VOLUME 15º-A

TRIBUNAL MARÍTIMO

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DIVISÃO JUDICIÁRIA
N.º 3162-B
TRIBUNAL MARÍTIMO

CERTIDÃO

Certifico, para os devidos fins, que o **volume nº 15º**, constituído pelas **fls. 3.017 a 3.361**, do **Processo nº 19.489/2001**, **"P-36"**, foi desmembrado em dois volumes, passando a compor este **volume 15º** as **fls. 3.017 a 3.162-a**, e, o **volume 15º-A**, as **fls. 3.162-b a 3.361** , a fim de oferecer melhores condições para consulta pelos **Exmos. Srs. Juízes Relator e Revisor, Representante da Procuradoria Especial da Marinha e Srs. Advogados**.

O referido é verdade e dou fé.

Aos 31 de outubro de 2003.

DINÉIA DA SILVA
Diretora da Divisão Judiciária

CÓPIA FIEL DO DOCUMENTO ORIGINAL

JOSÉ CARLOS PIMENTEL OUSMÃO
Diretor da Divisão de Serviços Cartorários

ANEXO

Nº 9

Norma Italiana

CEI EN 60079-10

Data Pubblicazione	*Edizione*
1996-10	Prima
Classificazione	*Fascicolo*
31-30	2895

Titolo

Costruzioni elettriche per atmosfere esplosive per la presenza di gas
Parte 10: Classificazione dei luoghi pericolosi

Title

Electrical apparatus for explosive gas atmospheres
Part 10: Classification of hazardous areas

IMPIANTI E SICUREZZA DI ESERCIZIO

SOMMARIO

La presente Norma stabilisce i criteri essenziali per la valutazione della possibilità di formazione di atmosfera esplosiva e fornisce una guida su grandezze caratteristiche di progetto ed esercizio utilizzabili per ridurre detta possibilità (classificazione dei luoghi pericolosi).
Per quanto attiene alle costruzioni (apparecchi) elettriche da impiegarsi in tali luoghi, essa è utilizzata per la loro corretta scelta ed installazione, rinviando alle relative norme per i requisiti specifici.
Essa sostituisce la Norma CEI 64-2 per quanto si riferisce alla classificazione dei luoghi con presenza, in qualunque stato fisico, di sostanze, esclusi gli esplosivi e le polveri infiammabili, che sotto forma di vapori, gas o nebbie possono determinare con l'aria un'atmosfera pericolosa; in particolare essa sostituisce il Capitolo III – Luoghi di Classe 1 (C1) ed il Capitolo V – Luoghi di Classe 3 (C3).

DESCRITTORI • *DESCRIPTORS*

Apparecchiatura elettrica • *Electric equipment;* Atmosfere esplosive • *Explosive atmosphere;* Gas infiammabili • *Flammable gases;* Definizioni • *Definitions;* Pericoli • *Hazards;* Luoghi • *Regions;* Classificazione • *Filing;* Sicurezza • *Safety;* Protezione contro l'esplosione • *Explosion proofing;* Ventilazione • *Ventilation;*

COLLEGAMENTI/RELAZIONI TRA DOCUMENTI

Nazionali (SOP) CEI 64-2:1990-11;

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LEGENDA
(SOP) La Norma in oggetto sostituisce parzialmente le Norme indicate dopo il riferimento (SOP)
(IDT) La Norma in oggetto è identica alle Norme indicate dopo il riferimento (IDT)

PREMESSA NAZIONALE

La presente Norma è la prima parte di un corpo normativo CENELEC riguardante l'importante argomento degli impianti elettrici nei luoghi con pericolo di esplosione; ad essa faranno seguito altre norme riguardanti la classificazione dei luoghi con presenza di esplosivi o polveri infiammabili, nonché norme riguardanti i requisiti di sicurezza degli impianti elettrici, attualmente in studio in sede IEC e CENELEC.

La presente norma si applica alla classificazione dei luoghi pericolosi di opere od applicazioni nuove e trasformazioni radicali di quelle esistenti; naturalmente, essa può essere utilizzata anche per la classificazione dei luoghi di opere od applicazioni esistenti.

La presente norma sostituisce la Norma CEI 64-2 per quanto si riferisce alla classificazione dei luoghi con presenza, in qualunque stato fisico, di sostanze, esclusi gli esplosivi e le polveri infiammabili, che sotto forma di vapori, gas o nebbie, possono determinare con l'aria un'atmosfera pericolosa; in particolare, essa sostituisce il Capitolo III - Luoghi di classe 1 (C1) ed il Capitolo V - Luoghi di classe 3 (C3).

Le parti della Norma CEI 64-2 oggetto della presente norma restano contemporaneamente in vigore fino al 31 dicembre 1997; le Appendici della Norma CEI 64-2/A, in attesa di nuove Guide CEI e della norma CENELEC relativa ai requisiti degli impianti elettrici in atmosfere esplosive per la presenza di gas, se non vengono abrogate, possono essere applicate, sia per la classificazione, sia per la scelta dei tipi di impianti elettrici a sicurezza, anche oltre la data del 31 dicembre 1997.

Il periodo di contemporanea validità delle norme sopra indicate ha lo scopo di consentire il completamento delle classificazioni dei luoghi in corso di esecuzione ed ai tecnici di adeguarsi alla presente norma.

La data del 31 dicembre 1997 è stata stabilita dal CENELEC e deve essere considerata ultimativa per l'abrogazione di tutte le prescrizioni normative in conflitto con quelle della presente norma; detto conflitto riguarda principalmente i luoghi di Classe 3 ed i relativi impianti elettrici.

Si fa presente a quanti si apprestano ad iniziare una classificazione dei luoghi in conformità alla Norma CEI 64-2 dopo la pubblicazione della presente norma di valutare attentamente i tempi di esecuzione per non incorrere nelle conseguenti difficoltà qualora ultimassero il lavoro dopo la data del 31 dicembre 1997.

La presente norma di classificazione dei luoghi pericolosi ha un campo di applicazione nominalmente più vasto di quello proprio della Norma CEI 64-2, in quanto non sono esplicitamente esclusi alcuni luoghi o impianti esclusi dalla Norma CEI 64-2; di questo occorre tener conto non derivandone l'obbligo, per i luoghi pericolosi non compresi nel campo di applicazione della Norma CEI 64-2, di usare tipi di impianti elettrici a sicurezza convenuti nella norma stessa, anche in considerazione del campo di applicazione prevalente delle norme del Comitato Tecnico 31 IEC e CENELEC.

Per i luoghi pericolosi compresi nel campo di applicazione della Norma CEI 64-2 quarta edizione (Fascicolo n. 1431), la scelta dei tipi di impianti elettrici a sicurezza in relazione ai tipi di zona 0, 1 e 2 della presente norma, deve essere operata in conformità alla Tabella IV della Norma CEI 64-2 stessa, tenuto conto della Errata Corrige (Fascicolo n. 1973V), secondo il seguente criterio:

- per la zona 0, i tipi di impianti elettrici a sicurezza previsti per la zona C1Z0;
- per la zona 1, i tipi di impianti elettrici a sicurezza previsti per la zona C1Z1;
- per la zona 2, i tipi di impianti elettrici a sicurezza previsti per la zona C1Z2.

Si fa notare che la classificazione dei luoghi pericolosi viene trattata nella presente norma secondo criteri di analisi del rischio (e del grado di sicurezza equivalente) già fatti propri dalla Norma CEI 64-2 (art. 1.1.03.b); quest'ultima, nella quarta edizione del 1990, introduceva la possibilità di determinare le zone pericolose utilizzando i principi dell'analisi del rischio oltre che con i metodi convenzionali già presenti nelle precedenti edizioni.

Essa quindi non fornisce estensioni convenzionali delle zone pericolose (come ad esempio indicato nei capitoli III e V della Norma CEI 64-2) ma lascia al tecnico incaricato della classificazione del luogo il compito della loro determinazione in base alle grandezze che le condizionano (ad es. portata di emissione).

La classificazione dei luoghi, considerando i principi su cui si basa, è utile anche per la valutazione del rischio nell'ambito del Decreto Legislativo 19.09.1994, n° 626.

Nella presente norma è detto che l'estensione delle zone può essere stabilita facendo riferimento a guide e raccomandazioni relative a specifiche industrie od applicazioni. Il tecnico preposto alla classificazione, valutandone l'affidabilità, l'applicabilità al suo caso ed il rispetto della presente norma, può fare riferimento ad estensioni desunte da dette guide e raccomandazioni, dalle appendici A, B e C della presente norma, i cui contenuti sono solo informativi e quindi senza obbligo di applicazione, od anche dalle Norme CEI 64-2 e 64-2/A quarta edizione (Fascicoli n. 1431 e n. 1432) tenuto conto della Errata Corrige (Fascicolo n. 1973V).

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CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a National Standard without any alteration.

Up-to-date lists and bibliographical references concerning such National Standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German).

A version in any other language and notified to the CENELEC Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

I Comitati Nazionali membri del CENELEC sono tenuti, in accordo col regolamento interno del CEN/CENELEC, ad adottare questa Norma Europea, senza alcuna modifica, come Norma Nazionale.

Gli elenchi aggiornati e i relativi riferimenti di tali Norme Nazionali possono essere ottenuti rivolgendosi al Segretario Centrale del CENELEC o agli uffici di qualsiasi Comitato Nazionale membro.

La presente Norma Europea esiste in tre versioni ufficiali (inglese, francese, tedesco).

Una traduzione effettuata da un altro Paese membro, sotto la sua responsabilità, nella sua lingua nazionale e notificata al CENELEC, ha la medesima validità.

I membri del CENELEC sono i Comitati Elettrotecnici Nazionali dei seguenti Paesi: Austria, Belgio, Danimarca, Finlandia, Francia, Germania, Grecia, Irlanda, Islanda, Italia, Lussemburgo, Norvegia, Olanda, Portogallo, Regno Unito, Spagna, Svezia e Svizzera.

FOREWORD

The text of document 31J/39/FDIS, future edition 3 of IEC 79-10, prepared by SC 31J, Classification of hazardous areas and installation requirements, of IEC TC 31, Electrical apparatus for explosive atmospheres, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60079-10 on 1995/11/28.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national Standard or by endorsement
  (dop) 1996/09/01
- latest date by which the national Standards conflicting with the EN have to be withdrawn
  (dow) 1996/09/01

Annexes designated "normative" are part of the body of the Standard.

Annexes designated "informative" are given for information only.

In this Standard, Annex ZA is normative and Annexes A, B and C are informative.

Annex ZA has been added by CENELEC.

ENDORSEMENT NOTICE

The text of the International Standard IEC 79-10 (1995), together wit h its Corrigendum May 1996, was approved by CENELEC as a European Standard without any modification.

PREFAZIONE

Il testo del documento 31J/39/FDIS, futura terza edizione della Pubblicazione IEC 79-10, preparato dal Sottocomitato SC 31J, Classification of hazardous areas and installation requirements, del Comitato Tecnico della IEC TC 31, Electrical apparatus for explosive atmospheres, è stato sottoposto al voto parallelo IEC ENELEC ed approvato dal CENELEC come Norma Europea EN 60079-10 il 28 novembre 1995.

Sono state fissate le seguenti date:

- data ultima entro la quale la EN deve essere applicata a livello nazionale mediante pubblicazione di una Norma nazionale identica o mediante adozione
  (dop) 01/09/1996
- data ultima entro la quale le Norme nazionali contrastanti con la EN devono essere ritirate
  (dow) 01/09/1996(1)

Gli Allegati designati "normativo" fanno parte della presente Norma.

Le Appendici designate "informativa" sono fornite solo a titolo di informazione.

Nella presente Norma, l'Allegato ZA è normativo e le Appendici A, B e C sono informative.

L'Allegato ZA è stato aggiunto dal CENELEC.

AVVISO DI ADOZIONE

Il testo della Pubblicazione IEC 79-10 (1995), con il suo Corrigendum maggio 1996, è stato approvato dal CENELEC come Norma Europea senza alcuna modifica.

(1) È stata concessa all'Italia una proroga fino al 31 dicembre 1997.

INTRODUCTION

In areas where dangerous quantities and concentrations of flammable gas or vapour may arise, protective measures are to be applied in order to reduce the risk of explosions.

The objective of this Standard is to set out the essential criteria against which the risk of ignition can be assessed, and to give guidance on the design and control parameters which can be used in order to reduce this risk.

In the case of electrical apparatus, this Standard is used as a basis for the proper selection and installation of apparatus for use in a hazardous area. Reference should be made to the appropriate Standard(s) for details.

INTRODUZIONE

Nei luoghi dove possono essere presenti quantità e concentrazioni pericolose di gas o vapori infiammabili, devono essere adottate misure di prevenzione per ridurre il rischio di esplosioni.

L'obiettivo della presente Norma CEI è di stabilire criteri essenziali per la valutazione della possibilità di formazione di atmosfera esplosiva e di fornire una guida su grandezze caratteristiche di progetto ed esercizio utilizzabili per ridurre detta possibilità.

Per quanto attiene alle costruzioni (apparecchi) elettriche da impiegarsi in tali luoghi, essa è utilizzata per la loro corretta scelta ed installazione, rinviando alle relative norme per i requisiti specifici.

1.1 Scope

This Standard is concerned with the classification of hazardous areas where flammable gas or vapour risks may arise, in order to permit the proper selection and installation of apparatus for use in such hazardous areas (see notes 1 and 4).

It is intended to be applied where there may be a risk of ignition due to the presence of flammable gas or vapour, mixed with air under normal atmospheric conditions (see note 2), but it does not apply to:

a) mines susceptible to firedamp;
b) the processing and manufacture of explosives;
c) areas where a risk may arise due to the presence of ignitable dusts or fibres;
d) catastrophic failures which are beyond the concept of abnormality dealt with in this Standard (see note 3);
e) rooms used for medical purposes;
f) areas where the presence of flammable mist may give rise to an unpredictable risk and which require special consideration (see note 5).

This Standard does not take into account the effects of consequential damage.

Definitions and explanations of terms are given together with the main principles and procedures relating to hazardous area classification.

For detailed recommendations regarding the extent of the hazardous areas in specific industries or applications, reference may be made to the codes relating to those industries or applications.

Notes/Note:
1 *For the purpose of this Standard, an area is a three-dimensional region or space.*
2 *Atmospheric conditions include variations above and below reference levels of 101,3 kPa (1013 mbar) and 20°C (293 K), provided that the variations have a negligible effect on the explosion properties of the flammable materials.*
3 *Catastrophic failure in this context is applied, for example, to the rupture of a process vessel or pipeline, and such events that are not predictable.*
4 *In any process plant, irrespective of size, there may be numerous sources of ignition apart from those associated with electrical apparatus. Appropriate precautions will be necessary to ensure safety in this context. This Standard may be used with judgement for other ignition sources.*
5 *Mists may form or be present at the same time as flammable vapours. This may affect the way flammable material disperses and the extent of any hazardous areas. The strict application of area classification for gases and vapours may not be appropriate because the flammability characteristics of mists are not always predictable. Whilst it can be difficult to decide upon the type*

Oggetto e scopo

La presente Norma tratta la classificazione dei luoghi pericolosi ove possono manifestarsi dei rischi associati alla presenza di gas o vapori infiammabili, allo scopo di permettere la corretta scelta ed installazione delle costruzioni (apparecchi) da impiegarsi in tali luoghi (note 1 e 4).

Essa si applica ai luoghi in cui vi può essere il rischio di accensione dovuto alla presenza di gas o vapori infiammabili in miscela con aria in condizioni atmosferiche normali (nota 2), ma non si applica a:

a) miniere con possibile presenza di grisou;
b) luoghi di trattamento e produzione di esplosivi;
c) luoghi dove un rischio di esplosione può manifestarsi per la presenza di polveri o fibre infiammabili;
d) guasti catastrofici non compresi nel concetto di anormalità trattato in questa norma (nota 3);
e) locali adibiti ad uso medico;
f) luoghi dove la presenza di nebbie infiammabili può dare origine ad un rischio imprevedibile e che richiede considerazioni particolari (nota 5).

La presente Norma non considera gli effetti dei guasti consequenziali (indotti da un guasto primario).

Essa contiene le definizioni e le spiegazioni dei termini, nonché i principi e le procedure fondamentali relativi alla classificazione dei luoghi.

Per specifiche industrie ed applicazioni, l'estensione dei luoghi pericolosi può essere definita facendo riferimento a guide e raccomandazioni relative a dette industrie o applicazioni.

1 *Ai fini di della presente Norma, un luogo è una parte tridimensionale dello spazio.*
2 *Le condizioni atmosferiche includono variazioni sopra e sotto i valori di riferimento di 101,3 kPa (1013 mbar) e 20°C (293 K), purché le variazioni abbiano un effetto trascurabile sulle proprietà esplosive delle sostanze infiammabili.*
3 *Il termine "guasti catastrofici" si applica ad esempio, alla rottura di un recipiente a pressione o di una tubazione ed agli eventi non prevedibili.*
4 *In ogni impianto di processo, indipendentemente dalla sua dimensione, ci possono essere numerose sorgenti di accensione (innesco) oltre a quelle relative all'impianto elettrico. In tale caso si rendono necessarie altre idonee precauzioni per garantire la sicurezza. La presente Norma potrà essere utilizzata con cautela per altre sorgenti di accensione.*
5 *Nebbie possono formarsi o essere presenti contemporaneamente a vapori infiammabili. Ciò può influire sul modo di dispersione delle sostanze infiammabili e sull'estensione dei luoghi pericolosi. La rigorosa applicazione della classificazione dei luoghi pericolosi per gas e vapori può non essere adatta poichè le caratteristiche di infiammabilità delle nebbie non sono sempre prevedibili. Sebbene sia*

and extent of zones, the criteria applicable to gases and vapours will, in most cases, give a safe result. However, special consideration should always be given to the danger of ignition of flammable mists.

difficile decidere sul tipo ed estensione delle zone, i criteri applicabili ai gas e vapori danno, nella maggior parte dei casi, risultati sicuri. Tuttavia, è opportuno tenere sempre in particolare considerazione il pericolo di accensione di nebbie infiammabili.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below[1]. Members of IEC and ISO maintain registers of currently valid international Standards.

Riferimenti normativi

Le Norme sotto elencate contengono disposizioni che, tramite riferimento nel presente testo, costituiscono disposizioni per la presente Norma. Al momento della pubblicazione della presente Norma, le edizioni indicate erano in vigore. Tutte le Norme sono soggette a revisione, e gli utilizzatori della presente Norma sono invitati ad applicare le edizioni più recenti delle Norme sotto elencate[1]. Presso i membri della IEC e dell'ISO sono disponibili gli elenchi aggiornati delle Norme in vigore.

2 DEFINITIONS AND TERMS

DEFINIZIONI E TERMINI

For the purpose of this Standard, the following definitions and terms apply.

Ai fini della presente Norma, si applicano le seguenti definizioni e termini.

2.1 Explosive gas atmosphere

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 unconsumed mixture. [IEV 426-02-03, modified]

Note/Nota *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.*

Atmosfera esplosiva per la presenza di gas

miscela in aria di una sostanza infiammabile sotto forma di gas o vapore, in condizioni atmosferiche normali, in cui, dopo l'accensione, la combustione si propaga alla miscela incombusta. [IEV 426-02-03, modificato]

Una miscela avente una concentrazione maggiore del limite superiore di esplodibilità (UEL), non è un'atmosfera esplosiva, ma può facilmente diventare tale; pertanto, in certi casi, ai fini della classificazione, è consigliabile considerarla atmosfera esplosiva.

2.2 Hazardous area

An area in which an explosive gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of apparatus. [IEV 426-03-01, modified]

Luogo pericoloso

Luogo in cui è o può essere presente un'atmosfera esplosiva per la presenza di gas, in quantità tale da richiedere provvedimenti particolari per la realizzazione, l'installazione e l'impiego delle costruzioni (apparecchi). [IEV 426-03-01, modificato]

2.3 Non-hazardous area

An area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of apparatus. [IEV 426-03-02, modified]

Luogo non pericoloso

Luogo in cui non si prevede la presenza di un'atmosfera esplosiva per la presenza di gas, in quantità tale da richiedere provvedimenti particolari per la realizzazione, l'installazione e l'impiego delle costruzioni (apparecchi). [IEV 426-03-02, modificato]

2.4 Zones

Hazardous areas are classified into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere, as follows.

Zone

In relazione alla frequenza di formazione ed alla permanenza di un'atmosfera esplosiva per la presenza di gas, i luoghi pericolosi sono classificati nelle seguenti zone.

(1) **Editor's Note:** For the list of Publications, see Annex ZA.

(1) **N.d.R.** Per l'elenco delle Pubblicazioni, si rimanda all'Allegato ZA.

2.4.1 **Zone 0**

An area in which an explosive gas atmosphere is present continuously or for long periods. [IEV 426-03-03, modified]

2.4.2 **Zone 1**

An area in which an explosive gas atmosphere is likely to occur in normal operation. [IEV 426-03-04]

2.4.3 **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. [IEV 426-03-05, modified]

Note/Nota *Indications of the frequency of the occurrence and duration may be taken from codes relating to specific industries or applications.*

Zona 0

Luogo dove è presente continuamente o per lunghi periodi un'atmosfera esplosiva per la presenza di gas. [IEV 426-03-03, modificato.

Zona 1

Luogo dove è possibile sia presente durante il funzionamento normale un'atmosfera esplosiva per la presenza di gas. [IEV 426-03-04]

Zona 2

Luogo dove non è possibile sia presente un'atmosfera esplosiva per la presenza di gas durante il funzionamento normale o, se ciò avviene, è possibile sia presente solo poco frequentemente e per breve periodo. [IEV 426-03-05, modificato]

Indicazioni sulla frequenza e sulla durata di presenza di un'atmosfera esplosiva possono essere ricavate da guide e raccomandazioni relative ad industrie ed applicazioni specifiche.

2.5 Source of release

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]

Sorgente di emissione

Un punto o parte da cui può essere emesso nell'atmosfera un gas, un vapore o un liquido infiammabili con modalità tale da originare un'atmosfera esplosiva. [IEV 426-03-06, modificato][1].

2.6 Grades of release

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.

Gradi di emissione

sono stabiliti tre gradi fondamentali di emissione, qui di seguito elencati in ordine decrescente di probabilità di presenza di atmosfera esplosiva per la presenza di gas

a) grado continuo;
b) primo grado;
c) secondo grado.

Una sorgente di emissione può dar luogo ad uno di questi tre gradi di emissione o ad una loro combinazione[2].

2.6.1 Continuous grade of release

A release which is continuous or is expected to occur for long periods.

Emissione di grado continuo

Emissione continua o che può avvenire per lunghi periodi.

2.6.2 Primary grade of release

A release which can be expected to occur periodically or occasionally during normal operation.

Emissione di primo grado

Emissione che può avvenire periodicamente od occasionalmente durante il funzionamento normale.

(1) Nota: (Non contenuta nelle pubblicazioni IEC e CENELEC) - *Il termine "sorgente di emissione" modifica il termine "centro di pericolo" della IEV 426-03-06.*

(2) Nota: (Non contenuta nelle pubblicazioni IEC e CENELEC) - *L'ordine decrescente di probabilità di presenza di atmosfera esplosiva abbinato ai gradi di emissione è indicato senza tener conto della modulazione della presenza di atmosfera esplosiva dovuta, a volte, alla ventilazione. Esso può essere inteso anche come ordine decrescente di probabilità di emissione con modalità tale da originare un'atmosfera esplosiva.*

2.6.3 **Secondary grade of release**

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

Emissione di secondo grado

Emissione che non è prevista durante il funzionamento normale e che se avviene è possibile solo poco frequentemente e per brevi periodi.

2.7 Release rate

The quantity of flammable gas or vapour emitted per unit time from the source of release.

Portata di emissione

Quantità di gas o vapore infiammabile emessa nell'unità di tempo dalla sorgente di emissione.

2.8 Normal operation

The situation when the equipment is operating within its design parameters.

Notes/Note: 1 *Minor releases of flammable material may be part of normal operation. For example, releases from seals which rely on wetting by the fluid which is being pumped are considered to be minor releases.*

2 *Failures (such as the breakdown of pump seals, flange gaskets or spillages caused by accidents) which involve urgent repair or shut-down are not considered to be part of normal operation.*

Funzionamento normale

Situazione in cui l'impianto funziona entro le grandezze caratteristiche di progetto.

1 *Piccole emissioni di sostanze infiammabili possono essere comprese nel funzionamento normale. Per esempio, si considerano piccole emissioni le perdite da tenute che per costruzione sono umidificate dal fluido di processo.*

2 *Guasti quali rottura di tenute di pompe, di guarnizioni, di flange, o spandimenti accidentali che richiedono riparazioni urgenti o fermate, non sono considerate far parte del funzionamento normale.*

2.9 Ventilation

Movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (for example fans or extractors).

Ventilazione

Movimento dell'aria e suo ricambio con aria fresca causati dall'effetto del vento, da gradienti di temperatura, o da mezzi artificiali (esempio: ventilatori o estrattori).

2.10 Explosive limits

2.10.1 Lower explosive limit (LEL)

The concentration of flammable gas or vapour in air, below which the gas atmosphere is not explosive. [IEV 426-02-09, modified]

2.10.2 Upper explosive limit (UEL)

The concentration of flammable gas or vapour in air, above which the gas atmosphere is not explosive. [IEV 426-02-10, modified]

Note/Nota *For the purpose of this Standard, the terms "explosive" and "flammable" should be considered synonymous.*

Limiti di esplodibilità

Limite inferiore di esplodibilità (LEL)

Concentrazione in aria di gas o vapore infiammabile, al di sotto della quale l'atmosfera non è esplosiva. [IEV 426-02-09, modificato]

Limite superiore di esplodibilità (UEL)

Concentrazione in aria di gas o vapore infiammabile, al di sopra della quale l'atmosfera non è esplosiva. [IEV 426-02-10, modificato]

Ai fini della presente Norma, i termini "esplosivo" e "infiammabile" sono considerati sinonimi.

2.11 Relative density of a gas or a vapour

The density of a gas or a vapour relative to the density of air at the same pressure and at the same temperature (air is equal to 1,0).

Densità relativa di un gas o vapore

Densità di un gas o vapore relativa a quella dell'aria alla stessa pressione ed alla stessa temperatura (la densità relativa dell'aria è posta uguale a 1,0).

2.12 Flammable material

A material which is flammable of itself, or is capable of producing a flammable gas, vapour or mist.

Sostanza infiammabile

Sostanza di per sé infiammabile, o in grado di produrre un gas, un vapore o una nebbia infiammabili.

2.13 Flammable liquid

A liquid capable of producing a flammable vapour under any foreseeable operating conditions.

Liquido infiammabile

Liquido in grado di produrre vapore infiammabile in una qualsiasi condizione operativa prevedibile.

2.14	**Flammable gas or vapour**	**Gas o vapore infiammabile**
	Gas or vapour which, when mixed with air in certain proportions, will form an explosive gas atmosphere.	Gas o vapore che, se miscelato con l'aria in determinate proporzioni, origina un'atmosfera esplosiva per la presenza di gas.
2.15	**Flammable mist**	**Nebbia infiammabile**
	Droplets of flammable liquid, dispersed in air so as to form an explosive atmosphere.	Goccioline di liquido infiammabile disperse in aria in modo da formare un'atmosfera esplosiva.
2.16	**Flashpoint**	**Temperatura d'infiammabilità**
	The lowest liquid temperature at which, under certain standardized conditions, a liquid gives off vapours in a quantity such as to be capable of forming an ignitable vapour/air mixture. [IEV 426-02-14]	La più bassa temperatura di un liquido alla quale, in condizioni specifiche normalizzate, esso emette vapori in quantità sufficiente a formare con l'aria una miscela infiammabile. [IEV 426-02-14]
2.17	**Boiling point**	**Temperatura di ebollizione**
	The temperature of a liquid boiling at an ambient pressure of 101,3 kPa (1013 mbar).	Temperatura alla quale un liquido bolle alla pressione ambiente di 101,3 kPa (1 013 mbar).
Note/Nota	*For liquid mixtures, the initial boiling point should be used. Initial boiling point is used for liquid mixtures to indicate the lowest value of the boiling point for the range of liquids present, as determined in a standard laboratory distillation without fractionation.*	*Per le miscele di liquidi, si fa riferimento alla temperatura di ebollizione iniziale. Tale temperatura è usata per indicare il più basso valore della temperatura di ebollizione per la gamma di liquidi presenti nella miscela e si determina con una distillazione normale di laboratorio senza frazionamento.*
2.18	**Vapour pressure**	**Tensione di vapore (pressione di vapore)**
	The pressure exerted when a solid or liquid is in equilibrium with its own vapour. It is a function of the substance and of the temperature.	Pressione esercitata quando un solido o un liquido è in equilibrio con i suoi stessi vapori. La tensione di vapore varia in funzione della temperatura e del tipo di sostanza.
2.19	**Ignition temperature of an explosive gas atmosphere**	**Temperatura di accensione di un'atmosfera esplosiva per la presenza di gas**
	The lowest temperature of a heated surface at which, under specified conditions, the ignition of a flammable substance in the form of a gas or vapour mixture with air will occur.	Minima temperatura di una superficie riscaldata alla quale, in condizioni specificate, avviene l'accensione di una sostanza infiammabile allo stato di gas o vapore in miscela con aria.
Note/Nota	*IEC 79-4 and IEC 79-4A standardize a method for the determination of this temperature. [IEV 426-02-01, modified]*	*Nelle pubblicazioni IEC 79-4 e IEC 79-4A è precisato un metodo per la determinazione di detta temperatura. [IEV 426-02-01, modificato]*
3	**SAFETY AND AREA CLASSIFICATION**	**SICUREZZA E CLASSIFICAZIONE DEI LUOGHI**
3.1	**Safety principles**	**Principi di sicurezza**
	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 the case of maintenance activities other than those of normal operation, the extent of the zone may be affected but it is expected that	Gli impianti dove vengono lavorate o depositate sostanze infiammabili devono essere progettati, eserciti e mantenuti in modo da ridurre al minimo le loro emissioni e le conseguenti estensioni dei luoghi pericolosi, sia nel funzionamento normale, sia in quello anormale, con riferimento alla frequenza, durata e quantità delle emissioni. Gli interventi di manutenzione non ordinaria (diversi da quelli eseguiti in esercizio ordinario) possono produrre variazioni nelle estensioni dei luoghi peri-

this would be dealt with by a permit-to-work system.

