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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Twenty-fifth Meeting
Montreal, 29-31 July 1998

HYDROCARBON SAFETY

NOTE FROM THE SECRETARIAT
ON
THE STUDY ON SAFETY RELATED COSTS OF HYDROCARBON TECHNOLOGIES

Introduction

1. The note presents the background information to safety costs, the Committee's previous decisions, the process by which the safety costs study was undertaken, an overview of the study and its results. A proposal for a decision by the Executive Committee in relation to the findings of the study is also presented.

Background

2. In a number of recently submitted projects using hydrocarbon technologies the proposed system designs to ensure adequate safety varied widely. Consequently, the claims for eligibility of safety related costs have also varied depending on the interpretation of "adequate safety" by the experts or enterprises preparing the projects.

3. Additionally, in the process of project preparation, individual consideration needs to be given to whether a particular enterprise has the minimum prerequisites to convert to hydrocarbon technology. If hydrocarbon technology is to be used, it may be necessary to identify and cost the measures needed to rectify deficiencies in the baseline situation of the enterprise so that the conversion activity can proceed. Improvements in the baseline situation may confer additional benefits to the enterprise which are not related to the conversion, as well as to the conversion process, or may be related to the normal development or upgrading of the operation of the enterprise.

4. The concept of safety related costs was discussed at the 23rd Meeting of the Executive Committee. In Decision 23/18 the Executive Committee decided that:

> "(a) safety standards should follow international standards, where these are higher than standards in the country concerned. The practical application of established standards should be based on industry norms and practice in European countries.
>
> (b) Projects should be prepared and reviewed on the basis of this principle."

5. In regards to the deficiencies in the baseline situation, the Executive Committee felt that the existing decisions on incremental costs should apply.

6. To give effect to Decision 23/18, the Fund Secretariat commissioned a report by a recognized industry consultant to evaluate safety costs for conversion of the production of domestic refrigerators to hydrocarbon technology taking into account international standards and industry norms and practice in European countries. The progress on the preparation of the

Hydrocarbon Safety Cost Study was reported to the 24th Meeting of the Executive Committee. The Executive Committee decided "to request the Secretariat to continue its process of completing the report and submit it to the Twenty-fifth Meeting in July 1998, so that the Executive Committee could discuss it on its technical merits. On the basis of the Committee's consideration of the report, the guidelines for hydrocarbon safety-related costs would emerge and would be applied to projects submitted for approval to the Twenty-sixth Meeting." (Decision 24/57).

7. The Hydrocarbon Safety Cost Study was prepared by the consultant according to the Terms of Reference designed to capture the Committee's views presented in paras 5 and 6 above. The draft of the Hydrocarbon Safety Cost Study were circulated to the implementing agencies for comments. TÜV (an internationally recognized body (Germany) in industrial safety) was also engaged to conduct a review of the Study. TÜV is actively involved in certification of refrigerator manufacturing plants converted to hydrocarbon technologies in both developed and Article 5 countries. Comments from the implementing agencies and from TÜV were received by the Secretariat. The Secretariat and the implementing agencies convened an interagency meeting to *inter alia,* discuss a second draft of the study which incorporated the relevant comments and opinions expressed by implementing agencies, TÜV and the Secretariat. The study was finalized by the consultant on the basis of the discussions at the interagency meeting. A copy of the final study is included as Annex I to this paper.

The Scope of the Hydrocarbon Safety Cost Study

8. The Hydrocarbon Safety Cost Study addresses the following issues in the terms indicated.

Safety standards

9. The use of flammable substances is regulated by a number of international standards. Hydrocarbon-based technologies in the production of polyurethane foams are widely and successfully used in European countries, where industry norms and practices for safe applications of these technologies are well established. The study is developed on the basis of the experience of European countries to provide guidance and to assist experts in designing safety systems and in estimating the costs of projects using hydrocarbon-based foam technologies in Article 5 countries.

Enterprise baseline situation

10. The introduction of hydrocarbon technologies depends on the availability of baseline utilities and general industrial safety facilities. The study establishes the minimum prerequisites at the enterprise level to make the conversion to hydrocarbon technologies feasible. The baseline production equipment is analyzed providing guidance for the replacement or retrofitting the existing equipment depending on its condition and design.

Safety principles

11. The production of hydrocarbon-based foams involves the use of flammable blowing agents (cyclopentane, n-pentane, butane and others) which could create an explosive atmosphere when mixed with air. An area in which an explosive atmosphere is present, or may be expected to be present is classified as a hazardous area. Installations in which flammable materials are handled or stored should be designed, operated and maintained so that any releases of flammable material, and consequently the extent of hazardous areas, are kept to a minimum.

12. In a situation in which there may be an explosive atmosphere, either the likelihood of an explosive atmosphere or the source of ignition should be eliminated. In emergency situations, several measures can be undertaken: cut-off of power to unprotected electrical equipment; shut-down of the process; isolation of process vessels; containment of spillages; and provision of additional emergency ventilation. The Study provides specific recommendations regarding the implementation of safety principles.

Hazardous area classification

13. The environment in which an explosive atmosphere may occur, can be analyzed and classified to select the appropriate electrical apparatus and equipment. The analysis of potentially hazardous areas involves examination of the likely frequency, duration and rate of release of flammable material, and its concentration in the air. This analysis also involves examination of the application of ventilation to reduce the concentration of flammable gas below the maximum admissible level. The hazardous areas are classified into three zones (0,1 and 2) based upon the frequency of the occurrence and duration of an explosive atmosphere. The study provides guidance on the classification of hazardous zones, required grades of ventilation and the selection of the type of the most suitable electrical equipment related to the particular circumstances of hydrocarbon foam production process.

14. The study does not specifically deal with use of hydrocarbon for charging the refrigeration circuit. However, it should be noted that the safety principles are the same and the design elements are very similar. For example, the main safety requirements for hydrocarbon refrigerant charging are the provisions of ventilation and gas detectors, both of which are specified in principle and in detail in relation to the foam operation. The only equipment involved is that required to charge the refrigerant (a charging board) which is always procured as a new item in hydrocarbon refrigeration projects and is thus intrinsically safe as it is designed for this purpose by the manufacturer.

Detailed conversion aspects

15. The conversion involves the supplier of equipment from one side and the implementing agency and the enterprise from the other. Their respective roles in making the conversion safe are identified in the study. The study also addresses the definition and technical requirements for the following specific components of a typical conversion project:

- cyclopentane storage and distribution
- premix area and foaming machines
- foaming jigs
- nitrogen blanketing
- ventilation
- gas detection system
- electrical grounding
- electrical cabling
- safety training

16. In each case, the study indicates where work can be done locally.

Identification of related safety costs

17. The study included an assessment of the costs of the most important items involved in a theoretical conversion project. However, this assessment is made from the perspective of the specific supplier of the equipment, Cannon Italy. More work is required to be done on equipment costs. Eventually, the cost information in project completion reports and the equipment cost database when completed will be taken into account to establish the cost range for major items related to safety. What the study has done is to provide a sound technical basis for the specifications of essential safety-related equipment items.

Conclusions

18. The Hydrocarbon Safety Cost Study establishes a solid technical ground for designing safety systems during conversion to hydrocarbon technology. The study can serve as guidance to the implementing agencies, enterprises in Article 5 countries in preparation of investment projects and to the Secretariat in reviewing the submitted projects.

19. The Secretariat will continue to work with the implementing agencies to further fine-tune the costs associated with safety in hydrocarbon projects by analyzing the reports on completed projects, the equipment costs incorporated in the database of equipment and through the updating the existing cost templates if necessary.

Recommendations

20. It is recommended that, on the basis of the discussion foreshadowed in Decision 24/57, the Executive Committee note the Hydrocarbon Safety Cost Study and agree to its findings being used as guidelines for the design of safety-related equipment, on which the eligibility of funding for such equipment in hydrocarbon refrigeration projects will be based.

Conversion of Refrigerator Production Plant to the Hydrocarbons technology

SAFETY COST EVALUATION

Final issue

prepared for

THE MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL

by

BRUNO FIERRO

INDEX

1. INTRODUCTION

1.1 SCOPE OF THE JOB

By the Terms of Reference issued by Multilateral Fund Secretariat on 27th September 1997, we have been asked to develop a draft methodology for evaluating the Safety related Cost to convert a Refrigerator Production Plant to the Hydrocarbons Technology.

The study has been completed taking into consideration the necessity to standardise, as much as possible, the Safety Measures, in order to allow the Implementing Agencies to issue Technical Specification for different projects always following a common and homogeneous guide-line.

1.2 BASIC PRINCIPLES & RELEVANT COMMENTS

According to the T.O.R., there are three basic principles to be taken into consideration by developing the study. With regard to those principles, we feel of paramount importance to make clear our relevant opinion.

1.2.1 FIRST PRINCIPLES

Safety standards applied by implementing agencies should follow international standards (ICE/CEO).[1] *Practical application of established standards should be based on industry norms and practice in European countries since hydrocarbon based technologies have been widely and successfully used in non-Article 5 countries in Europe. Existing national safety standards in Article 5 countries should also be taken into consideration.*

This principle arises from Executive Committee Decision 23/18 which reads as follows:
" *Safety standards should follow international standards, where these are higher than standards in the country concerned. The practical application of established standards should be based on industry norms and practice in European countries* "

The Safety Measures to be implemented in an industrial context are connected to the level of the industrial culture. The approach to this technology by the European refrigerator makers changed along the period of 10 years in which hydrocarbon technology has been used. This is because of the acquired confidence in using explosive blowing agent. Therefore we are going to develop our study assuming that a **risk can be considered tolerable only when it is acceptable in the given contest of a contingent situation.**

As a conclusion from this first consideration, while the study is based on European norms and practice, some specific recommendations have been made which exceed the safety requirements indicated by those norms.

[1] Remark: All international standards taken into consideration as reference are listed in Annex I

1.2.2 SECOND PRINCIPLE

Determination of eligible incremental safety-related costs should follow the basic principles of the Multilateral Fund. Safety-related costs need to be analysed according to the nature of the costs and the incrementality of each cost item has to be assessed.

Reading the explanation of the above reported principle (see point 9 of your T.O.R.), it is clear the necessity to define certain baseline conditions of the enterprises requiring the funding for the conversion.

We fully agree on this point; it means that even in an Article-5 country, **some minimum Safety requirements in terms of a production line configuration and organisation must be required**. On this point, the minimum requirements will be clearly indicated in our study for different items taken into consideration.

1.2.3 *THIRD PRINCIPLE*

The only purpose of the present study is to define the costs related to the safety aspects of a conversion project.

Process and production design criteria and relevant costs (not associated with safety aspects) are not taken into consideration.

1.3 PLANNING OF STUDY

The study is divided in two main parts.

PART I - GENERAL CRITERIA

- Classification of the Hazardous Area and identification of the required protection modes.
- Definition and evaluation of the existing situation related to the production line to be converted.

