, at the same time, to install thermal firewires, in adequate configuration around the potential dangerous equipment with a fuse temperature value of 137 °C / 180 °C, according to the ambient temperature surrounding the equipment; for the ORC plant, the medium / large fire hazard zone is identified in the area of air (or liquid) cooler.

ORC outdoor process area

The preferred solution for this lay-out is the adoption of a combination of IR/UV detectors and thermal firewires to have a fully protected process area ; therefore, the following sensors must be installed :

- four IR/UV detectors surrounding the zones of evaporator with preheaters, turboexpander with lube oil skid, the recuperator and the Isopentane pumps (in practice, the corresponding LP or HP zone of ORC plant)
- a thermal firewire covering the air cooler (or liquid cooler) area, installed below the supporting frame with a serpentine configuration around single fans group

In case of small area covered by the condenser (for instance, in case of liquid condensers) the thermal firewires can be substituted by IR/UV flame detectors.

ORC indoor process area

Also for this type of ORC lay-out, the single-point IR/UV detectors are adequate for the scope ; the numbers and positioning of gas detectors must be determined time by time according to the dimension of the building and obstacles.

As basic requirement, the detectors must be placed in opposite positions forming or a virtual diagonal line (in case of only two detectors) or a triangle shape (if three sensors are applied) ; further detectors should be necessary in function of equipment lay-out and size of the area.

If some process equipment are placed in a underground basin or pit or trench, a thermal firewire must be placed along the contour of this basin.

Indoor working area and equipment

Where dedicated buildings are present for the CCR, offices, electrical rooms (High-Low voltage, MCC, PLC Room), single point smoke sensors should be provided ; the number of these smoke detectors must be defined time by time in accordance to rooms extension and detector data from the manufacturer datasheet.

In case of a room ventilation, the smoke detector should be placed closer to intake air outlet duct.

Installation and control system

The detectors (IR/UV or thermal firewire) must be connected to the Control Unit with a closed-loop for the power supply and the signals transmission (see first scheme below); this connection should be : an analog signal 0-20 mA or a digital signal via an HART protocol using the same wires of analog signal.

The Control Unit shall be placed in a substation room or in another room dedicated to instrumentation equipment and electrical panels ; this Control Unit shall be linked directly to DCS or to the fire controller via RS485 ModBus (this second configuration is represented in the third scheme attached below).

The system shall provide audible alarms inside and outside of the control room.

5.3 Manual Alarm Call Points

In the ORC plant, open areas and indoor spaces, Manual Alarm Call Points must be installed such that the operators can activate the optical and acoustic alarms from the audible sirens.

The Manual Alarm Call Points must be positioned in such a way that they are clearly recognizable from a distance ; if necessary, they must be provided with signs to better indicate their positioning.

They must be located according to the following criteria :

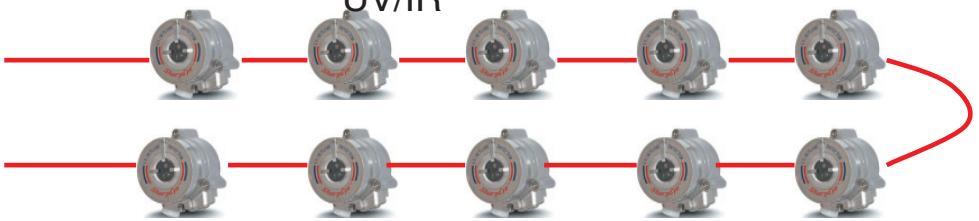
- at the exit from buildings
- along escape routes
- along safe paths from open area, such as process zone
- on the virtual perimeter of hazardous area, such as the Isopentane unloading station

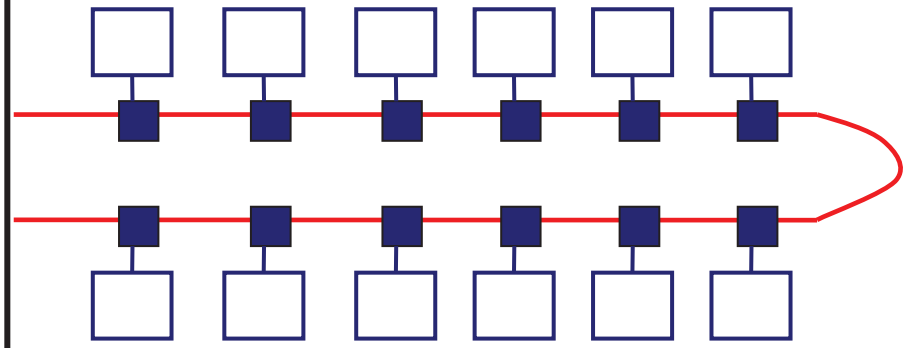
Manual Alarm Call Points has to be installed at a height of 1.4 mt above the ground level and they must not be far away over 30 mt from any point of the installation.