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 spillages and, if possible, 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.

Where this is not possible, protective measures, process equipment, systems and procedures should be selected and prepared so the likelihood of the coincidence of a) and b) is so small as to be acceptable. Such measures may be used singly if they are recognized as being highly reliable, or in combination to achieve an equivalent level of safety.

colosi, ma è previsto che tali interventi vengano trattati con una procedura di permesso di lavoro.

In situazioni di emergenza deve essere prevista la possibilità di interrompere l'alimentazione dell'impianto elettrico non idoneo, arrestare l'impianto di processo, intercettare le apparecchiature di processo, contenere le fuoriuscite e, se possibile, azionare un sistema di ventilazione addizionale di emergenza.

Nei casi in cui vi è possibilità di un'atmosfera esplosiva devono essere effettuati i seguenti interventi:

a) escludere la possibilità che l'atmosfera esplosiva si trovi in prossimità di una sorgente d'innesco, oppure
b) eliminare la sorgente d'innesco.

Quando ciò non sia possibile, devono essere scelte ed adottate misure protettive, apparecchiature di processo, sistemi e procedure tali che la probabilità di contemporanea presenza di atmosfera esplosiva e sorgente d'innesco sia così piccola da poter essere accettabile. Tali misure possono essere usate singolarmente, se sono altamente affidabili, o in combinazione, al fine di raggiungere un livello di sicurezza equivalente.

3.2 Area classification objectives

Area classification is a method of analysing and classifying the environment where explosive gas atmospheres may occur so as to facilitate the proper selection and installation of apparatus to be used safely in that environment, taking into account gas groups and temperature classes.

In most practical situations where flammable materials are used, it is difficult to ensure that an explosive gas atmosphere will never occur. It may also be difficult to ensure that apparatus will never give rise to a source of ignition. Therefore, in situations where an explosive gas atmosphere has a high likelihood of occurring, reliance is placed on using apparatus which has a low likelihood of creating a source of ignition. Conversely, where the likelihood of an explosive gas atmosphere occurring is reduced, apparatus constructed to a less rigorous standard may be used.

It is rarely possible by a simple examination of a plant or plant design to decide which parts of the plant can be equated to the three zonal definitions (zones 0, 1 and 2). A more detailed approach is therefore necessary and this involves the analysis of the basic possibility of an explosive gas atmosphere occurring.

The first step is to assess the likelihood of this, in accordance with the definitions of zone 0, zone 1 and zone 2. Once the likely frequency and duration of release (and hence the grade of release), the release rate, concentration, velocity, ventilation and other factors which affect the

Obiettivi della classificazione dei luoghi

La classificazione dei luoghi è un metodo per analizzare e classificare l'ambiente dove si possono formare delle atmosfere esplosive, al fine di facilitare la corretta scelta ed installazione delle costruzioni (apparecchi) da impiegarsi con sicurezza in tali luoghi, tenendo conto dei gruppi e delle classi di temperatura dei gas.

Nella maggior parte delle situazioni pratiche in cui si usano sostanze infiammabili, è difficile garantire che non vi possa mai essere la presenza di atmosfera esplosiva. È anche difficile garantire che una costruzione non sia mai una sorgente di accensione. Perciò, in situazioni in cui vi sia un'alta probabilità di presenza di atmosfera esplosiva ci si affida all'uso di costruzioni che hanno una bassa probabilità di essere sorgenti di accensione. Per contro, dove la probabilità che sia presente un'atmosfera esplosiva è ridotta, si possono impiegare costruzioni realizzate secondo criteri meno severi.

Dal semplice esame di un'opera od applicazione ovvero del suo progetto, è molto difficile individuare quali parti possano essere assimilate alle tre definizioni di zona (zona 0, 1 e 2). È perciò necessario uno studio più dettagliato comprendente un'analisi della possibilità che si formi atmosfera esplosiva.

Innanzi tutto, occorre valutare la probabilità che ciò avvenga, in accordo con le definizioni di zona 0, zona 1, zona 2. Dopo aver determinato: la possibile frequenza e durata dell'emissione (e quindi il grado delle emissioni), la portata, la concentrazione, la velocità di emissione, la ventilazio-

type and/or extent of the zone have been determined, there is then a firm basis on which to determine the likely presence of an explosive gas atmosphere in the surrounding areas. This approach therefore requires detailed consideration to be given to each item of process equipment which contains a flammable material, and which could therefore be a source of release.

In particular, zone 0 or zone 1 areas should be minimized in number and extent by design or suitable operating procedures. In other words, plants and installations should be mainly zone 2 or non-hazardous. Where release of flammable material is unavoidable, process equipment items should be limited to those which give secondary grade releases or, failing this (that is where primary or continuous grade releases are unavoidable), the releases should be of very limited quantity and rate. In carrying out area classification, these principles should receive prime consideration. Where necessary, the design, operation and location of process equipment should ensure that, even when it is operating abnormally, the amount of flammable material released into the atmosphere is minimized, so as to reduce the extent of the hazardous area.

Once a plant has been classified and all necessary records made, it is important that no modification to equipment or operating procedures is made without discussion with those responsible for the area classification. Unauthorized action may invalidate the area classification. It is necessary to ensure that all equipment affecting the area classification which has been subjected to maintenance is carefully checked during and after re-assembly to ensure that the integrity of the original design, as it affects safety, has been maintained before it is returned to service.

ne e gli altri fattori che influenzano il tipo e/o l'estensione delle zone, si dispone di una solida base per stabilire la possibile presenza di un'atmosfera esplosiva. Questo approccio richiede pertanto considerazioni dettagliate per ciascun componente di processo contenente sostanze infiammabili e che potrebbe perciò essere una sorgente di emissione.

In particolare, in sede di progetto o con idonee procedure operative, dovrebbero essere ridotte al minimo numero ed estensione delle zone 0 e zona 1. In altre parole, gli impianti e le installazioni dovrebbero essere principalmente zone 2 o luoghi non pericolosi. Quando l'emissione di sostanza infiammabile è inevitabile, i componenti di processo dovrebbero essere limitati a quelli con emissioni di secondo grado. Quando invece sia inevitabile la presenza di emissioni di grado continuo o primo grado, le stesse dovrebbero essere molto limitate in numero e portata. Nell'eseguire la classificazione, questi principi devono essere considerati prioritari. Quando necessario, il progetto, le modalità di funzionamento e la dislocazione dei componenti dell'impianto di processo dovrebbero garantire che, in condizioni di funzionamento anormale, la quantità di sostanza infiammabile emessa nell'atmosfera, sia la minore possibile in modo da ridurre l'estensione del luogo pericoloso.

Quando un'opera od applicazione è stata classificata e tutti i dati di riferimento sono stati registrati, è importante che nessuna modifica all'opera od applicazione stessa ed alle procedure operative avvenga senza l'accordo con i responsabili della classificazione. Azioni non concordate possono invalidare la classificazione dei luoghi pericolosi. È necessario che tutti i componenti dell'impianto di processo che hanno influenzato la classificazione e che sono stati oggetto di manutenzione, siano attentamente controllati durante e dopo il loro riassemblaggio e prima della loro rimessa in servizio, per garantire che la loro integrità, per quanto attiene alla sicurezza, sia stata mantenuta conforme al progetto originale.

4 AREA CLASSIFICATION PROCEDURE

4 PROCEDIMENTO DI CLASSIFICAZIONE DEI LUOGHI

4.1 General

The area classification should be carried out by those who have knowledge of the properties of flammable materials, the process and the equipment, in consultation, as appropriate, with safety, electrical and other engineering personnel.

The following subclauses give guidance on the procedure for classifying areas in which there may be an explosive atmosphere and on the extent of zones 0, 1 and 2. An example of a schematic approach to the classification of hazardous areas is given in figure C.1.

Generalità

La classificazione dei luoghi pericolosi dovrebbe essere eseguita da persone a conoscenza delle proprietà delle sostanze infiammabili, del processo e delle relative apparecchiature, consultando, per quanto di competenza, i tecnici della sicurezza, dell'impianto elettrico ed altri specialisti.

I paragrafi che seguono forniscono una guida per il procedimento di classificazione dei luoghi con possibile presenza di atmosfera esplosiva e di determinazione dell'estensione delle zone 0, 1 e 2. Un esempio di approccio schematico alla classificazione dei luoghi pericolosi è dato nell'Appendice C fig. C.1.

Sources of release

The basic elements for establishing the hazardous zone types are the identification of the source of release and the determination of the grade of release.

Since an explosive gas atmosphere can exist only if a flammable gas or vapour is present with air, it is necessary to decide if any of these flammable materials can exist in the area concerned. Generally speaking, such gases and vapours (and flammable liquids and solids which may give rise to them) are contained within process equipment which may or may not be totally enclosed. It is necessary to identify where a flammable atmosphere can exist inside a process plant, or where a release of flammable materials can create a flammable atmosphere outside a process plant.

Each item of process equipment (for example tank, pump, pipeline, vessel, etc.) should be considered as a potential source of release of flammable material. If the item cannot contain flammable material, it will clearly not give rise to a hazardous area around it. The same will apply if the item contains a flammable material but cannot release it into the atmosphere (for example an all-welded pipeline is not considered to be a source of release).

If it is established that the item may release flammable material into the atmosphere, it is necessary, first of all, to determine the grade of release in accordance with the definitions, by establishing the likely frequency and duration of the release. It should be recognized that the opening-up of parts of enclosed process systems (for example during filter changing or batch filling) should also be considered as sources of release when developing the area classification. By means of this procedure, each release will be graded either *continuous*, *primary* or *secondary*.

Having established the grade of the release, it is necessary to determine the release rate and other factors which may influence the type and extent of the zone.

Sorgenti di emissione

Gli elementi fondamentali per la determinazione del tipo di zona pericolosa, sono l'identificazione delle sorgenti di emissione e del grado di emissione.

Poiché un'atmosfera esplosiva esiste solamente se è presente un gas o un vapore infiammabili in miscela con l'aria, è necessario stabilire se nel luogo considerato possono essere presenti tali sostanze infiammabili. In generale, gas e vapori (ed i liquidi e solidi infiammabili che possono generarli) sono contenuti all'interno di apparecchiature di processo che possono risultare a tenuta totale o meno. È necessario individuare dove l'atmosfera esplosiva può essere presente, all'interno dell'impianto, od all'esterno di esso.

Ogni parte dell'impianto (per esempio serbatoio, pompa, tubazione, recipiente, ecc.) deve essere considerata come una potenziale sorgente di emissione. Se la parte non contiene sostanze infiammabili, ovviamente non darà origine al suo esterno ad un luogo pericoloso. Lo stesso dicasi se la parte contiene sostanze infiammabili ma non può emetterle nell'atmosfera (ad esempio una tubazione completamente saldata non è considerata sorgente di emissione).

Quando è stabilito che una parte può emettere sostanza infiammabile nell'atmosfera, è necessario, prima di tutto, determinare il grado di emissione, in accordo con le definizioni, stabilendo la possibile frequenza e durata dell'emissione stessa. Nello sviluppo della classificazione dei luoghi devono essere considerate sorgenti di emissione anche le parti dei sistemi di processo chiusi che possono essere aperte (es. durante la sostituzione di filtri o riempimenti discontinui). Con questo procedimento ogni emissione viene definita di *grado continuo*, di *primo grado* o di *secondo grado*.

Stabilito il grado dell'emissione, è necessario determinarne la portata e gli altri fattori che possono influenzare il tipo e l'estensione della zona.

4.3 Type of zone

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

Note/Nota *A continuous grade of release normally leads to a zone 0, a primary grade to zone 1 and a secondary grade to zone 2 (see Annex B).*

Tipo di zona

La probabilità di presenza di un'atmosfera esplosiva e quindi il tipo di zona dipende principalmente dal grado dell'emissione e dalla ventilazione.

Una emissione di grado continuo determina, normalmente, una zona 0, una emissione di primo grado, una zona 1, e una emissione di secondo grado, una zona 2 (Appendice B).

Extent of zone

The extent of the zone is mainly affected by the following chemical and physical parameters, some of which are intrinsic properties of the flammable material; others are specific to the process. For simplicity, the effect of each parameter listed below assumes that the other parameters remain unchanged.

4.1 Release rate of gas or vapour

The greater the release rate the larger the extent of the zone. The release rate depends itself on other parameters, namely:

a) Geometry of the source of release
This is related to the physical characteristic of the source of release, for example an open surface, leaking flange, etc. (see Annex A).

b) Release velocity
For a given source of release, the release rate increases with the release velocity. In the case of a product contained within process equipment, the release velocity is related to the process pressure and the geometry of the source of release. The size of a cloud of flammable gas or vapour is determined by the rate of flammable vapour release and the rate of dispersion. Gas and vapour flowing from a leak at high velocity will develop a coneshaped jet which will entrain air and be self-diluting. The extent of the explosive atmosphere will be almost independent of wind velocity. If the release is at low velocity or if its velocity is destroyed by impingement on a solid object, it will be carried by the wind and its dilution and extent will depend on wind velocity.

c) Concentration
The release rate increases with the concentration of flammable vapour or gas in the released mixture.

d) Volatility of a flammable liquid
This is related principally to the vapour pressure, and the heat of vaporization. If the vapour pressure is not known, the boiling point and flashpoint can be used as a guide.
An explosive atmosphere cannot exist if the flashpoint is above the relevant maximum temperature of the flammable liquid. The lower the flashpoint, the greater may be the extent of the zone. If a flammable material is released in a way that forms a mist (for example by spraying) an explosive atmosphere may be formed below the flashpoint

Estensione della zona

L'estensione della zona è principalmente influenzata dalle grandezze chimiche e fisiche seguenti. Alcune grandezze sono proprietà intrinseche della sostanza infiammabile, altre sono invece specifiche del processo. Per semplicità, l'effetto di ciascuna grandezza presuppone che le altre rimangano costanti.

Portata di emissione di gas o vapore

Maggiore è la portata di emissione, più grande risulterà l'estensione della zona. La portata di emissione dipende a sua volta da altre grandezze di seguito indicate:

a) Geometria della sorgente di emissione
Essa è in relazione alle caratteristiche fisiche della sorgente di emissione, per esempio: una superficie libera, una flangia dalla quale avviene una perdita, o altro (Appendice A).

b) Velocità di emissione
Per una data sorgente di emissione la portata aumenta con la velocità di emissione. Nel caso di una sostanza contenuta entro un'apparecchiatura di processo, la velocità di emissione è correlata alla pressione di processo ed alla geometria della sorgente di emissione. La dimensione di una nube di gas o vapore infiammabile è determinata dalla sua portata di emissione e dalla portata di dispersione. I gas e vapori che vengono emessi ad alta velocità sviluppano un getto a forma di cono che trascina l'aria e si auto-diluisce. L'estensione dell'atmosfera esplosiva risulterà, in genere, indipendente dalla velocità del vento. Se l'emissione avviene a bassa velocità o se la velocità viene annullata per impatto contro un oggetto solido, l'emissione sarà trasportata dal vento e la sua diluizione ed estensione dipenderà dalla velocità di quest'ultimo.

c) Concentrazione
La portata di emissione aumenta con l'aumentare della concentrazione del vapore o gas infiammabile nella miscela rilasciata.

d) Volatilità di un liquido infiammabile
Essa dipende principalmente dalla tensione di vapore e dal calore di vaporizzazione. Se la tensione di vapore non è conosciuta, possono essere prese come riferimento la temperatura di ebollizione e la temperatura di infiammabilità.
Un'atmosfera esplosiva non può esistere se la temperatura d'infiammabilità è superiore alla massima temperatura alla quale si trova il liquido infiammabile. Più bassa è la temperatura d'infiammabilità, maggiore risulterà l'estensione della zona. Se la sostanza infiammabile viene emessa in modo da formare una nebbia (per esempio a seguito di spruzzo) si può formare

of the material for example.

Notes/Note: 1 *Flashpoints of flammable liquids are not precise physical quantities, particularly where mixtures are involved.*

2 *Some liquids (for example certain halogenated hydrocarbons) do not possess a flashpoint although they are capable of producing an explosive gas atmosphere. In these cases, the equilibrium liquid temperature which corresponds to the saturated concentration at the lower explosive limit should be compared with the relevant maximum liquid temperature.*

e) Liquid temperature
The vapour pressure increases with temperature, thus increasing the release rate due to evaporation.

Note/Nota *The temperature of the liquid after it has been released may be increased, for example, by a hot surface or by a high ambient temperature.*

4.4.2 Lower explosive limit (LEL)

For a given release volume, the lower the LEL the greater will be the extent of the zone.

4.4.3 Ventilation

With increased ventilation, the extent of the zone will be reduced. Obstacles which impede the ventilation may increase the extent of the zone. On the other hand, some obstacles, for example dykes, walls or ceilings, may limit the extent.

4.4.4 Relative density of the gas or vapour when it is released

If the gas or vapour is significantly lighter than air, it will tend to move upwards. If significantly heavier, it will tend to accumulate at ground level. The horizontal extent of the zone at ground level will increase with increasing relative density and the vertical extent above the source will increase with decreasing relative density.

Notes/Note: 1 *For practical applications, a gas or vapour which has a relative density below 0,8 is regarded as being lighter than air. If the relative density is above 1,2 it is regarded as being heavier than air. Between these values, both of these possibilities should be considered.*

2 *Experience has shown that ammonia is hard to ignite and a gas release will dissipate rapidly in the open air, so any explosive gas atmosphere will be of negligible extent.*

4.4.5 Other parameters to be considered

a) Climatic conditions.

b) Topography.

4.5 Illustrative examples

Some ways in which the above-mentioned parameters affect the vapour or gas release rate

un'atmosfera esplosiva pur con temperatura della sostanza inferiore a quella d'infiammabilità.

1 *Le temperature d'infiammabilità dei liquidi infiammabili non sono grandezze fisiche esatte, specialmente quando si riferiscono a miscele.*

2 *Alcuni liquidi (per esempio certi idrocarburi alogenati) non hanno una temperatura d'infiammabilità, anche se sono capaci di produrre atmosfera esplosiva. In questi casi è opportuno comparare la temperatura di equilibrio del liquido, che corrisponde alla concentrazione di saturazione al limite inferiore di esplodibilità, con la massima temperatura alla quale può trovarsi il liquido stesso.*

e) Temperatura del liquido
La tensione di vapore aumenta con la temperatura del liquido, aumentando così la portata di emissione dovuta all'evaporazione.

La temperatura del liquido dopo la sua emissione, può aumentare, per esempio, per effetto di una superficie calda o di un'alta temperatura ambiente.

Limite inferiore di esplodibilità (LEL)

Per un dato volume emesso, minore è il LEL, maggiore risulta l'estensione della zona.

Ventilazione

All'aumentare della ventilazione, l'estensione della zona si riduce. Gli ostacoli che impediscono la ventilazione possono incrementare l'estensione della zona. Al contrario, alcuni ostacoli, per esempio argini, dighe, pareti e soffitti, possono limitarne l'estensione.

Densità relativa del gas o vapore al momento del rilascio

Se il gas o vapore è significativamente più leggero dell'aria, tenderà a salire verso l'alto. Se è significativamente più pesante, tenderà ad accumularsi al livello del terreno. L'estensione orizzontale della zona al livello del terreno aumenterà all'aumentare della densità relativa e l'estensione verticale sopra la sorgente aumenterà con la diminuzione della densità relativa.

1 *In pratica, un gas o vapore con densità relativa inferiore a 0,8 viene considerato più leggero dell'aria. Se la sua densità è invece superiore a 1,2 viene considerato più pesante dell'aria. Per valori compresi tra 0,8 e 1,2 verranno considerate entrambe le possibilità.*

2 *L'esperienza ha dimostrato che l'ammoniaca è di difficile accensione e che, all'aperto, una sua emissione allo stato gassoso si diffonde rapidamente, cosicché eventuali atmosfere esplosive risulteranno di estensione trascurabile.*

Altre grandezze da considerare

a) Condizioni climatiche.

b) Topografia.

Esempi illustrativi

Gli esempi dell'Appendice C illustrano alcuni modi con cui le grandezze sopra menzionate in-

and hence the extent of the zone are demonstrated in the examples in Annex C.

a) Source of release: open surface of liquid.

In most cases, the liquid temperature will be below the boiling point and the vapour release rate will depend principally on the following parameters:

- liquid temperature;
- vapour pressure of the liquid at its surface temperature;
- dimensions of the evaporation surface.

b) Source of release: virtually instantaneous evaporation of a liquid (for example from a jet or spray).
Since the discharged liquid vaporizes virtually instantaneously, the vapour release rate is equal to the liquid flow rate and this depends on the following parameters:

- liquid pressure;
- geometry of the source of release.

Where the liquid is not instantaneously vaporized, the situation is complex because droplets, liquid jets and pools may create separate sources of release.

c) Source of release: leakage of a gas mixture.

The gas release rate is affected by the following parameters:

- pressure within the equipment which contains the gas;
- geometry of the source of release;
- concentration of flammable gas in the released mixture.

For examples of sources of release see clause A.2.

4.5 Extent of zone - General comments

4.5.1 Consideration should always be given to the possibility that a gas which is heavier than air may flow into areas below ground level for example pits or depressions and that a gas which is lighter than air may be retained at high level for example in a roof space.

4.5.2 Where the source of release is situated outside an area or in an adjoining area, the penetration of a significant quantity of flammable gas or vapour into the area can be prevented by suitable means such as:

a) physical barriers;
b) maintaining a static overpressure in the area relative to the adjacent hazardous areas, so preventing the ingress of the hazardous atmosphere;
c) purging the area with a significant flow of air, so ensuring that the air escapes from all openings where the hazardous gas or vapour may enter.

fluenzano la portata di emissione e conseguentemente l'estensione della zona.

a) Sorgente di emissione: superficie libera di un liquido.
Nella maggior parte dei casi la temperatura del liquido è inferiore alla temperatura di ebollizione e la portata di emissione del vapore dipende principalmente dalle seguenti grandezze:

- temperatura del liquido;
- tensione di vapore del liquido riferita alla sua temperatura superficiale;
- dimensioni della superficie di evaporazione.

b) Sorgente di emissione: evaporazione praticamente istantanea di un liquido (es. da un getto o spruzzo).
Poiché il liquido emesso evapora potenzialmente all'istante, la portata di emissione del vapore è uguale alla portata di emissione del flusso liquido, che dipende dalle seguenti grandezze:

- pressione del liquido;
- geometria della sorgente di emissione.

Quando il liquido non evapora istantaneamente, la situazione è più complessa perché i liquidi nebulizzati, i getti di liquido e le pozze possono costituire sorgenti di emissione separate.

c) Sorgente di emissione: perdita di una miscela di gas.
La portata di emissione del gas è influenzata dalle seguenti grandezze:

- pressione all'interno dell'apparecchiatura che lo contiene;
- geometria della sorgente di emissione;
- concentrazione del gas infiammabile nella miscela emessa.

Per gli esempi di sorgenti di emissione si rimanda all'Appendice A.

4.5 Estensione della zona - Considerazioni generali

4.5.1 Si deve sempre considerare la possibilità che un gas più pesante dell'aria possa fluire in luoghi al di sotto del livello del terreno, per esempio pozzetti o depressioni e che un gas più leggero dell'aria possa accumularsi a livelli più alti, per esempio in uno spazio del soffitto.

4.5.2 Quando la sorgente di emissione si trova al di fuori di un determinato luogo o in un luogo contiguo, la propagazione di una quantità significativa di gas o vapore infiammabile nel luogo considerato può essere prevenuta adottando opportuni mezzi, quali:

a) barriere fisiche;
b) mantenimento di una sovrapressione statica nel luogo considerato rispetto ai luoghi pericolosi contigui, evitando così l'ingresso dell'atmosfera esplosiva;
c) bonifica del luogo considerato con un idoneo flusso d'aria, assicurando l'uscita dell'aria da tutte le aperture dalle quali potrebbe entrare il gas o vapore infiammabile.

5.1 General

Gas or vapour released into the atmosphere can be diluted by dispersion or diffusion into the air until its concentration is below the lower explosion limit. Ventilation, i.e. air movement leading to replacement of the atmosphere in a (hypothetical) volume around the source of release by fresh air, will promote dispersion. Suitable ventilation rates can also avoid persistence of an explosive gas atmosphere thus influencing the type of zone.

5.2 Main types of ventilation

Ventilation can be accomplished by the movement of air due to the wind and/or by temperature gradients or by artificial means such as fans. So two main types of ventilation are thus recognized:

a) natural ventilation;

b) artificial ventilation, general or local.

5.3 Degree of ventilation

The most important factor is that the degree or amount of ventilation is directly related to the types of sources of release and their corresponding release rates. This is irrespective of the type of ventilation, whether it be wind speed or the number of air changes per time unit. Thus optimal ventilation conditions in the hazardous area can be achieved and the higher the amount of ventilation in respect of the possible release rates, the smaller will be the extent of the zones (hazardous areas), in some cases reducing them to a negligible extent (non-hazardous area).

Practical examples for guidance on the degree of ventilation to be used are given in Annex B.

5.4 Availability of ventilation

The availability of ventilation has an influence on the presence or formation of an explosive atmosphere and thus also on the type of zone.

Guidance on availability is given in Annex B.

Note/Nota *Combining the concepts of degree of ventilation and level of availability results in a quantitative method for the evaluation of zone type (see Annex B).*

5.1 Generalità

I gas o vapori emessi nell'atmosfera possono diluirsi per dispersione o diffusione nell'aria finché la loro concentrazione scende al di sotto del limite inferiore di esplodibilità. La ventilazione, cioè il movimento dell'aria che provoca il ricambio dell'atmosfera con aria fresca in un (ipotetico) volume attorno alla sorgente di emissione, favorisce la dispersione. Idonee portate di ventilazione possono anche evitare la persistenza di atmosfera esplosiva influenzando in tal modo il tipo di zona.

5.2 Principali tipi di ventilazione

La ventilazione può avvenire tramite il movimento dell'aria dovuto al vento e/o ai gradienti di temperatura o tramite mezzi artificiali come ventilatori. Si possono pertanto distinguere due principali tipi di ventilazione:

a) ventilazione naturale;

b) ventilazione artificiale, generale o locale.

5.3 Grado di ventilazione

È importante notare che il grado o quantità di ventilazione è direttamente in rapporto con il tipo delle sorgenti di emissione e con la loro portata di emissione. Questo, indipendentemente dal tipo di ventilazione, sia che essa sia dovuta alla velocità del vento o ad un determinato numero di ricambi d'aria nell'unità di tempo. In tal modo si possono ottenere delle ventilazioni ottimali dei luoghi pericolosi e, tanto maggiore è la quantità della ventilazione rispetto alla portata di emissione, tanto minore è l'estensione delle zone (luoghi pericolosi), riducendola, in alcuni casi, ad estensione trascurabile (luogo non pericoloso).

Nell'Appendice B sono riportati esempi pratici da usarsi come guida al grado di ventilazione.

5.4 Disponibilità della ventilazione

La disponibilità della ventilazione ha influenza sulla presenza o formazione di un'atmosfera esplosiva e sui tipi di zone.

Nell'Appendice B è una guida sulla disponibilità della ventilazione.

Note/Nota *La combinazione dei concetti di grado di ventilazione e di livello della sua disponibilità dà come risultato un metodo quantitativo per la valutazione del tipo di zona (Appendice B).*

DOCUMENTATION

DOCUMENTAZIONE

6.1 General

It is recommended that area classification is undertaken in such a way that the various steps which lead to the final area classification are properly documented.

All relevant information used should be referred to. Examples of such information, or of a method used, would be:

a) recommendations from relevant codes and standards;

b) gas and vapour dispersion characteristics and calculations;

c) a study of ventilation characteristics in relation to flammable material release parameters so that the effectiveness of the ventilation can be evaluated.

The results of the area classification study and any subsequent alterations to it shall be placed on record.

Those properties which are relevant to area classification of all process materials used on the plant should be listed and should include flashpoint, boiling point, ignition temperature, vapour pressure, vapour density, explosive limits, gas group and temperature class. An example is given in tables C.1 and C.2.

Generalità

Si raccomanda che la classificazione dei luoghi venga effettuata in modo tale da documentare idoneamente le varie fasi che portano alla classificazione finale.

È opportuno che sia evidenziata ogni informazione attinente. Esempi di tali informazioni o del metodo usato possono essere:

a) raccomandazioni ricavate da norme o guide in materia;

b) caratteristiche di dispersione dei gas o vapori e calcoli;

c) studio delle caratteristiche di ventilazione in relazione alle grandezze caratteristiche di emissione delle sostanze infiammabili, per poterne valutare l'efficacia.

I risultati della classificazione del luogo e tutte le sue variazioni successive devono essere registrate.

Devono essere elencate le proprietà, attinenti alla classificazione del luogo, di tutte le sostanze presenti nell'impianto, includendo: la temperatura d'infiammabilità, la temperatura di ebollizione, la temperatura di accensione, la tensione di vapore, la densità del vapore, i limiti di esplodibilità, il gruppo delle costruzioni elettriche per atmosfere esplosive per gas o vapori e la classe di temperatura. Un esempio di elencazione è riportato nell'Appendice C, Tab. C.1 e C.2.

6.2 Drawings, data sheets and tables

Area classification documents should include plans and elevations, as appropriate, which show both the type and extent of zones, ignition temperature and hence temperature class and gas group.

Where the topography of an area influences the extent of the zones, this should be documented.

The documents should also include other relevant information such as:

a) the location and identification of sources of release. For large and complex plants or process areas, it may be helpful to itemize or number the sources of release so as to facilitate cross-referencing between the area classification data sheets and the drawings;

b) the position of openings in buildings (for example doors, windows and inlets and outlets of air for ventilation).

The area classification symbols which are shown in figure C.2 are the preferred ones, but alternatives may be used provided that they are clearly defined in the documents.

Disegni, fogli dati e tabelle

I documenti di classificazione dei luoghi dovrebbero comprendere, per quanto necessario, piante e prospetti che riportino il tipo e l'estensione delle zone, la temperatura di accensione, la classe di temperatura ed il gruppo delle costruzioni elettriche per atmosfere esplosive per gas o vapori.