PART II - DETAILED CONVERSION ASPECTS

- Definition of the technical solutions for enterprises converting to hydrocarbons technology in Article-5 countries based on a division by the following areas:

  - CycloPentane storage facilities
  - Premix area and Foaming machines
  - Foaming jigs
  - Grounding
  - Nitrogen blanketing
  - Ventilation
  - Gas Detection System
  - Safety training.

  All above reported items will be analysed taking into consideration the necessity to allow the definition of the eligible incremental costs. In particular, the following aspects are analysed:

- available technical solutions and relevant comparison
- baseline conditions
- tendering criteria
- safety costs estimation

SAFETY COST EVALUATION

PART I

2. CLASSIFICATION OF THE HAZARDOUS AREAS

For the zones classification we refer to the International Standards CEI-EN 60079-10 - Part 10 ("Electrical apparatus for explosive gas atmospheres" - "Classification of Hazardous Areas").

Generally, we can assure that, by considering these rules, the different Local Regulations of the Article 5 countries are respected.

2.1 ZONES

According to the above mentioned document, the Hazardous Areas are classified as follows.

- *ZONE 0*
  An area in which an explosive gas atmosphere is present continuously or for long periods (more than 1000 h/y).

- *ZONE 1*
  An area in which an explosive gas atmosphere is likely to occur in normal operation (between 10-1000 h/y).

- *ZONE 2*
  An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only (less than 10 h/y).

As definition of "Explosive Gas Atmosphere", we still refer to the one reported by the EN 60079-10 standards.

A mixture with air, under atmospheric conditions, of a flammable material in the form of gas or vapour in which, after ignition, combustion spreads throughout the unconsummated mixture.
As a further clarification of the given definition, we remark that although a mixture which has a concentration above the upper explosive limit (UEL) is not an explosive gas atmosphere, it can readily become so and, in certain cases for area classification purposes, it is advisable to consider it as an explosive gas atmosphere.

As we will see later, the use of one or more additional "active" safety system can decrease the hazardous degree of the zone taken into consideration up to a "non EXPLOSIVE" condition (NE zone).

2.2 RELEASES AND VENTILATION

The probability of the presence of an explosive gas atmosphere and hence the type of zone depends mainly on the grade of release and on the ventilation.

2.2.1 GRADES OF RELEASE

As definition of "Release Source" we can take the following:
a point or location from which a flammable gas, vapour, or liquid may be released into the atmosphere such that an explosive gas atmosphere could be formed. [IEV 426-03-06, modified]

There are three basic grades of release, as listed below in order of decreasing likelihood of the explosive gas atmosphere being present:

a) continuous grade;
b) primary grade;
c) secondary grade.

A source of release may give rise to any one of these grades of release, or to a combination of more than one.

CONTINUOUS GRADE OF RELEASE
A release which is continuous or is expected to occur for long periods.

PRIMARY GRADE OF RELEASE
A release which can be expected to occur periodically or occasionally during normal operation.

SECONDARY GRADE OF RELEASE
A release which is not expected to occur in normal operation and if it does occur, it is likely to do so only infrequently and for short periods.

Generally a continuous grade of release normally leads to a zone 0, a primary grade to zone 1 and a secondary grade to zone 2.

2.2.2 DEGREE OF VENTILATION

The effectiveness of the ventilation in controlling dispersion and persistence of the explosive atmosphere will depend upon the degree and availability of ventilation and the design of the system. For example, ventilation may not be sufficient to prevent the formation of an explosive atmosphere but may be sufficient to avoid persistence of an explosive atmosphere.

The following three degrees of ventilation are recognised:

HIGH VENTILATION (VH)
Can reduce the concentration at the source of release virtually instantaneously, resulting in a concentration below the lower explosive limit.
A zone of small (even negligible) extent results.

MEDIUM VENTILATION (VM)
Can control the concentration, resulting in a stable situation in which the concentration beyond the zone boundary is below the LEL whilst release is in progress and where the explosive atmosphere does not persist unduly after release has stopped.
The extent and type of zone are limited to the design parameters.

Low ventilation (VL)
Cannot control the concentration whilst release is in progress and/or cannot prevent undue persistence of a flammable atmosphere after release has stopped.

2.2.3 EVALUATION OF THE VENTILATION

The theoretical minimum ventilation flow rate to dilute a given release of flammable material to the required concentration below the lower explosive limit can be calculated by means of the formula:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293}$$

where:

(dV/dt)min is the minimum volumetric flowrate of fresh air (volume per time, m^3/s)];

(dG/dt)max is the maximum rate of release at source (mass per time, kg/s);

LEL is the lower explosive limit (mass per volume, kg/m^3);

k is a safety factor applied to the LEL; typically:
- k = 0,25

T is the ambient temperature (in kelvins degree).

With a given number of air changes per time unit C, related to the general ventilation of the area a hypothetical volume Vz of potentially explosive atmosphere around the source of release can be estimated using the following formula:

$$Vz = \frac{f \cdot (dV/dt)_{min}}{C}$$

where:

C is the number of fresh air changes per unit time (s^{-1})

f denotes the efficiency of the ventilation in terms of its effectiveness in diluting the explosive atmosphere, with f ranging from f = 1 (ideal situation) to, typically, f = 5 (impeded air flow).

The volume Vz represents the volume over which the mean concentration of flammable gas or vapour will be either 0,25 times the LEL.,

For an enclosed area, C is given by:

$$C = \frac{dV_{tot}/dt}{V_0}$$

where:

dV_{tot}/dt is the flow rate of fresh air, and
V_0 is the total volume being ventilated.

2.2.4 AVAILABILITY OF VENTILATION

The availability of ventilation has an influence on the presence or formation of an explosive atmosphere. Thus the availability (as well as the degree) of ventilation needs to be taken into consideration when determining the type of zone.

Three levels of availability of the ventilation should be considered:

- good ⇒ ventilation is present virtually continuously;
- fair ⇒ ventilation is expected to be present during normal operation;
  discontinuities are permitted provided they occur infrequently and for short periods;
- poor ⇒ ventilation which does not meet the standard of fair or good, but discontinuities are not expected to occur for long periods.

Ventilation that does not even meet the requirement for poor availability must not be considered to contribute to the ventilation of the area.

2.3 PRACTICAL GUIDE

The following table shows the effect of the ventilation and the grade of release on the zones identification.

GRADE OF RELEASE	VENTILATION						
	DEGREE						
	HIGH			MEDIUM			LOW
	AVAILABILITY						
	GOOD	FAIR	POOR	GOOD	FAIR	POOR	GOOD FAIR OR POOR
CONTINUOS	(Zone 0 NE) Non-hazardous[1]	(Zone 0 NE) Zone 2[1]	(Zone 0 NE) Zone 1[1]	Zone 0	Zone 0 + Zone 2	Zone 0 + Zone 1	Zone 0
PRIMARY	(Zone 1 NE) Non-hazardous[1]	(Zone 1 NE) Zone 2[1]	(Zone 1 NE) Zone 2[1]	Zone 1	Zone 1 + Zone 2	Zone 1 + Zone 2	Zone 1 or Zone 0[3]
SECONDARY	(Zone 2 NE) Non-hazardous[1]	Zone 2 NE Non-hazardous[1]	Zone 2	Zone 2	Zone 2	Zone 2	Zone 1 and even Zone 0[3]

(1) Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone which would be of negligible extent under normal conditions.

(2) The zone 2 area created by a secondary grade of release may exceed that attributable to a primary or continuous grade of release; in which case, the greater distance should be taken.

(3) Will be zone 0 if the ventilation is so weak and the release is such that in practice an explosive atmosphere exists virtually continuously (i.e. approaching a "no ventilation" condition).

"+" signifies "surrounded by"

Note:in the Part II of the present study it will be clearly indicated the belonging of the various items involved in a conversion project according to the above reported table, when it is not influenced by engineering solutions

The general criteria to be considered for the table used can be summarised as follows.

1. The volume Vz (see section 2.2.3) can be used to provide a means of rating the ventilation as high, medium or low.
   The ventilation can be regarded as HIGH when the volume Vz is very small or even negligible (at least one size order smaller that the volume to be controlled).
   The ventilation can be considered as MEDIUM when the volume Vz is comparable (same size order) with the volume to be controlled.
   The ventilation can be regarded as LOW in all other cases.

2. It is mandatory, for the installation under consideration, to have a GOOD AVAILABILITY of the ventilation; it means that the ventilation system must work continuously. A back-up fan is strongly suggested even if the EN rules allow the use of a single (double speed) fan where provision is made for preventing the release of flammable material when the ventilation has failed (i.e. automatic interruption of the process).

3. Provided that CONTINUOUS GRADE OF RELEASE are not admitted, the goal is to have all release points regarded as SECONDARY.
   In case of primary grade of release presence, the area is classified as ZONE 1 and the relevant solutions in term of electrical installation must be adopted.

4. In order to make the rules application easier, we are going to report here below some examples of source of release with the relevant classification.
   It is understood that these examples are not intended to be rigidly applied since some particular process definition by technological and technical sections may allow to vary the classification itself.

Sources giving a continuos grade of release

a) the surface of a flammable liquid in a fixed tank not in contact to blaqueted atmosphere

Sources giving a primary grade of release

a) seals of pumps or valves if release of flammable material during normal operation is expected (cyclopentane and all pumps running polyol and cyclopentane blend, all valves installed along the cyclopentane and blend piping);
b) water drainage points on vessel which contain flammable liquids, which may release flammable material into the atmosphere while draining during normal operation;
c) points which are expected to release flammable material into the atmosphere during normal operation (calibration head, required when an automatic ratio detector is not installed and foaming head);

Sources giving a secondary grade of release

a) seals of pumps and valves where release of flammable material during normal operation of the equipment is not expected;
b) flanges, connections and pipe fittings, where release of flammable material is not expected during normal operation;

5. We present now an application example to understand the practical impact of the required new approach to an hypothetical dosing machine suitable to work with cyclopentane: the Polyol side is enclosed in a dedicated box.

   The possible release points are the following:

- pump sealing
- valve and stream distributors sealing
- agitator sealing
- all possible leakage points

It is clear that all these points, under the normal working conditions, can only generate "secondary grade release".
Important remark: This is true and all consequent concepts can be applied only if a leakage monitoring system is installed onto the items which can be source of primary grades of release.

a) We can suppose that typically the installed ventilation system has a capability of 2000 cu.m./h; we estimate the volume of the box to be **10 cu.m.**, the number of **changes per hour (C) is 200 h^{-1} (0.055 S^{-1}, changes per second).**

b) To be conservative, we consider the worst conditions which would happens when the full quantity of chemicals contained inside the tank comes out because of leakage; under the machine Polyol side, there must be a sealed drip pan having an estimated surface of **2.5 sq.m**.
It means that the evaporation rate is the following:

80 g/sqm.h. (0,000042 Kg/s) in case of blending (Polyol + Cyclopentane);

4610 g/sqm.h (0,00325 Kg/s) in case of pure Cyclopentane;

c) LEL = 1.4% = 0,041 Kg/m^3.

d) Considering a temperature of 50° C = 323° K inside the box and using the formula (1) we get:

$$\left(\frac{dV}{dT}\right)_{min} = 0.0045 \text{ cu.m./s} = 16 \text{ cu.m./h}$$

note: this is the minimum ventilation required to keep the concentration of Cyclopentane vapour lower than 25% of LEL

e) Using the relevant formula, assuming f = 1 (which means that the efficiency of the ventilation is satisfactory because there are no obstacles inside the box) we get

Vz = 0.08 cu.m.