Controller

Cabinet in
Substation Building

Flame detectors
UV/IR





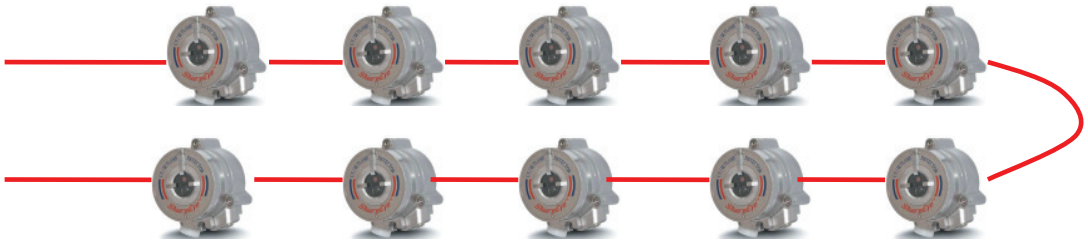
Thermal firewires

Scheme for Fire Detection System

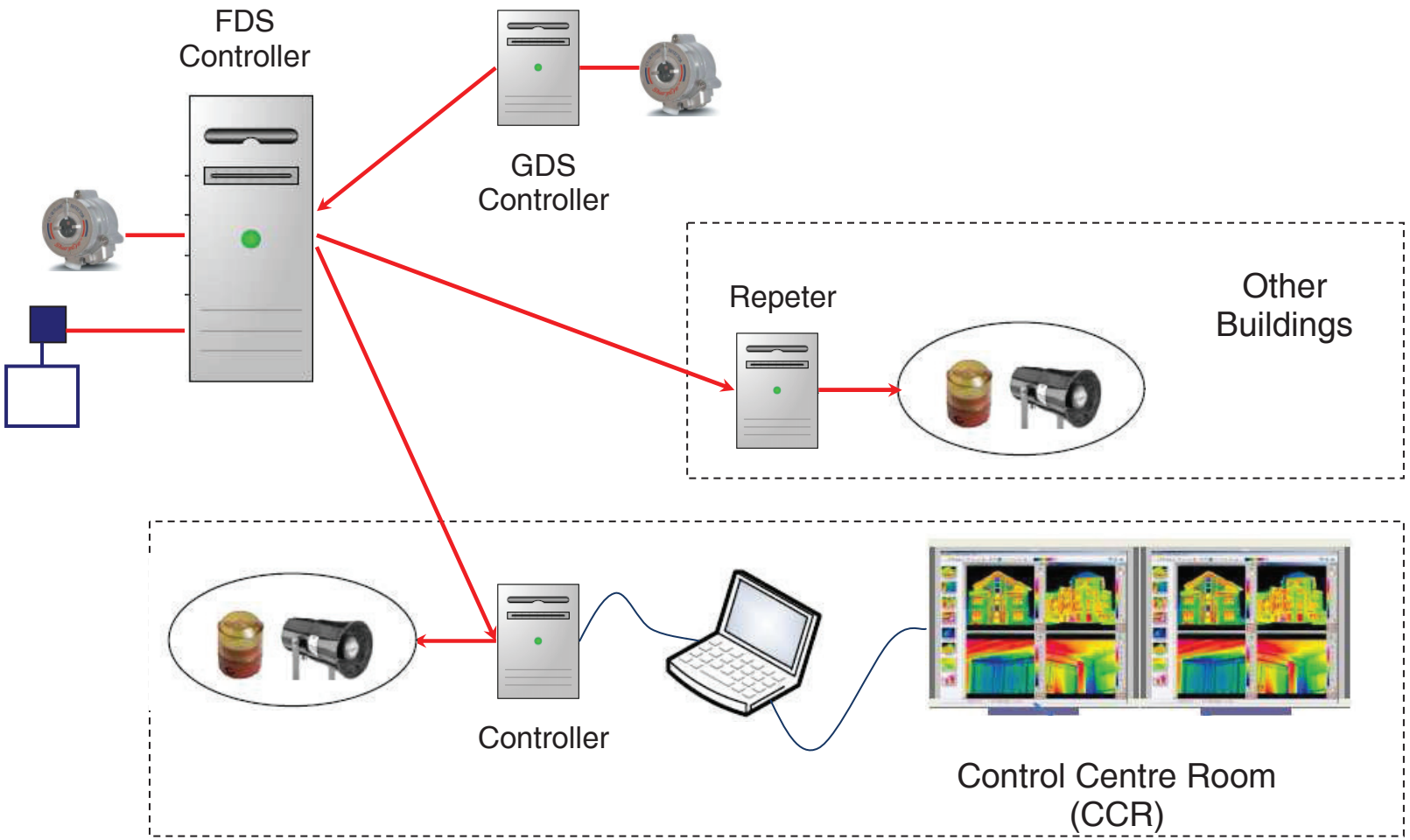
Controller

Cabinet in
Substation Building

Gas Detectors IR
(single point or open-path)



Scheme for Gas Detection System



General F&GDS layout

6 PASSIVE FIRE PROTECTION SYSTEMS

Passive fire protection, PFP, is a measure, integrated with the AFP systems, to provide inherent fire safety and protection by responding against flame, heat and smoke (if produced by a fire) to maintain the fundamental requirements of process equipment, building confinement, structural stability, fire separation and safe means of escape.

Passive fire protection (PFP) is intended to complement the AFP ; in particular PFP systems adopted shall be able to reduce the fire rate for a time period in order to facilitate the personnel escape to a safe location.

These PFP measures can be identified mainly in thermal insulation of plant / equipment structural frames ; due to this, these PFP measures and systems are fire protections for which a careful assessment has to be carried out and therefore these PFP systems should or should not be adopted and integrated into the fire fighting design development also in accordance to local Authorities suggestions or mandatory actions.

As a basic criteria for applying these PFP measures, the design could foresee the protection of following equipment and process structures :

- iron steel frames for the air cooler
- ground supports, in concrete or steel, for heavy horizontal equipment (recuperator or evaporator)
- iron steel frames for working platforms where it could be foreseen the presence of operators

In selecting the PFP materials, the following considerations must be taken into account :

- fire protection performance (mainly, time duration)
- weight limitations imposed by the supporting structure strength
- weather and mechanical strength
- ease application and reparability
- smoke generation and toxicity (when applied in closed spaces)