Dovrebbe essere documentata anche la topografia del luogo se ciò influisce sull'estensione delle zone.

La documentazione dovrebbe includere anche altre informazioni attinenti, quali:

a) l'ubicazione e l'identificazione delle sorgenti di emissione. Per impianti complessi e di grandi dimensioni o aree di processo, può essere utile codificare o numerare le sorgenti di emissione in modo da facilitare i riferimenti incrociati tra i vari fogli dati ed i disegni della classificazione del luogo;

b) la posizione delle aperture negli edifici (es. porte, finestre, ingressi e uscite dell'aria di ventilazione).

Nell'Appendice C, Fig. C.2 è indicata la simbologia preferenziale per la classificazione dei luoghi, tuttavia possono essere impiegati simboli alternativi, purché siano chiaramente definiti nei documenti.(1)

(1) Nota: (Non contenuta nelle pubblicazioni IEC e CENELEC) - *Per uniformità nazionale, si raccomanda vivamente di utilizzare la simbologia indicata; in ogni caso, non è ammesso invertire il significato dei simboli riportati nell'Appendice C, Fig. C.2.*

ANNEX A (informative) EXAMPLES OF SOURCES OF RELEASE

ALLEGATO A (informativo) ESEMPI DI SORGENTI DI EMISSIONE

A.1 Process plant

The following examples are not intended to be rigidly applied and may need to be varied to suit particular process equipment and situations.

A.1.1 Sources giving a continuous grade of release:

a) the surface of a flammable liquid in a fixed roof tank, with a permanent vent to the atmosphere;

b) the surface of a flammable liquid which is open to the atmosphere continuously or for long periods (for example an oil/water separator).

A.1.2 Sources giving a primary grade of release:

a) seals of pumps, compressors or valves if release of flammable material during normal operation is expected;

b) water drainage points on vessels which contain flammable liquids, which may release flammable material into the atmosphere while draining off water during normal operation;

c) sample points which are expected to release flammable material into the atmosphere during normal operation;

d) relief valves, vents and other openings which are expected to release flammable material into the atmosphere during normal operation.

A.1.3 Sources giving a secondary grade of release:

a) seals of pumps, compressors 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;

c) sample points which are not expected to release flammable material during normal operation;

d) relief valves, vents and other openings which are not expected to release flammable material into the atmosphere during normal operation.

A.2 Openings

The following examples are not intended to be rigidly applied, but may need to be varied to suit particular situations.

Impianti di processo

Gli esempi seguenti non sono destinati ad essere rigidamente applicati e possono essere necessari degli adattamenti nel caso di apparecchiature di processo e situazioni particolari.

Sorgenti con emissione di grado continuo:

a) la superficie di un liquido infiammabile in un serbatoio a tetto fisso con uno sfiato permanente all'atmosfera;

b) la superficie di un liquido infiammabile esposta all'atmosfera continuamente o per lunghi periodi (es. un separatore idrocarburi-acqua)

Sorgenti con emissione di primo grado:

a) le tenute di pompe, di compressori o di valvole, quando si prevede che possano emettere sostanze infiammabili durante il funzionamento normale dell'impianto;

b) i punti di drenaggio dell'acqua da recipienti che contengono liquidi infiammabili, che possono emettere sostanze infiammabili nell'atmosfera drenando acqua durante il funzionamento normale dell'impianto;

c) i punti di campionamento quando si prevede che possano emettere sostanze infiammabili nell'atmosfera durante il funzionamento normale dell'impianto;

d) le valvole di sicurezza, gli sfiati e le altre aperture quando si prevede che possano emettere sostanze infiammabili nell'atmosfera durante il funzionamento normale dell'impianto.

Sorgenti con emissione di secondo grado:

a) le tenute di pompe, compressori o valvole quando si prevede che non emettano sostanze infiammabili durante il funzionamento normale dell'impianto;

b) le flange, le giunzioni ed i raccordi delle tubazioni, quando si prevede che non emettano sostanze infiammabili durante il funzionamento normale dell'impianto;

c) i punti di campionamento quando si prevede che non emettano sostanze infiammabili nell'atmosfera durante il funzionamento normale dell'impianto;

d) le valvole di sicurezza, gli sfiati e le altre aperture quando si prevede che non emettano sostanze infiammabili nell'atmosfera durante il funzionamento normale dell'impianto.

Aperture

Gli esempi seguenti non sono considerati di rigida applicazione e possono richiedere degli adattamenti nel caso di situazioni particolari.

Openings as possible sources of release

Openings between areas should be considered as possible sources of release. The grade of release will depend upon:

- the zone type of the adjoining area;
- the frequency and duration of opening periods;
- the effectiveness of seals or joints;
- the difference in pressure between the areas involved.

Aperture come possibili sorgenti di emissione

Le aperture tra luoghi diversi dovrebbero essere considerate possibili sorgenti di emissione. Il loro grado di emissione dipende da:

- tipo di zona del luogo dal quale proviene il pericolo (a monte dell'apertura);
- frequenza e durata dei periodi di apertura;
- efficacia delle tenute e dei giunti;
- differenza di pressione tra i luoghi interessati;

A.2.2 **Openings classification**

Openings are classified as A, B, C, D with the following characteristics:

Classificazione delle aperture

Le aperture sono classificate di tipo A, B, C, D, con le caratteristiche riportate nei punti seguenti.

A.2.2.1 *Type A* - Openings not conforming to the characteristics specified for types B, C or D.

Examples:

- open passages for access or utilities, for example dusts, pipes through walls, ceilings and floors;
- fixed ventilation outlets in rooms, buildings and similar openings of types B, C and D which are opened frequently or for long periods.

Tipo A - Aperture non conformi alle caratteristiche specificate per i tipi B, C o D.

Esempi:

- passaggi aperti per l'accesso o per il passaggio di servizi, come condutture, tubazioni che attraversano pareti, soffitti e pavimenti;
- uscite di ventilazione fisse dei locali ed aperture simili, dei tipi B, C e D, che vengono aperte frequentemente o per lunghi periodi.

A.2.2.2 *Type B* - Openings which are normally closed (for example automatic closing) and infrequently opened, and which are close-fitting.

Tipo B - Aperture che sono normalmente chiuse (es. con dispositivo di autochiusura), aperte poco frequentemente e che hanno una buona tenuta su tutto il perimetro.

A.2.2.3 *Type C* - Openings normally closed and infrequently opened, conforming to type B, which are also fitted with sealing devices (for example a gasket) along the whole perimeter; or two openings type B in series, having independent automatic closing devices.

Tipo C - Aperture normalmente chiuse o aperte poco frequentemente, conformi a quelle di tipo B, provviste inoltre di dispositivi di tenuta (es. una guarnizione) su tutto il perimetro; oppure, due aperture di tipo B in serie, dotate di dispositivi indipendenti di autochiusura.

A.2.2.4 *Type D* - Openings normally closed conforming to type C which can only be opened by special means or in an emergency.

Type D openings are effectively sealed, such as in utility passages (for example ducts, pipes) or can be a combination of one opening type C adjacent to a hazardous area and one opening type B in series.

Tipo D - Aperture normalmente chiuse conformi a quelle di tipo C, apribili solamente con mezzi speciali od in caso di emergenza.

Le aperture di tipo D sono sicuramente a tenuta, come nei passaggi di servizi (es. condutture, tubazioni); oppure, possono essere una combinazione di un'apertura di tipo C, adiacente al luogo dal quale proviene il pericolo, in serie ad un'altra apertura di tipo B..

Tab. A.1 Effect of openings on grade of release — Correlazione tra aperture e grado di emissione

Qualifica della zona a monte dell'apertura *Zone upstream of opening*	Tipo di apertura *Opening time*	Grado di emissione dell'apertura considerata una sorgente di emissione *Grade of release of openings considered as sources of release*
Zona 0 *Zone 0*	A	Continuo_*Continuous*
	B	(Continuo)/primo_*(Continuous)/primary*
	C	Secondo_*Secondary*
	D	Nessuna emissione_*No release*
Zona 1 *Zone 1*	A	Primo_*Primary*
	B	(Primo)/secondo_*(Primary)/secondary*
	C	(Secondo)/nessuna emissione_*(Secondary)/no release*
	D	Nessuna emissione_*No release*
Zona 2 *Zone 2*	A	Secondo_*Secondary*
	B	(Secondo)/nessuna emissione_*(Secondary)/no release*
	C	Nessuna emissione_*No release*
	D	Nessuna emissione_*No release*

Nota_e Per i gradi di emissione indicati tra parentesi, in sede di progetto è opportuno prendere inconsiderazione la frequenza di apertura.
For grades of release shown in brackets, the frequency of operation of the openings should be considered in the design.

B APPENDICE normative informativa VENTILATION

Introduction

The purpose of this Annex is to assess the degree of ventilation and to extend clause 5 by defining ventilation conditions and by means of explanations, examples and calculation, so giving guidance on the design of artificial ventilation systems, since these are of paramount importance in the control of the dispersion of releases of flammable gases and vapours.

The methods developed allow the determination of the type of zone by:

- estimating the minimum ventilation rate required to prevent significant build-up of an explosive atmosphere and using this to calculate a hypothetical volume, Vz (PEDICE) which, with an estimated dispersion time, t, allows determination of the degree of ventilation. It is not intended that these calculations are used to determine the extent of the hazardous areas;
- determining the type of zone from the degree and availability of ventilation and the grade of release.

Although primarily of direct use in indoor situations, the concepts explained may assist in outdoor locations, for example by determination of the application of table B.1.

B.1 Natural ventilation

This is a type of ventilation which is accomplished by the movement of air caused by the wind and/or by temperature gradients. In open air situations, natural ventilation will often be sufficient to ensure dispersal of any explosive atmosphere which arises in the area. Natural ventilation may also be effective in certain indoor situations (for example where a building has openings in its walls and/or roof).

Note/Nota *For outdoor areas the evaluation of ventilation should normally be based on an assumed minimum wind speed of 0,5 m/s, which will be present virtually continuously. The wind spood will frequently be above 2 m/s.*

Examples of natural ventilation:

- open air situations typical of those in the chemical and petroleum industries for example open structures, pipe racks, pump bays and the like;
- an open building which, having regard to the relative density of the gases and/or vapours involved, has openings in the walls and/or roof so dimensioned and located that the ventilation inside the building, for the purpose of area

VENTILAZIONE

Introduzione

Lo scopo di questa appendice è di valutare il grado di ventilazione e di integrare il Capitolo 5 definendo le condizioni di ventilazione e, con l'ausilio di spiegazioni, esempi e calcoli, di fornire una guida per il progetto dei sistemi di ventilazione artificiale, che sono della massima importanza nel controllo della dispersione delle emissioni di gas e vapori infiammabili.

I metodi sviluppati consentono di determinare il tipo della zona attraverso:

- la stima della portata di ventilazione *minima* richiesta per prevenire la formazione di un'atmosfera esplosiva significativa ed il suo uso per calcolare un volume ipotetico V_z che, con un tempo stimato di dispersione *t*, permette di determinare il grado di ventilazione. Questi calcoli non sono finalizzati alla determinazione dell'estensione dei luoghi pericolosi;
- il grado e la disponibilità della ventilazione, nonché il grado dell'emissione.

I concetti illustrati, sebbene siano principalmente intesi per un uso specifico in luoghi al chiuso, possono essere di ausilio anche in caso di luoghi all'aperto, ad esempio, mediante l'applicazione della Tab. B.1.

Ventilazione naturale

La ventilazione naturale è quella che viene attuata dal movimento dell'aria causato dal vento e/o da gradienti di temperatura. All'aperto, la ventilazione naturale spesso è sufficiente ad assicurare la dispersione di ogni atmosfera esplosiva che si formi nel luogo. La ventilazione naturale può anche essere efficace in determinati luoghi al chiuso (per esempio in un edificio con aperture nei muri e/o sul soffitto).

Per la valutazione della ventilazione di luoghi all'aperto conviene normalmente basarsi su una velocità del vento minima presunta di 0,5 m/s, che in pratica è presente continuamente. La velocità del vento frequentemente può essere superiore a 2 m/s.

Esempi di ventilazione naturale:

- luoghi all'aperto tipici dell'industria chimica e petrolifera, per esempio: strutture aperte, percorsi delle tubazioni, zone pompe e simili;
- un edificio aperto che, tenuto conto della densità relativa dei gas e/o vapori presenti, ha le aperture nei muri e/o sul soffitto disposte e dimensionate in modo che la ventilazione al suo interno, ai fini della classificazione del

classification, can be regarded as equivalent to that in an open air situation;

- a building which is not an open building but which has natural ventilation (generally less than that of an open building) provided by permanent openings made for ventilation purposes.

luogo, possa essere considerata equivalente a quella di un luogo all'aperto.

- un edificio che non sia un edificio aperto ma che ha una ventilazione naturale (generalmente inferiore a quella di un edificio aperto) attuata tramite aperture permanenti realizzate ai fini della ventilazione.

B.2 Artificial ventilation

The air movement required for ventilation is provided by artificial means, for example fans or extractors. Although artificial ventilation is mainly applied inside a room or enclosed space, it can also be applied to situations in the open air to compensate for restricted or impeded natural ventilation due to obstacles.

The artificial ventilation of an area may be either general or local and, for both of these, differing degrees of air movement and replacement can be appropriate.

With the use of artificial ventilation it is possible to achieve:

- reduction in the extent of zones;
- shortening of the time of persistence of an explosive atmosphere;
- prevention of the generation of an explosive atmosphere.

Artificial ventilation makes it possible to provide an effective and reliable ventilation system in an indoor situation. An artificial ventilation system which is designed for explosion protection should meet the following requirements:

- its effectiveness should be controlled and monitored;
- consideration should be given to the classification immediately outside the extract system discharge point;
- for ventilation of a hazardous area the ventilation air should normally be drawn from a non-hazardous area;
- before determining the dimensions and design of the ventilation system, the location, grade of release and release rate should be defined.

In addition, the following factors will influence the quality of an artificial ventilation system:

- flammable gases and vapours usually have densities other than that of air, thus they will tend to accumulate near to either the floor or ceiling of an enclosed area, where air movement is likely to be reduced;
- changes in gas density with temperature;
- impediments and obstacles may cause reduced, or even no air movement, i.e. no ventilation in certain parts of the area.

Ventilazione artificiale

Ventilazione artificiale è quella in cui il movimento dell'aria necessario è attuato da mezzi artificiali, per esempio ventilatori o estrattori. Sebbene la ventilazione artificiale venga principalmente impiegata all'interno di un locale o spazio chiuso, essa può essere utilizzata anche all'aperto per compensare la riduzione della ventilazione naturale causata da ostacoli.

La ventilazione artificiale di un luogo può essere generale o locale e, in entrambi i casi, possono essere idonei differenti gradi di movimento e di ricambio d'aria.

Con l'impiego della ventilazione artificiale è possibile ottenere:

- riduzione dell'estensione delle zone;
- diminuzione del tempo di permanenza dell'atmosfera esplosiva;
- prevenzione della formazione di un'atmosfera esplosiva.

La ventilazione artificiale permette di avere un sistema di ventilazione efficace ed efficiente all'interno di un edificio. Un sistema di ventilazione artificiale progettato per la protezione contro l'esplosione dovrebbe possedere i seguenti requisiti:

- la sua efficacia (flusso d'aria) dovrebbe essere controllata e sorvegliata;
- dovrebbe essere presa in considerazione la classificazione immediatamente al di fuori del punto di scarico del sistema di estrazione;
- per la ventilazione di un luogo pericoloso, l'aria dovrebbe essere normalmente aspirata da un luogo non pericoloso;
- prima di definire le caratteristiche del sistema di ventilazione, dovrebbero essere definiti: l'ubicazione delle sorgenti di emissione, il grado e la portata delle emissioni.

Sulla qualità di un sistema di ventilazione artificiale influiscono inoltre i seguenti fattori:

- i gas e vapori infiammabili hanno, generalmente, densità diverse da quella dell'aria, quindi tenderanno ad accumularsi vicino al pavimento o al soffitto, di un luogo al chiuso, dove il movimento d'aria può essere ridotto;
- variazioni della densità del gas al variare della temperatura;
- impedimenti ed ostacoli possono causare riduzioni, e perfino annullamento del movimento dell'aria, cioè assenza di ventilazione in certe parti del luogo.

Examples of general artificial ventilation:

- a building which is provided with fans in the walls and/or in the roof to improve the general ventilation in the building;
- an open air situation provided with suitably located fans to improve the general ventilation of the area.

Examples of local artificial ventilation:

- an air/vapour extraction system applied to an item of process equipment which continuously or periodically releases flammable vapour;
- a forced or extract ventilation system applied to a small, ventilated local area where it is expected that an explosive atmosphere may otherwise occur.

Esempi di ventilazione artificiale generale:

- quella di un edificio dotato di ventilatori nelle pareti e/o nel soffitto, per migliorarne la ventilazione generale;
- quella di un luogo all'aperto con ventilatori ubicati in modo da migliorarne la ventilazione generale.

Esempi di ventilazione artificiale locale:

- quella di un sistema di estrazione aria/vapore applicato ad una parte di apparecchiatura di processo che emette vapori infiammabili continuamente o periodicamente;
- quella di un sistema di ventilazione forzata (ad immissione) o di estrazione, applicato ad un luogo di piccole dimensioni ventilato localmente, dove può generarsi un'atmosfera esplosiva.

B.3 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 recognized:

B.3.1 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.

B.3.2 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.

B.3.3 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.

B.4 Assessment of degree of ventilation and its influence on the hazardous area

The size of a cloud of flammable gas or vapour and the time for which it persists after release stops can be controlled by means of ventilation. A method for evaluating the degree of ventila-

Grado di ventilazione

L'efficacia della ventilazione nel controllare la dispersione e la persistenza dell'atmosfera esplosiva dipende dal suo grado e disponibilità e dalle caratteristiche del sistema. Per esempio, la ventilazione può non essere sufficiente per prevenire la formazione di un'atmosfera esplosiva, ma può essere sufficiente per evitarne la persistenza.

Si considerano i seguenti tre gradi di efficacia della ventilazione.

Alto (VH)

Quando la ventilazione è in grado di ridurre la concentrazione in prossimità della sorgente di emissione in modo praticamente istantaneo, limitando la concentrazione al di sotto del LEL. Ne risulta una zona di piccola estensione (perfino trascurabile).

Medio (VM)

Quando la ventilazione è in grado di influire sulla concentrazione, determinando una situazione stabile in cui la concentrazione oltre il limite della zona è inferiore al *LEL* mentre avviene l'emissione e dove l'atmosfera esplosiva non persiste eccessivamente dopo l'arresto dell'emissione.

L'estensione ed il tipo della zona sono condizionati dalle grandezze caratteristiche di progetto.

Basso (VL)

Quando la ventilazione non è in grado di controllare la concentrazione mentre avviene l'emissione e/o non può prevenire la persistenza eccessiva di un'atmosfera esplosiva dopo l'arresto dell'emissione.

Valutazione del grado di ventilazione e della sua influenza sul luogo pericoloso

La dimensione di una nube di gas o vapore infiammabile ed il suo tempo di persistenza dopo l'arresto dell'emissione possono essere controllati per mezzo della ventilazione. Di seguito viene de-

tion required to control the extent and persistence of an explosive atmosphere is described below.

It should be appreciated that the method is subject to the limitations described and therefore gives only approximate results. The use of the safety factors should, however, ensure that the results obtained err on the side of safety. The application of the method is illustrated by a number of hypothetical examples.

The assessment of the degree of ventilation first requires the knowledge of the maximum release rate of gas or vapour at the source of release, either by verified experience, reasonable calculation or sound assumptions.

Estimation of hypothetical volume V_z

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:

scritto un metodo per valutare il grado di ventilazione richiesto per controllare l'estensione e la persistenza di un'atmosfera esplosiva.

È doveroso evidenziare che il metodo è soggetto alle limitazioni descritte e perciò fornisce solamente dei risultati approssimati. Tuttavia, l'uso di fattori di sicurezza, dovrebbe assicurare che i risultati ottenuti siano cautelativi dalla parte della sicurezza. L'applicazione del metodo è illustrata da alcuni esempi ipotetici.

La valutazione del grado di ventilazione richiede innanzi tutto la conoscenza della massima portata di emissione di gas o vapore dalla sorgente di emissione, ricavata da una esperienza accertata, o calcoli idonei, o ipotesi fondate.

Valutazione del volume ipotetico V_z

La portata minima teorica di ventilazione per diluire una certa emissione di sostanza infiammabile alla concentrazione richiesta al di sotto del LEL, può essere calcolata con la formula:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} \qquad (B.1)$$

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 (continuous and primary grades of release); and k = 0,5 (secondary grades of release).
T	is the ambient temperature (in kelvins).

dove:

$(dV/dt)_{min}$	è la portata minima volumetrica di aria fresca (m^3/s);
$(dG/dt)_{max}$	è la portata massima di emissione di sostanza infiammabile (kg/s);
LEL	è il limite inferiore di esplodibilità (kg/m^3);
k	è un fattore di sicurezza applicato al LEL; tipicamente: k = 0,25 (per emissioni di grado continuo e primo), k = 0,5 (per emissioni di secondo grado).
T	è la temperatura ambiente in gradi kelvin (K).

Note/Nota *For converting LEL (vol %) to LEL (kg/m^3) the following formula may be used for normal atmospheric conditions as given in 1.1:*

Per convertire il LEL (vol %) in LEL (kg/m^3) si può usare la seguente formula valida per condizioni atmosferiche normali indicate in 1.1:

$$LEL\ (kg/m^3) = 0,416 \cdot 10^{-3} \cdot M \cdot LEL\ (\text{vol } \%)$$

where M is the molecular mass (kg/kmol).

dove M è la massa molecolare (kg/kmol).

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

Con un dato numero di ricambi d'aria per unità di tempo, C, riferito alla ventilazione generale del luogo, si può stimare un volume ipotetico V_z di atmosfera potenzialmente esplosiva, intorno alla sorgente di emissione, usando la seguente formula:

$$V_z = \frac{(dV/dt)_{min}}{C} \qquad (B.2)$$

where:

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

dove:

C	è il numero di ricambi d'aria fresca per unità di tempo (s^{-1}).

Formula (B.2) would hold for an instantaneous and homogeneous mixing at the source of release given ideal flow conditions of the fresh air. In practice, such ideal situations will generally not be found, for example because of possible impediments to the air flow, resulting in badly ventilated parts of the area. Thus, the effective air exchange at the source of release will be lower than that given by C in formula (B.4), leading to an increased volume V_z.

By introducing an additional correction (quality) factor, f to formula (B.2), one obtains:

La formula (B.2) presume una miscelazione istantanea ed omogenea in prossimità della sorgente di emissione, in condizioni ideali di flusso d'aria fresca. In pratica, tali condizioni ideali generalmente non si verificano, per esempio a causa di possibili impedimenti al flusso dell'aria, col risultato che alcune parti del luogo sono mal ventilate. Pertanto, l'effettivo ricambio d'aria in prossimità della sorgente di emissione risulta inferiore a quello indicato da C nella formula (B.4), portando ad un incremento del volume V_z.

Introducendo un fattore di correzione (fattore di qualità f) alla formula (B.2), si ottiene:

(B.3)
$$V_z = \frac{f \cdot (dV/dt)_{min}}{C}$$

where:

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 V_z represents the volume over which the mean concentration of flammable gas or vapour will be either 0,25 or 0,5 times the *LEL*, depending on the value of the safety factor, k used in formula (B.1). This means that, at the extremities of the hypothetical volume estimated, the concentration of gas or vapour will be significantly below the *LEL*, i.e. the hypothetical volume where the concentration is above the *LEL* would be less than V_z.

dove:

f esprime l'efficacia della ventilazione in termini di effettiva diluizione dell'atmosfera esplosiva, con f che varia, da f = 1 (situazione ideale) ad f = 5 (caso di flusso d'aria impedito da ostacoli).

Il volume V_z rappresenta il volume al di là del quale la concentrazione media del gas o vapore infiammabile è 0,25 o 0,5 volte il *LEL*, secondo il valore del fattore di sicurezza k, utilizzato nella formula (B.1). Ciò significa che, al limite dell'ipotetico volume stimato, la concentrazione di gas o vapore è significativamente inferiore al *LEL*, vale a dire che il volume ipotetico nel quale la concentrazione è superiore al *LEL* è più piccolo di V_z.

Enclosed area

For an enclosed area, C is given by:

Luogo al chiuso

Per un luogo al chiuso, C è dato da:

(B.4)
$$C = \frac{dV_{tot}/dt}{V_o}$$

where:

dV_{tot}/dt is the flow rate of fresh air, and

V_o is the total volume being ventilated.

dove:

dV_{tot}/dt è la portata totale di aria fresca,

V_o è il volume totale da ventilare.

Open air

In an open air situation even very low wind speeds will create a high number of air changes. For example, consider a hypothetical cube with the dimensions of a few metres in an open area. In this case a wind speed of approximately 0,5 m/s will provide an air exchange rate of more than 100/h (0,03/s).

Luogo all'aperto

In un luogo all'aperto, velocità del vento anche molto basse determinano un numero elevato di ricambi d'aria. Si consideri, per esempio, un ipotetico cubo all'aperto avente dimensioni di pochi metri. In questo caso, una velocità del vento di 0,5 m/s garantisce una portata d'aria di ricambio maggiore di 100/h (0,03/s).

In a conservative approximation using C = 0,03/s for an open air situation, a hypothetical volume V_z of potentially explosive atmosphere can be obtained by using formula (B.5):

Con prudente approssimazione, usando C = 0,03/s per un luogo all'aperto, dalla formula (B.5), si può ottenere un ipotetico volume di atmosfera potenzialmente esplosiva V_z:

(B.5)
$$V_z = \frac{(dV/dt)_{min}}{0,03}$$

where:

dV/dt is in volume units per second, and

0,03 is the number of air changes per second.

However, because of the different dispersion mechanism, this method will generally result in an overlarge volume. Dispersion is normally more rapid in an open air situation.

dove:

dV/dt è in unità di volume al secondo,

0,03 è il numero di ricambi d'aria al secondo.

Tuttavia, a causa del diverso meccanismo di dispersione, questo metodo da, generalmente, un volume sovrastimato. La dispersione è normalmente più rapida in un luogo all'aperto.

Estimation of persistence time t

The time (t) required for the average concentration to fall from an initial value X_o to the *LEL* times k after the release has stopped can be estimated from:

Valutazione del tempo di persistenza t

Il tempo t richiesto per far scendere la concentrazione media da un valore iniziale X_o a k volte il *LEL*, dopo l'arresto dell'emissione, può essere stimato con la formula:

(B.6)
$$t = \frac{-f}{C} \ln \frac{LEL \cdot k}{X_o}$$

where:

X_o is the initial concentration of the flammable substance measured in the same units as the *LEL*, i.e. % vol or kg/m³. Somewhere in the explosive atmosphere, the concentration of the flammable matter may be 100% vol (in general only in the very close vicinity of the release source). However, when calculating t, the proper value for X_o to be taken depends on the particular case, considering among others the affected volume as well as the frequency and the duration of the release, and for most practical cases it seems reasonable to take a concentration above *LEL* for X_o;

C is the number of air changes per unit time;

t is in the same time units as C, i.e. if C is the number of air changes per second, then the time t will be in seconds;

f is a factor to allow for imperfect mixing (see formula (B.3)). It varies from 5, for example for ventilation with air entering through cracks and a single exhaust opening, to about 1, for example for ventilation with air entering through a perforated ceiling and multiple exhausts;

ln is the natural logarithm, i.e. 2,303 $\log_{10}$;

k is a safety factor related to the *LEL*, see formula (B.1).

The numerical value of t obtained by equation (B.6) by itself does not constitute a quantitative

dove:

X_o è la concentrazione iniziale della sostanza infiammabile espressa nella stessa unità di misura del *LEL*, cioè in vol % o kg/m³. Talora nell'atmosfera esplosiva, la concentrazione di sostanza infiammabile può essere 100% in volume (generalmente solo nella immediata vicinanza della sorgente di emissione). Tuttavia, quando si calcola t, il valore idoneo da assumere per X_o dipende dalle singole situazioni considerando, tra l'altro, il volume interessato, la frequenza e la durata dell'emissione, per cui per la maggior parte dei casi pratici sembra ragionevole assumere per X_o una concentrazione superiore al *LEL*.

C è il numero di ricambi d'aria nell'unità di tempo;

t è nelle stesse unità di misura di C, cioè se C è il numero di ricambi d'aria al secondo, il tempo t è in secondi;

f è un fattore che tiene conto dell'imperfetta miscelazione (vedi formula (B.3)). Tale fattore può variare ad esempio: da 5 per una ventilazione con l'aria che entra attraverso fessure e una sola apertura di scarico, a circa 1, per una ventilazione con l'aria che entra da un soffitto perforato e scarichi multipli;

ln è il logaritmo naturale, cioè 2,303 · $\log_{10}$;

k è un fattore di sicurezza riferito al *LEL*, vedi formula (B.1).

Il valore numerico di t che risulta dalla formula (B.6), non costituisce di per sé un metodo quanti-

means of deciding on the zone type. It provides additional information that has to be compared with the time scale of the particular process and situation.

Estimation of degree of ventilation

A continuous grade of release normally leads to a zone 0, a primary grade to zone 1 and a secondary grade to zone 2. This may not always be true because of the effect of ventilation.

In some cases, the degree and level of availability of ventilation may be so high that in practice there is no hazardous area. Alternatively, the degree of ventilation may be so low that the resulting zone has a lower zone number (i.e. a zone 1 hazardous area from a secondary grade source). This occurs for example when the level of ventilation is such that the explosive atmosphere persists and is dispersed only slowly after the gas of vapour release has stopped. Thus the explosive atmosphere persists for longer than would be expected for the grade of release.

The volume V_z can be used to provide a means of rating the ventilation as high, medium or low. The persistence time t can be used to decide what degree of ventilation is required for one area to comply with the definitions of zones 0, 1 or 2.

The ventilation may be regarded as high (VH) when the volume V_z is very small or even negligible. With the ventilation in operation, the source of release can be regarded as not producing an explosive atmosphere, i.e. the surrounding area is non-hazardous. However, there will be an explosive atmosphere, albeit of negligible extent, close to the source of release.