Note: This is the volume where the concentration of Cyclopentane vapours can be 25% of LEL.

f) Vz is negligible respect to the volume to be controlled, which is the Polyol side box (7.5 cu.m.); according to theory indicated by the International Standards, the ventilation grade is HIGH. The approach to the Safety for Cyclopentane application requires that the ventilation is ALWAYS working; provided that this condition is respected, the availability of the ventilation is GOOD.

The conclusion is the following:

THE POLYOL SIDE OF THE CONSIDERED MACHINE IS "ZONE 2 - NON HAZARDOUS" AREA

We underline that the above reported example has general validity only.

It must not be considered as a reference calculation for practical project implementation.

3. IDENTIFICATION OF THE REQUIRED ELECTRICAL APPARATUS

3.1 SAFETY PRINCIPLES

- Installations in which flammable materials are handled or stored should be designed, operated and maintained so that any releases of flammable material, and consequently the extent of hazardous areas, are kept to a minimum, whether in normal operation or otherwise, with regard to frequency, duration and quantity.

- In emergency situations, reliance should be placed on the isolation of unsuitable electrical equipment, shut-down of the process, isolation of process vessels, containment of spillage and the provision of additional emergency ventilation.

- In a situation in which there may be an explosive gas atmosphere, the following steps should be taken:

  a) eliminate the likelihood of an explosive gas atmosphere occurring around the source of ignition,

  or

  b) eliminate the source of ignition.

For the installation under consideration, the possible source of ignition is, essentially, the electrical apparatus.

3.2 SELECTION OF ELECTRICAL INSTALLATION

Electrical apparatus should, as far as possible, be located in non-hazardous areas. Where it is not possible to do this it should be located in the least hazardous area.
Hazardous areas MUST be limited in extent by construction measures, for example walls or dams. By doing that, the use of ventilation can reduce the probability of the presence of an explosive gas atmosphere so that areas of grater hazard can be transformed to areas of lesser hazard or to non-hazardous areas.

In order to select the appropriate electrical apparatus for hazardous areas, the following information is required:
a) classification of the hazardous area (see also chapter 2)
b) the ignition temperature of the gas or vapour involved
c) ambient temperature.

3.2.1 SELECTION WITH RESPECT TO AREA CLASSIFICATION

For all hazardous zones identified by following the criteria reported in chapter 2 of the present study, a specific electrical installation (apparatus and wiring) is required.

ZONE 0

Only the following electrical apparatus, installed and marked in accordance with the requirements specified in its certificate, may be used:

a) intrinsically safe apparatus of category "ia";
b) other electrical apparatus specifically designed for use in Zone 0.

Intrinsically safe circuits shall be installed in accordance with the requirements for Zone 1 as specified below but, in addition, special requirements may apply for Zone 0.

ZONE 1

Electrical apparatus used in Zone 1 shall be constructed in accordance with the requirements for Zone 0 or one or more of the following types protection:

- explosion-proof enclosure "d"
- pressurised enclosure "p"
- sand-filled apparatus "q"
- oil-immersed apparatus "o"
- increased safety "e"
- intrinsic safety "i" (ia or ib).

The electrical apparatus shall be properly marked.

The different protection modes are the following.

- **d**: explosion proof. The electrical component is contained inside a dedicated housing which avoids that either high temperatures or one eventual explosion inside the housing itself prime the external explosive atmosphere. (Ex-d component).
- **p**: internal over-pressure. The electrical component is contained inside a dedicated housing which is over-pressurised compared to the outside part. In such a way the explosive atmosphere cannot penetrate into the housing itself. (Ex-p component).
- **q**: under send. The electrical component is covered by a quartz sand layer in order not to cause the ignition of the explosive atmosphere. (Ex-q component).
- **o**: oil submersed. The electrical component is covered by a dedicated oil head in order not to cause the ignition of the explosive atmosphere. (Ex-o component).
- **e**: increased safety. Some constructive measures are foreseen in order to minimise the probability of failures which can prime the explosive atmosphere. These measures are realised for those components which, by nature, can cause the priming during the normal working conditions (i.e. electrical cables, transformers, asynchronous motors, etc..). (Ex-e component).
- **i**: intrinsically safe. The electrical component and the relevant circuit do not have enough energy to prime the explosive atmosphere. (Ex-i component).

ZONE 2

The following electrical apparatus may be installed in Zone 2:

a) electrical apparatus for Zone 0 or Zone 1, or
b) electrical apparatus designed specifically for Zone 2 (minimum type of protection "n")

Ex-n: it means that some particular constructive measures are used in order to allow the installation of the electrical apparatus inside all are as where there is a small probability of explosive atmosphere presence (zone 2)

In the case of rotating electrical machines incendive sparking shall not occur during start-up unless measures are taken to ensure that an explosive atmosphere is not present.

NON EXPLOSIVE ZONES

It must be used electrical apparatus complying with the requirements of a recognised standard for industrial electrical apparatus which in normal operation does not have ignition capable hot surfaces and does not produce arcs or sparks. Enclosures containing bare live parts and enclosures containing only insulated parts require a degree of protection of at least IP54 and IP44 respectively.

3.2.2 SELECTION WITH RESPECT TO IGNITION TEMPERATURE

The electrical apparatus shall be so selected that its maximum surface temperature will not exceed the ignition temperature of the possible present explosive gas.

In case of CycloPentane the ignition temperature is 380°C.
It means that the electrical apparatus must be suitable for T2 class and should be properly marked.

3.2.3 SELECTION WITH RESPECT TO AMBIENT TEMPERATURE

The electrical apparatus shall be used within the limits of ambient temperature for which it is designed. If the marking of the electrical apparatus does not include an ambient temperature range, the apparatus shall be used only within the ambient temperature range from -20°C to +40°C.
If the marking of the electrical apparatus includes an ambient temperature range, this apparatus shall be used only within this range.

4. IDENTIFICATION OF THE REQUIRED SAFETY SOLUTIONS

Taking into consideration all general criteria illustrated up to this point, we want to summarise in the present Chapter the safety concepts indicating the practical solutions which MUST be implemented in order to run a refrigerator plant using Hydrocarbons in safe conditions.

A. *LIMITATION OF ALL HAZARDOUS AREAS*

The most suitable and convenient solution is to build-up safety enclosures, made of properly grounded metal sheets, around the working areas where CycloPentane emission can happen, even not during the normal working conditions.
The enclosures must be as small as possible, taking of course into consideration the minimum ergonomic space for the normal production or maintenance operations.
For the small installation, the limitation of the area can be realised by dedicated rooms.
There are other solutions such as local air suction systems which would also be adopted where the enclosure is not possible.

B. *PRIMARY VENTILATION SYSTEM*

A primary ventilation system must be always working (24 hours over 24 hours independently from the working time and during the period-off also).
The required minimum capability of this ventilation system must be calculated according to the method reported in the chapter 2 - section 2.2.3 of the present study.
The use of further safety coefficient (at least 2) is recommended.

C. APPROPRIATE ELECTRICAL APPARATUS

Provided that all installation should be realised by using the concept to minimise the presence of Zones 0 and 1, the electrical installation must be realised according to the criteria reported in the previous Section 3 of the present chapter. Any deviation from those assumption must be rejected.

D. SECONDARY VENTILATION SYSTEM

A second ventilator, back-up connected to the primary one and having the same flow capacity, should be installed.

This system would allow the switching off of the primary system for the normal maintenance operations keeping anyhow the required minimum level of ventilation.

The International Standards allow the use of the Primary ventilation System only, provided that in case of failure the production process is closed down. The installation of the Secondary Ventilation System would be suggestible because of the following reasons.

- The reliability of a locally maintained system, in some enterprises in Article-5 countries, is not enough to guarantee the functioning continuity; so, as a consequence, it would be often necessary to stop the production process causing negative impact on the installation.
- In the normal industrial practice the required continuity of a ventilation system can be assured only by a 100% - stand-by system.

E. ATMOSPHERE MONITORING SYSTEM

Since the "active" safety system, like the above described ventilation, always requires the input signal coming from a "passive" safety system, it is mandatory to provide such system. Considering that:

- the hazardous condition is connected to the concentration level of the explosive gas inside the atmosphere
- the hazardous concentration range is clearly identified for all hydrocarbons between the LEL and the HEL

The most convenient "passive" safety system is the atmosphere monitoring system suitable to measure continuously the concentration of the flammable gas inside the risky areas.

The gas sensors to be installed becomes a further necessary safety measure, even if not clearly stated by the International Standards taken into consideration.

F. SAFETY ELECTRIC CONTROL PANEL

A dedicated electric control panel to run the safety logic, in the way we are going to describe, is required. It is understood that within this section only the general philosophy to approach the problem is indicated.

It is necessary to divided all alarm signals coming from the field by the identified hazardous level and to connect the practical reaction of the safety system to these signals.

Three different levels, as a minimum condition, must be clearly identified.

LEVEL	HAZARD	SAFETY ACTION
1	LOW	– warning message on the Safety ECP screen – blue lamp lighting – starting of a counter set on a maximum time allowed to recover the alarm situation; once this time expires the level becomes "2"
2	MEDIUM	– warning message on the Safety ECP screen – yellow lamp lighting – 1 tone siren – secondary ventilation system switching on – process interruption – counter set on a maximum time allowed to recover the alarm situation; once this time expires the level becomes "3"
3	HIGH	– red lamp lighting – 2 tones siren – secondary ventilation system switching on – electrical power cut-off

As indicated by the above reported description of the alarm level 3, it is required to have a dedicated power supply (i.e. emergency power generator) feeding the Safety ECP which must be on in case of electrical power failure in order to grant the continuity of the required protection level.

5. DEFINITION OF THE EXISTING PLANT

5.1 INTRODUCTION

The purpose of this Section is to define some criteria for an homogeneous evaluation of the status of the production lines to be converted.
Of course, the validity of these criteria has to be considered as general; it is understood that the practice of an experienced technical advisor is the most reliable way to judge a practical situation.
Nevertheless, we feel of paramount importance to channel the technical information related to the various and different situation by a common and unique guideline.

5.2 IDENTIFICATION CRITERIA

The situation of the enterprise under evaluation has to be defined by identifying two different general aspects:
a) services
b) existing equipment status.