For the ORC process equipment the FPF materials selection should be between :

1. intumescent coating (paints or similar spray), painted on metal structures
2. light concrete mixture, sprayed on metal or concrete structures

In any case, the PFP materials must be certified and have the approval for a specific time duration from the manufacturer.

7 OTHER FIREFIGHTING DEVICES AND REQUIREMENTS

7.1 Wind direction indication

In order to facilitate the ORC plant site evacuation, a windsock must be installed in a strategic position of the site, well visible from all site points by the operators and personnel present.

7.2 Liquid Collecting Net

Since the vapours of working fluid Isopentane are heavier than air, the following preventive measures should be adopted :

- open channels, drains, trenches and pits shall be avoided in the ORC plant area
- air gap between electrical conduits and cables shall be sealed with suitable foam

It is recommended that ground in the ORC area is sloped, so as to lead possible spillages away from equipments ; the collecting point must be an open pit far from other structures (even from other external process areas) and not connected to drain nets.

7.3 Oil Spill Containment

The oil insulated transformers, Turboexpander-generator lube oil systems, and other equipment as deemed necessary shall have a concrete spill containment basin with sufficient volume to hold 10% more than the oil released during a worst case failure plus a 10 minute fire hose stream.

A retention wall around the turboexpander lube oil tank and all other oil reservoirs shall be provided to contain the volume capacity.

If off-line storage tanks containing flammable or combustible liquids are present close to ORC plant, a confinement system must be present in order to avoid that a release form these tanks can interfere with the ORC equipment, spreading eventual fires inside the perimeter of ORC plant.

8 PERSONNEL TRAINING

All personnel working in the plant shall receive adequate training about firefighting measures.

