



## CONSIDERATIONS ABOUT THE DESIGN OF A TEMPORARY REFUGE LOCATED IN A ON-SHORE OR OFF-SHORE COMPLEX IN THE OIL & GAS SECTOR

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## THE DESIGN OF A TEMPORARY REFUGE

### 0) Introduction

This document purpose is to give a guideline for the correct engineering of a Temporary Refuge related to an oil and gas complex. This kind of installation can be useful both for on-shore and off-shore field.

We can summarize the main points to be focused in this short list:

- 1) POB to be mustered inside the TR
- 2) Definition of the normal operations and emergency condition
- 3) Duration of the emergency condition
- 4) TR construction design
- 5) Vital systems inside the TR
- 6) HVAC System configuration - Breathing air or Oxygen
- 7) Sequence of operations during emergency condition
- 8) Type of accommodation of the POB inside the TR

### Abbreviations

AHU	Air Handling Unit
ATEX	ATmosphères EXplosives
BA	Breathing Air
CO <sub>2</sub>	Carbon dioxide
EDG	Emergency Diesel Generator
FERA	Fire and Explosion Risk Analysis
F&G	Fire and gas
FMECA	Failure Mode Effects Criticality Analysis
HC	Hydrocarbon Gas
HVAC	Heating, Ventilation and Air Conditioning
H <sub>2</sub> S	Hydrogen Sulphide
HSE	Health, Safety and Environment
HAZID	Hazard Identification Study
HAZOP	hazard and operability study
Pa	Pascal
POB	Personnel on Board
SCBA	Self Contained Breathing Apparatus
SIL	Safety Integrity Level
TLC	Telecommunication system
TR	Temporary Refuge



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## THE DESIGN OF A TEMPORARY REFUGE

### 1) POB to be mustered inside the TR

The first input data necessary for the sizing of a Temporary Refuge Complex is the number of people to be accommodated inside. This element is fundamental to size the area of the TR and the space of the other vital rooms. On the base of the “People on board” (POB) is possible to calculate the correct amount of fresh air supplied by the HVAC system and the correct air flow of Breathing Air (BA) or oxygen to supplied during the emergency condition. Can be useful to note some preliminary values:

For each person inside the TR room shall be assured 30-40m<sup>3</sup>/h of fresh air during the normal operation mode

For each person inside the TR room shall be assured 40 l/min. of BA during emergency

For each person inside the TR room shall assure an area of 1,5-3 m<sup>2</sup> (included services rooms)

### 2) Definition of the normal operations and emergency condition

The normal operation mode is considered when no alarms are activated during the operation in the complex. In this situation the Temporary Refuge there are no occupation by the personnel, and there is a preservation of the temperature and humidity in order to be ready to accommodate all the POB in Emergency. During the normal operation mode, only the maintenance crew will be in the TR.

During normal operation mode the HVAC system will be arranged to operate with variable ratio of re-circulated air, up to 50% of the total air supply in order to have the maximum energy saving .

The Emergency condition is activated in case of accident (release of toxic gases from the wells or hydrocarbons, jet fires and explosions). In this situation it is necessary to muster the workforce into a Temporary Safe Refuge capable to protect them from toxic gases, fire and blast.

During Emergency Condition the HVAC System will be arranged to operate recirculating the entire quantity of air. The “new” breathing air will be supplied by a bottled air system that will ensure the breathing air necessary to the POB inside the TR and other vital rooms.

### 3) Duration of the emergency condition

Typically the duration of the emergency condition can be of 2 or 3 hours, but the maximum is determined by the storage of the energy and breathing air installable inside the TR complex. In the calculation of the quantity of energy (electric, thermal, cooling) shall be considered the 100% spare. The same value shall be applied to vital equipments and/or systems, so we will have 1 component 100% running and 1 component 100% stand-by.



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## THE DESIGN OF A TEMPORARY REFUGE

### 4) TR construction design

The TR complex shall be designed in order to assure:

- the gas tightness (in order to prevent ingress of toxic hydrocarbon gas)
- the blast resistant from external explosion
- the fire protection (shall be provided insulation all along the TR surface, including floors and ceilings, A60 rated as a minimum and B15 in the internal walls as well).
- the IP55 degree of protection
- the thermal insulation
- minimal hook-up with external services
- space and facilities for maintenance and replacement of equipment
- safe boarding and evacuation
- long design life
- operating on a full-time all-year-round basis without service interruptions

The complex construction mode, the typology of structures and partition, the hazardous area classification and the fire&gas philosophy will be arranged after the FERA analysis. The Fire and Explosion Risk Analysis (FERA) shall identify the fire and explosion hazards in the operation area and will assess the magnitude of these hazards. The objective is to provide input to the passive and active fire protection, the blast rating, buildings and outdoor vital equipment.



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## THE DESIGN OF A TEMPORARY REFUGE

### 5) Vital systems inside the TR

Inside the Temporary Refuge complex shall be assure this vital systems:

- Electric energy assured by battery storage
- TLC-Radio system
- Emergency lighting
- Drinking water system
- HVAC system (to assure an acceptable temperature inside the vital rooms)
- Breathing air system
- Fire fighting system (Inergen system for the electrical rooms)

Shall be necessary to define the hazardous area classification. Typically all external equipments are ATEX certified.