5.2.1 SERVICES

The services status evaluation has a direct and fundamental impact on the definition of the baseline

conditions of the production lines under evaluation.
It is mandatory to fix a precise border between those installations which can be reasonably converted to the hydrocarbon technology and the ones which are still far away from a minimum required technological level.

5.2.1.1 GENERAL SERVICES

INDUSTRIAL WATER LINE
As a base line condition, it must be required the availability of a water distribution line at a normal exercise pressure (2÷3 bar_G), for the thermostatization system (i.e. chiller unit) of the equipment to be installed.

COMPRESSED AIR
As a baseline condition, it must be required the availability of a compressed air line distribution at an exercise pressure of 6-7 bar_G.
The compressed air must be:
- dry
- without residual oil

for the correct operation of the pneumatic devices to be installed.
Note: whether the Nitrogen generator supply is required, the technical features of the compressed air at least available flow rate and purity have to be clearly indicated in the project specification.

ELECTRICAL ENERGY SUPPLY
Thought that all voltages and frequencies are admitted, as a baseline condition, it must be required the continuity of the energy supply.
It means that in case of periodical black-out, officially foreseen by the local authorities, the enterprise is required to provide a dedicated stand-by electric power generator.
Note: when the stand-by electric power generator is already installed, the project specification must indicate clearly the relevant technical features and the available residual power.

5.2.1.2 SAFETY SERVICES

GROUNDING
As a baseline condition, it must be required the availability of a grounding system for the entire building. The project specification must indicate clearly the technical features of the existing system.

LIGHTNING ROD
As a baseline condition, it must be required the availability of a lighting rod for the building where the new hydrocarbons technology has to be implemented. This is in accordance to the recommendation reported at point 6,5 of the IEC 79-14 International Standards.

5.2.2 *EXISTING EQUIPMENT STATUS*

The evaluation of the existing equipment status can be made by using a dedicated questionnaire to be filled in by the technical advisor who will be responsible of the project presentation.
For each part of the line to be converted it will be presented an appropriate check list with the relevant instruction for the use.

The parts which will be taken into consideration are the following:

EXISTING PLANT ITEMS LIST	RETROFITTABLE	NOT RETROFITTABLE
1. PRE-MIX BUFFER TANK BLEND DELIVERY PUMP	 X 	 X
2. PIPING BETWEEN PREMIX-MACHINE	X	
3. FOAMING MACHINE/S - POLYOL SIDE - ISOCYANATE SIDE	 X	 X
4. PIPING MACHINE-HEAD/S	X	
5. MIXING HEAD/S GROUP - HEAD BODY - STREAM DISTRIBUTOR (POL LINE)	 X 	 X
6. CABINET FOAMING PLANT	X	
7. DOOR FOAMING PLANT	X	

* The Secretariat has informed the consultant that for all high pressure foaming machines current practice is for the eligible cost of conversion to be based on the cost of retrofit, independently of the condition of the machine. Therefore, retrofitability criteria for foaming machines are not included in the attached questionnaire (Annex II).

5.2.2.1 RETROFITTABLE ITEMS

The questionnaires as attached in Annex II provides the necessary information to assess the retrofitability border of the item under evaluation (please see Annex II).

5.2.2.2 NON-RETROFITTABLE ITEMS

In the above reported "existing plant items list" some items are indicated as "non-retrofittable"; here below the explanation of these indications is reported.

A) BLEND DELIVERY PUMP

The main reason of the indication to replace the existing delivery pump by a new one is that the pump itself has to run (direct contact) explosive liquid containing hydrocarbons. It is requested a dedicated leakage monitoring system of the seal, which must be "double seal" type.

Furthermore, the viscosity of the new formulation with hydrocarbons requires different performances which could not be granted by the existing pumping group.

B) FOAMING MACHINE POLYOL SIDE

Basically, it is possible to take into consideration the retrofittability of the machine Polyol side only when the used foaming technology is the HP type. Because of the necessity to make a complete revision of wiring, seals and electrical devices and considering that HP pump and all instruments inside the tank must be replaced, the retrofitting of the machine Polyol side is not a cost-effective choice. The industrial and experienced practice of all P/U machines manufacturers confirms this attitude.

C) POLYOL LINE STREAM DISTRIBUTORS

We consider the stream distributor valves the only part of the foaming head which is not retrofittable by principle; this is because, during the normal working operation, such valve is a primary grade of release. Since it is already clarified that the right approach to the safety system is to minimise the level of hazardous areas, it becomes mandatory to install monitored stream distributors.

SAFETY COST EVALUATION

PART II

6. DETAILED CONVERSION ASPECTS

6.1 INTRODUCTION

The purpose of this second Part of the Study is to define the most important aspects related to the safety for the implementation of the conversion project to the cyclopentane technology.

As already anticipated the points which will be taken into consideration for the different areas of a production line are the following:

- baseline conditions
- tendering criteria
- available technical solutions and relevant comparison
- safety costs estimation

Within this general introduction, it is important to underline the principle driving the development of the "Tendering criteria" section.-

6.1.1 FIRST PRINCIPLE: "RESPONSIBILITY OF THE BIDDER/ CONTRACTOR"

It must be clear that the full responsibility on the safety aspects has to be undertaken by the Bidder/Contractor; one of the main points concerning the Safety is the clean and unequivocal definition of the different "hazardous areas" and the relevant classification as well.

According to the general explanation of the first part of the study, there are different impacts of the engineering solutions on the classification of "zones", this means that it is possible to implement different safe solutions at different costs.
As a consequence of this principle, the tender document MUST require the Bidders to provide, within the proposal, a detailed evaluation of the hazardous level of the operative areas taken into consideration by the project. Of course, these evaluations have to be done following the general criteria previously explained.

Furthermore, the tender MUST require, as part of the scope of supply, the technical documentation including all relevant calculation endorsing the areas identification reported in the proposal. This document can be named "Safety Report" and it must be signed by the person assuming the legal responsibility on behalf of the Contractor.

6.1.2 SECOND PRINCIPLE: "NECESSITY OF DETAILED ENGINEERING"

In the name of the necessity to optimise the cost of the project implementation, it is of paramount importance to take into consideration the possibility to use local manpower which is normally available at lower cost. On the other hand, it is absolutely unsuggestible to leave completely the practical realisation of the Safety to people who have not been fully trained in all safety details. Furthermore, it is necessary to make practical and active the Bidder/Contractor responsibility.

As a consequence of the above reported consideration, the tender MUST require, as part of the Scope of Supply, the "detailed engineering" representing the reference documents of the project implementation.

The requested "detailed engineering" can be summarised by the following items:

- lay out of all converted areas
- constructive drawings for all jobs which are supposed to be at counterpart charge and not included in the baseline conditions (i.e. pipelines, tanks, enclosures, ecc..)
- safety items layout and instruction for the relevant installation (i.e. gas sensor, ventilators, air ducts, ecc...)
- instructions (dimensional drawings) for the execution of the required civil works excluding the structural calculation related to the ground and local features.

6.1.3 THIRD PRINCIPLE: "SAFETY REQUIRES QUALITY"

The transferring of a technology involving the use of hydrocarbons in Article-5 countries has to be considered a delicate industrial operation.
For this reason, it is important to activate all additional available and no-cost selection criteria in order to increase the safety level of all the implemented solutions.
It is world wide recognised that working within a Quality system mainly where the development of engineering jobs is required, involves automatically an improvement of the manufacturing accuracy which means the increase of the intrinsical Safety levels of the produced equipment.

Thought that the most hazardous areas of a converted plant are easily identifiable in the ones where the cyclopentane (pure and blended) is contained and that within these areas new equipment are required, it is possible to conclude that the tender document should impose all Bidders to present the quality certification as per ISO 9000 international system, of the suppliers of the equipment to be installed inside the above mentioned areas.
It is clear that, within this logic, the ISO 9001 Certification of the equipment suppliers is recommended.
This critical equipment can be identify as follows:
- cyclopentane storage accessories
- premix
- foaming machines

6.1.4 TENDERING CRITERIA PURPOSE

It is clear that, by applying the above principles, the tender will have to require all necessary documents to execute the conversion project respecting the safety conditions.

Provided that the preparation of the equipment specification is at the implementing agency charge, within the " tendering criteria "section dedicated to the various items of a production line, we will clearly indicate what has to be requested as additional safety aspects.

7. CYCLOPENTANE STORAGE AREA AND DISTRIBUTION PIPING

7.1 BASELINE CONDITIONS FOR C5 STORAGE TANK

As a baseline condition it must be required:
- the availability of the installation area at a sufficient distance from all the buildings according to the selected solutions and to the local authorities indications;
- the availability of a dedicated water line distribution, at least inside the building closest to the selected area, at a working pressure of 12 bar_G as minimum value.

7.2 TENDERING CRITERIA

7.2.1 AREA CLASSIFICATION

Thought that the areas classification depend always from the technical solutions decided by the designer of the conversion project, we report here below an **EXAMPLE** of what has to be clearly demonstrated by the Contractor for the project implementation within the area classification section.

Inside the tank:

- degree of ventilation: LOW
- availability of ventilation: POOR
- grade of release: CONTINUOS

Conclusion: ZONE 0

On top of, we remind the suggestion of the International Standard for the classification of the area outside the storage tank.

Outside the underground tank

- 3m horizontally from the separator and 1 m above ground level : **zone 1**
- 7,5 m horizontally and 3 m above ground level: **zone 2**

Outside the above ground tank

- 3m from vent openings: **zone 1**
- 3 m above the roof and 3 m horizontally from the tank: **zone 2**

The above reported classification are obtained considering a natural ventilation having medium degree and good availability.

7.2.2 PARTS TO BE LOCALLY MADE

The items which can be sourced locally are:

- storage tank
- man holes well
- filling system piping
- delivery piping to the pre-mix unit
- ground of the storage tank
- fire protection system

Local manufacturing of tank and relevant distribution piping is a cost effective alternative provided that :

1. The contractor is in a position to supply the complete and detailed engineering.
2. The local supplier is in a position to manufacture the tank at a competitive price (previous experiences tell that for double-wall solution it is not always economically convenient, even considering the freight cost).

Anyhow, all tank accessories should be supplied by the Contractor because of the impossibility to source the critical components locally.

7.2.3 SCOPE OF SUPPLY

The tender must require the following additional items:

- constructive drawings of the storage tank and relevant manholes well
- technical indication for the realisation of filling system and fire protection system
- dimensional drawings for the execution of civil works inside storage area.
- distribution piping arrangement including layout and sketches
- electrical schematic drawing related to new circuits and modified ones as well

7.3 AVAILABLE TECHNICAL SOLUTIONS AND RELEVANT COMPARISON

Two solutions are available

1. IBC (Intermediate Bulk Containers)
2. Storage tank

7.3.1 IBC

They are certified, qualified and stockable containers for transportation; they must be suitable for flammable liquids. They are particularly recommendable when different means of transport are required.

The typical volume is 4-5 cu.m.