ANNEX 1

MSDS OF FLAMMABLE / COMBUSTIBLE FLUIDS

Scheda dei Dati di Sicurezza

Secondo le Direttive 91/155/CEE

164462 **n-Pentano 95%** PS

1. Identificazione della sostanza/preparato e della societá o ditta

1.1 Identificazione della sostanza o del preparato

Denominazione secondo l' allegato I:
n-Pentano 95%

1.2 Nome della societá o ditta:

PANREAC QUIMICA, S.A. E 08110 Montcada i Reixac
(Barcelona) España Tel.: (+34) 935 642 408
Denominazione:
n-Pentano 95% PS
Soccorso:
Instituto Nacional de Toxicología (Madrid)
Tel.: (+34) 915 620 420

2. Composizione/Informazione dei componenti

Denominazione: n-Pentano 95%
Formula: C_5H_{12} M.=72,15 CAS [109-66-0]
EINECS 203-692-4 CEE 601-006-00-1

3. Identificazione dei pericoli

Facilmente infiammabile.

4. Primi soccorsi

4.1 Indicazioni generali:

In caso di perdita di conoscenza non dare da bere né provocare il vomito.

4.2 Inalazione:

Trasportare la persona all'aria aperta. In caso di asfissia effettuare la respirazione artificiale.

4.3 Contatto con la pelle:

Lavare con acqua abbondante. Togliere gli indumenti contaminati.

4.4 Occhi:

Lavare abbondantemente con acqua mantenendo le palpebre aperte. Nel caso di irritazione, chiedere l'aiuto di un medico.

4.5 Ingestione:

Precauzione al vomitare (esiste pericolo di aspirazione). Fornire olio di vaselina con lassante (3 ml/Kg). Lassanti: solfato sodico (1 cucchiario grande in 250 ml. d'acqua). Non bere latte. Chiedere l'aiuto di un medico.

5. Misure di lotta contro gli incendi

5.1 Misure di estinzione adatte:

Schiuma. Polvere secca. Diossido di carbono (CO_2).

5.2 Misure di estinzione che NON devono utilizzarsi:

———-

5.3 Pericoli speciali:

Infiammabile. Tenere lontano da fonti di ignizione. I vapori sono piú pesanti dell'aria, per cui possono muoversi a livello terra. Puó formare miscele esplosive con l'aria. Evitare la formazione di cariche elettrostatiche.

5.4 Attrezzature di protezione:

———-

6. Misure a prendere in caso di versamento accidentale

6.1 Precauzioni individuali:

Non inalare i vapori.

6.2 Precauzioni per proteggere l'ambiente:

Non permettere il passaggio al sistema di scarico. Evitare la contaminazione del suolo, acque e scarichi.

6.3 Metodi di raccolta/pulizia:

Raccogliere con materiali assorbenti (Assorbente General Panreac, Kieselguhr, ecc.) oppure con sabbia o terra secca e depositare in contenitori per residui per la posteriore eliminazione d'accordo con le normative vigenti. Pulire i residui con abbondante acqua.

7. Manipolazione e stoccaggio

7.1 Manipolazione:

Evitare la formazione di cariche elettrostatiche.

7.2 Stoccaggio:

Recipienti ben chiusi. In locale ben ventilato. Lontano da fonti di ignizione e calore. Temperatura ambiente. Non immagazzinare in recipienti di plastica.

8. Controlli di esposizione/protezione personale

8.1 Misure tecniche di protezione:
Assicurarsi una buona ventilazione e rinnovo dell'aria del locale.

8.2 Controllo limite di esposizione:
MAK: 1000 ml/m3 o 2950 mg/m3.
TLV-TWA: 600 ppm o 1770 mg/m3

8.3 Protezione respiratoria:
In caso di formazione di vapori/aerosol, utilizzare le attrezzature respiratorie adatte.

8.4 Protezione delle mani:
Utilizzare guanti adatti.

8.5 Protezione degli occhi:
Utilizzare occhiali adatti.

8.6 Misure igieniche particolari:
Togliere gli abiti contaminati. Utilizzare le attrezzature di protezione complete.
Lavarsi le mani e il viso prima degli intervalli e alla fine del lavoro.

9. Proprietà fisiche e chimiche

Aspetto:
Liquido trasparente e incolore.
Odore:
Caratteristico.