In practice, high ventilation can generally be applied only to a local artificial ventilation system around a source, to small enclosed areas or to very low release rates. Firstly, most enclosed areas contain multiple sources of release. It is not good practice to have multiple small hazardous areas within an area generally classified as non-hazardous. Secondly, with the typical release rates considered for area classification, natural ventilation is often insufficient even in the open. Furthermore, it is normally impracticable to ventilate artificially larger enclosed areas at the rates required.

The volume V_z does not give any indication of the time for which the explosive atmosphere would persist after release has stopped. This is not relevant in the high ventilation (VH) case but is a factor in assessing if the ventilation is medium (VM) or low (VL).

tativo per definire il tipo della zona. Esso fornisce un'informazione addizionale che deve essere comparata con la scala dei tempi del processo e della situazione specifica.

Valutazione del grado di ventilazione

Una emissione di grado continuo determina generalmente una zona 0, una di primo grado una zona 1 ed una di secondo grado una zona 2. Ciò può non sempre essere vero a causa degli effetti della ventilazione.

In alcuni casi, il grado e la disponibilità della ventilazione possono essere così alti che in pratica il luogo pericoloso non esiste. Al contrario, il grado di ventilazione può essere così basso da far risultare una zona con un numero più basso di zona (ad esempio, una zona 1 generata da una emissione di secondo grado). Questo accade ad esempio, quando la ventilazione è tale che l'atmosfera persiste e, dopo l'arresto dell'emissione del gas o vapore, si disperde lentamente. Cosicché l'atmosfera esplosiva permane più a lungo di quanto ci si sarebbe atteso in relazione al grado di emissione.

Il volume V_z può essere usato come mezzo per valutare il grado di ventilazione come alto, medio o basso. Il tempo di persistenza t può essere utilizzato per determinare il grado di ventilazione necessario perché un luogo soddisfi alle definizioni di zona 0, 1 o 2.

Il grado della ventilazione può essere considerato alto (VH) quando il volume V_z è molto piccolo o trascurabile. Con la ventilazione in funzione, si può considerare che la sorgente di emissione non generi un'atmosfera esplosiva, cioè il luogo ad essa circostante non è pericoloso. Esiste tuttavia, un'atmosfera esplosiva, per quanto di estensione trascurabile, adiacente alla sorgente di emissione.

In pratica, il grado di ventilazione alto può generalmente essere ottenuto solamente con un sistema di ventilazione artificiale locale il cui flusso d'aria investe la sorgente di emissione, o in piccoli luoghi al chiuso, oppure con portate di emissione molto basse. Innanzi tutto, la maggior parte dei luoghi al chiuso contiene più sorgenti di emissione e non è buona norma avere tante piccole zone pericolose all'interno di un luogo classificato non pericoloso. In secondo luogo, con le tipiche portate di emissione considerate nella classificazione, per ottenere il grado di ventilazione alto anche la ventilazione naturale è sovente insufficiente. Inoltre, normalmente non è possibile ventilare artificialmente i luoghi al chiuso di notevoli estensioni con le portate di aria che sarebbero richieste per il grado di ventilazione alto.

Il volume V_z non dà alcuna indicazione sul tempo di persistenza della atmosfera pericolosa dopo l'arresto dell'emissione. Questo non è rilevante con grado di ventilazione alto (VH), ma è un fattore di valutazione se il grado è medio (VM) o basso (VL).

Ventilation regarded as medium (VM) should control the dispersion of the release of flammable vapour or gas. The time taken to disperse an explosive atmosphere after release has stopped should be such that the condition for either a zone 1 or zone 2 is met, depending on whether the grade of release is primary or secondary. The acceptable dispersion time depends on the expected frequency of release and the duration of each release. The volume V_z will often be less than the volume of any enclosed area. In this case it may be acceptable to classify only part of the enclosed area as hazardous. In some cases, depending on the size of the enclosed area, the volume V_z can be similar to the enclosed volume. In this case, all of the enclosed area should be classified as hazardous.

If the zonal concept is not met, then the ventilation should be regarded as low (VL). With low ventilation the volume V_z will often be similar to or greater than the volume of any enclosed area. Low ventilation (VL) should not generally occur in open air situations except where there are restrictions to air flow, for example, in pits.

Il grado di ventilazione medio (VM) dovrebbe controllare la dispersione dell'emissione del gas o vapore infiammabile. Il tempo impiegato per disperdere un'atmosfera esplosiva dopo l'arresto dell'emissione dovrebbe essere tale da rispettare le condizioni sia di zona 1 sia di zona 2, a seconda che l'emissione sia di primo o secondo grado. Il tempo di dispersione accettabile dipende dalla frequenza e durata previste per ogni emissione. Il volume V_z risulta spesso più piccolo del volume del luogo al chiuso. In questo caso può essere ammesso classificare come pericolosa solamente una parte di detto luogo. In alcuni casi il volume V_z può risultare simile al volume del luogo al chiuso. In tal caso, tutto detto luogo dovrebbe essere classificato come pericoloso.

Quando non sono rispettati gli abbinamenti tra grado di emissione e tipo di zona secondo i quali una emissione di grado continuo determina una zona 0, una di primo grado una zona 1 ed una di secondo grado una zona 2, il grado della ventilazione deve essere considerato basso (VL). Con il grado basso, il volume V_z spesso risulta simile o più grande del volume dei luoghi al chiuso. Il grado basso (VL) non dovrebbe generalmente riscontrarsi in situazioni all'aperto, eccetto dove ci siano restrizioni al flusso dell'aria, ad esempio nelle fosse.

B.5 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 (see examples in Annex C):

- 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.

Natural ventilation

For outdoor areas the evaluation of ventilation should normally be based on an assumed minimum wind speed of 0,5 m/s, which will be present virtually continuously. In which case

Disponibilità della ventilazione

La disponibilità della ventilazione ha influenza sulla presenza o formazione di un'atmosfera esplosiva. Pertanto, la disponibilità (come pure il grado) della ventilazione deve essere presa in considerazione quando si determina il tipo della zona.

Si considerano i seguenti tre livelli di disponibilità della ventilazione (vedi esempi nell'allegato C):

- buona: quando la ventilazione è presente in pratica con continuità;
- adeguata: quando la ventilazione è considerata presente durante il funzionamento normale. Sono ammesse delle interruzioni purché siano poco frequenti e per brevi periodi.
- scarsa: quando la ventilazione non risponde ai requisiti di adeguata o buona, tuttavia non sono previste interruzioni per lunghi periodi.

Una ventilazione che non risponde neanche ai requisiti previsti dalla scarsa disponibilità non deve essere considerata come contributo alla ventilazione del luogo.

Ventilazione naturale

Per i luoghi all'aperto la valutazione dell'estensione, dovrebbe normalmente basarsi su una velocità del vento minima stimata di 0,5 m/s, che di fatto è presente continuamente. In questo caso la

the availability of the ventilation can be considered as "good".

Artificial ventilation

In assessing the availability of artificial ventilation, the reliability of the equipment and the availability of, for example, standby blowers should be considered. Good availability will normally require, on failure, automatic start-up of standby blower(s). However, if provision is made for preventing the release of flammable material when the ventilation has failed (for example by automatically closing down the process), the classification determined with the ventilation operating need not be modified, i.e. the availability may be assumed to be good.

disponibilità della ventilazione può essere considerata come "buona".

Ventilazione artificiale

Nel valutare la disponibilità della ventilazione artificiale, dovrebbe essere considerata l'affidabilità delle apparecchiature e, per esempio, la disponibilità di ventilatori di riserva. La disponibilità buona richiede normalmente, in caso di guasto, la partenza automatica dei ventilatori di riserva. Tuttavia se vengono presi dei provvedimenti per prevenire l'emissione della sostanza infiammabile quando viene meno la ventilazione (per esempio mediante arresto automatico del processo), non è necessario modificare la classificazione determinata con la ventilazione in funzione, cioè la disponibilità può essere assunta come buona.

B.6 Practical guide

The effect of ventilation on the type of the zones can be summarized in table B.1. Some calculations are included in B.7.

Guida pratica

L'effetto della ventilazione sui tipi di zone è riassunto nella Tab. B.1. Alcuni calcoli sono riportati nell'articolo B.7.

Tab. B.1 **Influence of ventilation on type of zone** — **Influenza della ventilazione sui tipi di zone**

Grado della emissione *Grade of release*	Ventilazione *Ventilation*						
	Grado *Degree*						
	Alto *High*			Medio *Medium*			Basso *Low*
	Disponibilità *Availability*						
	Buona *Good*	Adeguata *Fair*	Scarsa *Poor*	Buona *Good*	Adeguata *Fair*	Scarsa *Poor*	Scarsa *Good* Buona, *Good* Adeguata *Fair* o Scarsa *or poor*
Continuo *Continuos*	(Zona 0 NE) *(Zone 0 NE)* Zona non pericolosa[1] *Non-hazardous*[1]	(Zona 0 NE) *(Zone 0 NE)* Zona 2 [1] *Zone 2* [1]	(Zona 0 NE) *(Zone 0 NE)* Zona 1[1] *Zone 1* [1]	Zona 0 *Zone 0*	Zona 0 + Zona 2 *Zone 0 + Zone 2*	Zona 0 + Zona 1 *Zone 0 + Zone 1*	Zona 0 *Zone 0*
Primo *Primary*	(Zona 1 NE) *(Zone 1 NE)* Zona non pericolosa[1] *Non-hazardous*[1]	(Zona 1 NE) *(Zone1 NE)* Zona 2[1] *Zone 2* [1]	(Zona 1 NE) *(Zone1 NE)* Zona 2[1] *Zone 2* [1]	Zona 1 *Zone1*	Zona 1 + Zona 2 *Zone 1 + Zone 2*	Zona 1 + Zona 2 *Zone 1 + Zone 2*	Zona 1 o Zona 0[3] *Zone 1 or Zone 0* [3]
Secondo[2] *Secondary*[2]	(Zona 2 NE) *(Zone 2 NE)* Zona non pericolosa[1] *Non-hazardous*[1]	Zona 2 NE *Zone 2 NE* Zona non pericolosa[1] *Non-hazardous*[1]	Zona 2 *Zone 2*	Zona 2 *Zone 2*	Zona 2 *Zone 2*	Zona 2 *Zone 2*	Zona 1 o anche Zona 0[3] *Zone 1 and even Zone 0* [3]

(1) Zona 0 NE, 1 NE o 2 NE indicano una zona teorica dove, in condizioni normali, l'estensione è trascurabile.
Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone which would be of negligible extent under normal conditions.

(2) La zona 2 creata da una emissione di secondo grado può superare quella imputabile ad una emissione di primo grado o di grado continuo; in tal caso, si dovrebbe considerare la distanza maggiore.
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) È zona 0 se la ventilazione è così debole e l'emissione è tale che un'atmosfera esplosiva esiste praticamente in continuazione (cioè si è vicini ad una situazione di assenza di ventilazione).
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).

Nota_e "+" significa "circondata da".
"+" signifies "surrounded by".

B.7 Calculations to ascertain the degree of ventilation

Calculation No. 1

Characteristics of release	
Flammable material	toluene vapour
Source of release	flange
Lower explosion limit (*LEL*)	0,046 kg/m³ (1,2% vol.)
Grade of release	continuous
Safety factor, k	0,25
Release rate, $(dG/dt)_{max}$	$2,8 \cdot 10^{-10}$ kg/s

Ventilation characteristics	
Indoor situation	
Number of air changes, *C*	1/h, $(2,8 \cdot 10^{-4}$/s)
Quality factor, f	5
Ambient temperature, *T*	20°C (293 K)
Temperature coefficient, (*T*/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{2,8 \cdot 10^{-10}}{0,25 \cdot 0,046} \cdot \frac{293}{293} = 2,4 \cdot 10^{-8} m^3/s$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{5 \cdot 2,4 \cdot 10^{-8}}{2,8 \cdot 10^{-4}} = 4,3 \cdot 10^{-4} m^3$$

Time of persistence:

This is not applicable to a continuous release.

Conclusion

The hypothetical volume V_z is reduced to a negligible value.

The degree of ventilation is considered as high with regard to the source.

Calcoli per la determinazione del grado di ventilazione

Calcolo n° 1

Caratteristiche dell'emissione	
Sostanza infiammabile	vapori di toluene
Sorgente di emissione	flangia (non guasta)
Limite inferiore di esplodibilità (*LEL*)	0,046 kg/m³ (1,2% vol.)
Grado di emissione	continuo
Fattore di sicurezza, k	0,25
Portata di emissione, $(dG/dt)_{max}$	$2,8 \cdot 10^{-10}$ kg/s

Caratteristiche della ventilazione	
Luogo al chiuso	
Numero di ricambi d'aria, *C*	1/h, $(2,8 \cdot 10^{-4}$/s)
Fattore di efficacia, f	5
Temperatura ambiente, *T*	20 °C (293 K)
Coefficiente di temperatura, (*T*/293 K)	1

Portata volumetrica minima di aria fresca:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{2,8 \cdot 10^{-10}}{0,25 \cdot 0,046} \cdot \frac{293}{293} = 2,4 \cdot 10^{-8} m^3/s$$

Valutazione del volume ipotetico V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{5 \cdot 2,4 \cdot 10^{-8}}{2,8 \cdot 10^{-4}} = 4,3 \cdot 10^{-4} m^3$$

Tempo di persistenza:

Non applicabile ad una emissione di grado continuo.

Conclusione

Il volume ipotetico V_z è ridotto ad un valore trascurabile.

Il grado di ventilazione, in relazione all'emissione, è considerato alto.

Calculation No. 2

Characteristics of release

Flammable material	toluene vapour
Source of release	failure of flange
Lower explosion limit (*LEL*)	0,046 kg/m³ (1,2% vol.)
Grade of release	secondary
Safety factor, k	0,5
Release rate, $(dG/dt)_{max}$	$2,8 \cdot 10^{-6}$ kg/s

Ventilation characteristics

Indoor situation	
Number of air changes, *C*	1/h ($2,8 \cdot 10^{-4}$/s)
Quality factor, f	5
Ambient temperature, *T*	20°C (293 K)
Temperature coefficient, (*T*/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{2,8 \cdot 10^{-6}}{0,5 \cdot 0,046} \cdot \frac{293}{293} = 1,2 \cdot 10^{-4} m^3/s$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{5 \cdot 1,2 \cdot 10^{-4}}{2,8 \cdot 10^{-4}} = 2,2\ m^3$$

Time of persistence:

$$t = \frac{-f}{C} \ln \frac{LEL \cdot k}{X_0} = \frac{-5}{1} \ln \frac{1,2 \cdot 0,5}{100} = 25,6\ h$$

Conclusion

The hypothetical volume V_z is significant but can be controlled.

The degree of ventilation is considered as medium with regard to the source on this basis. However any release would persist and the concept of zone 2 may not be met.

Calcolo n° 2

Caratteristiche dell'emissione

Sostanza infiammabile	vapori di toluene
Sorgente di emissione	guasto di una flangia
Limite inferiore di esplodibilità (*LEL*)	0,046 kg/m³ (1,2% vol.)
Grado di emissione	secondo
Fattore di sicurezza, k	0,5
Portata di emissione, $(dG/dt)_{max}$	$2,8 \cdot 10^{-6}$ kg/s

Caratteristiche della ventilazione

Luogo al chiuso	
Numero di ricambi d'aria, *C*	1/h, ($2,8 \cdot 10^{-4}$ /s)
Fattore di efficacia, f	5
Temperatura ambiente, *T*	20 °C (293 K)
Coefficiente di temperatura, (*T*/293 K)	1

Portata volumetrica minima d'aria fresca:

Valutazione del volume ipotetico V_z:

Tempo di persistenza:

Conclusione

Il volume ipotetico V_z è significativo ma può essere controllato.

Il grado di ventilazione, in relazione all'emissione, è considerato medio; tuttavia, si avrebbe la persistenza di atmosfera esplosiva a seguito di una qualsiasi emissione, per cui potrebbe non essere rispettata la definizione di zona 2.

Calculation No. 3

Characteristics of release	
Flammable material	propane gas
Source of release	can-filling nozzle
Lower explosion limit(*LEL*)	0,039 kg/m^3 (2,1% vol.)
Grade of release	primary
Safety factor, k	0,25
Release rate, $(dG/dt)_{max}$	0,005 kg/s

Ventilation characteristics	
Indoor situation	
Number of air changes, *C*	20/h (5,6 · 10^{-3} /s)
Quality factor, f	1
Ambient temperature, *T*	35°C (308 K)
Temperature coefficient, (*T*/293 K)	1,05

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{0,005}{0,25 \cdot 0,039} \cdot \frac{308}{293} = 0,6 \text{ m}^3/\text{s}$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{1 \cdot 0,6}{5,6 \cdot 10^{-3}} = 1,1 \cdot 10^2 \text{ m}^3$$

Time of persistence:

$$t = \frac{-f}{C} \ln \frac{LEL \cdot k}{X_0} = \frac{-1}{20} \ln \frac{2,1 \cdot 0,25}{100} = 0,26 \text{ h}$$

Conclusion

The hypothetical volume V_z is significant but can be controlled.

The degree of ventilation is considered as medium with regard to the source based on this criterion. With a persistence time of 0,26 h, the concept of zone 1 may not be met if the operation is repeated frequently.

Calcolo n° 3

Caratteristiche dell'emissione	
Sostanza infiammabile	gas propano
Sorgente di emissione bombole	ugello di riempimento
Limite inferiore di esplodibilità (*LEL*	0,039 kg/m^3 (2,1% vol.)
Grado di emissione	primo
Fattore di sicurezza, k	0,25
Portata di emissione, $(dG/dt)_{max}$	0,005 kg/s

Caratteristiche della ventilazione	
Luogo al chiuso	
Numero di ricambi d'aria, *C*	20/h (5,6 · 10^{-3}/s)
Fattore di efficacia, f	1
Temperatura ambiente, *T*	35 °C (308 K)
Coefficiente di temperatura, (*T*/293 K)	1,05

Portata volumetrica minima d'aria fresca:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{0,005}{0,25 \cdot 0,039} \cdot \frac{308}{293} = 0,6 \text{ m}^3/\text{s}$$

Valutazione del volume ipotetico V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{1 \cdot 0,6}{5,6 \cdot 10^{-3}} = 1,1 \cdot 10^2 \text{ m}^3$$

Tempo di persistenza:

$$t = \frac{-f}{C} \ln \frac{LEL \cdot k}{X_0} = \frac{-1}{20} \ln \frac{2,1 \cdot 0,25}{100} = 0,26 \text{ h}$$

Conclusione

Il volume ipotetico V_z è significativo ma può essere controllato.

Il grado di ventilazione, in relazione all'emissione, è considerato medio. Con un tempo di persistenza di 0,26 h, potrebbe non essere rispettata la definizione di zona 1 nel caso di operazione ripetuta frequentemente.

Calculation No. 4

Characteristics of release	
Flammable material	ammonia gas
Source of release	evaporator valve
Lower explosion limit(*LEL*)	0,105 kg/m³ (14,8% vol.)
Grade of release	secondary
Safety factor, k	0,5
Release rate, $(dG/dt)_{max}$	$5 \cdot 10^{-6}$ kg/s

Ventilation characteristics	
Indoor situation	
Number of air changes, *C*	15/h, $(4{,}2 \cdot 10^{-3}$/s)
Quality factor, f	1
Ambient temperature, *T*	20°C (293 K)
Temperature coefficient, (*T*/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{5 \cdot 10^{-6}}{0,5 \cdot 0,105} \cdot \frac{293}{293} = 9,5 \cdot 10^{-5} \text{ m}^3/\text{s}$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{1 \cdot 9,5 \cdot 10^{-5}}{4,2 \cdot 10^{-3}} = 0,02 \text{ m}^3$$

Time of persistence:

$$t = \frac{-f}{C} \ln \frac{LEL \cdot k}{X_0} = \frac{-1}{15} \ln \frac{14,8 \cdot 0,5}{100} = 0,17 \text{ h (10 min)}$$

Conclusion

The hypothetical volume V_z is reduced to a negligible value.

The degree of ventilation is considered as high with regard to the source. However any equipment located adjacent to the valve should be suitable for zone 2 (see table B. 1)

Calcolo n° 4

Caratteristiche dell'emissione	
Sostanza infiammabile	ammoniaca gassosa
Sorgente di emissione	valvola dell'evaporatore
Limite inferiore di esplodibilità (*LEL*)	0,105 kg/m³ (14,8% vol.)
Grado di emissione	secondo
Fattore di sicurezza, k	0,5
Portata di emissione, $(dG/dt)_{max}$	$5 \cdot 10^{-6}$ kg/s

Caratteristiche della ventilazione	
Luogo al chiuso	
Numero di ricambi d'aria, *C*	15/h $(4{,}2 \cdot 10^{-3}$/s)
Fattore efficacia, f	1
Temperatura ambiente, *T*	20 °C (293 K)
Coefficiente di temperatura, (*T*/293 K)	1

Portata volumetrica minima d'aria fresca:

Valutazione del volume ipotetico V_z:

Tempo di persistenza:

Conclusione

Il volume ipotetico V_z è ridotto ad un valore trascurabile.

Il grado di ventilazione, in relazione all'emissione, è considerato alto. Tuttavia, le apparecchiature installate adiacenti alla valvola dovrebbero essere adatte per la zona 2 (vedi Tab. B.1).

Calculation No. 5

Characteristics of release

Flammable material	propane gas
Source of release	compressor seal
Lower explosion limit (*LEL*)	0,039 kg/m³ (2,1% vol.)
Grade of release	secondary
Safety factor, k	0,5
Release rate, $(dG/dt)_{max}$	0,02 kg/s

Ventilation characteristics

Indoor situation	
Number of air changes, *C*	2/h, $(5,6 \cdot 10^{-4}/s)$
Quality factor, f	5
Ambient temperature, *T*	20°C (293 K)
Temperature coefficient, (*T*/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{0,02}{0,5 \cdot 0,039} \cdot \frac{293}{293} = 1,02\ m^3/s$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{5 \cdot 1,02}{5,6 \cdot 10^{-4}} = 9200\ m^3$$

Time of persistence:

$$t = \frac{-f}{C} \ln \frac{LEL \cdot k}{X_0} = \frac{-5}{2} \ln \frac{2,1 \cdot 0,5}{100} = 11,4\ h$$

Conclusion

In a room of 10 m · 15 m · 6 m for example, the hypothetical volume V_z would extend beyond the physical boundaries and would persist.

The degree of ventilation is considered as low with regard to the source.

Calcolo n° 5

Caratteristiche dell'emissione

Sostanza infiammabile	gas propano
Sorgente di emissione	tenuta di un compressore
Limite inferiore di esplodibilità (*LEL*)	0,039 kg/m³ (2,1% vol.)
Grado di emissione	secondo
Fattore di sicurezza, k	0,5
Portata di emissione, $(dG/dt)_{max}$	0,02 kg/s

Caratteristiche della ventilazione

Luogo al chiuso	
Numero di ricambi d'aria, *C*	2/h $(5,6 \cdot 10^{-4}/s)$
Fattore di efficacia, f	5
Temperatura ambiente, *T*	20 °C (293 K)
Coefficiente di temperatura, (*T*/293 K)	1

Portata volumetrica minima d'aria fresca:

Valutazione del volume ipotetico V_z:

Tempo di persistenza:

Conclusione

In un locale di 10 m · 15 m · 6 m, ad esempio, il volume ipotetico V_z si estenderebbe oltre i confini fisici e persisterebbe.

Il grado di ventilazione, in relazione all'emissione, è considerato basso.

Calculation No. 6

Characteristics of release	
Flammable material	methane gas
Source of release	pipe fitting
Lower explosion limit (*LEL*)	0,033 kg/m³ (5% vol.)
Grade of release	secondary
Safety factor, k	0,5
Release rate, $(dG/dt)_{max}$	1 kg/s

Ventilation characteristics	
Outdoor situation	
Minimum wind speed	0,5 m/s
Resulting in an air exchange, *C*	$>3 \cdot 10^{-2}$ /s
Quality factor, f	3
Ambient temperature, *T*	15°C (288 K)
Temperature coefficient, (*T*/293 K)	0,98

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{1}{0,5 \cdot 0,033} \cdot \frac{288}{293} = 58,1 \text{ m}^3/\text{s}$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{3 \cdot 58,1}{3 \cdot 10^{-2}} = 5810 \text{ m}^3$$

Time of persistence:

$$t = \frac{-f}{C} \ln \frac{LEL \cdot k}{X_o} = \frac{-3}{0,03} \ln \frac{5 \cdot 0,5}{100} = 370 \text{ s (massimo\_}\textit{maximum}\text{)}$$

Conclusion

The hypothetical volume V_z is significant but can be controlled, and would not persist.

The degree of ventilation is considered as medium with regard to the source.

Calcolo n° 6

Caratteristiche dell'emissione	
Sostanza infiammabile	gas metano
Sorgente di emissione	raccordo di tubazione
Limite inferiore di esplodibilità (*LEL*)	0,033 kg/m³ (5% vol.)
Grado di emissione	secondo
Fattore di sicurezza, k	0,5
Portata di emissione, $(dG/dt)_{max}$	1 kg/s

Caratteristiche della ventilazione	
Luogo all'aperto	
Minima velocità del vento	0,5 m/s
Corrispondenti ad un ricambio d'aria, *C*	$3 \cdot 10^{-2}$/s
Fattore di efficacia, f	3
Temperatura ambiente, *T*	15 °C (288 K)
Coefficiente di temperatura, (*T*/293 K)	0,98

Portata volumetrica minima d'aria fresca:

Valutazione del volume ipotetico V_z:

Tempo di persistenza:

Conclusione

Il volume ipotetico V_z è significativo ma può essere controllato e non persisterebbe.

Il grado di ventilazione, in relazione all'emissione, è considerato medio(1).

(1) (Non contenuta nelle pubblicazioni IEC e CENELEC) - *I risultati dei calcoli non corrispondono a quelli errati della EN 60079-10.*

Calculation No. 7

Characteristics of release	
Flammable material	toluene vapour
Source of release	failure of flange
Lower explosion limit (*LEL*)	0,046 kg/m³ (1,2% vol.)
Grade of release	secondary
Safety factor, k	0,5
Release rate, $(dG/dt)_{max}$	$6 \cdot 10^{-4}$ kg/s

Ventilation characteristics	
Indoor situation	
Number of air changes, *C*	12/h ($3{,}33 \cdot 10^{-3}$)
Quality factor, f	2
Ambient temperature, *T*	20°C (293 K)
Temperature coefficient, (*T*/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \cdot LEL} \cdot \frac{T}{293} = \frac{6 \cdot 10^{-4}}{0,5 \cdot 0,046} \cdot \frac{293}{293} = 26 \cdot 10^{-3}\ m^3/s$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \cdot (dV/dt)_{min}}{C} = \frac{2 \cdot 26 \cdot 10^{-3}}{3,33 \cdot 10^{-3}} = 15,7\ m^3$$

Time of persistence:

$$t = \frac{-f}{C} \ln \frac{LEL \cdot k}{X_o} = \frac{-2}{12} \ln \frac{1,2 \cdot 0,5}{100} = 0,85\ h\ (51\ min)$$

Conclusion

The hypothetical volume V_z is significant but can be controlled.

The degree of ventilation is considered as medium with regard to the source. Based on this persistence time, the concept of zone 2 would be met.

Calcolo n° 7

Caratteristiche dell'emissione	
Sostanza infiammabile	vapori di toluene
Sorgente di emissione	guasto di una flangia
Limite inferiore di esplodibilità (*LEL*)	0,046 kg/m³ (1,2% vol.)
Grado di emissione	secondo
Fattore di sicurezza, k	0,5
Portata di emissione, $(dG/dt)_{max}$	$6 \cdot 10^{-4}$ kg/s

Caratteristiche della ventilazione	
Luogo al chiuso	
Numero di ricambi d'aria, *C*	12/h ($3{,}33 \cdot 10^{-3}$/s)
Fattore di efficacia, f	2
Temperatura ambiente, *T*	20 °C (293 K)
Coefficiente di temperatura, (*T*/293 K)	1

Portata volumetrica minima d'aria fresca:

Valutazione del volume ipotetico V_z:

Tempo di persistenza:

Conclusione

Il volume ipotetico V_z è significativo ma può essere controllato.

Il grado di ventilazione, in relazione all'emissione, è considerato medio. Sulla base del tempo di persistenza determinato, sarebbe rispettata la definizione di zona 2.

informative
informative

EXAMPLES OF HAZARDOUS AREA CLASSIFICATION

C.1 The practice of area classification involves a knowledge of the behaviour of flammable gases and liquids when they are released from containment, and sound engineering judgement based on experience of the performance of items of plant equipment under specified conditions. For this reason, it is not practicable to give every conceivable variation of plant and process characteristics. Therefore, the examples chosen are those which best describe the overall philosophy of area classification, so as to permit the safe use of apparatus in hazardous locations, where the dangerous material is a flammable liquid, liquefied gas or vapour, or material which is normally gaseous and flammable when mixed with air in appropriate concentrations.

C.2 In arriving at the distances shown in the diagrams, specific plant component conditions have been given. The leakage conditions have been considered in relation to the mechanical performance of the equipment and other representative design criteria. They are not generally applicable; factors such as inventory of process material, shut-off time, dispersion time, pressure, temperature and other criteria related both to plant components and process material all affect the area classification and will need to be applied to the particular problem being considered. Thus these examples represent guidance only and will need to be adapted so as to take into account particular circumstances.

C.3 According to the national or industrial code selected, the shape and extent of the zones may vary.

C.4 The intention of the examples which follow is not primarily that they should be used for area classification. Their principal objective is to demonstrate typical results which might be obtained in practice in a number of different situations by following the guidance and procedures in this Standard. They may also be of use in developing detailed supplementary standards.