Advantages	• the containers are rented by the raw material supplier to the Counterpart • easy to be - found - transported - imported • the containers can be pressurised by N2 for the pre-mix priming (no pump is required)
Disadvantages	• nitrogen pressurisation circuit is required • the container can not be positioned more than 50 m. far from the pre-mix station • the storage area must be located far away from the factory building
Conclusion	Safer solution than drums, anyhow to be taken into consideration only in case of: a) difficult access to the factory (road transportation) b) medium-low C5 consumption.

7.3.2 FIXED STORAGE TANK

The optimal volume ranges from 0,5 up to 35 cu.m. depending from the cyclopentane consumption and relevant availability (drums or trucks).
The minimum recommended size of the storage tank has to be determined taking into consideration a consumption of 2 months.
The 25 cu.m. is preferred when the transportation is made by standard 20 cu.m. fixed container truck.
The 35 cu.m. solution is recommended when the transportation can be done by articulated lorry truck or trailer truck. This solution allows cost saving in transport.
Lower-sized tank (i.e. 10 cu.m.) is considered a feasible solution only in case of no-space availability around the factory.

According to the European standards double-wall tank is mandatory only in case of underground solution. This is because the main inconvenience is that the integrity of the tank against corrosion cannot be checked. Therefore a double-wall tank with relevant leak monitoring should be used.
The double-wall solution has a negative impact on the manufacturing cost which is 60% higher.
Single-wall tank should not be used for underground solution, unless it is installed inside a proper concrete and water tight pit filled with gravel.

On top of it, the tank must be protected against external corrosion by a proper painting procedure:

a) above ground: - 75 μ of inorganic zinc primer

b) under ground: - sand blasting (SA 3 grade)
- 400 μ of epoxy paint with relevant certificate

Unless ample plot space is available, underground storage should be preferred for new installations, because it offers two main advantages over aboveground: the fire risk and the evaporation losses are much reduced. Installation costs are comparable: underground tanks are more expensive as such, but require less fire fighting facilities, and can in most cases be filled by gravity, eliminating the need for a truck unloading pump.

The tank design pressure should be 3 bar gage minimum, which is 1.5 times the vapour pressure of isopentane at 40°. It does not need to withstand to full vacuum, but should be fitted with a vacuum vent, to allow air inlet to the tank to compensate for offtakes by users.

Aboveground pentane storage cannot be installed too close to other facilities. Regulations differ from country to country, but a distance of 25 m to the nearest building or to the property limit seems to be a minimum. Some countries (e.g. UK) do not allow installation of flammable liquids and gasses on the same plot. Distances to truck unloading, drum storage, access roads or other facilities must be examined as well. Sometimes concrete walls may be built to shield these off and allow closer distances.

Aboveground storage tanks should be installed within a bundwall with a capacity equal to at least 50% of the total storage (or more if required by the authorities) or 100% of the largest tank. Current environmental regulations require an impervious concrete flooring within this retention basin.

Aboveground storage of pentane requires fixed fire fighting facilities. In case of leak, fire can indeed occur under or around the tank, and heat its content up. The pressure in the tank will rise to the setpoint of the safety valve, or higher if the safety valve is not properly sized. If flame impingement then burns a hole in the vessel, a high proportion of the escaping liquid will immediately flash. This will create a BLEVE (boiled liquid expanding vapour explosion), which is a major disaster. To avoid this, a water spray system designed for 10 litres per m^2 per minute should be fitted on the tank (m^2 refer to the tank shell surface area). For this reason also, a minimum design pressure of 6 bar is recommended.

For both solutions some particular arrangements have to be undertaken regarding the unloading area (trucks or drums). A dedicated concrete basement has to be realised, it must have an inclination of 1% and it must end with all open pit with a volume ranging between o,5 and 3 cu.m. according to the total quantity of unloaded cyclopentane.

Basically, the same considerations reported for the storage tank can be done also for the distribution piping to the pre-mix unit. To summarise, this means that in case of underground pipeline it is requested the double-wall solution, while for the aboveground situation, a single-wall piping is acceptable.

A double-wall piping solution costs roughly 15-20% more than the single-wall one (excluding the leak detection system).

In both cases, the piping must be high pressure designed (over 150 bar) to prevent the hazard coming from the liquid thermic dilatation.

In case of underground tank, just anti-detonation dampers are required, these devices must be installed along the pipe-line between storage and pre-mix. An alternative and feasible solution can be the implementation of a Nitrogen blanketing system inside the storage tank.

Costwise, the two solutions are comparable.

In addition to the above items, in case of aboveground tank, it is mandatory the building up of a dedicated bundwall and the installation of a fire fighting facilities.

As a conclusion we can summarise the comparison between the two solution as follows:

ABOVEGROUND	UNDERGROUND
■ **Advantages**	**Advantages**
■ no double-wall solution is required (easier local manufacturing)	■ lower distance from other facilities ■ no fire protection system is required ■ filling by gravity ■ no pressurisation is required
Disadvantages	**Disadvantages**
■ a minimum distance must be respected ■ fire protection system is required ■ protection and containing pit roof must be provided ■ tank insulation is required as per TUV recommendation ■ filling by gravity is not allowed.	■ double-wall is required with relevant leak detection system

8. PREMIX AREA, FOAMING MACHINES AND INTERCONNECTION PIPING

8.1 BASELINE CONDITION

As baseline conditions, it must be required the availability of (see point 5.2.1.1):

- industrial water line
- compressed air distribution line
- electrical energy supply

8.2 TENDERING CRITERIA

8.2.1 AREA CLASSIFICATION

Thought that the areas classification depend always from the technical solutions decided by the designer of the conversion project, we report here below an **EXAMPLE** of what has to be clearly demonstrated by the Contractor for the project implementation within the area classification section.

Following the indication reported in Chapter 2.3 of this Study, having as minimum conditions:

- ventilation availability **GOOD**
- ventilation degree **MEDIUM**
- grade of release **SECONDARY**

The area under consideration is classified as **ZONE 2.**

However, the tender MUST require a clear and written statement of the Bidder about the zones classification.
All quoted solutions must be according to the above statement.

8.2.2 PARTS TO BE LOCALLY MADE

The interconnection piping between the pre-mix area and the foaming m/cs can be realised locally.

8.2.3 SCOPE OF SUPPLY

The tender must require the following additional items:

- technical information for the preparation of the pre-mix area
- interconnecting piping arrangement including layout and relevant sketches
- electrical schematic drawings related to new circuits and modified ones as well
- installation technical drawings of the equipment

8.3 AVAILABLE TECHNICAL SOLUTIONS

Provided that a machine has been indicated as retrofittable, the following actions have to be considered:

1) Replacement of the complete Polyol tank. The new tank must be suitable for Cyclopentane use and all ancillary accessories installed inside the tank(level controls, temperature transducers,

etc...) must be Ex-i rated due to the classification as zone 0 of the inner part of the tank.
The agitator must have at least the mechanical seal with liquid monitored barrier. The use of magnetic joint agitator would minimise possible leakages and maintenance operations.
Other requirements are :

⇒ re-filling system including super-max. control with an independent circuit
⇒ fire-safe shut down valve to isolate the tank in case of fire

If the tank is pressurised with nitrogen the area inside the tank became "not classified" so the explosion proof accessories are not mandatory.

1) Replacement of the Polyol metering group including a monitored barrage liquid on the sealing of continuous moving part (pump and stream distributor)
2) Addition of a new electrical board to house all safety electrical barrier and controls, as well as the interface with the existing electrical cabinet.
3) All new Polyol side must be mounted over a dedicated drip pan suitable to collect the full quantity of chemical contained inside the tank. The basin must include a proper level switch control giving one alarm signal in case of leakage.
4) All new Polyol part must be enclosed inside a safety box made of properly grounded metal sheets or anti-static material, the box must include all ventilation ducts to be connected to the main ventilation system. All eventual doors must be monitored by dedicated limit-switches.

9. FOAMING JIGS AND CONNECTION PIPING BETWEEN WET AND DRY

9.1 BASELINE CONDITIONS

As baseline conditions, it must be required the availability of (see point 5.2.1.1):

- industrial water line
- compressed air distribution line
- electrical energy supply

9.2 TENDERING CRITERIA

9.2.1 AREA CLASSIFICATION

Thought that the areas classification depend always from the technical solutions decided by the designer of the conversion project, we report here below an example of what has to be clearly demonstrated by the Contractor for the project implementation within the area classification section..

Following the indication reported in Chapter 2.3 of this Study, we have to consider two different situations inside this area:

a) **RESTRICTED AREA AROUND THE JIG**

This area can be considered as the volume of the ideal parallelepiped that contains the jig having the dimension equal to the jig's dimension plus as about 50 mm for each side.
In this area we have the following conditions:

- ventilation availability **GOOD**
- ventilation degree **MEDIUM**
- grade of release **PRIMARY** (injection hole and complete perimeter of the wall's fixture)

So that we can consider this area classified as **ZONE 1**

b) **FOAMING AREA**

This area is delimited with an enclosure containing all the jigs treated in the above point a).
In this area we have the following conditions:

- ventilation availability **GOOD**
- ventilation degree **MEDIUM**
- grade of release **SECONDARY**

So that we can consider this area classified as **ZONE 2**

Due to the big volume considered, it can be possible to have also an **high degree of ventilation.**

In this case the zone can be considered as **ZONE 2 NE**

However, the tender MUST require a clear and written statement of the Bidder about the zones classification.
All quoted solutions must be according to the above statement.

9.2.2 PARTS TO BE LOCALLY MADE

The items which can be realised locally, in the name of a low-cost policy, are the following.

- Safety enclosures
- Ventilation ducts system (inside and outside the enclosures)

9.2.3 SCOPE OF SUPPLY

The tender MUST require the following additional items:

- constructive drawings of all safety enclosures and ventilation ducts system including clear indication concerning construction materials and assembling instruction.
- layout of the converted production line configuration
- electrical schematic drawing related to the new circuits and modified ones as well
- technical information for the modification/preparation of the converted production line
- in case of use of one head for different jigs, a dedicated device with relevant logic control suitable to detect the positioning and the inserting of the head itself inside the right injection hole. The position of the head is easily controlled either by a microswitch for each foaming position installed on the head carriage (automatic/semiautomatic) or by a sliding contact installed on a rotating boom (manual) with the identification of each foaming position.

The insertion of the head in the identified injection hole can be controlled by a magnetic switch installed on the head and a magnetic contact installed on the jig close to the injection hole (the circuit is closed when the head is in the right position.

9.3 AVAILABLE TECHNICAL SOLUTIONS

9.3.1 CABINET SINGLE LINE (FIXED OR MANUALLY MOVABLE)

Provided that a machine has been indicated as retrofittable, the following actions have to be considered:

- The complete line must be enclosed inside a safety box made of anti-static material, the box must include all ventilation ducts to be connected to the main ventilation system. All eventual doors must be monitored by dedicated limit-switches. For more details on the ventilation concepts, please refer to the relevant section.