Punto di ebollizione:35-37°C
Punto di fusione: -129,7°C
Punto di infiammazione: -40°C
Temperatura di auto ignizione: 285°C
Limiti di esplosione (inferiore/superiore): 1,4 / 7,8 Vol. %
Pressione del vapore: (20°C) 573 hPa
Densitá (20/4): 0,63
Solubilitá: Poco solubile in acqua.

10. Stabilità e reattività

10.1 Condizioni che si devono evitare:
———-

10.2 Materie che si debbono evitare:
———-

10.3 Prodotti di decomposizione pericolosi:
———-

10.4 Informazione complementare:
I gas/ vapori possono formare miscele esplosive con l'aria.

11. Informazione tossicologica

11.1 Tossicitá acuta:

CLLo inh topo: 325 g/m3/2h

11.2 Effetti pericolosi per la salute:

Per ingestione ed inalazione: narcosi, spasmi, paralisi respiratoria. Non si scarta: Irritazioni sulle mucose.
In contatto con la pelle: Puó avere un efetto sgrassante sulla pelle, con pericolo di infezione secondaria.

12. Informazione Ecològica

12.1 Mobilitá:

———-

12.2 Ecotossicitá:

12.2.1 - Test EC 50 (mg/l):
Pesci = EC_0 60 mg/l ; Classificazione: Estremamente tossico
Organismi idrologici = 10 mg/l ; Classificazione: Estremamente tossico
12.2.2 - Medio recettore:
Pericolo per l'ambiente acquatico = Medio
Pericolo per l'ambiente terrestre = Basso
12.2.3 - Osservazioni:
Ecotossicitá acuta in funzione della concentrazione versata.

12.3 Degradabilitá:

12.3.1- Test:————-
12.3.2 - Classificazione sulla degradazione biotica:
DBO_5/DQO Biodegradabilitá = ——
12.3.3 - Degradazione abiotica secondo il pH: ————-
12.3.4 - Osservazioni:
Dati non disponibili.

12.4 Accumulazione:

12.4.1 - Test:
————-
12.4.2 - Bioaccumulazione:
Pericolo = ——-
12.4.3 - Osservazioni:
Dati non disponibili.

12.5 Altri eventuali effetti alla natura:

Prodotto poco contaminante. Non inserire nei terreni né agli acquiferi.

13. Considerazioni sullo smaltimento

13.1 Sostanza o preparato:

L'Unione Europea non stabilisce regole omogenee per l'eliminazione dei residui chimici, dato che sono residui speciali. Il loro trattamento ed eliminazione dipende della Leggi interne di ogni Paese. Per cui, per ogni caso, bisogna contattare le Autoritá competenti, oppure con le imprese legalmente autorizzate alla eliminazione dei residui.

13.2 Imballaggi contaminati:

I recipienti e imballaggi contaminati con sostanze o preparati pericolosi, avranno lo stesso trattamento dei prodotti.

14. Informazione relativa al trasporto

Terrestre (ADR/RID):
Denominazione tecnica: n-Pentano 95%
ONU 1265 Classe: 3 Casella e lettera: 2b
Marittima (IMDG):
Denominazione tecnica: n-Pentano 95%
ONU 1265 Classe: 3.1 Gruppo d'imballo: I
Aerea (ICAO-IATA):
Denominazione tecnica: Pentanos
ONU 1265 Classe: 3 Gruppo d'imballo: II
Istruzione di imballaggio: CAO 303 PAX 302

15. Informazione regolamentare

Etichettato secondo le Direttive della CEE
Simboli: 
Indicazioni di pericolo: Facilmente infiammabile
Frasi R: 11 Facilmente infiammabile.
Frasi S: 9-16-29-33 Conservare il recipiente in luogo ben ventilato. Conservare lontano da fiamme e scintille - Non fumare. Non gettare i residui nelle fognature. Evitare l'accumulo di cariche elettrostatiche.
Numero dell'indice CEE: 601-006-00-1

16. Altre informazioni

Numero e data di revisione:0 02.06.98
I dati registrati con la presente Scheda di Sicurezza sono basati nelle nostre attuali conoscenze, avendo come unico obiettivo informare sugli aspetti della sicurezza e non si garantiscono le proprietà e caratteristiche in esse indicate.