C.5 The figures shown are taken from, or correspond closely to, those in various national or industrial codes. They are intended only as a guide to the magnitude of the zones; in individ-

ESEMPI DI CLASSIFICAZIONE DEI LUOGHI PERICOLOSI

La pratica della classificazione dei luoghi implica una conoscenza del comportamento dei gas e liquidi infiammabili quando vengono emessi dal loro contenitore, ed una valida valutazione tecnica basata sull'esperienza del comportamento delle singole apparecchiature dell'impianto in specifiche condizioni. Per questa ragione, non è possibile indicare tutti i casi di impianti e processi. Tuttavia, gli esempi scelti sono quelli che descrivono meglio la filosofia generale di classificazione dei luoghi, in modo da permettere l'uso sicuro delle costruzioni nei luoghi pericolosi, dove la sostanza pericolosa è un liquido infiammabile, un gas liquefatto o un vapore, oppure è una sostanza normalmente gassosa ed infiammabile miscelata con l'aria in appropriate concentrazioni.

Per i componenti dell'impianto sono state indicate le condizioni particolari che hanno condotto alle distanze indicate nelle figure. Le caratteristiche della perdita sono state considerate in relazione alla prestazione meccanica dell'apparecchiatura ed altri criteri di progetto rappresentativi. Tali caratteristiche non sono applicabili a tutti i casi; fattori come la molteplicità delle sostanze impiegate nel processo, il tempo di arresto, il tempo di dispersione, la pressione, la temperatura ed altri criteri relativi sia ai componenti dell'impianto che alle sostanze di processo, influenzano tutti la classificazione dei luoghi ed è necessario considerarli nel caso specifico in esame. Pertanto, questi esempi rappresentano solo una guida e richiedono gli adattamenti del caso per tener conto delle circostanze particolari.

La forma e l'estensione delle zone possono differire in relazione alle guide e raccomandazioni nazionali o industriali prescelte.

Gli esempi che seguono non hanno lo scopo primario di essere utilizzati per la classificazione dei luoghi pericolosi. Il loro principale obiettivo è esprimere dei risultati tipici che possono essere ottenuti in un numero di luoghi differenti, seguendo i criteri e le procedure di questa Norma. Questi esempi possono anche essere utilizzati per l'elaborazione di norme dettagliate supplementari.

Le figure sono state ricavate da diverse guide e raccomandazioni nazionali o industriali, o sono loro molto simili. Esse vanno intese solamente come una guida alla grandezza delle zone; in ciascun caso par-

ual cases, the extent and shape of the zones may be taken from the relevant code.

ticolare, l'estensione e la forma delle zone può essere ricavata dalla guida o raccomandazione specifica.

C.6 If it is intended that the examples given in this Standard be used for area classification in practice, account must be taken of the specific details of each individual case.

Se nella classificazione dei luoghi pericolosi si intende impiegare gli esempi di questa Norma, si devono considerare le particolarità di ogni singolo caso.

C.7 In each example, some but not all of the parameters which influence the type and extent of zones are given. The result of the classification normally gives a conservative result, taking into account those factors which have been specified and others which it has been possible to identify but not quantify. This means that, if it is possible to specify the operating parameters more closely, a more precise classification will be obtained.

Per ciascun esempio vengono indicate alcune grandezze, ma non tutte, che influenzano il tipo e l'estensione delle zone. Normalmente, considerando i fattori che sono stati specificati ed altri che sono stati identificati ma non quantificati, il risultato della classificazione è cautelativo. Questo significa che se è possibile specificare più dettagliatamente le grandezze operative, si otterrà una classificazione più precisa.

Example No. 1

A normal industrial pump mounted at ground level, situated outdoors, pumping flammable liquid:

CAPTION

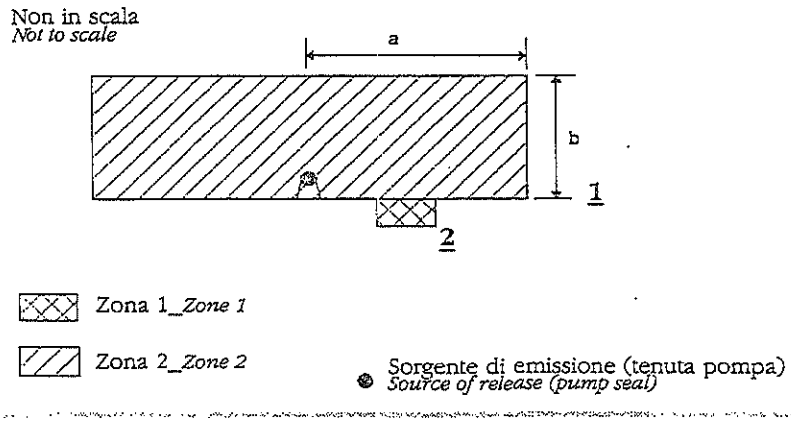
1 Ground level§
2 Sump

Esempio N° 1

Una normale pompa industriale installata a livello del suolo, situata all'aperto, che pompa liquido infiammabile:

LEGENDA

1 Livello del suolo
2 Fossa



Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo..... *Type*.....	Naturale *Natural*	Artificiale *Artificial*
Grado..... *Degree*.....	Medio *Medium*	Alto* *High*
Disponibilità..... *Availability*.....	Scarsa *Poor*	Adeguata *Fair*

Sorgente di emissione ***Source of release***	**Grado di emissione** ***Grade of release***
Tenuta della pompa..... *Pump seal*	Primo e secondo *Primary and sendary*

Sostanza
Product

Temperatura di infiammabilità.. *Flash point*.....	Inferiore alla temperatura di processo e alla temperatura ambiente *Below process and ambient temperature*
Densità dei vapori..... *Vapour density*.....	Superiore a quella dell'aria *Greater than air*

*Flusso d'aria proveniente dal motore della pompa
**Airflow from pump motor*

Taking into account relevant parameters, the following are typical values which will be obtained for a pump having a capacity of 50 m^3/h and operating at a low pressure:

a = 3 m horizontally from source of release;

b = 1 m from ground level and up to 1 m above the source of release.

Note/Nota *Due to the high air flow, the extent of zone 1 is negligible.*

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per una pompa da 50 m^3/h e funzionante a bassa pressione:

a = 3 m in orizzontale dalla sorgente di emissione;

b = 1 m dal livello del suolo e fino ad 1 m sopra la sorgente di emissione.

Grazie all'elevato flusso dell'aria, l'estensione della zona 1 intorno alla sorgente di emissione è trascurabile.

Example No. 2

A normal industrial pump mounted at ground level, situated indoors, pumping flammable liquid:

CAPTION

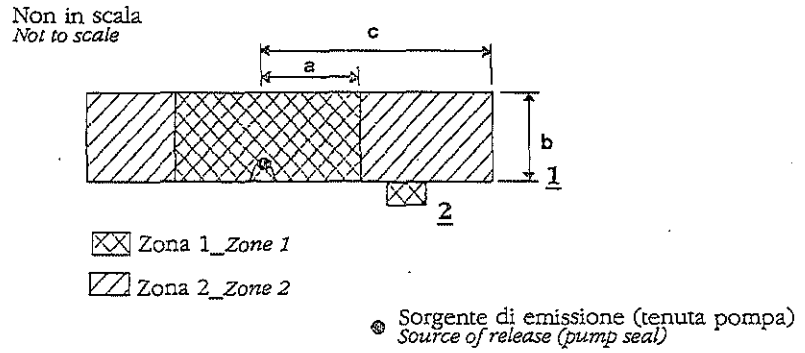
1 Ground level§
2 Sump

Esempio N° 2

Una normale pompa industriale installata a livello del suolo, situata al chiuso, che pompa liquido infiammabile:

LEGENDA

1 Livello del suolo
2 Fossa



Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo.....	Artificiale
Type.....	*Artificial*
Grado.....	Medio
Degree.....	*Medium*
Disponibilità.....	Adeguata
Availability.....	*Fair*

Sorgente di emissione ***Source of release***	**Grado di emissione** ***Grade of release***
Tenuta della pompa premistoppa e pozza al livello del suolo..... *Pump seal (packed gland) and pool at floor level*.....	Primo e secondo *Primary and sendary*

Sostanza
Product

Temperatura di infiammabilità..	Inferiore alla temperatura di processo e alla temperatura ambiente
Flash point.....	*Below process and ambient temperature*
Densità dei vapori.....	Superiore a quella dell'aria
Vapour density.....	*Greater than air*

Taking into account relevant parameters, the following are typical values which will be obtained for a pump having a capacity of 50 m^3/h and operating at a low pressure.

a = 1,5 m horizontally from source of release;

b = 1 m from ground level and up to 1 m above the source of release;

c = 3 m horizontally from source of release.

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per una pompa da 50 m^3/h e funzionante a bassa pressione:

a = 1,5 m in orizzontale dalla sorgente di emissione;

b = 1 m dal livello del suolo e fino ad 1 m sopra la sorgente di emissione;

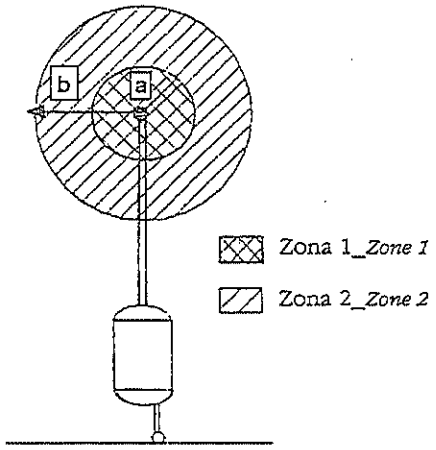
c = 3 m in orizzontale dalla sorgente di emissione.

Example No. 3

Pressure breathing valve in the open air, from process vessel:

Esempio N° 3

Valvola di sfioro in aria libera, da un serbatoio di processo:



Sorgente di emissione (sfiato della valvola da 25 mm di diametro)
Source of release (vent outlet diameter 25 mm)

Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo.....	Naturale
Type.....	*Natural*
Grado.....	Medio
Degree.....	*Medium*
Disponibilità.....	Adeguata
Availability.....	*Fair*

Sorgente di emissione	**Grado di emissione**
Source of release	***Grade of release***
Sfiato della valvola.....	Primo
Outlet from valve.....	*Primary*

Sostanza
Product

Benzina
Gasoline

Densità dei vapori.....	Superiore a quella dell'aria
Gas density.....	*Greater than air*

Taking into account relevant parameters, the following are typical values which will be obtained for a valve where the opening pressure of the valve is approximately 0,15 MPa (1,5 bar):

a = 3 m in all directions from source of release;

b = 5 m in all directions from source of release.

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per una valvola con una pressione di apertura di circa 0,15 MPa (1,5 bar):

a = 3 m in tutte le direzioni dalla sorgente di emissione;

b = 5 m in tutte le direzioni dalla sorgente di emissione.

Example No. 4

Control valve, installed in a closed process pipework system conveying flammable gas:

CAPTION

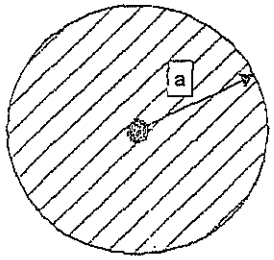
1 Ground level

Esempio N° 4

Valvola di regolazione, installata in un sistema di tubazioni a circuito chiuso che trasportano gas infiammabile

LEGENDA

1 Livello del suolo



1

Sorgente di emissione (valvola)
Source of release (valve)

Zona 2_*Zone 2*

Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo.....	Naturale
Type.....	*Natural*
Grado:.....	Medio
Degree.....	*Medium*
Disponibilità.....	Adeguata
Availability.....	*Fair*

Sorgente di emissione	**Grado di emissione**
Source of release	***Grade of release***
Guarnizione di tenuta dell'asse della pompa.....	Secondo
Valve shaft seal.....	*Secondary*

Sostanza
Product

Gas.....	Propano
Gas.....	*Propane*
Densità dei vapori.....	Superiore a quella dell'aria
Gas density.....	*Greater than air*

Taking into account relevant parameters, the following are typical values which will be obtained for this example:

a = 1 m in all directions from source of release.

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per questo esempio:

a = 1 m in tutte le direzioni dalla sorgente di emissione.

Example No. 5

A fixed process mixing vessel, situated indoors, being opened regularly for operational reasons. The liquids are piped into and out of the vessel through all welded pipework flanged at the vessel:

CAPTION

1 Drain below ground level
2 Process liquid
3 Ground leve

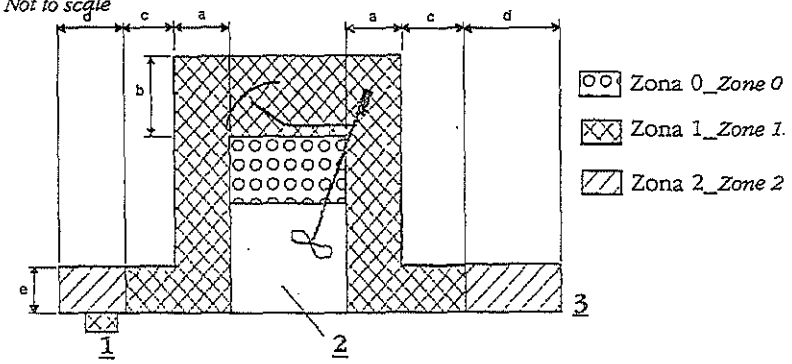
Esempio N° 5

Miscelatore industriale di tipo fisso, situato all'interno, che viene regolarmente aperto per ragioni funzionali. I liquidi vengono immessi e scaricati attraverso tubazioni completamente saldate e flangiate al miscelatore:

LEGENDA

1 Fossa al di sotto del livello del suolo
2 Liquido di processo
3 Livello del suolo

Non in scala
Not to scale



Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo..... *Type*.....	Artificiale *Artificial*
Grado..... *Degree*.....	Basso all'interno del miscelatore *Low inside the vessel* Medio all'esterno del miscelatore *Medium outside the vessel*
Disponibilità..... *Availability*.....	Adeguata *Fair*

Sorgente di emissione ***Source of release***	**Grado di emissione** ***Grade of release***
La superficie del liquido all'interno del miscelatore..... *Liquid surface within the vessel*.....	Continuo *Continuos*
L'apertura del miscelatore..... *The opening in the vessel*.....	Primo *Primary*
Spandimenti o perdite del liquido in prossimità del miscelatore..... *Spillage or leakage of liquid close to the vessel*.....	Secondo *Secondary*

Sostanza
Product

Temperatura di infiammabilità.. *Flash point*.....	Inferiore alla temperatura di processo e alla temperatura ambiente *Below process and amibient temperature*
Densità dei vapori..... *Vapour density*.....	Superiore a quella dell'aria *Greater than air*

Taking into account relevant parameters, the following are typical values which will be obtained for this example:
a = 1 m horizontally from source of release;
b = 1 m above source of release;
c = 1 m horizontally;
d = 2 m horizontally;
e = 1 m above ground.

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per questo esempio:
a = 1 m in orizzontale dalla sorgente di emissione;
b = 1 m al di sopra della sorgente di emissione;
c = 1 m in orizzontale;
d = 2 m in orizzontale;
e = 1 m sopra il suolo.

Example No. 6

Oil/water gravity separator, situated outdoors, open to the atmosphere, in a petroleum refinery:

CAPTION

1 Ground livel
2 Liquid

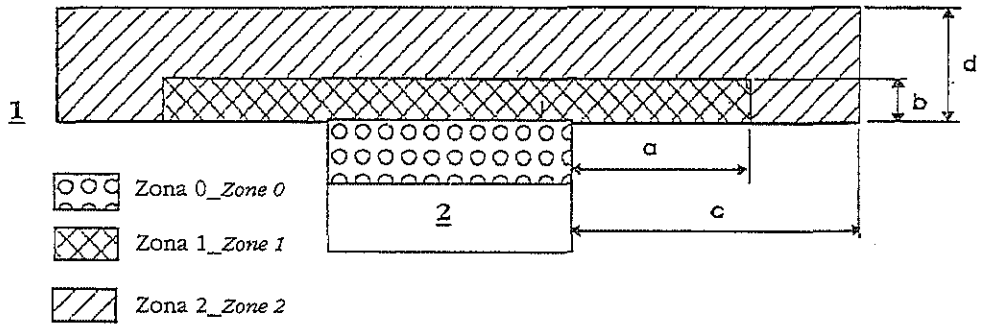
Esempio N° 8

Serbatoio di stoccaggio di liquido infiammabile, situato all'esterno, con tetto fisso e senza tetto galleggiante interno.

LEGENDA

1 Livello del suolo
2 Liquido

Non in scala
Not to scale



Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo / *Type*	Naturale / *Natural*
Grado / *Degree*	Medio / *Medium*
Disponibilità / *Availability*	Scarsa / *Poor*

Sorgente di emissione / ***Source of release***	**Grado di emissione** / ***Grade of release***
La superficie del liquido / *Liquid surface*	Continuo / *Continuos*
Irregolarità del processo / *Process disturbance*	Secondo / *Secondary*

Sostanza
Product

Temperatura di infiammabilità / *Flash point*	Inferiore alla temperatura di processo e alla temperatura ambiente / *Below process and ambient temperature*
Densità dei vapori / *Vapour density*	Superiore a quella dell'aria / *Greater than air*

Taking into account relevant parameters, the following are typical values which will be obtained for this example.

a = 3 m horizontally from the separator;

b = 1 m above ground level;

c = 7,5 m horizontally;

d = 3 m above ground level.

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per questo esempio:

a = 3 m a partire dallo sfiato;

b = 1 m al di sopra del tetto;

c = 7,5 m in orizzontale dal serbatoio;

d = 3 m al di sopra del tetto.

Example No. 7

Hydrogen compressor in a building which is open at ground level.

CAPTION

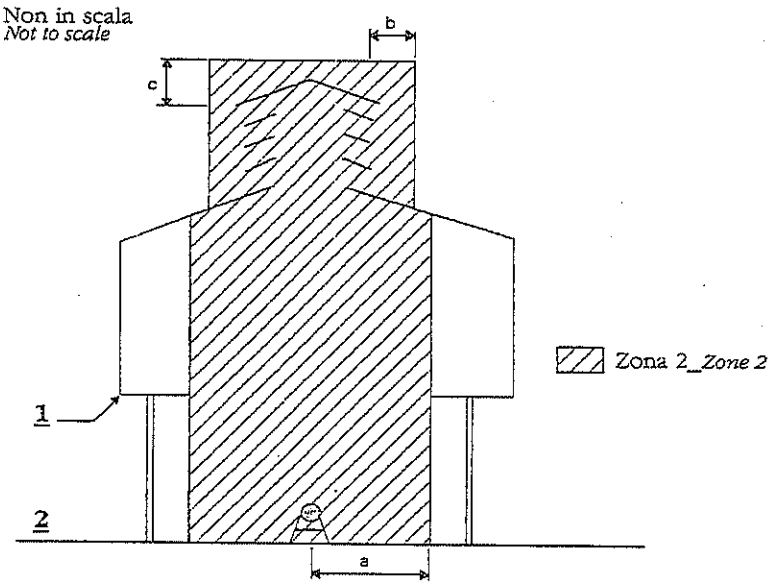
1 Bottom of enclosed
2 Compressor level

Esempio N° 7

Un compressore di idrogeno installato in un edificio aperto al livello del suolo:

LEGENDA

1 Fondo della parte chiusa
2 Livello del compressore



Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo.....	Naturale
Type.....	*Natural*
Grado.....	Medio
Degree.....	*Medium*
Disponibilità.....	Buona
Availability.....	*Good*

Sorgente di emissione ***Source of release***	**Grado di emissione** ***Grade of release***
Tenute del compressore, valvole e flange vicine al compressore..... *Compressor seals, valves and flanges close to the compressor*.....	Secondo *Secondary*

Sostanza
Product

Gas	Idrogeno
Gas	*Hydrogen*
Densità dei vapori	Inferiore a quella dell'aria
Gas density	*Lighter than air*

Taking into account relevant parameters, the following are typical values which will be obtained for this example:
a = 3 m horizontally from source of release;
b = 1 m horizontally from ventilation openings;
c = 1 m above ventilation openings.

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per questo esempio:
a = 3 m in orizzontale della sorgente di emissione;
b = 1 m orizzontalmente dalle aperture di ventilazione;
c = 1 m al di sopra delle aperture di ventilazione.

Example No. 8

Flammable liquid storage tank, situated outdoors, with fixed roof and no internal floating roof:

CAPTION

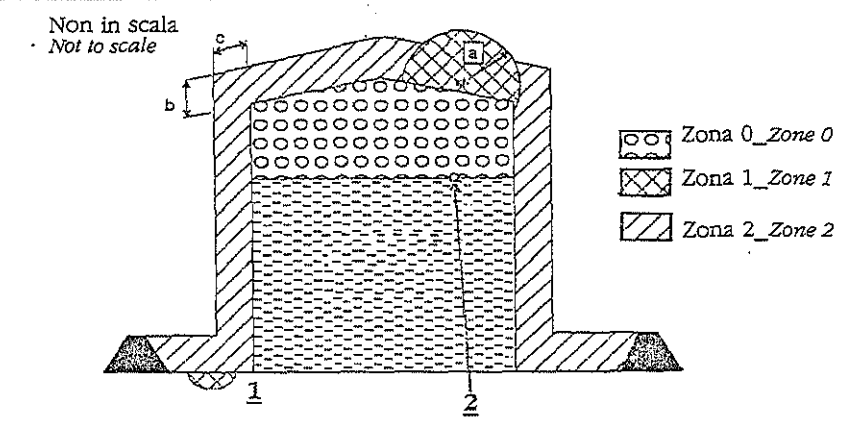
1 Sump
2 Liquid surface

Esempio N° 8

Serbatoio di stoccaggio di liquido infiammabile, situato all'esterno, con tetto fisso e senza tetto galleggiante interno:

LEGENDA

1 Fossa
2 Superficie del liquido



Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo..... *Type*.....	Naturale *Natural*
Grado..... *Degree*.....	Medio* *Medium**
Disponibilità..... *Availability*.....	Buona *Good*

Sorgente di emissione ***Source of release***	**Grado di emissione** ***Grade of release***
Superficie del liquido..... *Liquid surface*.....	Continuo *Continuos*
Sfilato ed altre aperture nel tetto..... *Vent opening and other openings in the roof*.....	Primo *Primary*
Flange, ecc. all'interno del bacino dei contenimento e tracimazioni dal serbatoio *Flanges, etc. inside bund and overfilling of the tank*.....	Secondo *Secondary*

Sostanza
Product

Temperatura di infiammabilità.. *Flash point*.....	Inferiore alla temperatura di processo e alla temperatura ambiente *Below process and ambient temperature*
Densità dei vapori..... *Vapour density*.....	Superiore a quella dell'aria *Greater than air*

*All'interno del serbatoio e della fossa, basso.
**Within the tank and the sump, low.*

Taking into account relevant parameters, the following are typical values which will be obtained for this example:
a = 3 m from vent openings;
b = 3 m above the roof;
c = 3 m horizontally from the tank.

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per questo esempio:
a = 3 m a partire dallo sfiato;
b = 3 m al di sopra del tetto;
c = 3 m in orizzontale dal serbatoio.

Example No. 9

Tank car filling installation, situated outdoors, for gasoline, top filling:

CAPTION

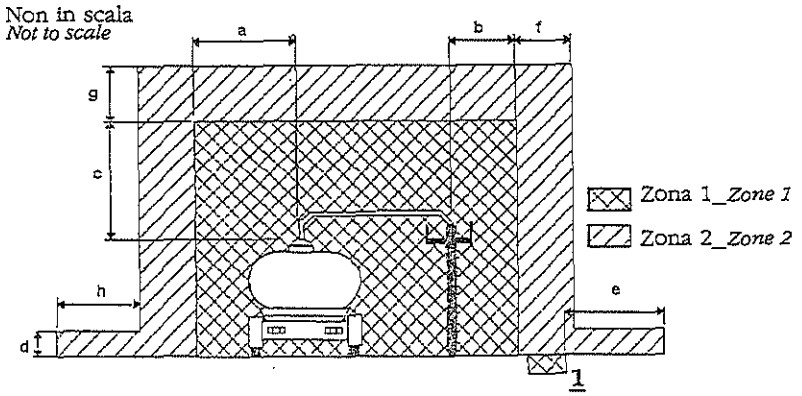
1 Drainage channel

Esempio N° 9

Impianto di carico autobotti, situato all'esterno, per benzina, carica dall'alto:

LEGENDA

1 Canale di drenaggio



Principali fattori che influenzano il tipo e l'estensione delle zone
Principal factors which influence the type and extent of zones

Impianto e processo
Plant and process

Ventilazione
Ventilatation

Tipo..... *Type*.....	Naturale *Natural*
Grado..... *Degree*.....	Medio *Medium*
Disponibilità..... *Availability*.....	Scarsa *Poor*

Sorgente di emissione ***Source of release***	**Grado di emissione** ***Grade of release***
Aperture nel tetto del serbatoio..... *Openings in tank roof*.....	Primo *Primary*
Spandimenti al livello del suolo..... *Spillage at ground level*.....	Secondo *Secondary*

Sostanza
Product

Temperatura di infiammabilità..... *Flash point*.....	Inferiore alla temperatura di processo e alla temperatura ambiente *Below process and ambient temperature*
Densità dei vapori..... *Vapour density*.....	Superiore a quella dell'aria *Greater than air*

Taking into account relevant parameters, the following are typical values which will be obtained for this example.

a = 1,5 m horizontally from source of release;
b = horizontally to island (gantry) boundary;
c = 1,5 m above source of release;
d = 1 m above ground level;
e = 4,5 m horizontally from drainage channel;
f = 1,5 m horizontally from zone 1;
g = 1,0 m above zone 1.

Note/Nota *If the system is a closed system with vapour recovery, the distances can be reduced, such that zone 1 may be of negligible extent and zone 2 significantly reduced.*

Tenendo conto delle grandezze specifiche, si ottengono i seguenti valori tipici per questo esempio:

a = 1,5 m in orizzontale dalla sorgente di emissione;
b = in orizzontale fino al limite della passerella di carico;
c = 1,5 m al di sopra della sorgente di emissione;
d = 1 m sopra il livello del suolo;
e = 4,5 m in orizzontale dal canale di drenaggio;
f = 1,5 m in orizzontale dalla zona 1;
g = 1 m al di sopra della zona 1;
h = 3 m in orizzontale dalla zona 2.(1)

Se il sistema è del tipo chiuso con recupero dei vapori, le distanze possono essere ridotte al punto che la zona 1 può essere di estensione trascurabile e la zona 2 risulta significativamente ridotta.

(1) *(Questa quota non è prevista nelle Pubblicazioni IEC e CENELEC)*

Example No. 10

Mixing room in a paint factory:

CAPTION

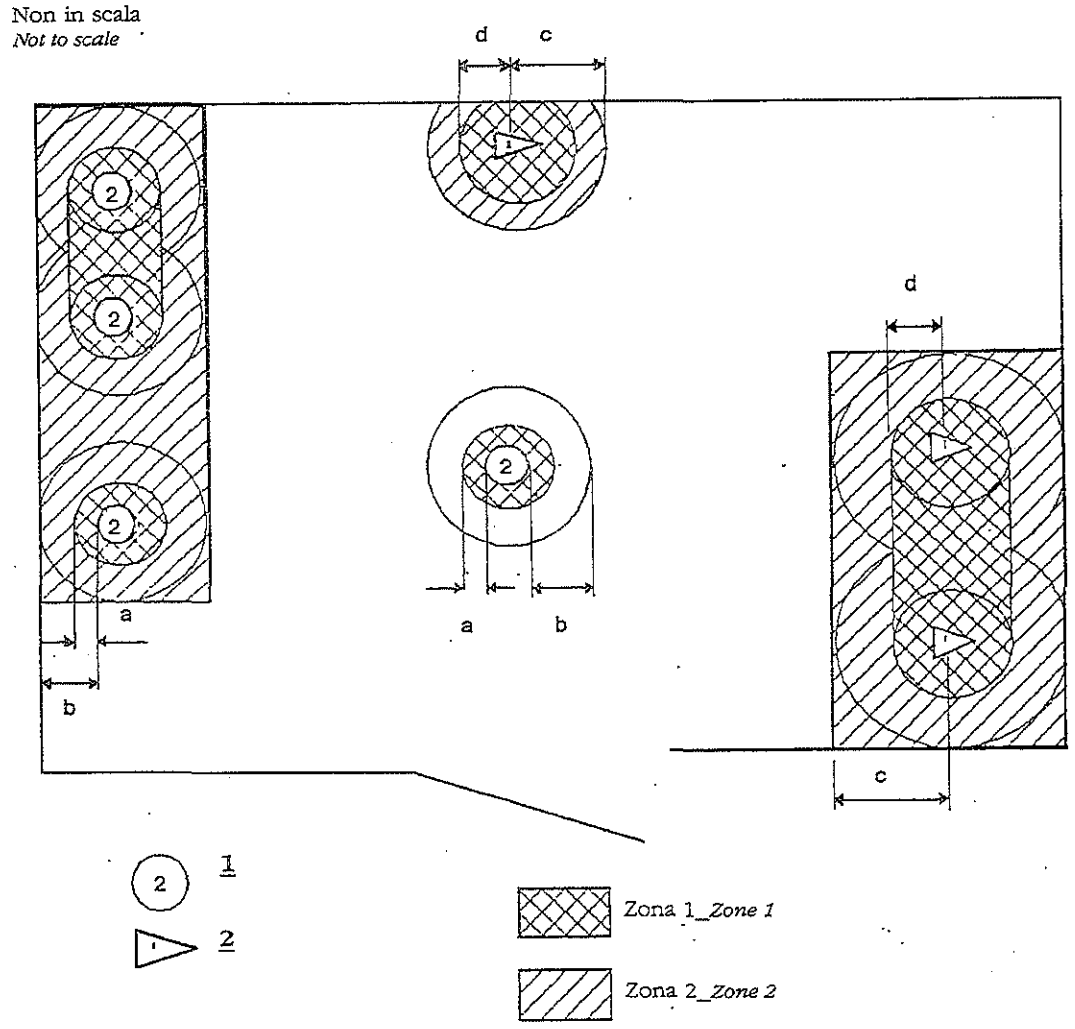
1 Missing vessel
2 Pump

Esempio N° 10

Locale miscelazione di un'industria di vernici:

LEGENDA

1 Recipiente di miscelazione
2 Pompa



This example shows one way of using the individual examples Nos. 2 and 5. In this simplified example, four paint-mixing vessels (item 2) are situated in one room. There are also three pumps (item 1) for liquid in the same room.