All vital systems shall be able to run also under this alarms

- Loss of pressurisation.
- Both duty plant fail to operate
- Intake damper open and F&G signal
- Internal H<sub>2</sub>S levels
- Internal CO<sub>2</sub> levels
- Fire detection

This kind of consideration can be performed only after HSE sessions of:

- 1st step – HAZID
- 2nd step – HAZOP
- 3rd step – SIL
- 4th step – FMECA on vital systems



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### 6) HVAC System configuration - Breathing air or Oxygen

During the normal operation mode supply and exhaust fans shall be continuously powered by the emergency power distribution system in order to maintain a positive pressure (typically 50 Pa minimum), to prevent the possibility of gas or smoke ingress in the vital areas and to maintain air changes for healthy conditions.

shall be provided smoke, toxic gas and flammable gas detectors at the HVAC air intakes. In the event of smoke or gas being detected outside the fresh air intake, the fire & gas dampers shall shut and the control logic system shall automatically switch the HVAC system into re-circulating mode utilising only the existing air volume.

In this condition shall be started the emergency condition mode.

There are two choices to design the breathing air system inside the TR.

The first choice is to use an oxygen storage to mix the recirculating air of the TR, monitoring the O<sub>2</sub> level and adopting CO<sub>2</sub> scrubbing system in order to maintain air quality for the TR endurance period.

A chemical air filter shall be provided on the supply air and a polishing type filter shall also be provided on the return air duct.

To keep the correct pressurization the HVAC system shall incorporate a back-up air pressurisation system (compressed breathing air). This system shall be designed to prevent ingress of toxic hydrocarbon gas within the TR and the associated airlocks.

The second choice is to use full recirculating HVAC system (only for temperature control) and a pressurization with breathing air system composed by a suitable breathing air storage (high pressure air bottles storage). This system shall be connected with an overpressure system and with the differential pressure transmitters installed in the TR rooms. During emergency condition the T.R. overpressure system shall be able to exhaust all the breathing air necessary to assure the personnel's respiration and contemporarily assuring the correct pressure value inside the rooms considering the leakage rate of structures, partitions, doors, walls and roof, HVAC penetrations measured during commissioning.

The HVAC intakes and outlets ductworks shall be in accordance with the details below.

- All HVAC fresh air intakes to be from a non-hazardous area.
- All air intake ducts shall be sized to retain gas concentration for a minimum period of 10 seconds.

The fresh air intake shall be composed by:

- Smoke and heat detectors
- HC (expressed in terms of CH<sub>4</sub> equivalent) and Toxic Gas detectors
- Ductwork sized to retain gas for a minimum of 10 seconds
- 2No Fire and gas dampers (i.e. dampers will close in case of detection of heat and/or smoke, for fire & gas protection against fire, and in case of detection of flammable gases / toxic gases, for toxic gas protection expressed in terms of CH<sub>4</sub>, H<sub>2</sub>S or SO<sub>2</sub>)
- Blast resistant damper



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## THE DESIGN OF A TEMPORARY REFUGE

Dedicated HVAC system (with dedicated AHU and exhaust fan or overpressure system) shall be provided for those rooms:

- Battery room
- TR rooms – air lock
- Technical rooms or other rooms not running during emergency
- Toilets
- First aid-hospital
- Stores
- Emergency Electrical rooms

The Breathing Air System shall be composed by:

- breathing air compressors package,
- breathing air bottles system package,
- pressure reduction groups,
- breathing air cascade system,
- air lock breathing air pressurization and nozzles washing system,
- TR breathing air pressurization system,
- SCBA refilling package

All the main BA system and vital equipment shall be arranged such that the total complement shall be 2 x100% (1 package 100% running, 1 package 100% spare in stand-by).



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### 7) Sequence of operations during emergency condition

- Fire and gas detection system send an alarm
- All the personnel run to the muster point near the TR Complex
- The TR F&G system run the emergency sequence operation, close the F&G dampers and lock the external doors
- The diesel generators stop and the electric power is supplied by batteries
- The HVAC system is switched from “fresh air” mode to “full recirculation” mode.
- Is activated the compressed air pressurization system and the BA system.
- The air lock BA washing system is ready to start
- The air lock doors are unlocked for the first mustering sequence
- A predetermined number of personnel go inside the air lock (the TR doors are still closed)
- Start the BA washing sequence inside the air lock (the air lock doors are now closed)
- A toxic gas analyzer verify the absence of gas (if the gas is revealed, start an additional washing sequence)
- The TR rooms doors can be opened.
- Start another mustering sequence (during the mustering, people outside the TR complex waiting for their turn are connected with the outdoor BA Cascade system)
- People inside the TR rooms take their sit or their numbered position, waiting for the rescue vehicle or for the end of the alarm.
- In case of TR evacuation (at the end of the 2 or 3 hours of emergency capacity of the TR), will start the disembarking sequence (through the air lock with only 1 washing sequence).



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### 8) Type of accommodations inside the TR

The Temporary Refuge complex shall contain:

- Temporary refuge rooms with accommodation facilities
- Coffee/tea Room
- Radio & Telecommunications Room (with access from the complex safe area)
- Electrical Rooms
- Battery Rooms
- Transformer – EDG Room
- Airlocks for entrance
- Airlock for exit with direct access into escape tunnel
- Compressed Breathing Air Cylinder & Water Tank/Pump Room
- HVAC room
- Inergen Room
- Area for external equipments
- Control room - Office Area
- Workshop and stores
- First Aid - hospital
- Toilet and washroom facilities