- All electrical components inside this area must be IP 54 as minimum provided that they can be switched off for a period (120 seconds) across the foam injection. Otherwise all electrical devices must be replaced by Ex-i ones.
  Of course the electrical items installed on the mixing head/s which cannot be switched off during the injection, must be Ex-i.
  In case of incandescent electrical heating system use, it is a must to replace it by a safe alternative.

- The heating system is usually electric type and it is possible to retrofit it either providing the cut-off of the power for a period of 120 sec. across the foam injection or substituting it with a water heating system.
  The cut-off is recommended for the following reasons:
  - it is not always possible to install the water exchangers inside the jigs because the available space is not enough to place them without impact on the refrigerator's dimensions
  - the cut-off system is safe and is the most cost effective solution

9.3.2 CABINET CONVEYOR LINE

We consider as cabinet conveyor line all those production lines that have the jigs automatically rounding by a motorised driving chain or conveyor following either a circular or a rectangular production circuit.

Usually those lines are named "carousel" line and the injection can be made by one head automatically or manually operated.

In addition to the recommendations listed at the previous section the following items have to be taken into consideration:

- at least three stations of the conveyor line have to be enclosed inside the safety box made of antistatic material. The box must include all ventilation ducts to be connected to the main ventilation system. The stations to be enclosed are the loading/unloading stations, the foaming stations and the station after the foaming one. In case of manual injection the front site of the box will be open in order to allow the manual operation.
- the ovens with direct heating system have to be replaced with indirect heating systems.
- the ovens have to be provided with a specific air purging system in order to remove constantly part of the accumulated flammable vapours.
- in case of presence of pits local ventilation is required and all electrical components must be Ex-i.

9.3.3 DOOR LINE

We consider as door fixed line the single jig or press with more than one floor that can be injected manually or automatically operating by one foaming head.
Usually he conveyor line for door is a "paternoster" or a "carousel" having some door jigs mixed with the cabinet jigs.

Also for this conveyor door line is possible to have both manual and automatic injection system with one foaming head.

All recommendations reported for cabinet lines retrofittings are still valid for the door fixed lines and conveyor system.

10. GROUNDING

10.1 BASELINE CONDITIONS

As baseline condition, it must be required the availability of a grounding system for the entire building (see section 5.2.1.2). The existing main grounding system must be designed to discharge also the short circuit currents.

10.2 TENDERING CRITERIA

10.2.1 AREA CLASSIFICATION

A proper grounding system plays an extremely important role in the definition of the hazardous area; its correct realisation allows not to consider all metallic frames inside the area as potential ignition source, because of possible electrostatic charges.

10.2.2 PARTS TO BE LOCALLY MADE

The realisation of the entire grounding system of the converted equipment can be realised locally; even the necessary materials can be locally provided

10.2.3 SCOPE OF SUPPLY

The tender MUST require the following additional items:

- detailed instructions and relevant schematic drawings for the realisation of the grounding system for electrostatic charges
- detailed instruction and relevant schematic drawings for the connection of the realised grounding system to the existing main one.
- indication of the technical features of the required materials
- report (either dedicated or part of the "Safety Report") indicating the particular precaution which have to be undertaken by the operators working inside the grounded areas

10.3 AVAILABLE TECHNICAL SOLUTIONS

The grounding system must be co-ordinated with the protection devices in order to prevent it from being the place where you can find arcs, sparks or surface temperatures higher than the maximum temperature permitted in relation to the dangerous substances used. The component parts of the grounding system and, in particular, ground conductors, protection conductors and equipotential ones are concerned by these thermal limitations.

Ground collectors and tests points are preferably situated aboveground and in accessible positions.

The ground resistance/potential equalization must be less than 0,5 ohm.

Metal pipes used in land plants to convey substances that may lead to the generation of electrostatic charges must be grounded at both ends.
If the joints of these pipes do not assure metal continuity, equipotential connections (e.g.: metal U bolts) must be used.

NOTE: As the current values relevant to the dispersion of electrostatic charges are low (a few milliampers), there are not particular limitations concerning the electric-resistance value as for the connections and the disperser; it is enough that metal continuity is permanently assured (generally speaking 10^6 ohms are thought to be sufficient). As for flanged joints, their tightening bolts or rods suffice to comply with the requirements mentioned above.

As for land installations of loading and unloading area means used to transport flammable fluids, the ground and equipotential connection of the loading/unloading equipment with the means of transport is required.
The connections between the means of transport and the grounding system must be of such a kind that the discharge-to-the-ground circuit is made in a construction of the type permitted for Z1. Grounding must take place before the loading/unloading of the fluid.

11. NITROGEN BLANKETING

11.1 BASELINE CONDITION

As baseline conditions it must be required the availability of (see point 5.2.1.1):
- compressed air distribution line
- electrical energy supply

11.2 TENDERING CRITERIA

11.2.1 AREA CLASSIFICATION

Not significant.

11.2.2 PARTS TO BE LOCALLY MADE

The Nitrogen distributor piping can be realised locally.

11.2.3 SCOPE OF SUPPLY

The Tender MUST require the following additional items:

- Nitrogen generator having at least a production capability of 280 Nl for each cabinet to be foamed, anyhow the generator must grant a final atmosphere where the oxygen concentration is less than 11%.
- Nitrogen distribution piping arrangement including layout and relevant sketches.

On top of it, a 20% oversizing of the nitrogen generator is recommended.

11.3 AVAILABLE TECHNICAL SOLUTIONS

The line is composed of the following main parts:

a) accumulator intermediate tank
b) distribution piping
c) hydraulic valve for the N_2 direct injection through the mixing head

a) Accumulator intermediate tank

The tank should contain at least the Nitrogen quantity required to perform two flushing operations consecutively; in such a way the inertisation is done within few seconds (3-4 sec) in order to minimise the time loss.
Without the intermediate tank, the maximum possible output should be the one coming out from the storage piping.

Tank specifications:
- certified for N_2 and air use
- pressurisation at 7-8 bar
- check valve mounted on the inlet line
- safety valve
- drain valve for condensate
- fixing system to the floor

b) Distribution Piping

Technical features of the pipe-line:
- 3/4" or 1" size (to be decided according to the plan layout)
- DN 16
- directional solenoid valve; it is normally open and closes only in case of emergency; one valve is requested for each line
- flow-meter with a double function:
  a) to indicate the N2 output
  b) to give an alarm signal in case of piping breakage in order to avoid suffocation risk.

c) Hydraulic valve for the N_2 direct injection through the mixing head

This is the key-point of the Safety topics for a refrigerator plant using C5 as blowing agent.
All closed cavities must be properly blanketed by Nitrogen; open mould pouring does not

require the blanketing operation.

To guarantee that the cavity is properly flushed, it is suggested to perform this operation just before the foam injection and through the same injection hole and by the mixing head itself.

Furthermore, the use of the foaming head also for Nitrogen blanketing operation avoid hazardous situations related to the accidental emission of Nitrogen inside the box atmosphere (operator safety).

Manual nitrogen injection can also be safely implemented if properly controlled.

12. VENTILATION

12.1 BASELINE CONDITION

As baseline conditions it must be required the availability of (see point 5.2.1.1):

- electrical energy supply
- stand-by electric power generator in case of periodical black out officially foreseen by the local authorities.

12.2 TENDERING CRITERIA

12.2.1 AREA CLASSIFICATION

The capability of the ventilation system is one of the main design parameters having a fundamental impact on the area classification.
For the general criteria of the relevant evaluation, please refer to part I of the present Study.

12.2.2 PARTS TO BE LOCALLY MADE

As already indicated within the previous Section 9.2.2., the ventilation ducts system outside the Safety enclosures can be locally realised.

12.2.3 SCOPE OF SUPPLY

The Tender MUST require the following additional items:

- constructive drawings and relevant arrangement of all ventilation ducts and the relevant chimney
- dimensioning evaluation of the ventilation ducts
- detailed calculation of the ventilation system to be installed with clear and technical explanation of zones classification
- anti-spark ventilators complete with relevant differential pressure switches
- flow-diagram of the ventilation entire system

12.3 AVAILABLE TECHNICAL SOLUTIONS

Essentially a correct and safe operative condition is assured by a redundant artificial ventilation system combined with a flammable vapour detection and monitoring system.
The exhaust ventilation system has to be designed so to maintain the concentration of the flammable vapours, released during the use or in case of accidental leakage in the protected area, almost under the 30 percent of the Lower Explosion Limit.

Both systems MUST operate continuously and safe also in presence of flammable vapours, they MUST automatically give the alarm in a proper manned area and they MUST switch off automatically the electrical power supply of the area where the dangerous condition happens.
Therefore the counterpart MUST install for the a.m. unit a proper electrical save switch provided with minimum voltage opening coil.

In alarm conditions, before switching on the electrical power in the protected area, the counterpart MUST repair the cause of alarm and flush the area involved exhausting the equivalent of almost five volumes of air.
The power line for the safety alarm and control system MUST be a dedicated line, separated from the power supply line of the a.m. unit and it MUST be backed-up immediately in case of failure of the general power supply.

Basic characteristics for the exhaust system are as follows:

- suction ducting shall be fire and shock resistant
- the suction points have to be positioned as close as possible to the vapour emission sources
- efficiency of ventilation has to be tested on site by artificial smoke generator
- the functioning of the exhausting shall be checked continuously by properly installed testing devices
- fans have to be sparkfree and designed according to VDEM 24169
- exhausted air has to be conveyed outside the building at a proper distance from the roof
- the control of the ventilation is performed by a proper safety logic panel and it must be interfaced with the alarm system and the vapour monitoring system
- the ventilation system must run continuously even in case of production stop.

13. GAS DETECTION SYSTEM

13.1 BASELINE CONDITION

As baseline conditions it must be required the availability of (see point 5.2.1.1):

- electrical energy supply
- stand-by electric power generator in case of periodical black out officially foreseen by the local authorities.