The principal factors which influence the type of zones are given in the tables in examples Nos. 2 and 5.

Taking into account relevant parameters, (see hazardous area classification data sheets), the following are typical values which will be obtained for this example:

a = 2 m;

b = 4 m;

c = 3 m;

d = 1,5 m.

Questo esempio illustra un modo di utilizzo degli esempi N° 2 e 5. In questo esempio semplificato, quattro miscelatori di vernice (indicate con 2) sono installati in un locale. Nello stesso locale si trovano anche tre pompe (indicate con 1).

I principali fattori che influenzano il tipo di zone sono indicati nelle tabelle degli esempi N° 2 e 5.

Tenendo conto delle grandezze specifiche (vedere il foglio dati di classificazione dei luoghi pericolosi), si ottengono i seguenti valori tipici per questo esempio:

a = 2 m;

b = 4 m;

c = 3 m;

d = 1,5 m.

The drawing No. 10 is a plan view, for vertical extent of the zones see examples Nos. 2 and 5.

Note/Nota *As in examples Nos. 2 and 5, the zones have a cylindrical shape around the sources of release. However, in practice, the zones are usually increased to a box shape if the vessels are situated close to each other. In this way there are no unclassified small pockets.*

It is assumed that the pumps and vessels are connected by all-welded pipework and that flanges, valves, etc. are located close to these items of equipment.

In practice, there may be other sources of release in the room, for example open vessels, but these have not been taken into account in this example.

If the room is small, it is recommended that zone 2 extends to the limits of the room.

Il disegno dell'esempio N° 10 riporta la pianta del locale, per le estensioni verticali delle zone vedere gli esempi N° 2 e 5.

Come negli esempi N° 2 e 5, le zone hanno una forma cilindrica attorno alle sorgenti di emissione. Tuttavia, in pratica, se i miscelatori sono posti uno in prossimità dell'altro, le zone vengono ingrandite per dar loro una forma parallelepipeda. Così facendo si evita l'esistenza di piccoli volumi non classificati.

Si assume che le pompe e i miscelatori siano connessi mediante tubazioni completamente saldate e che le flange, valvole, ecc. siano situate in prossimità di dette apparecchiature.

In pratica ci possono essere altre sorgenti di emissione all'interno del locale, per esempio recipienti aperti, ma in questo esempio tali sorgenti non sono state considerate.

Se il locale è di piccole dimensioni, si raccomanda che la zona 2 venga estesa a tutto il locale.

Hazardous area classification data sheet - Part I: Flammable material list and characteristics (Sheet 1 of 2)

Foglio dati per la classificazione dei luoghi pericolosi - Parte I: Elenco delle sostanza infiammabili e loro caratteristiche (Foglio 1 di 2)

Impianto: industria di vernici (esempio 10) *Plant: paint factor (example 10)*

Luogo: *Area:*

Disegno di riferimento: planimetria *Reference drawing: layout*

1	2	3	4	5	6	7	8	9	10	11	12
	Sostanza infiammabile *Flammable*			LEL		Volatilità[1] *Volatility*					
N°	Nome *Name*	Composizione *Composition*	Temperatura di infiamm. *Flashpoint*	kg/m³	vol.%	Tensione di vapore a 20 °C *Vapour pressure 20°C* kPa	Temperatura di ebollizione *Boiling point* °C	Densità relativa all'aria del gas o vapore[2] *Relative density of gas or vapour to air*[2]	Temperatura di accensione *Ignition temperature*	Gruppo e classe di temperatura[3] *Group and temperature class*[3]	Altre informazioni di rilievo e/o osservazioni *Any other relevant information and remarks*
1	Solvente con bassa temperatura di infiammabilità *Solvent with low flashpoint*	C_6H_{12}	–18	0,042	1,2	5,8	81	2,9	260	IIAT3	

(1) Normalmente viene indicato il valore della tensione di vapore ma in assenza di questo può essere impiegata la temperatura di ebollizione (rif.4.4.1 d).
Normally, the value of vapour pressure is given but in the absence of that boiling point can be used (reference 4.4.1 d).

(2) Vedere 4.4.4.
See 4.4.4.

(3) Per esempio, IIBT3.
For example, IIBT3.

Hazardous area classification data sheet - Part II: List of source of release (Sheet 2 of 2)

Foglio dati per la classificazione dei luoghi pericolosi - Parte II: Elenco delle sorgenti di emissione (Foglio 2 di 2)

Impianto: Industria di vernici (esempio 10) *Plant: paint factor (example 10)*

Luogo: *Area:*

Disegno di riferimento planimetria *Reference drawing layout*

1	2	3	4	5	6		7	8			9	10	11	12	13
	Sorgente di emissione *Source of release*			**Sostanza infiammabile** *Flammable material*				**Ventilazione** *Ventilation*			**Luogo pericoloso** *Hazardous area*				
N°	**Descrizione** *Description*	**Posizione** *Position*	**Grado di emissione**[1] *Grade of release*[1]	**Riferimento**[2] *Reference*[2]	**Temperatura e pressione di esercizio** °C	kPa	**Stato**[3] *State*[3]	**Tipo**[4] *Type*[4]	**Grado**[5] *Degree*[5]	**Disponibilità**[5] *Availability*[5]	**Tipo di zona** *Zone type* 0-1-2	**Estensione della zona** *Zone extent* m Verticale *Vertical*	Orizzontale *Horizontal*	**Riferimento** *Reference*	**Altre informazioni di rilievo e osservazioni** *Any other relevant information and remarks*
1	Tenuta di una pompa solvente *Sea of solvent pomp*	Area pompe *Pump area*	P,S	1	Ambiente *Ambient*	Ambiente *Ambient*	L	A	Medio *Medium*	Adeguata *Fair*	1	1,0*	1,0*	Esempio *Example* N° 2	* Sopra la sorgente di emissione ** Above the source of release* ** Dalla sorgente di emissione *** From the source of release*
2	Pozza a livello del suolo, sotto la pompa di solvente *Pool at floor level below solvent pump*	Area pompe *Pump area*	S	1	Ambiente *Ambient*	Ambiente *Ambient*	L	A	Medio *Medium*	Adeguata *Fair*	2	1,0*	3,0*	Esempio *Example* N° 2	* Sopra il livello del suolo ** Above ground level* ** Dalla sorgente di emissione *** From the source of release*
3	Superficie del liquido nel miscelatore *Liquid surface on mixing vessel*	Area miscelatori *Mixing area*	C	1	Ambiente *Ambient*	Ambiente *Ambient*	L	A	Basso *Low*	Scarsa *Poor*	0	*	*	Esempio *Example* N° 5	* L'interno del miscelatore ** Inside vessel*

(1) C-Continuo; S-Secondo; P-Primo.
C - Continuos; S - Secondary; P - Primary.

(2) Indicare il numero dell'elenco della Parte I.
Quote the number of list in Part I.

(3) G-Gas; L - Liquido; GL-Gas liquido; S-Solido.
G - Gas; L - Liquefied gas; S - solid.

(4) N - Naturale; A - Artificiale.
N - Natural; A- Artificial.

(5) Vedere allegato B.
See annex B.

Example No. 11

Tank farm for gasoline and oil:

CAPTION

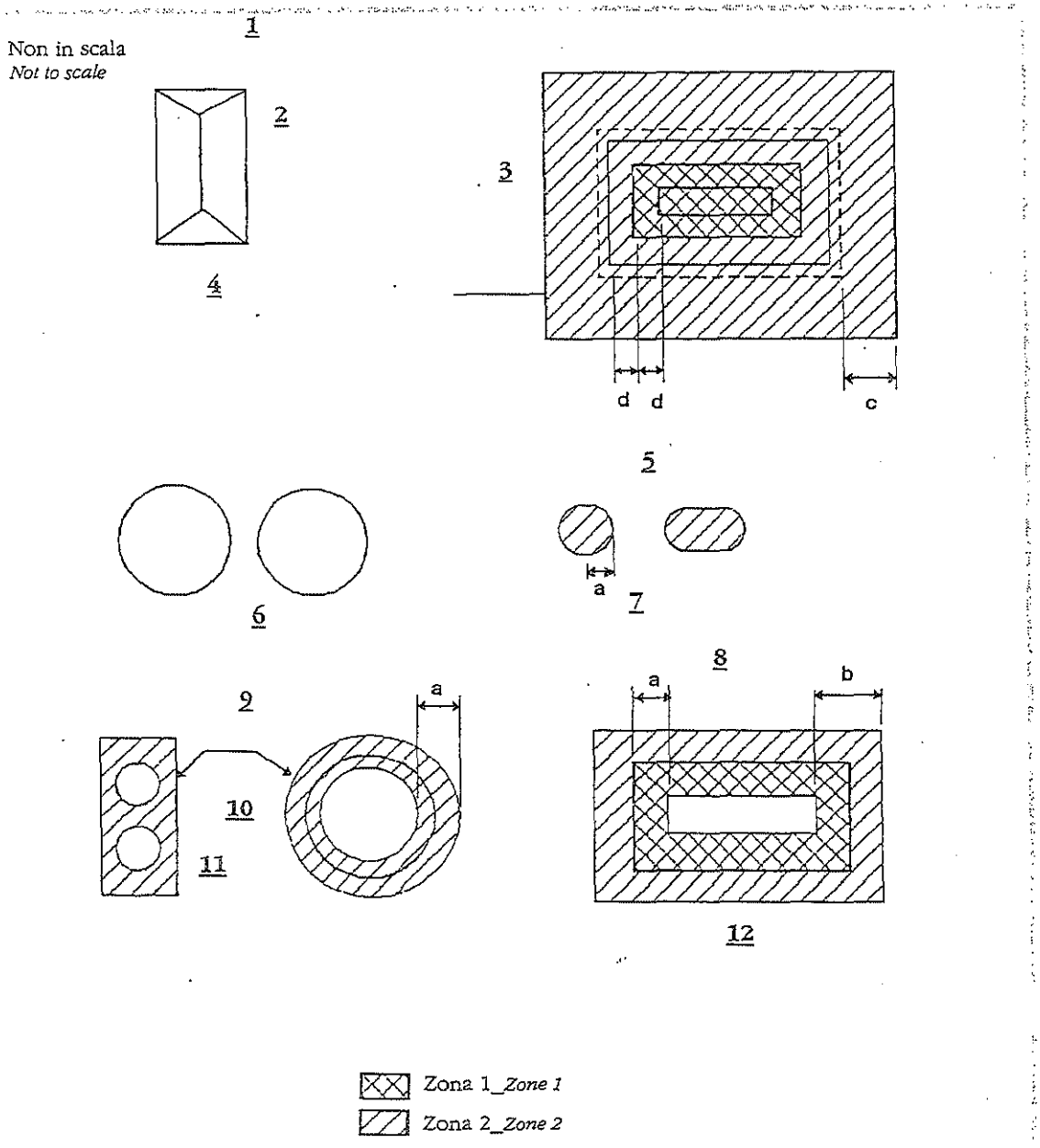
1 Gate
2 Office
3 Item 4
4 Tank car filling installation
5 Item 1
6 Oil tanks item 5
7 Pump
8 Item 2
9 Bund
10 Item 3
11 Tanks
12 Separator

Esempio n° 11

Deposito di benzina e gasolio

LEGENDA

1 Cancello
2 Ufficio
3 Elemento 4
4 Impianto di riempimento autobotti
5 Elemento 1
6 Serbatoio di gasolio elemento 5
7 Pompe
8 Elemento 2
9 Muri di contenimento
10 Elemento 3
11 Serbatoi di benzina
12 Separatore



This example shows one way of using the individual example Nos. 1, 6, 8 and 9.

In this simplified example, three storage tanks (bunded) for gasoline (item 3), five liquid pumps (item 1) placed close to each other, one single pump (item 1), one tank car filling installation (item 4), two oil tanks (item 5) and one oil/water gravity separator (item 2) are situated within the tank farm.

The principal factors which influence the types of zones are given in examples Nos. 1, 6, 8 and 9.

Taking into account relevant parameters, (see hazardous area classification data sheets), the following are typical values which will be obtained for this example.

a = 3 m

b = 7,5 m

c = 4,5 m

d = 1,5 m

The drawing No. 11 is a plan view; for vertical extent of the zones, see examples Nos. 1, 6, 8 and 9.

For details (zoning inside vessels, zoning extent, zoning around tank vents, etc.) see examples Nos. 1, 6 ,8 and 9.

Note/Nota *It is necessary to use examples Nos. 1, 6, 8 and 9 to obtain the correct zoning of the interior of tanks and separator (zone 0) together with zoning at tank vents (zone 1).*

In practice there may be other sources of release; however for simplicity, these have not been taken into account.

In questo esempio è illustrato un modo di utilizzo degli esempi N° 1, 6, 8 e 9.

All'interno del deposito si trovano: tre serbatoi di benzina con bacino di contenimento (elemento 3), cinque pompe di liquido installate una a fianco all'altra (elemento 1), una pompa singola (elemento 1), un impianto per il caricamento di autobotti (elemento 4), due serbatoi di gasolio (elemento 4) e un separatore a gravità olio/acqua (elemento 2).

I principali fattori che influenzano il tipo di zone sono indicati nelle tabelle degli esempi N° 1, 6, 8 e 9.

Tenendo conto delle grandezze specifiche (vedere il foglio dati di classificazione dei luoghi pericolosi), si ottengono i seguenti valori tipici per questo esempio:

a = 3 m

b = 7,5 m

c = 4,5 m

d = 1,5 m

Il disegno dell'esempio N° 11 riporta la pianta del deposito, per le estensioni verticali delle zone vedere gli esempi N° 1, 6, 8 e 9.

Per i dettagli (zone all'interno dei serbatoi, estensione delle zone attorno agli sfiati dei serbatoi) vedere gli esempi N° 1, 6, 8 e 9.

È necessario servirsi degli esempi n° 1, 6, 8 e 9 per definire in modo corretto le zone all'interno dei serbatoi e del separatore (zona 0) oltre a quelle relative agli sfiati dei serbatoi (zona 1).

In pratica ci possono essere altre sorgenti di emissione; tuttavia, per semplicità, queste non sono state considerate.

Hazardous area classification data sheet - Part I: Flammable material list and characteristics (Sheet 1 of 3)

Foglio dati per la classificazione dei luoghi pericolosi - Parte I: Elenco delle sostanze infiammabili e loro caratteristiche (Foglio 1 di 3)

Impianto: deposito di benzina e gasolio (esempio 11) *Plant: Tank farm for gasoline (example 11)*

Luogo: *Area:*

Disegno di riferimento planimetria *Reference drawing layout*

1	2	3	4	5	6	7	8	9	10	11	12
	Sostanza infiammabile *Flammable material*		**LEL**			**Volatilità** *Volatility*					
N°	**Nome** *Name*	**Composizione** *Composition*	**Temperatura di infiamm.** *Flashpoint* °C	**kg/m³**	**Vol%** °C	**Tensione di vapore 20 °C** *Vapour pressure 20 °C*	**Temperatura di ebollizione** *Boiling-point*	**Densità relativa all'aria del gas vapore** (2) *Relative density of gas or vapour to air* (2)	**Temperatura di accensione** *Ignition temperature* °C	**Gruppo e classe di temperatura** (3) *Group and temperature class* (3)	**Altre informazioni di rilievo e/o osservazioni** *Any other relevant information and remarks*
1	Benzina *Gasoline*		<0	0,022	0,7	50	<210	<2,5	280	IIAT3	
2	Gasolio *Fuel oil*		55÷65	0,043	1	6	200	3,5	330	IIAT2	
3	Acqua contenente gasolio e benzina *Water containing oil and gasoline*		<0	—	<0,7			>1,2	>280	IIAT3	Valori stimati *The value are estimated*

(1) Normalmente viene indicato il valore della tensione di vapore ma in assenza di questo può essere impiegata la temperatura di ebollizione (rif. 4.4.1 d).
Normally, the value of vapour pressure is given, but in the absence of that, boiling-point can be used (reference 4.4.1d).

(2) Vedere 4.4.4.
See 4.4.4.

(3) Per esempio, IIBT3.
For example IIBT3.

Hazardous area classification data sheet - Part II: Flammable material list and characteristics (Sheet 2 of 3)

Foglio dati per la classificazione dei luoghi pericolosi - Parte II: Elenco delle sostanze infiammabili loro caratteristiche (Foglio 2 di 3)

Continua_*Continued*

1	2	3	4	5	6		7	8			9	10	11	12	Disegno di riferimento planimetria *Reference drawing layout* 13
Sorgente di emissione *Source of release*				Sostanza infiammabile *Flammable material*				Ventilazione *Ventilation*			Luogo pericoloso *Hazardous area*				
N°	Descrizione *Description*	Posizione *Location*	Grado di emissione[1] *Grade of release*[1]	Riferimento [2] *Reference*[2]	Temperatura e pressione di esercizio *Operating temperature and pressure* °C	kPa	Stato [3] *State* [3]	Tipo[4] *Type*[4]	Grado[5] *Degree*[5]	Disponibilità [6] *Availability*[5]	Tipo di zona *Zone type* 0-1-2	Estensione della zona *Zone extent* m Verticale *Vertical*	Orizzontale *Horizontal*	Riferimento *Reference*	Altre informazioni di rilievo e osservazioni *Any other relevant information and remarks*
1	Tenuta della pompa di benzina *Seal of gasoline pump*	Area pompe *Pump area*	P e S	1	Ambiente *Ambient*	Ambiente *Ambient*	L	A	Medio *Medium*	Adeguata *Fair*	2	1,0*	3,0**	Esempio *Example* N° 1	* Sopra la sorgente di emissione ** Above source of release* ** Dalla sorgente di emissione *** From the source of release*
2	Superficie del liquido del separatore *Liquid surface on separator*	Trattamento acque reflue *Waste water treatment*	C	3	Ambiente *Ambient*	Ambiente *Ambient*	L	N	Basso *Low*	Scarsa *Poor*	0	*	*	Esempio *Example* N° 6	* All'interno del separatore al di sotto del livello del suolo ** Inside separator below ground level*
								N	Alto *High*	Scarsa *Poor*	1	1,0*	3,0*	Esempio *Example* N° 6	* Sopra il livello del suolo ** Above ground level* ** Dal separatore *** From separator*
								N	Alto *High*	Scarsa *Poor*	2	3,0*	7,5*	Esempio *Example* N° 6	* Sopra il livello del suolo ** Above ground level* ** Dal separatore *** From separator*
3	Superficie del liquido nei serbatoi di benzina *Liquid surface on gasoline tank*	Area serbatoi *Tank areas*	C	1	Ambiente *Ambient*	Ambiente *Ambient*	L	N	Medio *Medium*	Scarsa *Poor*	0	*	*	Esempio *Example* N° 8	* L'interno del serbatorio ** Inside the tank*
4	Sfiato del serbatoio di benzina *Vent opening in gasoline tank*	Area serbatoi *Tank areas*	P	1	Ambiente *Ambient*	Ambiente *Ambient*	L	N	Medio *Medium*	Buona *Good*	1	3,0*	3,0*	Esempio *Example* N° 8	* 3 m a partire dallo sfiato ** 3 m around the vent*
5	Flange ecc., nel bacino di contenimento *Flanges, etc. inside bund of gasoline tanks*	Area serbatoi *Tank areas*	S	1	Ambiente *Ambient*	Ambiente *Ambient*	L	N	Medio *Medium*	Adeguata *Fair*	2	*	*	Esempio *Example* N° 8	* All'interno del bacino di contenimento ** Inside bund*

Continua_*Continued*

Hazardous area classification data sheet - Part II: List of source of release (Sheet 3 of 3)

Foglio dati per la classificazione dei luoghi pericolosi - Parte II: Elenco delle sorgenti di emissione (Foglio 3 di 3)

Continua_*Continued*

Impianto:deposito benzina e gasolio (esempio 11) *Plant:tank farm gasoline (example 11)*

Luogo: *Area:*

Disegno di riferimento planimetria *Reference drawing layout*

1	2	3	4	5	6		7	8			9	10	11	12	13
	Sorgente di emissione *Source of release*			**Sostanza infiammabile** *Flammable material*				**Ventilazione** *Ventilation*			**Luogo pericoloso** *Hazardous area*				
N°	**Descrizione** *Description*	**Posizione** *Location*	**Grado di emissione**(1) *Grade of release*(1)	**Riferimento** (2) *Reference*(2)	**Temperatura e pressione di esercizio** *Operating temperature and pressure* °C	kPa	**Stato** (3) *State* (3)	**Tipo**(4) *Type*(4)	**Grado**(5) *Degree*(5)	**Disponibilità** (6) *Availability*(5)	**Tipo di zona** *Zone type* 0-1-2	**Estensione della zona** *Zone extent* m Verticale *Vertical*	Orizzontale *Horizontal*	**Riferimento** *Reference*	**Altre informazioni di rilievo e osservazioni** *Any other relevant information and remarks*
6	Tracimazioni e spandimenti dal serbatoio *Overfilling of gasoline tanks*	Area serbatoi *Tank areas*	S	1	Ambiente *Ambient*	Ambiente *Ambient*	L	N	Medio *Medium*	Buona *Good*	2	3,0*	3,0**	Esempio *Example* N° 8	* Sopra il livello del suolo ** Above ground level*
7	Aperture nel tetto del serbatoi dell'impianto caricamento autobotti *Opening in tank roof of tank car filling installation*	Area di carico *Loading area*	P	1	Ambiente *Ambient*	Ambiente *Ambient*	L	N	Medio *Medium*	Scarsa *Poor*	1	1,5*	1,5*	Esempio *Example* N° 9	* Sopra il livello del suolo ** Above ground level* ** Dalla sorgente di emissione *** From release*
											2	1,0*	1,5*	Esempio *Example* N° 9	* Sopra la sorgente di emissione ** Above release* ** Dalla sorgente di emissione *** From release*
8	Spandimenti a terra all'interno del canale di drenaggio dell'impianto di carico dell'autobotte *Spillage at ground inside drainage channel of tank car filling installation*	Area di carico *Loading area*	S	1	Ambiente *Ambient*	Ambiente *Ambient*	L	N	Medio *Medium*	Scarsa *Poor*	2	1,0*	4,5*	Esempio *Example* N° 9	* Sopra il livello del suolo ** Above ground level* ** Dal canale di drenaggio ***From drain channel*
9	Serbatoio di gasolio *Oil tank*	Area serbatoi *Tank areas*	—	2	—	—	L	—	—	—		...*	...*		* Luogo non pericoloso grazie all'alta temperatura di infiammabilità del gasolio ** No hazardous area due to the high flashpoint of oil*

(1) G-Gntinuo; S-Secondo; P-Primo_G - *Continuos; S - Secondary; P - Primary.*Indicare il numero dell'elenco della Parte I_*Quote the number of list in Part I*
(1) G-Gas; L - Liquido; GL-Gas liquido; S-Solido_G - *Gas; L - Liquefied gas; S - solid.*
(1) N - NAturale; A - Artificiale_*N - Natural; A- Artificial.*
(2) Vedere allegato B_*See annex B.*

Tab. C.1 **Hazardous area classification data sheet - Part I: Flammable material list and characteristics (Sheet 1 of 1)**

Foglio dati per la classificazione dei luoghi pericolosi - Parte I: Elenco delle sostanze infiammabili e loro caratteristiche (Foglio 1 di 1)

Impianto: *Plant:*

Luogo: *Area:*

Disegno di riferimento planimetria *Reference drawing layout*

1	2	3	4	5	6	7	8	9	10	11	12
	Sostanza infiammabile *Flammable material*		LEL			Volatilità *Volatility*					
N°	Nome *Name*	Composizione *Composition*	Temperatura di infiamm. *Flashpoint* °C	kg/m³	Vol% °C	Tensione di vapore 20 °C *Vapour pressure 20 °C*	Temperatura di ebollizione *Boiling-point*	Densità relativa all'aria del gas vapore (2) *Relative density of gas or vapour to air (2)*	Temperatura di accensione *Ignition temperature* °C	Gruppo e classe di temperatura (3) *Group and temperature class (3)*	Altre informazioni di rilievo e/o osservazioni *Any other relevant information and remarks*

(1) Normalmente viene indicato il valore della tensione di vapore ma in assenza di questo può essere impiegata la temperatura di ebollizione (rif. 4.4.4.1.d).
Normally, the value of vapour pressure is given, but in the absence of that, boiling point can be used (reference 4.4.1.d).

(2) Per esempio, IIBT3.
For example IIBT3.

Tab. C.2 **Hazardous area classification data sheet - Part II: List of sources of release (Sheet 1 of 1)**

Foglio dati per la classificazione dei luoghi pericolosi - Parte II: Elenco delle sorgenti di emissione (Foglio 1 di 1)

Impianto: *Plant:*	Luogo: *Area:*	Disegno di riferimento planimetria *Reference drawing layout*

1	2	3	4	5	6		7	8			9	10	11	12	13
Sorgente di emissione *Source of release*				Sostanza infiammabile *Flammable material*				Ventilazione *Ventilation*			Luogo pericoloso *Hazardous area*				
N°	Descrizione *Description*	Posizione *Position*	Grado di emissione[1] *Grade of release*[1]	Riferimento [2] *Reference*[2]	Temperatura e pressione di esercizio *Operating temperature and pressure operating* °C	kPa	Stato [3] *State* [3]	Tipo[4] *Type*[4]	Grado[5] *Degree*[5]	Disponibilità [5] *Availability*[5]	Tipo di zona *Zone type* 0-1-2	Estensione della zona *Zone extent* m Verticale *Vertical*	Orizzontale *Horizontal*	Riferimento *Reference*	Altre informazioni di rilievo e osservazioni *Any other relevant information and remarks*

(1) C-Cntinuo; S-Secondo; P-Primo.
C - Continuos; S - Secondary; P - Primary.

(2) Indicare il numero dell'elenco della Part I.
Quote the number of list in Part I.

(3) G-Gas; L - Liquido; GL-Gas liquido; S-Solido.
G - Gas; L - Liquefied gas; S - solid.

(4) N - Naturale; A - Artificiale.
N - Natural; A- Artificial.

(5) Vedere allegato B.
See annex B.

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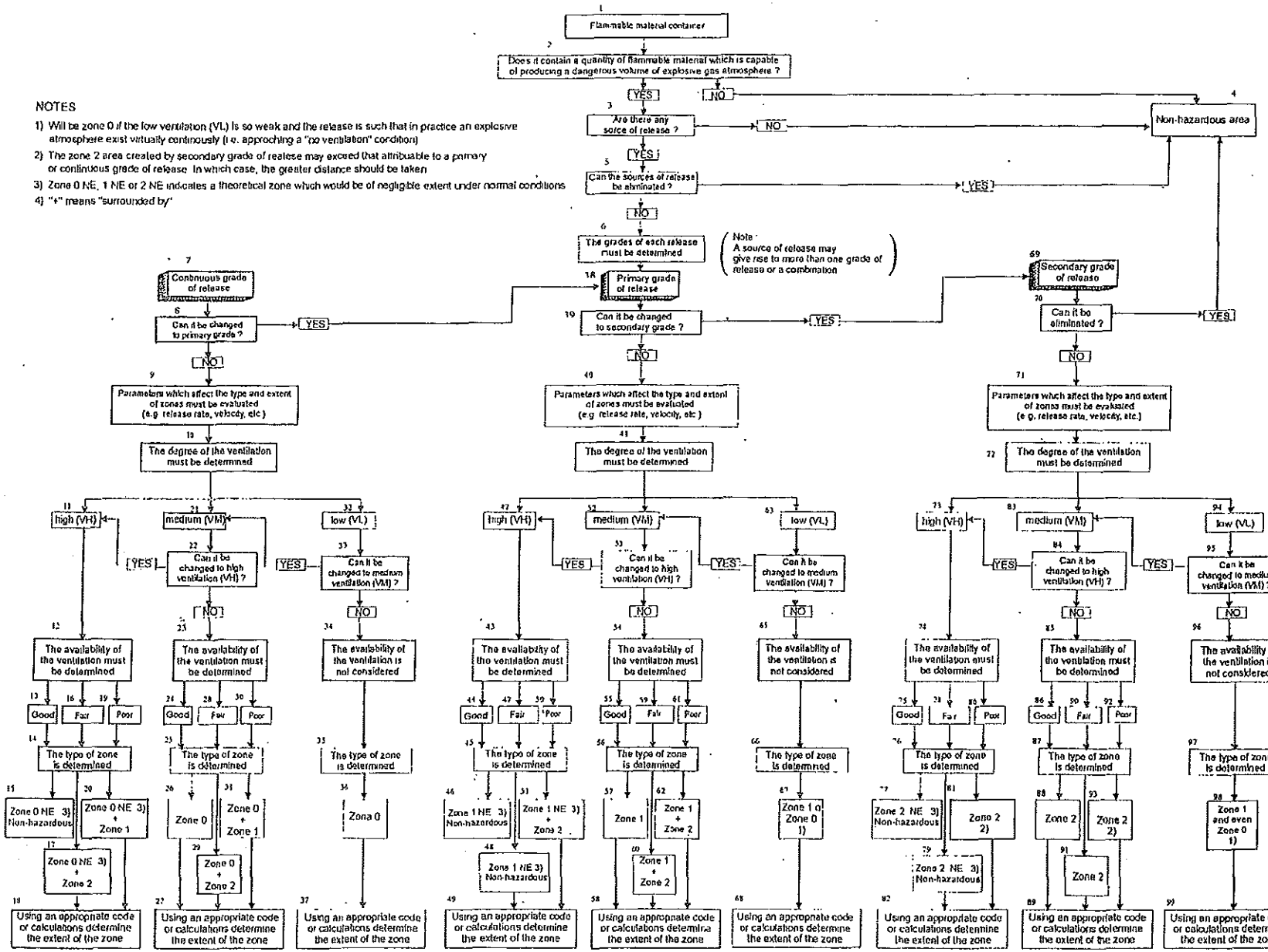
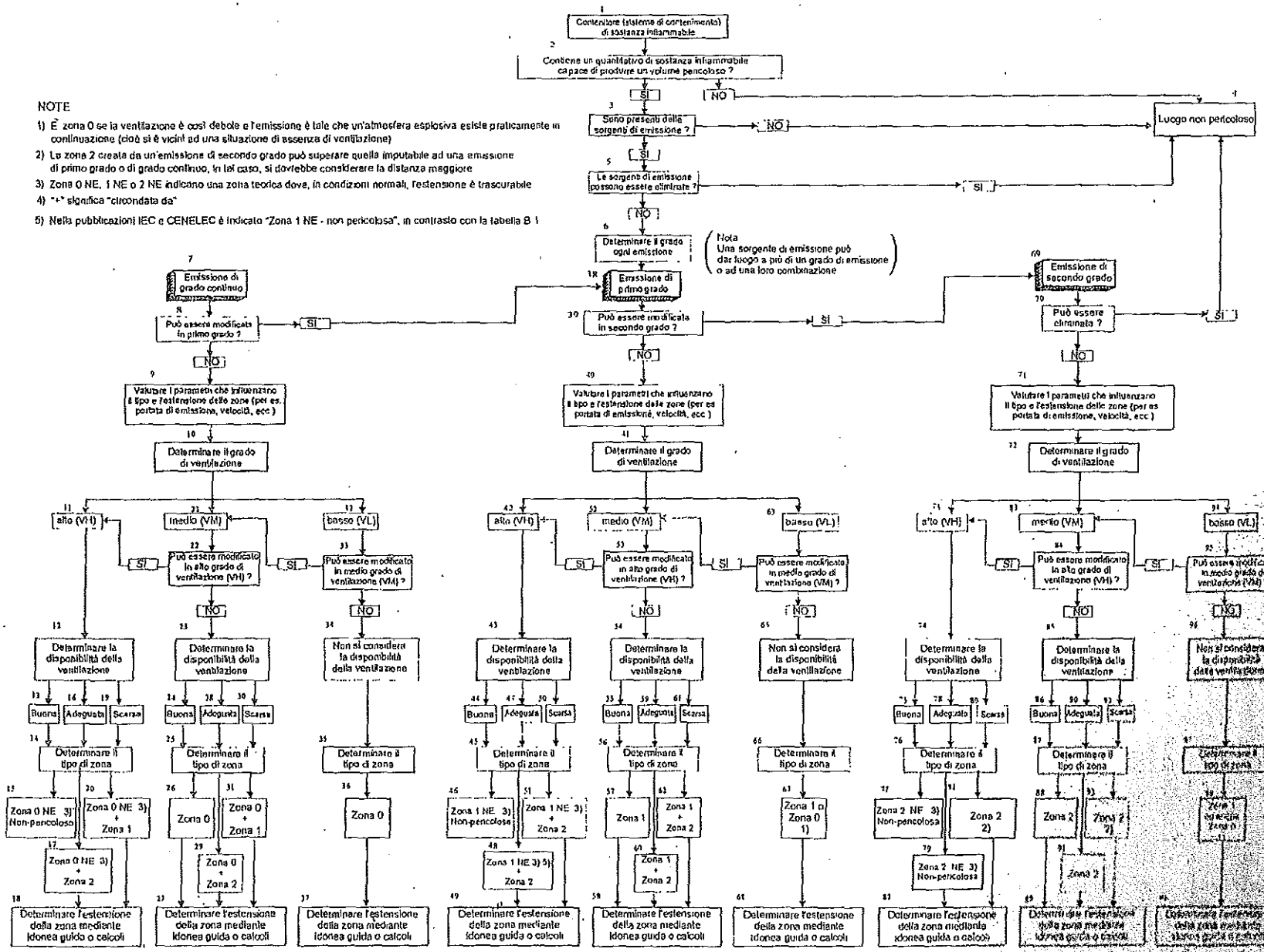


NOTES

1) Will be zone 0 if the low ventilation (VL) is so weak and the release is such that in practice an explosive atmosphere exist virtually continously (i.e. approching a "no ventilation" condition)
2) The zone 2 area created by secondary grade of realese may exceed that attribuable to a primary or continuous grade of release. In which case, the greater distance should be taken
3) Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone which would be of negligible extent under normal conditions
4) "+" means "surrounded by"

Fig. C.1 Schematic approach to the classification of hazardous areas

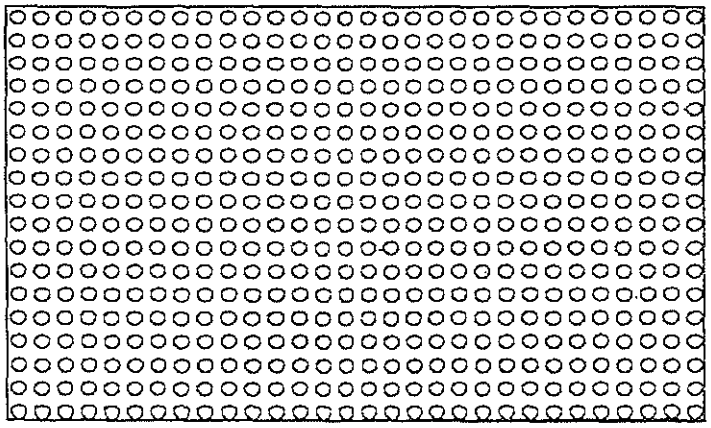
Fig. C.1 **Approccio schematico alla classificazione dei luoghi pericolosi**



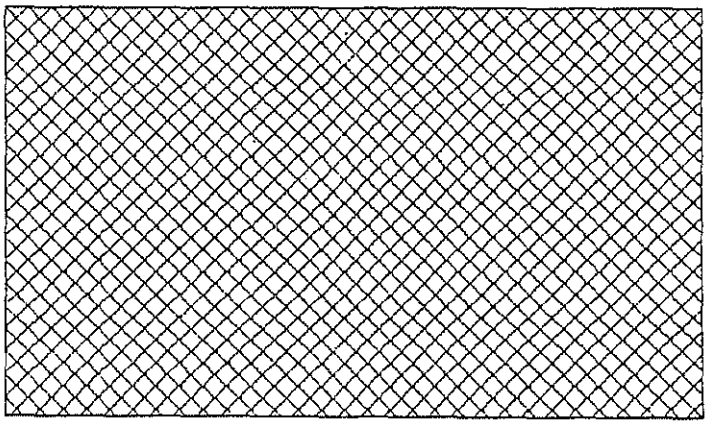
NOTE

1) E' zona 0 se la ventilazione è così debole e l'emissione è tale che un'atmosfera esplosiva esiste praticamente in continuazione (cioè si è vicini ad una situazione di assenza di ventilazione)
2) La zona 2 creata da un'emissione di secondo grado può superare quella imputabile ad una emissione di primo grado o di grado continuo, in tal caso, si dovrebbe considerare la distanza maggiore
3) Zona 0 NE, 1 NE o 2 NE indicano una zona teorica dove, in condizioni normali, l'estensione è trascurabile
4) "+" significa "circondata da"
5) Nella pubblicazioni IEC e CENELEC è indicato "Zona 1 NE - non pericolosa", in contrasto con la tabella B.1

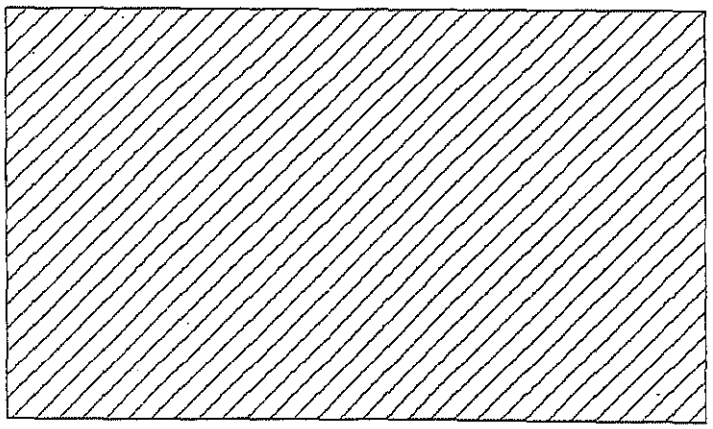
Fig. C.2 **Preferred symbols for hazardous area zones** — **Simbologia preferenziale per le zone dei luoghi pericolosi**



Zona 0_*Zone 0*



Zona 1_*Zone 1*



Zona 2_*Zone 2*

ANNEX/ALLEGATO
ZA

Normative references to international Publications with their corresponding European Publications

This European Standard incorporates by dated or undated reference, provisions from other Publications. These normative references are cited at the appropriate places in the text and the Publications are listed hereafter. For dated references, subsequent Amendments to or revisions of any of these Publications apply to this European Standard only when incorporated in it by Amendment or revision. For undated references the latest edition of the Publication referred to applies (including Amendments).

Note/Nota *When an international Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.*

Riferimenti normativi alle Pubblicazioni internazionali con le loro corrispondenti Pubblicazioni Europee

La presente Norma include, tramite riferimenti datati e non datati, disposizioni provenienti da altre Pubblicazioni. Questi riferimenti normativi sono citati, dove appropriato, nel testo e qui di seguito sono elencate le relative Pubblicazioni. In caso di riferimenti datati, le loro successive modifiche o revisioni si applicano alla presente Norma solo quando incluse in essa da una modifica o revisione. In caso di riferimenti non datati, si applica l'ultima edizione della Pubblicazione indicata (comprese le Modifiche).

Quando la Pubblicazione Internazionale è stata modificata da modifiche comuni CENELEC, indicate con (mod), si applica la corrispondente EN/HD.

Pubbl. IEC *IEC Publication*	Data *Date*	Titolo *Title*	EN/HD	Data *Date*	Norma CEI *CEI Standard*
50(426)	1990	Vocabolario Elettrotecnico Internazionale (IEV). Capitolo 426: Costruzioni elettriche per atmosfere esplosive. *International Electrotechnical Vocabulary (IEV) Chapter 426: Electrical apparatus for explosive atmospheres*	—	—	—
79-4	1975	Costruzioni elettriche per atmosfere esplosive per presenza di gas. Parte 4: Metodo di prova per la temperatura di accensione. *Electrical apparatus for explosive gas atmospheres Part 4: Method of test for ignition temperature*	—	—	—
79-4A	1970	Primo supplemento alla IEC 79-4 (1966). *First supplement to IEC 79-4 (1966)*	—	—	—

Fine Documento

La presente Norma è stata compilata dal Comitato Elettrotecnico Italiano
e beneficia del riconoscimento di cui alla legge 1º Marzo 1968, n. 186.

Editore CEI, Comitato Elettrotecnico Italiano, Milano - Stampa in proprio
Autorizzazione del Tribunale di Milano N. 4093 del 24 luglio 1956
Responsabile: Ing. E. Camagni

31 – Materiali antideflagranti

CEI 31-1 (EN 50018) (Ed. 1978)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Custodie a prova di esplosione «d» - Norma Europea

CEI EN 50018 (CEI 31-1) (Ed. 1995)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Custodie a prova di esplosione "d"

CEI 31-2 (EN 50016)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Modo di protezione a sovrapressione interna «p» - Norma Europea

CEI 31-5 (EN 50015) (Ed. 1978)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Costruzioni immerse in olio «o» - Norma Europea

CEI EN 50015 (CEI 31-5) (Ed. 1995)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Costruzioni immerse in olio "o"

CEI 31-6 (EN 50017) (Ed. 1978)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Costruzioni sotto sabbia «q» - Norma Europea

CEI EN 50017 (CEI 31-6) (Ed. 1995)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Costruzioni a riempimento polverulento "q"

CEI 31-7 (EN 50019) (Ed. 1978)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Modo di protezione a sicurezza aumentata «e» - Norma Europea

CEI EN 50019 (CEI 31-7) (Ed. 1994)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Modo di protezione a sicurezza aumentata "e"

CEI 31-8 (EN 50014) (Ed. 1978)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Regole generali - Norma Europea

CEI EN 50014 (CEI 31-8) (Ed. 1993)
Costruzioni elettriche per atmosfere potenzialmente esplosive. Regole generali

CEI 31-9 (EN 50020) (Ed. 1978)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Modo di protezione a sicurezza intrinseca «i» - Norma Europea

CEI EN 50020 (CEI 31-9) (Ed. 1995)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Sicurezza intrinseca "i"

CEI 31-10 (EN 50039)
Costruzioni elettriche per atmosfere potenzialmente esplosive - Sistemi elettrici a sicurezza intrinseca «i» - Norma Europea

CEI 31-11
Costruzioni elettriche per atmosfere potenzialmente esplosive. Modo di protezione «n»

CEI 31-12 (EN 50050)
Costruzioni elettriche per atmosfere potenzialmente esplosive. Apparecchiature portatili di spruzzatura elettrostatica

CEI 31-13 (EN 50028)
Costruzioni elettriche per atmosfere potenzialmente esplosive. Incapsulamento "m"

CEI 31-14 (EN 50053-1)
Prescrizioni per la scelta, l'installazione e l'uso di apparecchiature di spruzzatura elettrostatica per prodotti infiammabili. Parte 1

CEI EN 50033 (CEI 31-15)
Costruzioni elettriche per atmosfere potenzialmente esplosive. Lampade a casco per miniere grisoutose.

CEI 31-16 (EN 50053-2)
Prescrizioni per la scelta, l'installazione e l'uso di apparecchiature di spruzzatura elettrostatica per prodotti infiammabili. Parte 2: Pistole manuali per la spruzzatura elettrostatica di polvere con un limite di energia di 5 mJ e loro apparati associati

CEI 31-17 (EN 50053-3)
Prescrizioni per la scelta, l'installazione e l'uso di apparecchiature di spruzzatura elettrostatica per prodotti infiammabili. Parte 3: Pistole manuali per la spruzzatura elettrostatica di fiocco con un limite di energia di 0,24 o 5 mJ e loro apparati associati

CEI 31-18 (EN 50054)
Apparecchiature elettriche per la rilevazione e misura di gas combustibili. Prescrizioni generali e metodi di prova

CEI 31-19 (EN 50055)
Apparecchiature elettriche per la rilevazione e misura di gas combustibili. Prescrizioni relative alle prestazioni di apparecchiature di Gruppo I che indicano fino al 5%(v/v) di metano nell'aria

CEI 31-20 (EN 50056)
Apparecchiature elettriche per la rilevazione e misura di gas combustibili. Prescrizioni relative alle prestazioni di apparecchiature di Gruppo I che indicano fino a 100% (v/v) di metano

CEI 31-21 (EN 50057)
Apparecchiature elettriche per la rilevazione e misura di gas combustibili. Prescrizioni relative alle prestazioni di apparecchiature di Gruppo II che indicano fino a 100% del limite di infiammabilità inferiore

CEI 31-22 (EN 50058)
Apparecchiature elettriche per la rilevazione e misura di gas combustibili. Prescrizioni relative alle prestazioni di apparecchiature di Gruppo II che indicano fino a 100% (v/v)di gas

CEI EN 50059 (CEI 31-23)
Prescrizioni per le apparecchiature portatili di spruzzatura elettrostatica di prodotti non-infiammabili, per verniciatura e finissaggio

CEI 31-24
Guida per l'ispezione ai fini della manutenzione di impianti elettrici nei luoghi con pericolo di esplosione di classe 1 e 3 (diversi dalle miniere)

CEI 31-25
Luoghi con pericolo di esplosione. Guida per la costruzione e l'uso di locali o edifici pressurizzati in luoghi di Classe 1

CEI 31-26
Guida per la manutenzione delle costruzioni elettriche utilizzate nei luoghi con pericolo di esplosione di Classe 1 e 3 (diversi dalle miniere)

CEI EN 61241-2-2 (CEI 31-28)
Costruzioni elettriche destinate ad essere utilizzate in presenza di polveri combustibili. Parte 2: Metodi di prova - Sezione 2: Metodo per determinare la resistività elettrica di polvere in strati

CEI EN 50104 (CEI 31-29)
Costruzioni elettriche per la rilevazione e la misura di ossigeno. Requisiti di funzionamento e metodi di prova

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REPORT

"P-36"

14 May 2003	**Our Ref: 4467/AJS/R02/LOCL**

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FIGURES

APPENDICES

1. INTRODUCTION

1.1 INSTRUCTION

We have been instructed by RINA to provide consultancy services in connection with the technical investigation into the loss of the floating production unit P-36 (unit) and RINA's involvement in that.

1.2 BACKGROUND

1.2.1 The P-36 sank at the Roncador Field offshore Brazil on 20 March 2001. As stated in the investigation reports, the first incident was the rupturing of a drains storage tank forming part of the structure of the starboard column of the unit. A second explosion followed and consequent flooding, which, after various operations to try to stabilise the unit and after 5 days from the first incident, determined the sinking of the unit. Subsequently, the Petroleum National Agency (ANP) and the Port Coast Directorate (DPC) of the Brazilian Navy command formed a joint committee to investigate the cause of the loss. The ANP/DPC Investigation Committee Report dated July 2001 identified a probable scenario for the loss which can be summarised as four phases:

A) A first mechanical explosion of the drains storage tank (DST) in the aft starboard column, on 15 March 2001, due to an over pressure within the tank.

B) A second chemical explosion, about 20 minutes later, following the dispersion of gases from the ruptured tank within the starboard column and the upper levels.

C) Progressive flooding of the unit due to water ingress from the upper sea water ring and the fire-fighting system through compartments within the column causing the the unit to list, followed by several attempts to stabilise the unit.

D) Sinking of the unit on 20 March 2001.

1.2.2 There was a DST in each of the two aft (port and starboard) columns of the unit and they are described as such in the unit's Operating Manual. However, the ANP/DPC report refers to the DSTs as Emergency Drains Tanks (EDTs). In this report we use the terminology DST but this could be equally replaced by EDT.

1.2.3 This report related to RINA's role in the approval of the hazardous area classification of the DSTs. In general terms the classification depends on an assessment of the likelihood or risk that an ignitable gas or vapour will exist during normal operation. This will only arise when there is an appropriate mixture of gas/vapour and air. In particular, the classification is relevant to the specification of electrical equipment which may provide a source of ignition. The accidental release of a flammable gas or vapour because of, for instance, a leaking valve or pump seal is included. However catastrophic failures, such as the rupture of a tank, giving rise to release of a flammable gas or vapour are not considered in such an assessment.

1.2.4 The classification of hazardous areas is carried out in accordance with applicable international standards. As we discuss below, RINA, as classification society and organisation acting on behalf of the Italian flag Administration, applied its Rules for the Construction and Classification of Mobile Offshore Drilling Units, which incorporate the IMO MODU (Mobile Offshore Drilling Unit) Code and relevant IEC (International Electrotechnical Commission) standards .

1.2.5 It is important to clarify that the word classification in the context of hazardous areas is used in these Rules and standards to reflect the process of assigning a category to each space in the unit's layout. The classification of hazardous areas is a duty of the designers, who have to assign it as a function of the intended use and operation of the unit. Then, the duty of the classification society or certifying body is to approve this classification as part of the scope for the classification / certification of the unit. It is therefore to be distinguished from the classification of the whole unit, which is a totally different concept.

1.2.6 It is anticipated that the reader of this report is familiar with the content of the ANP/DPC report which provides a description of the unit and the circumstance of the incident. It is not intended to repeat this information in the body of this report

although for convenience, we have included in Figures and Appendices to this report some relevant particulars and description of the unit.

1.3 SCOPE

1.3.1 The scope of this report is to discuss whether the hazardous area classification to the interior of the DSTs and/or to areas within the aft columns adjacent to the DSTs was adequate, according to the RINA Rules and related MODU Code and IEC standards, and considering the nature of the tanks and the interconnection of the tanks with the process plant. The report assumes the process plant was to be operated in accordance with the operating/operations manuals.

1.3.2 The report also considers to what extent, if any, a more stringent hazardous area classification may have influenced the events that occurred and their outcome. In addition the report addresses whether RINA was kept properly informed of damages and repairs to the unit that may have influenced its classification/certification status.

1.3.3 We have made reference to the documents listed in Appendix A when preparing this report. We have also obtained background information through discussion with RINA head office personnel. The plans and documents available to us have in the main consisted of revisions of design plans and documents from the original design.

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2. GENERAL DESCRIPTION OF UNIT

2.1 MODIFICATIONS

2.1.1 The unit P36, originally named 'Spirit of Columbus', was built by Fincantieri Shipyard in Palermo, for a range of operating conditions and location around the world. The 'Spirit of Columbus' was modified, upgraded and re-named as Petrobras Trentasei (P36) to meet the production capacity of the Roncador Field in the Campos Basin (Brazil).

2.1.2 The modifications included amongst other things, the replacement and upgrading of the process plant, the removal of drilling equipment, the upgrading of the mooring system, the provision of structure to receive risers from the sea bed and the addition of stability boxes.

2.1.3 The modifications were apparently managed by the company Maritima. The process plant was designed by AMEC Process and Energy (AMEC) and modifications to the vessel's structure were designed by Noble Denton (ND). The actual modifications were carried out by Davie Industries at Quebec, Canada although the work was not apparently completed until the vessel arrived at the Roncador Field. Apart from various plans there are two principal documents that we have sighted that explain the planned operation of the unit and the process equipment these are:

a) The Operating Manual ET-3010.38-1200-941-AMK-924 rev. b which was apparently prepared by AMEC and;

b) The Operations Manual MA-3010.38-1320-915-NBD-909-01 rev. a which was apparently prepared by ND.

2.2 GENERAL LAYOUT

2.2.1 The P36 had twin shaped lower hulls supporting four columns, a central caisson and a box-type, watertight upper hull. This comprised a double bottom, second deck and main deck. These are illustrated on a photograph of the unit as shown in Figure 1.

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2.2.2 The lower hulls or pontoons contained tanks (i.e. water ballast, fuel oil, voids spaces, etc.), chain lockers, water injection equipment, thruster room and pump rooms. The columns contained tanks (i.e. water ballast, fresh water, waste oil, drain storage, etc.) as well as void spaces and compartments through which access could be made via stairs or elevators from the top of the columns to the lower hulls. Within the centre caisson there were voids and machinery spaces.

2.2.3 Within the upper hull were machinery spaces and accommodation quarters on two levels. Power generation and distribution for utility services, production and ancillary equipment were provided from the machinery spaces.

2.2.4 On the main deck there was a drilling derrick which was converted to use as a flare tower. A raised helicopter deck and living quarters were located at the forward end. The production plant was located at the aft end of the main deck. Two cranes of 50 tonnes and 22 tonnes capacity were located on the main deck.

2.2.5 Underneath the upper hull a riser (spider) deck has been added, from which the production and water injection riser bundles and export flowlines were supported. The principal dimensions of the unit after modification were as follows:-

2.3 PRINCIPAL DIMENSIONS

Length overall of unit	112,776 m
Breadth overall of unit	97,580 m
Column height	22,860 m
Column width	13,716 m
Central caisson height	24,384 m
Central caisson diameter (external)	11,582 m
Pontoon length	112,776 m
Pontoon breadth (amidships)	13,716 m
Pontoon depth (amidships)	9,144 m
Displacement (transit draft – 11,0 m)	37083 Tons
Displacement (operating draft – 22,0 m)	56503 Tons
Displacement (transit draft – 18,0 m)	50390 Tons

É CÓPIA FIEL DO ORIGINAL

JOSÉ CARLOS PIMENTEL CURIÃO
Diretor da Divisão de Serviços Técnicos

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2.4 ARRANGEMENT OF COLUMNS

2.4.1 Of particular interest are the terms used to describe the various decks or levels within the aft columns as well as the decks or levels within and on the hull above the columns.

2.4.2 Each aft column was composed of several levels, or floors as indicated in Fig 2. These are defined in the vessel's plans and documentation by a numbering system and the height of the levels above the unit's base line (keel) in millimetres. The levels were as follows:

- Fifth level (level 5) or Lower Hull at 12192 ABL (ABL: Above Base Line)
- Fourth level (level 4) at 21336 ABL
- Third level (level 3) at 28956 ABL
- Second level (level 2) at 32004 ABL
- First level (level 1) or Upper Hull (top of column) at 35052 ABL

Above the Upper Hull (as illustrated in Figure 3) there were:

- Tank Top at 36576 ABL
- Second Deck at 39624 ABL
- Main Deck at 42672 ABL

2.4.3 All the spaces located between the above mentioned levels within the columns were enclosed areas.

2.5 PROCESS PLANT

2.5.1 During the conversion from drilling unit to FPO unit (Floating Production Off-loading) carried out in Canada, the process plant was replaced and some utility systems were

updated or replaced. The plant was arranged in a number of separate skid packages on the Main Deck and on the Tank Top aft extension. As part of the modifications, the drilling facilities were removed.

2.5.2 The wellstream from 15 subsea wells, containing oil, gas and water were flow controlled manually by topside choke valves. The wellstreams were directed to the production manifold, feeding two production trains. Each of them consisted of feed heaters and two stages of separation via an oil electrostatic dehydrator between the separators. Sand production was not expected or allowed for.

2.5.3 The oil was stabilised at near atmospheric pressure and exported by booster and main pumps through three pipelines to the FSO, P-47.

2.5.4 The gas from the atmospheric separator was compressed by two booster compressors to join the gas from the first stage production separator. The combined gas passed through the Safety Gas KO Drum to remove entrained liquids from the oil separators and then compressed to the gas export pressure of 196 barg by gas turbine driven, three stage compressors. Three HP compression trains were provided. The HP gas was dehydrated with triethylene glycol in two contactors. Some of the dry gas was used as lift gas in the wells and the balance was metered. Some of the metered gas was used for fuel gas and the balance exported by pipeline to shore.

2.5.5 The produced and condensed water separated from the oil in the separators and dehydrators was cleaned with hydrocyclones before passing to the sea via the production caisson. Each wellstream could be routed to a test manifold and well testing train which consisted of a feed heater, three-phase separator, oil pumps and hydrocyclones. Pigging facilities were provided for the well flowlines, oil export pipelines, gas export pipelines, and the fuel gas export pipeline to the P-47. Water injection facilities were provided to feed 7 remote wells. After the conversion, the P36 process plant had the following capability:

Production wells	15 + 6 future + 2 spare
Wellhead shut-in pressure	264.8 barg
Oil Production	Feed 30825 m^3/d at 8° C Export 28600 m^3/d (180.000 bpd)
HP Compression capacity	7.2 x 10^6 m^3/d, at 196 barg
Gas export	3.0 x 10^6 m^3/d, at 196 barg
Lift gas	2.0 x 10^6 m^3/d, at 196 barg
Produced water capacity	6000 m^3/d, to 20ppm oil in water

2.6 SURVEY AND CERTIFICATION HISTORY

2.6.1 The unit was originally constructed under the survey of RINA. On completion of construction, in 1996, RINA issued a certificate of class and statutory certificates acting on behalf of the Italian flag state authority, including a statement of compliance with the MODU code. Classification assigned for the then named "Spirit of Columbus" was:-

Class Characteristics: *100-A-1.1-NAV IL: Perf-Prod - FPO

Special Notations: + ELI ; ICE Class ID

Service: Unrestricted.

Trade: Drilling operations of the seabed, for the exploration or exploitation of resources beneath the same bed. Production of hydrocarbons extracted from the seabed by means of specific arrangements. Process and off-loading of liquid hydrocarbons extracted from the seabed.

2.6.2 Lloyd's Register of Shipping (LR) also surveyed the unit during construction and they also issued a certificate of classification.

2.6.3 The unit was then laid up at Palermo, Italy until 1997, where RINA carried out necessary periodic and occasional surveys.

2.6.4 In July 1997 RINA were contracted by Petromec Inc. to, in summary, carry out surveys during the modification works and to issue all necessary certification. ABS were also contracted by Petromec Inc to certify the unit's production plant. A co-operation agreement was signed between ABS and RINA to ensure co-ordination of activities.

2.6.5. The unit was towed from Palermo to Davie Ind. Shipyard, Quebec, Canada where it was laid up for the modification works. RINA carried out surveys in Quebec from September 1997 to October 1999. At the end of 1999 the unit was transported on a heavy lift vessel to Rio de Janeiro, Brazil.

2.6.6 At Rio de Janeiro, RINA carried out further surveys and on 28 April 2000 the attending surveyor endorsed class until 30 September 2000. RINA head quarters issued class and other necessary certificates on 29 September 2000 valid until 28 February 2005. These included an International Loadline Certificate and a Statement of Compliance with the MODU code. Classification was:-

Class Characteristics: *100-A-1.1-NavIL; Prod-FPO

Trade:

a) Production of hydrocarbons extracted from the seabed by means of specific arrangements.

b) Process and offloading of liquid hydrocarbons extracted from the seabed.

Service: Unrestricted

2.6.7 The next periodic survey that RINA was due to carry out was the annual class survey (hull and machinery), due on 28 February 2001 which could be carried out at any time between 1 December 2000 and 31 May 2001. The loss of the unit occurred before the end of this period.

2.6.8 Prior to the incident, RINA were not informed of any damages, repairs or alterations to the normal functions of the unit and because of this did not carry out any (unscheduled) survey.

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3. DESCRIPTION OF DSTS

3.1 BACKGROUND

3.1.1 The DSTs were located in the aft columns between levels at 19812mm and 30480mm above the base line. They were located at level 4 but extended into level 3 and level 5. The tanks had an internal volume of 450m^3 each. They were bounded on one side by the outside skin of the cylindrical column and on the inside by a cylindrical steel bulkhead forming a double skin to the column. The tanks were thus within the double skin but they only extended around half the circumference of the column. The tanks were an integral part of the structure of the column.

3.1.2 An important structural feature of the tanks is that they were designed to store liquids at normal atmospheric pressure and temperature. They were not designed as pressure vessels.

3.2 CHANGE FROM BASE OIL TANKS

3.2.1 The tanks were originally named "Base Oil Tanks" prior to the modifications and were intended for the storage of non-dangerous mineral oil resulting from drilling. During the course of the modification works it appears that the decision was taken to make use of the base oil tanks as DSTs. The first documented evidence that we have sighted of this is a proposal resulting from a HAZOP study conducted between 9 June and 11 July 1997. This resulted in the proposal to use the "structural base oil tanks in the port/aft leg for periodic closed drains storage". It is indicated that during the draining of large process vessels the closed drains drum would not be large enough and instead liquids would be drained to the DSTs.