13.2 TENDERING CRITERIA

13.2.1 AREA CLASSIFICATION

Independently from the zone classification, it does not make sense to install sensors which are not Ex-d protected and/or suitable for ZONE 0, this is because the purpose of the sensors is to be in direct contact with a potential explosive atmosphere.
Of course they must be suitable to work in presence of cyclopentane vapours and certified according to EN 50054

13.2.2 PARTS TO BE LOCALLY MADE

None

13.2.3 SCOPE OF SUPPLY

The Tender MUST require the following additional items:

- Ex-d rated gas sensors with relevant cards (the Tender must indicate precisely the number of units required)
- electrical cables for the sensors wiring (the Tender must indicate precisely the required total length)
- safety electric control board complete with Synoptic scheme of the converted plant; the purpose of this synoptic is to allow an easy identification of the alarmed gas sensors or, at least, the alarmed area.
- battery system to keep the sensors on for a possible back-out period of 10 minutes. After this period, the stand-by electrical power generator is for sure full running.
- electrical schematic drawings of all safety circuits
- detailed report on the safety logic and alarms level classification for the entire converted plant

13.3 AVAILABLE TECHNICAL SOLUTIONS AND RELEVANT COMPARISON

The gas detection system is a safety system redundant and independent from the ventilation. It guarantees a second level of safety.
The gas detectors measure the presence of flammable vapours in case of insufficient ventilation due to increased vapours emission or ventilation shut-off.
Since the C5 vapours are heavier than the air, the gas detectors have to be positioned close to the floor just between the vapour source and the suction system. The right criteria to determine the total number and position of the gas detectors to be installed depends on the plant configuration, anyhow the following configuration can be considered as a basic indication:

• **storage area**	⇒ not requested
• **premix area**	⇒ 1 close to the mixer and 1 close to the buffer tank
• **foaming unit**	⇒ 1 between tank and metering pump, ⇒ 1 close to the stream distributor (if outside the enclosure)
• **dry area (fixed lines)**	⇒ 1 every fixed jig
• **dry area (conveyor line)**	⇒ 2 close to the foaming area ⇒ 1 closed to the foam expansion area ⇒ 1 close to the unloading area ⇒ 1 inside the oven area

Furthermore, it is understood that sensors are required everywhere there is the possibility to have explosive atmosphere.
Final consideration are:

- The gas detectors must be always in operation also in presence of flammable vapours (Ex-d)
- they must give 3 different signals in safety logic:
  - 15% LEL requiring ventilation increase
  - 30% LEL requiring increasing ventilation and power switch off

- SENSOR FAULT

A comparison between the infra red and catalytic gas sensors can be as follows:

	CATALYTIC	INFRA RED
COST	cheaper	70% higher
AVAILABILITY	very common	common
INSTALLATION	easy	easy
TESTING	easy	higher skill
RELIABILITY	easy to be contaminated*	low sensibility to contamination**
MAINTENANCE	3 months	6 months

* The contamination may result from exposure to substances as silicones, tetraethyl-lead, sulphur compounds, phosphate esters.
Has to be taken into consideration that presence of such substances in refrigerator factories is extremely rare.

** Serious errors are likely to occur, with some detectors, due to the presence of water vapour or interfering gases or both.

As a conclusion in article 5 countries catalytic gas sensors can be suggested.

14. ELECTRIC CABLES AND LIGHTING SYSTEM

14.1 BASELINE CONDITION

As baseline condition, it must be required the presence, inside the converted area, of the energy power distribution net. This net must be suitable for the connection to the electric control boards of the converted plant.

In term of lighting, it must be requested an acceptable condition related to the normal working operations.

14.2 TENDERING CRITERIA

14.2.1 AREA CLASSIFICATION

All consideration on the lighting system refer to the safety enclosures of the dry parts, in those cases where the human presence is foreseen.

14.2.2 PARTS TO BE LOCALLY MADE

The items which can be sourced locally in the name of low-cost policy are the following:
- cable trays
- IP 54 lamps for lighting during the normal working conditions

14.2.3 SCOPE OF SUPPLY

The Tender MUST require the following additional items:

- electrical cables for the interconnection between the supplied parts for different areas and for the connection of the various parts to the Safety Electric Control board
- cables arrangement (wiring instructions) and relevant sketches
- Emergency Ex-proof lamps to be positioned along the escape way switching-on automatically in case of fire

15. FIRE EXTINGUISHING SYSTEM

15.1 BASELINE CONDITIONS

As baseline conditions it must be required the availability of (see point 5.2.1.1):

- electrical energy supply
- stand by electrical power generator in case of periodical black out officially foreseen by the local authorities

15.2 TENDERING CRITERIA

15.2.1 AREA CLASSIFICATION

Independently from the zone classification, it does not make sense to install fire extinguishing electrical apparatus which are not Ex-d protected, this is because they must be always working, even in case of explosive atmosphere presence.

15.2.2 PARTS TO BE LOCALLY MADE

The required fire extinguishing bottles can be sourced locally.
As already explained previously (see point 7.3.3.), in case of above ground cyclopentane storage tank, it is required a dedicated water spray system to protect the tank itself; the complete water distributor net can be realised locally.

15.2.3 SCOPE OF SUPPLY

The tender must require the following additional items:

- constructive drawing and relevant arrangement on the spray water system for the cyclopentane storage area (only in case of above-ground tank)
- sprinkler units (only in case of above-ground tank)
- ex-rated flame detector units to be installed inside the areas protected by enclosures (the tender must indicate precisely the number of units required)
- technical indications and lay-out of the complete fire extinguishing system indicating precise number location of the extinguishing bottles.
- electrical schematic drawings to connect the flame detectors to the safety logic.

15.3 AVAILABLE TECHNICAL SOLUTIONS

The technical solution we are going to indicate is not based on any International Standard; this is because several countries have their own local regulations on this matter. It is clear that, if so, the

Contractor is obliged to strictly follows those rules as unique reference guide-line. On this point, the tender document must clearly indicate the eventual presence of local regulations to be followed.

After that, we intend to present a general solution based on our practical industrial experience.

Essentially there are two possible alternatives to approach the problem of the fire extinguishing system in case of explosive atmosphere presence.

a) Protection of the hazardous areas against external fire
b) Limitation of fire risk inside the hazardous areas

The first approach comes from the consideration that an atmosphere with hydrocarbons vapours inside is not flammable, but explosive. It means that the only requested care is to have a dedicated system against external fire which is a possible explosion source.

The second approach is based on the consideration that also inside hazardous areas there is the possibility of fire; if so, it becomes mandatory to detect immediately the presence of fire by installing dedicated fire detectors and relevant against fire.

Thought that the water is not suitable to extinguish effectively fire generated by hydrocarbons (it could be a feasible solution only to cool down an area to protect it from an external fire, like in case of above ground cyclopentane storage tank), the suggestible solution a compromise between the above reported approaches taking into consideration the cost-effective goal.

In this sense a semi-automatic system composed of fire extinguishing media bottles (foam, powders or CO_2) with relevant flame detectors properly located is good enough to protect the hazardous areas from external and internal fire as well.

It is understood that the alarm signal coming from the installed flame detectors must interrupt the process (level 2 alarm).

16. SAFETY TRAINING

16.1 BASELINE CONDITION

As baseline condition, it must be required that the attendants the training understand and speak English.

16.2 TENDERING CRITERIA

16.2.1 AREA CLASSIFICATION

Not significant

16.2.2 PARTS TO BE LOCALLY MADE

None

16.2.3 SCOPE OF SUPPLY

The Tender must require the following additional items:

- a precise training program of the safety aspects for a period estimated to be sufficient to transfer all safety arguments in the way that the plant can be run in safety conditions by the local personnel
- the above mentioned training has to be divided by two sections:
  1) overseas training (at Contractor's facilities) 5 working days for 3 people, having the following operative functions:
     ⇒ electrician service responsible
     ⇒ production dpt responsible
     ⇒ maintenance dpt responsible
  2) on the job training (Counterpart site): this phase will be held during the commissioning & start-up period by a qualified Contractor's technician and it will be oriented to the practical aspects of the converted plant operation

ANNEX 1

LIST OF THE INTERNATIONAL STANDARDS TAKEN INTO CONSIDERATION AS REFERENCE

1) European CEI EN 60079-10
   "Electrical Apparatus for Explosive Gas Atmosphere"
   Part 10 - Classification of hazardous areas

2) International standard CEI-IEC 79-14
   "Electrical Apparatus for Explosive Gas Atmosphere"
   Part 14 - Electrical Installation in hazardous Areas

3) European norm CEI EN 50054-31-18
   "Electrical Apparatus for Detection and Measurement of Flammable Gas" - General requirements and testing methods

4) European norm CEI EN 1612-1
   "Equipment for Rubber and Plastic Materials - Equipment for Reaction Moulding"
   Part 1 - Safety requirements for dosing and mixing units.

Conversion of Refrigerator Production Plant to the Hydrocarbons technology

SAFETY COST EVALUATION

ANNEX II

QUESTIONNAIRE

QUESTIONNAIRE

ITEM "1": <u>BUFFER TANK/S</u>

SCHEMATIC DRAWING

PLEASE INDICATE FOLLOWING DATA:

CAPACITY ______________

PREMIX

1 BUFFER TANK/S

A) IS THE CERTIFICATION DOCUMENT FOR PRESSURISED TANKS AVAILABLE?

YES ☐

NO ☐

B) IS IT CLEARLY INDICATED ON THIS DOCUMENT THE AUTHORISATION FOR THE USE OF CYCLOPENTANE (INTENDED PURPOSE)?

YES ☐

NO ☐

C) MAXIMUM ALLOWED PRESSURISATION LEVEL:

- MORE THAN 5 BAR ☐

- LESS THAN 5 BAR ☐

D) IS THE AGITATOR INSTALLED?

YES ☐

NO ☐

E) IS THE TANK JACKETED?

YES ☐

NO ☐

F) IS THE TANK PROPERLY INSULATED?

YES ☐

NO ☐

1 BUFFER TANK/S

G)	ARE THREE INSTRUMENT FLANGES AVAILABLE ON THE UPPER PART OF THE TANK? (THESE CONNECTION JOINTS ARE REQUIRED FOR THE INSTALLATION OF NEW TEMPERATURE AND LEVELS CONTROLS)	
	YES	☐
	NO	☐
H)	ARE RUSTED AREAS CLEARLY VISIBLE?	
	YES	☐
	NO	☐
I)	WHERE IS THE TANK INSTALLED?	
	-DEDICATED ROOM (PLS INDICATE THE OVERALL DIMENSIONS)	☐
	- INSIDE PRODUCTION AREA	☐
	- OPEN SPACE UNDER PROTECTION ROOF	☐

NOTE

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QUESTIONNAIRE

ITEM "2": PIPING BETWEEN PREMIX AND MACHINE TANK

SCHEMATIC DRAWING

2 PIPING BETWEEN PREMIX AND MACHINE TANK

A)	IS A BUFFER TANK (EITHER NEW OR RETROFITTED) REQUIRED?	**YES**	☐
		NO	☐
B)	IS THE EXISTING PIPING "HIGH PRESSURE" DESIGNED (300 BAR)? THE RELEVANT DOCUMENT MUST BE AVAILABLE	**YES**	☐
		NO	☐
C)	IS THE PIPING COMPLETELY WELDED?	**YES**	☐
		NO	☐
D)	HOW LONG IS THE PIPE-LINE (DELIVERY AND RETURN LINE TOGETHER)?	**- MORE THAN 100 M**	☐
		- LESS THAN 100 M	☐
E)	IS THE EXISTING PIPE LINE IN ACCORDANCE WITH THE FORESEEN CONVERTED PLANT?	**YES**	☐
		NO	☐
F)	ARE SOME VALVES (MANUAL/AUTOMATIC) INSTALLED ALONG THE PIPE LINE?	**YES**	☐
		NO	☐
G)	IS THE EXISTING PIPE-LINE INSULATED?	**YES**	☐
		NO	☐

2 PIPING BETWEEN PREMIX AND MACHINE TANK

H) ARE THERE SOME UNDERGROUND SECTIONS?		
	YES	☐
	NO	☐

NOTE

ITEM "3": PIPING BETWEEN M/C AND MIXING HEAD

SCHEMATIC DRAWING

3 PIPING BETWEEN M/C AND MIXING HEAD

A)	IS THE EXISTING PIPING "HIGH PRESSURE" DESIGNED (300 BAR)? THE RELEVANT DOCUMENT MUST BE AVAILABLE	**YES** **NO**	☐ ☐
B)	IS THE POLYOL PIPING COMPLETELY WELDED?	**YES** **NO**	☐ ☐
C)	IS THE EXISTING PIPE LINE IN ACCORDANCE WITH THE FORESEEN CONVERTED PLANT?	**YES** **NO**	☐ ☐
D)	IS THE EXISTING PIPE-LINE INSULATED?	**YES** **NO**	☐ ☐
E)	ARE THERE SOME UNDERGROUND SECTIONS?	**YES** **NO**	☐ ☐

NOTE

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QUESTIONNAIRE

ITEM "4": MIXING HEAD/S

SCHEMATIC DRAWING

PLEASE INDICATE FOLLOWIGN DATA:

HEAD MODEL ________________
SERIAL NUMBER________________

4 MIXING HEAD/S

A)	HOW HOLD IS THE MIXING HEAD?		
		MORE THAN 500.000 SHOTS	☐
		AMONG 200.000÷500.000 SHOTS	☐
		LESS THAN200.000 SHOTS	☐
B)	ARE THE INSTALLED PROXIMITY SWITCHES MAGNETIC LOW ENERGY TYPE?		
		YES	☐
		NO	☐
C)	IS THERE THE POSSIBILITY TO INJECT NITROGEN THROUGH THE INJECTION NOSE?		
		YES	☐
		NO	☐
D)	IS THE EXISTING HEAD "HIGH PRESSURE" TYPE?		
		YES	☐
		NO	☐
E)	WHETHER THE ELECTRIC CONTROL BOARD IS MOUNTED CLOSE TO THE HEAD, IS IT "EX-I" VERSION?		
		YES	☐
		NO	☐
F)	IS THE MIXING HEAD MADE IN EUROPE OR USA?		
		YES	☐
		NO	☐

NOTE ____

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QUESTIONNAIRE

ITEM "5": DRY PLANT

- **5.1 JIGS (CABINET & DOOR)**
- 5.2 OVEN
- 5.3 HEAD HANDLING SYSTEM
- 5.4 PRODUCTION SYSTEM
- 5.5 PLUG/S

SCHEMATIC DRAWING

5.1 JIGS (CABINET & DOOR)

A)	HOW HOLD IS THE FOAMING JIG?		
		MORE THAN 20 YEARS	☐
		BETWEEN 10 AND 20 YEARS	☐
		LESS THAN 10 YEARS	☐
B)	IS THE FOAMING JIG MADE IN EUROPE OR USA?		
		YES	☐
		NO	☐
C)	HOW IS THE CLOSING SYSTEM OF THE FOAMING JIG?		
		MANUAL	☐
		AUTOMATIC (HYDRAULICALLY OPERATED)	☐
		AUTOMATIC (PNEUMATICALLY OPERATED)	☐
D)	HOW IS THE LOADING/UNLOADING SYSTEM OF THE FOAMING JIG?		
		MANUAL	☐
		AUTOMATIC	☐
E)	IS THE JIG MANUALLY MOVABLE?		
		YES	☐
		NO	☐
F)	ARE THE JIG'S WALLS MADE OF WOOD?		
		YES	☐
		NO	☐

5.1 JIG

G)	WHICH TYPE OF HEATING SYSTEM FOR THE JIG'S WALLS IS USED?		
		ELECTRICAL RESISTANCES	☐
		BY HOT WATER	☐
		NO HEATING SYSTEM INSTALLED	☐
H)	ONLY IN CASE OF AUTOMATIC PLUG. CABINET RELATIVE MOVEMENT; MAY THE MECHANICAL DRIVING SYSTEM BE CONSIDERED ACCEPTABLE		
		YES	☐
		NO	☐
I)	WHERE IS THE JIG'S ELECTRIC CONTROL BOARD LOCATED?		
		NOT EXISTING	☐
		MOUNTED ON THE JIG'S FRAME	☐
		MORE THAN 1 MT FAR AWAY FROM THE JIG FRAME	☐
L)	ARE THE EXISTING ELECTRICAL INSTALLATIONS AND WIRINGS REALISED ACCORDING TO (AT LEAST) THE INTERNATIONAL IP 54 PROTECTION DEGREE?		
		YES	☐
		NO	☐
		NO ELECTRICAL INSTALLATION	☐
M)	IS THE FOAMING HEAD ENTERING DIRECTLY THE INJECTION HOLE? (NO ADDITIONAL PROLONGERS ARE REQUIRED)		
	YES		☐
	NO		☐

NOTE____
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QUESTIONNAIRE

ITEM "5": DRY PLANT

- 5.1 JIGS (Cabinet & Door)
- **5.2 Oven**
- 5.3 Head handling system
- 5.4 Production system
- 5.5 Plug/s

SCHEMATIC DRAWING

Please indicate following data:

Overall dimension of the oven ____________________

5.2 OVEN

A) WHICH TYPE OF HEATING SYSTEM IS USED?		
	ELECTRICAL RESISTANCE INSIDE THE OVEN	☐
	STEAM HEATERS INSIDE THE OVEN	☐
	BLOWED HOT AIR HEATED BY STEAM	☐
	BLOWED HOT AIR HEATED BY DIRECT BURNER	☐
B) IS THE OVEN GROUNDED?		
	YES	☐
	NO	☐

NOTE

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QUESTIONNAIRE

ITEM "5": DRY PLANT

5.1 JIGS (CABINET & DOOR)
5.2 OVEN
5.3 HEAD HANDLING SYSTEM
5.4 PRODUCTION SYSTEM
5.5 PLUG/S

SCHEMATIC DRAWING

PLEASE INDICATE FOLLOWING DATA:

OVERALL DIMENSIONS ______________

5.3 HEAD HANDLING SYSTEM

A) WHICH TYPE OF HEAD HANDLING SYSTEM IS INSTALLED?

MANUAL ☐

AUTOMATIC ☐

B) IS THE FORESEEN LAYOUT OF THE CONVERTED LINE ALLOWING THE POSITIONING OF THE HEAD HANDLING SYSTEM OUTSIDE THE ENCLOSURE OF THE RELEVANT FOAMING AREA?

YES ☐

NO ☐

C) IS AN ELECTRICAL/ELECTRONIC SYSTEM PROVIDED IN ORDER TO DETECT THE HEAD POSITION DURING THE FOAMING CYCLE?

YES ☐

NO ☐

D) IN CASE OF AUTOMATIC HANDLING SYSTEM ARE ANY INSTALLED ELECTRICAL DEVICES MADE ACCORDING, AT LEAST, TO THE INTERNATIONAL IP 54 PROTECTION DEGREE?

YES ☐

NO ☐

E) IS THE HEAD HANDLING SYSTEM GROUNDED?

YES ☐

NO ☐

F) CAN THE EXISTING HEAD HANDLING SYSTEM BE USED IN THE SAME POSITION CONSIDERING THE FINAL LAYOUT OF THE CONVERTED LINE?

YES ☐

NO ☐

5.3 HEAD HANDLING SYSTEM

G) Is the existing head handling system compatible with the **HP** foaming system?	
YES	☐
NO	☐

NOTE

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QUESTIONNAIRE

ITEM "5": DRY PLANT

- 5.1 JIGS (CABINET & DOOR)
- 5.2 OVEN
- 5.3 HEAD HANDLING SYSTEM
- **5.4 PRODUCTION SYSTEM**
- 6.5 PLUG/S

SCHEMATIC DRAWING

5.4 PRODUCTION SYSTEM

A) WHICH TYPE OF PRODUCTION SYSTEM IS USED?

- [ ] **SINGLE LINE** (FIXED OR MANUALLY MOVABLE)
- [ ] **MOVABLE TYPES** (I.E. CAROUSEL/PATERNOSTER)

B) IS ANY ENCLOSURE OR DEDICATED ROOM TO CONFINE THE LINE TO BE CONVERTED ALREADY EXISTING?

- [ ] **YES**
- [ ] **NO**

C) IS THERE ENOUGH AVAILABLE SPACE FOR THE INSTALLATION OF A SAFETY ENCLOSURE AROUND THE TOTAL FOAMING AREA, TAKING INTO CONSIDERATION THE NORMAL WORKING AND MAINTENANCE OPERATION?

- [ ] **YES**
- [ ] **NO**

D) ARE ANY INSTALLED ELECTRICAL DEVICES MADE ACCORDING, AT LEAST, TO THE INTERNATIONAL IP 54 PROTECTION DEGREE?

- [ ] **YES**
- [ ] **NO**

E) ARE THERE ANY ELECTRICAL MOTORS WHICH CANNOT BE SWITCHED OFF DURING THE NORMAL WORKING CONDITION INSTALLED CLOSE TO FOAMING JIG (DISTANCE SHORTER THAN 500 MM)?

- [ ] **YES**
- [ ] **NO**

F) ARE THERE ANY TRENCES AND PITS CONTAINING ELECTRICAL DEVICES INSIDE THE FOAMING PRODUCTION AREA?

- [ ] **YES**
- [ ] **NO**

5.4 PRODUCTION SYSTEM

G) CONSIDERING EACH PRODUCTION LINE TO BE CONVERTED, WHICH IS THE RATIO BETWEEN THE REFRIGERATORS PRODUCED PER HOUR AND THE NUMBER OF JIGS USED FOR THAT PRODUCTION?

BETWEEN 6 AND 9 ☐

BETWEEN 2 AND 6 ☐

LESS THAN 2 ☐

NOTE

QUESTIONNAIRE

ITEM "5": <u>DRY PLANT</u>

5.1 JIGS (CABINET & DOOR)
5.2 OVEN
5.3 HEAD HANDLING SYSTEM
5.4 PRODUCTION SYSTEM
5.5 PLUG/S

SCHEMATIC DRAWING

5.5 PLUG/S

A) ARE THE PLUG MADE OF WOOD	**YES**	☐
	NO	☐
B) WHICH TYPE OF HEATING SYSTEM FOR THE PLUGS IS USED?	**ELECTRICAL RESISTANCES**	☐
	BY HOT AIR (BLOWER)	☐
	NO HEATING SYSTEM	☐
C) ARE THE EXISTING ELECTRICAL INSTALLATION AND WIRINGS REALISED ACCORDING TO, AT LEAST, THE INTERNATIONAL IP 54 PROTECTION DEGREE?	**YES**	☐
	NO	☐
	NO ELECTRICAL INSTALLATION	☐

NOTE

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