3.3 P AND I DIAGRAMS

3.3.1 P and I diagrams were submitted by the designers to RINA for approval. These diagrams showed diagrammatically the arrangement of the piping and instrumentation system of the process plant. One of the drawings, No. DE- 3010.38-5336-944-AMK-398, is titled P and I Diagram Drains Storage Tanks Revision C (refer

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to Appendix B). The drawing indicates the schematic arrangement of pipes that were connected to the two tanks. These are:

A. A 5-inch diameter vent pipe to the top of each tank connected to the unit's atmospheric vent system.

B. A 3-inch inlet pipe to each tank via an inlet valve which is marked as locked open (V-534 and V-535, respectively on the port and starboard DST's).

C. A 3-inch diameter outlet pipe connected via a suction valve to a discharge pump for each tank. There is also a valve at the discharge side of the pump.

D. A 1-inch diameter nitrogen purge pipe to each tank via a needle valve. The pipe is shown to connect to a dip (or sounding pipe) which extends to the bottom of each of the tanks.

3.3.2 The inlet and discharge pipes from each tank connect to a common 3-inch diameter header pipe to which in turn has the following connections to the process plant:

E. A 3-inch diameter pipe via a valve shown as locked closed to the production caisson (part of the process plant).

F. A 3-inch diameter pipe from the produced water de-gasser via a valve at the de-gasser.

G. A 3-inch diameter pipe from the atmospheric separators and the booster pumps via a remotely operated valve at the crude oil booster pumps marked as "fail open".

H. A 3-inch diameter pipe from the closed drains drum. The connection was via an automatic dump valve (refer to 3.4.3.3 below).

I. A 3-inch diameter pipe connected to/from the process inlet manifolds via a remotely operated valve (valve XV 53360004).

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3.3.3 The ways in which the DSTs could be connected to the process plant depend upon the open or closed status of valves.

3.3.4 To fully understand how it was intended to make use of use the DSTs and the purpose of the various connections to them it is necessary to consider the Operating and Operation Manuals.

3.4 OPERATING MANUAL

3.4.1 **Drains System**

The Operating Manual describes the DSTs in the context of being part of the closed drains system. From the process point of view, the drains system was intended to provide segregation between hazardous and non-hazardous drains fluids. There were three separate drains systems to accomplish this namely closed drains for pressurised hazardous fluids, hazardous open drains for atmospheric hazardous drains and non-hazardous open drains.

3.4.2 **Open Drains System**

3.4.2.1 The open drain system was used for collecting liquids from skid floor drains and open deck drains and it was subdivided in three sub-systems:

- Hazardous open drains;
- Non-hazardous open drains; and
- Deluge water drains.

3.4.2.2 *Hazardous open drains*: The liquids drained onto the floor of skids handling hydrocarbons on the main deck or above were collected by the hazardous open drains drum, V-45001, on the tank top aft extension (according the relevant P and I diagram no. DE-3010.38-5336-944-AMK-394, rev. B, approved by RINA on 02.06.1998) included at Appendix C. The drum was connected to the atmospheric vent system, as were the DSTs. There was therefore a connection to the DSTs via the atmospheric vent system and it is through this system that the ANP/DPC report

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concludes that fluids may have originally entered the port DST due to overflow from the drum. Liquid received in the drum was pumped by the hazardous open drains pumps, P-45002 A/B to the produced water degasser. The drains from the skids on the tank top were collected by the low level hazardous open drains piping system feeding the tank top deck sump, V-533605, located in the tank top deck.

3.4.2.3 *Non-hazardous open drains:* Liquids from deck drains in safe areas were collected by the non-hazardous open drains piping system, and were led to the skim pile (YD/731A), located on the outside of the central caisson below the tank top level. The skim pile allowed any oil present in the liquid to separate, rise to the top and discharge the water into the sea. The oily emulsion collected at the top is pumped out under level control by the skim oil pump (YD/731C), to the matrix water separator (YD/731B) on the main deck. The water separator removed water and returned it to the skim pile. The oil was transferred to the production trains by the matrix separator oil pump (YD/731E). Floor drains in the top of the central caisson were piped to the seawater disposal caisson, TD-51102, mounted inside the central caisson. Drains from the water injection treatment packages are piped to the 600mm overboard dump pipes attached to the port-aft and starboard-aft columns.

3.4.2.4 *Deluge water drains:* Deluge water from skids handling large quantities of oil was collected and drained to the production caisson, (TD-5336601), mounted on the outside of the central caisson below the tank top level. Other deluge water flowed over the edges of the decks into the sea. The units provided with deluge water removal drains were the production separator skids, LP flare drum, and safety gas KO drum. The deluge water entered the production separation below the oil/water interface, passed through the caisson and discharged into the sea via a seal loop. The production caisson was designed to remove oil from the normal flowing stream of produced water, not from the flows of deluge water.

3.4.2.5 There was, in conclusion, no physical connection between the hazardous open drains and the DSTs other than through the atmospheric vent system.

3.4.3 **Closed Drains System including DSTs**

3.4.3.1 According to the Operating Manual ET-3010.38-1200-941-AMK-924 rev. B, the closed drain system was used *"for draining pressurised process systems during*

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normal operation and for maintenance." The closed drain system was subdivided in three sub-systems:

- Normal closed drains system;
- Oil storage system;
- Tank top deck sump system.

3.4.3.2 *Normal closed drains system:* This was used in normal operations to collect most of the process equipment drains as well as any flash vapour produced by reduction in pressure. The fluids were drained, either continuously under level control or intermittently by hand control, to the closed drain drum (V-45002), located on the tank top at 36576mm ABL (refer to the P and I diagram at Appendix D).

The liquids separated in the drum were pumped to the production trains. The drum was equipped with two identical pumps, one normally operating and the other in stand-by condition, ready to start if the liquid flow was too large for one pump only.

It is stated in the Operating Manual that *"When the inflow to the drum exceeds the capacity of one pump, the second pump starts, and if the pump fails to start, the dump valve XV53360102 opens and liquids are discharged under on/off level control to the Drains Storage Tanks."* It is also stated that *"liquids from the HP and LP Flare Drum Pumps, matrix separator via pump and closed drains pumps which normally go to the inlet of the production trains can be directed to the system for a limited period if a problem occurs in the oil separation trains".* Thus, water/hydrocarbons could be automatically routed to the DSTs from the closed drains drum but only in the case of pump failure and emergency shut down of the process plant.

3.4.3.3 *Oil storage system:* This is described as the use of the DSTs *"to collect liquids drained for maintenance or an emergency from equipment with a capacity too large for the Closed Drains Drum".* The oil storage system was to be employed only during maintenance or emergency conditions, in order to collect fluid coming directly from:

- the atmospheric separators (SG-12230303A/B), by valves manually operated.

- the produced water degasser (V-533601) to which other production separation vessels can be drained, by valves manually operated.

- the closed drains drum, when the liquids exceeded the capacity of the drum itself. If the stand-by pump failed to start (i.e. when low pressure at the common pipe line downstream from the pumps and high level in the drum were detected together), the closed drain drum was intended to discharge, under level control, fluids to the oil storage system, through the dump valve XV53360102. This valve would automatically open and close, if a high level condition was detected inside the DSTs (this is the system shown on the P and I diagram, DE-3010.38-5336-944-AMK-392, rev. B included in Appendix D). Alternatively, if both production trains were shut down because of emergency or maintenance, liquids collecting in the closed drains drum would be drained to the DSTs. They could not in such circumstances be pumped back to the process trains.

- the process inlet manifolds, by valves manually operated.

3.4.3.4 *The Tank Top Deck Sump System:* This was designed to hold drains from equipment on the tank top, which were too low to be routed to the closed drains drum. Liquids contained in the sump were pumped to the closed drain header and then the closed drains drum.

Items draining to the sump were:-

- Crude export pig launchers (LP-122301/A/B/C);

- Crude oil pipeline pumps (B-122302A/B/C);

- Crude oil pipeline pumps manifold (UQ-122312-02);

- Crude oil booster pumps (B-122301A/B/C);

- Fuel gas KO drum drain (V-513501);

- Fuel gas filters drain (FT-513501A/B).

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3.4.3.5 The closed drain system was not normally shutdown in the case of shutdown of the process system as drainage could continue running from the utilities. The system could have been shutdown only if the whole unit was shutdown and all liquids were no longer addressed into the system. This may have occurred for maintenance purpose.

3.4.3.6 In case of emergency shutdown in the closed drains drum caused, for example, by a high level alarm, the automatic functions of the Emergency Shutdown procedures would have stopped the drain pumps and closed the relevant valves. When both production trains were shutdown and the associated valves XV12230111/12230211 closed, the valve XV53360004 could have been opened to direct liquids to the DSTs.

3.4.4 **Atmospheric Vent System**

3.4.4.1 The units process plant was provided with three separate vent systems for the collection and release of gases and vapours to the atmosphere:-

i) The high pressure (HP) flare system. Gases and vapours entering this system originated from process equipment held under a relatively high internal pressure and were taken to the top of the flare tower.

ii) The low pressure (LP) flare system. Gases and vapours entering this system originated from process equipment at a lower internal pressure and again were taken to the top of the flare tower.

iii) The atmospheric vent system. Gases and vapours entering this system originated from process equipment and the DSTs which were not required to have an internal pressure greater than 0.5 bar above atmospheric pressure which is a very low internal pressure.

3.4.4.2 The P and I diagram for the atmospheric vent system (ET-3010.38-1200-941-AMK-924-14, rev. 0) included at Appendix E and the Operating Manual "HP and LP Flare and Atmospheric Vent" (E-3010.38-1200-941-AMK-924-14 rev. 0) describes the nature and use of the atmospheric vent system. As indicated above, it collected hazardous releases from low pressure systems including the TEG (Triethylene

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Glycol) regenerator, the gas booster compressor seals, the oxygen scavenger tank and the DSTs.

3.4.4.3 The vent system consisted of an 8-inch diameter header pipe leading to a vent exit at a position on the flare tower. Pipes from parts of the process plant and the DSTs connected to this header pipe. A flame arrestor was fitted at the vent exit. A pressure sensor was fitted to detect high pressure in the vent arising from blockage of the flame arrestor but there was no low-pressure sensor. There was also a temperature sensor to detect the presence of a flame at the vent tip should the gas/vapour be accidentally ignited. There was a CO_2 system at the tip to extinguish such a flame.

3.4.4.4 At initial start up the entire process plant including atmospheric vent system was to be filled (purged) with nitrogen. This was to include the internal space of the DSTs. The purpose of the nitrogen purge would have been to exclude oxygen from the system and exclude the possibility of an explosive oxygen/gas/vapour mixture. Once the plant was in operation the flow of gas/vapour out of the system should have excluded the entry of air including oxygen.

3.4.4.5 It is to be recalled that the ANP/DPC report concluded that the overflow of the hazardous open drains drum into the atmospheric vent pipes was one of three possible sources that led to the initial filling of the DSTs. This should not have occurred since the drum was fitted with two high level sensors, one to start the relevant standby pump and the second to initiate ESD level 2 (emergency shutdown). For over filling to have occurred then both sensors must have been defective or, if not, emergency shutdown must have been disabled. Furthermore, a consideration of the configuration of the piping and the levels of various equipment connected to it would suggest that had the drums overflowed they would not have flowed to the DSTs but that the fluids would instead have overflowed the coamings of the drains of skids onto the main deck aft. This leads us to question the validity of the possibility arising from the ANP/DPC investigation that filling of the DSTs may have occurred due to overflowing of the hazardous open drains storage drum through the atmospheric vent system. If we are correct, the other two sources may have been the cause or there may be some other reason for the DSTs having initially been partly filled with water and oil. The two other sources mentioned in the ANP/DPC report

were discharging oil from the waste oil tank via the closed drain vessel and draining of water used in hydrostatic tests of the process plant.

3.4.5 **Level Control**

3.4.5.1 Each DST was equipped with two level switches, one high level and one low level. At initial start up of the process plant the Operating Manual required the DSTs to be filled with fresh water to above the level of the low level switch. If the liquid level in the tank reached the high level switch it would initiate emergency shutdown.

3.4.5.2 If the liquid level in the tank at the time of the rupture had reached or exceeded the height of the high level switch, then this would have caused an emergency shutdown. It follows that either the liquid level had not reached this level or that the switch was not functioning, as it should have.

3.4.6 **Pumping Out the DSTs**

3.4.6.1 The discharge pumps, one at each of the port and starboard DSTs are described on the P and I diagram for the DSTs as of a capacity of $50m^3$/hour at a delivery pressure of 19.0 bar. In the Operating Manual they are described as having a capacity of $60m^3$/hour at a delivery pressure of 19.0 bar.

3.4.6.2 The Operating Manual makes it clear that the operation of the DST pumps required manual intervention by the pressing of a start/stop push button at the pumps. Liquids in the tanks could be pumped out to either of two locations:

i) To the drains inlet manifold which was at the inlet of the production trains before crude and gas from the wells was processed. This was to be the case where there was oil in the tank. In so doing there would have been the risk of crude oil and/or gas flowing from the inlet manifold into a DST. This would have occurred should one of the tank inlet valves have leaked or been left open or should one of the pumps have failed or been defective to operate so as to allow the reverse flow of gas or fluid. This is what is stated to have actually occurred prior to the first mechanical explosion (rupture) of the starboard DST.

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ii) If the liquid consisted of a large volume of water it was to be pumped to the Production Caisson for disposal to sea. If liquid was directed to the Caisson there was no risk of crude oil or gas flowing back to the DSTs.

3.4.6.3 The Operating Manual states that when pumping from a DST to the drains inlet manifold it was first necessary to check that the production trains were "lined up" to receive fluid, that is there were no valves closed at the production trains such as to prevent the flow of fluids into them. The next step was to close the inlet valve to the relevant DST. This is shown on the P and I diagram as a locally operated valve which is normally locked open. The remotely controlled valve (XV5336004) to the inlet manifold was then to be opened. The next stage was to open the suction and discharge valves to the pump, these were remotely operated valves and the valve status was to be checked. The next stage was to start the pump by the push button at the pump.

3.4.6.4 The level in the tank was then to be monitored as the tank was pumped out and when the level had reached the low-level trip the pump would automatically stop. The pump suction and discharge valves were then to be closed as was the valve to the inlet manifold.

3.4.6.5 In the case of pumping to the Production Caisson the Operating Manual stipulates that the liquid was to be sampled frequently to prevent the transfer of oil to the caisson but no description is provided of how the liquid was to be sampled.

3.4.7 **Monitoring the Level of Liquid in the DSTs and Purging**

3.4.7.1 The Operating Manual - Closed Drains under the heading "System Description", states that:-

"The tanks are purged by a small flow of nitrogen through a dip pipe which also gives an indication of level".

Under the heading *"Normal Operation"* it states *"check that a small flow of nitrogen is maintained to the Deck Sump and Drains Storage Tanks for level measurement".*

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3.4.7.2 The P and I diagram for the DSTs indicates a 1" diameter nitrogen purge line connected to a dip (or sounding) pipe to each tank via a needle valve.

The Operating Manual - HP and LP Flare and Atmospheric Vent states that at initial start up the process system the entire atmospheric vent system and DSTs are purged with nitrogen and that "*the nitrogen purge to the drains storage tanks is started to prevent air entering the system*".

3.5 SOURCES OF FLAMMABLE MATERIALS IN DSTS

3.5.1 We summarise below the circumstances under which flammable liquids and/or gas/vapour could have been released into the DSTs. This summary is based on information concerning the planned use of the tanks available from drawings and manuals submitted to RINA for approval or information.

a) *Malfunction of Valves in Piping to Process System*

In normal operation gas/vapour and/or flammable liquid may have leaked through valves and into pipes connecting the process plant to the DSTs. Alternatively such valves may have been opened due to human error. In either case the release to the tanks would be accidental and very infrequent.

b) *In Emergency Automatically*

In the case of the closed drains drum pumps failure and high level of liquids in the drum, the contents of the closed drains drum would be automatically routed to the DSTs. This should have occurred very infrequently as it would require the failure of two pumps. It should also only have occurred together with an emergency shutdown so that the amount of fluid entering should have been relatively small.

c) *In Emergency by Manual Intervention*

In the case of a problem with the oil separation trains, liquid from the HP and LP flare drain pumps, matrix separator oil pumps and closed drains

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pumps could be diverted from the process inlet manifold to the DSTs. In addition, in the case of shutdown of the production trains, liquid draining to the closed drains drum could be routed to the DSTs.

The use in these circumstances would only result from an emergency in terms of a shutdown or failure of equipment and would be expected to occur very infrequently.

d) *During Maintenance of the Process Plant*

During maintenance of the process plant the contents of the atmospheric separators and other vessels being greater than the closed drains drum could be drained to the DSTs. Such use would be expected to have occurred infrequently, in light of the operating/operations manuals.

e) *During Pumping Out of the DSTs to Process Inlet Manifold*

When pumping out the DSTs to the process inlet manifold, the inlet and discharge piping would have been subject to back pressure from the process inlet manifold as pumping out of fluids to the process inlet manifold could only occur with production in operation.

Pumping out of fluids would have been an infrequent event as it could only have resulted from one of the emergency or maintenance activities stated above.

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4. DESCRIPTION OF SPACES ADJACENT TO DSTS

4.1 There are some important features concerning the various compartments around the DSTs, namely those in the aft columns that are relevant to the hazardous area classification of those spaces. The features concern the connections between the compartments through which a flammable vapour, gas or fluid might pass and the ventilation arrangements.

4.2 VENTILATION

4.2.1 The compartments in the columns were ventilated as per Fincantieri drawing no. A51633080 "Hull Ventilation System – One line diagram " rev. G (see particulars in Fig. 4 and Fig. 5) and document no. G51633065 "Hull Ventilation System – Calculation". We understand that according to the information provided to RINA, there has not been any variation in the column ventilation during and after the conversion. For each column, the number of air changes per hour was set to 10. In each aft column the supply airflow rate was designed at 14900 m^3/h: in particular, in the compartment between 21336 ABL and 28956 ABL (level 4), the air supply and exhaust flow rate was designed at 6000 m^3/h.

4.2.2 Each of the aft columns was served by a supply fan and an exhaust fan located at second deck level. Air was delivered to the supply ducting to level 2 in each column from where it was supplied by vent piping to all working levels and the lower hulls below. An exhaust trunk located at the centre of each column ran from the lower hulls to level 3. Air was extracted into this trunk at various levels of the column. From level 3 it was piped via a trunk from level 3 to the tank top and then to the exhaust fan. The exhaust trunk also served to house vent pipes running down the columns as well as electrical cables.

4.2.3 The exhaust and supply fans were connected to ventilator heads located on the main deck. Remotely operated watertight valves were placed in the supply and exhaust vents at watertight divisions below the upper hull. This was to prevent water flowing from one watertight compartment to another in the event that one or more compartments became accidentally flooded.

4.2.4 The various tank and void spaces in the columns were vented separately in the usual way by air pipes.

4.2.5 There was an elevator at the centre of each column which ran continuously from the lower hulls to the second deck. This ran beside the ventilation exhaust trunk. Watertight doors were fitted between the trunk and the column at the lower pontoon, level 4, level 3 and tank top. At the second deck level there was a fire door.

4.2.6 Each of the elevator trunks were ventilated by a separate system to the columns. They were each fitted with an exhaust fan of 600m^3/hour capacity located at second deck level. The fan is directly connected to a gooseneck type vent pipe at main deck level.

4.3 ACCESS STAIRS AND DOORS BETWEEN LEVELS IN THE COLUMNS

4.3.1 Stairs at second deck level leading into the aft columns and the upper deck were fitted with watertight doors. At tank top level, stairs down to level 2 were also fitted with watertight doors. From second deck level stairs ran to level 3. At level 3 a watertight hatch in the deck gave access to level 4. At level 4 a watertight door gave access to stairs leading to the lower hull.

4.3.2 Thus, at level 4 there were two watertight doors, one serving stairs to the lower hull and the other the elevator. They were both sliding doors.

4.3.3 The hatch at level 3 leading to level 4 was a flush watertight hatch which, according to the Operating Manual (MA-3010.38-1320-915-NBD-909-04 rev. 0, para. 4, item 4.1.4.2), was to be normally kept closed.

4.4 MACHINERY INSTALLATION

4.4.1 We list below items of machinery installed in the starboard aft column. The list has been compiled from Drawing no. DE-3010.38-1200-200-AMK-117 "Unit P36 Plant Layout – Riser Platform Aft/Star EL.28956-EL.35000 ABL", rev. E attached to the "Operations Manual – Vol. 1 General, no. MA-3010.38-1320-915-NBD-909-01, rev. A" (refer to Fig. 6) and to the AMEC document "Equipment List", no. LI-3010.38-1200-941-AMK-002, rev. B dated 03.10.1997. We understand that the plant layout drawing

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attached to the Operations Manual was never sent to RINA for information or approval.

Between Level 3 and 4

i) Drains Storage Pump

ii) Potable Water Transfer Pump - this pump was an existing pump for use in drilling operations and was therefore redundant.

iii) Vacuum Pump

iv) Waste Oil Pump

Between Level 2 and 3

v) Oily Water Separator

4.5 BILGE PIPING AND DRAINS PIPING:

4.5.1 According to the original builders drawings (Fincantieri drawings no. A51531060 "Diagram – Interior Deck, Drain Piping System", rev. D and no. A50521175 "Diagram Bilge Piping System", rev. N) at level 4 of the aft starboard column coamings with strainers were fitted around the base oil pump (which was changed to a drains storage pump) and the waste oil pump to collect any fluids leaking from them. Each of these two coamings was connected to a pipe of 50mm diameter that joined a drain line of 65mm diameter coming from the level 3 compartment (refer to Fig. 7). The 65mm drain ran down to the lower hull to a quick acting, self closing valve (SE*019VX). This valve was manually operated locally. The drain pipe then led to the bilge sump, which also connected drains from other not hazardous spaces, i.e. voids, through remotely operated stop-check valves which were fitted with manual override (SE*029VD, SE*029DV, SE*030VD, SE*030DV). We understand that such drawings were not updated, either during or after the conversion indicating that these arrangements were not altered during the modification of the unit.

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4.5.2 In summary, the drains connected the level 4 compartment to the lower hull but via a valve that was only opened to release fluids collecting in the pump coamings to the bilge sump from where they would have been pumped out by the bilge system. Such valves would normally be kept closed and would only be opened if it was necessary to drain fluids and then only for the short period of time necessary to remove a very small volume of fluid.

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5. RULES AND STANDARDS FOR HAZARDOUS AREA CLASSIFICATION

5.1 GENERAL PRINCIPLES

5.1.1 We have provided a general definition of a hazardous area at paragraphs 1.2.3 to 1.2.5 in the introduction to this report.

5.1.2 We now provide a description of the Rules and standards applicable to RINA's approval of hazardous area classification.

5.1.3 We understand that RINA publish three sets of rules, which may have relevance to the classification of hazardous areas and, to the specification of equipment in those locations, as per following paragraphs.

5.2 RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF MOBILE OFFSHORE DRILLING UNITS AND OTHER SIMILAR UNITS (RINA RULES)

5.2.1 **Definitions**

5.2.1.1 These Rules are a copy of the MODU Code but provide additional requirements. We therefore do not intend to describe the MODU Code provisions separately. A hazardous area is defined at 1.3.4.1.1. as *"Hazardous areas are those areas where, due to possible presence of a flammable atmosphere arising from the drilling operations, the use without proper consideration of machinery or electrical equipment may lead to fire hazard or explosion"*. An "area" is a space on, around or within the unit. It may be an enclosed space such as a tank or internal compartment or an open space such as the open deck.

5.2.1.2 A further definition of relevance is for an Enclosed Space, 1.3.4.1.1 *"Enclosed spaces are spaces delineated by floors, bulkheads and/or decks which may have doors and/or windows"*.

5.2.1.3 A limitation of the RINA Rules and the MODU Code is that, as the hazardous area definition above suggests they refer particularly to a unit arranged for drilling rather than production. However the RINA Rules (at para 5.3.1) make reference to the

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recommendations published by the International Electrotechnical Commission (IEC). Furthermore the RINA Rules (at para I.3.1) state that:

"Except as otherwise stated or modified in these Rules, the relevant requirements of the RINA Rules for the Construction and Classification of Ships apply."

5.2.1.4 These Rules in turn refer to the IEC standards. The IEC standards as discussed below provide specific guidance with respect to mobile production units.

5.2.2 **Zones**

5.2.2.1 Under RINA Rules, MODU Code and IEC standards, hazardous areas are divided into three zones, which define the likelihood that an explosive mixture will be present. The likelihood is a function of not only frequency of release of a flammable substance but also the rate of the release and the ventilation arrangement. The zones are generally defined (at 6.1.1) as:-

"Hazardous areas are divided into zones as follows:-

Zone 0: in which an explosive gas/air mixture is continuously present or present for long periods.

Zone 1: in which an explosive gas/air mixture is likely to occur in normal operation.

Zone 2: in which an explosive gas/air mixture is not likely to occur, or in which such a mixture, if it does occur, will only exist for a short time.

5.2.2.2 It can be seen from the above that the time period for which the explosive mixture will, or is likely to prevail in the zone in question, is fundamental to the zone definition. The Rules do not provide guidance on the duration in terms of hours or other measure that is to be associated with the description "long periods", "likely" or "short time" as stated in the Rules. The RINA Rules (at para 6.2) provide examples of assigning zones to hazardous areas on a drilling unit. These examples are of little assistance to the case of P-36, which was arranged for production, rather than drilling and so we do not discuss them here. In particular, the examples do not assist to any great extent in the

consideration of the consequence of the likelihood of occurrence of an explosive gas/air mixture. It is therefore appropriate to refer to the applicable IEC Standards for further guidance. These are considered at 5.5 and 5.6 below.

5.2.3 Openings Access Doors and Ventilation

5.2.3.1 Having classified a particular area as a particular zone then it is necessary to consider the influence of that area on any spaces connected to it. Para 6.3 of the MODU Code and the RINA Rules are relevant to openings, access doors and ventilation conditions affecting the extent of hazardous areas. Except for operational reasons it is provided that no opening should be provided between a non-hazardous space and a hazardous area or between a zone 2 space and a zone 1 space. Nevertheless, when it is not possible to give up such access doors or other openings, any space not reported in para. 6.2 and having direct access to any zone 1 location or zone 2 location becomes the same zone as the location, unless certain conditions are satisfied simultaneously. For instance, following the subpara. 6.3.1.2, an enclosed space with direct access to any zone 2 location is not considered hazardous if:

- the access is fitted with a self-closing gastight door that opens into the non-hazardous location, and
- ventilation is such that air flow with the door open is from the non-hazardous space into the zone 2 location, and
- loss of ventilation is alarmed at a manned station.

5.2.4 Piping Systems

There is a particular requirement in the RINA Rules and the MODU Code at paragraph 6.3.2 under the general heading *"Openings, Access and Ventilation Conditions Affecting the Extent of Hazardous Areas"* that:

"Piping systems should be designed to preclude direct communication between hazardous areas of different classifications and between hazardous and non-hazardous areas"

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5.3 RINA "RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF FLOATING UNITS INTENDED FOR THE PRODUCTION, STORAGE AND OFF-LOADING OF LIQUID HYDROCARBONS"

These Rules do not provide any particular definition of hazardous areas but point, at paragraph 7.1.1, to the necessity for compliance with RINA's "Rules for the Construction and Classification of Ships".

5.4 RINA "RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF SHIPS" (RINA SHIP RULES)

5.4.1 These Rules (at Sec. D, Part I, Ch.1, item 1.3.1 - edition 1996) state that:

"Where the requirements for some parts of electrical installations are not laid down by RINA Rules, reference is to be made to the standards of the Comitato Electrotecnico Italiano (CEI), the standard of the International Electrotechnical Commission (IEC) or the European Norms (EN) insofar as applicable to shipboard electrical installations. Materials, equipment or machinery complying with standards other than those of the CEI, IEC or EN referred to in these Rules may be accepted by RINA, provided they are in accordance with recognised standards."

5.4.2 With reference to the classification of hazardous areas, the RINA Rules (at Sec. D, Part II, Ch.1, Para. 1.3, item 1.3.2) state that:

"The electrical equipment specified in 1.3.1 is to be constructed in accordance with the relevant provisions of European Norms series EN 50...or with the IEC Publication 79 series or with other recognised standards. In addition, the specific requirements in Appendix A to IEC Publication 92-502 (1980) are also to be complied with."

5.4.3 A relevant part of the Rules appears to be Section D, Part V, Chapter 3 - Electrical Installations on Oil Tankers, Chemical Tankers and Gas Carriers. This provides a definition of a hazardous area (section 3.1.4) as follows:-

"Hazardous areas of ships specified in 3.1.1.2 are those where flammable or explosive gases or vapours may normally be expected to accumulate".

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5.4.4 At paragraph 3.1.4.3 it is clarified that hazardous areas may extend to such areas in which flammable or explosive gases or vapours may accumulate but only for short periods. At paragraph 3.1.4.4 it is stated *"Spaces containing cargo and all zones or spaces adjacent to cargo tanks are generally regarded as hazardous".*

5.4.5 These Rules are consistent with the MODU Code and applicable IEC standards, which are referred to.

5.5 INTERNATIONAL STANDARD IEC 61892-7 MOBILE AND FIXED OFFSHORE INSTALLATIONS- ELECTRICAL INSTALLATIONS- PART 7: HAZARDOUS AREA (IEC 61892-7)

The provisions of this standard are almost identical to the MODU Code and hence the RINA Rules. However, para *"4.4 Mobile production units" states that "Area classification of mobile production units shall comply with national recommendations. IEC 60079-10 shall be taken into account".*

5.6 INTERNATIONAL STANDARD IEC 60079-10 ELECTRICAL APPARATUS FOR EXPLOSIVE GAS ATMOSPHERES PART 10: CLASSIFICATION OF HAZARDOUS AREAS (IEC 79-10)

5.6.1 **Zones**

5.6.1.1 This standard is consistent with the MODU Code in that the definitions of zones, as set out below, is very similar. The standard clarifies that hazardous areas are classified into zones based on the frequency of occurrence and duration of an explosive gas atmosphere. The code notes that: *"Indications of the frequency of the occurrence and duration may be taken from codes relating to specific industries or applications."* This standard is particularly relevant as it sets out safety objectives, area classification objectives and in consequence an area classification procedure that is helpful with respect to the classification of the DSTs and adjacent areas.

5.6.1.2 The definition of zones according to IEC 79-10 is:

"Zone 0: An area in which an explosive gas atmosphere is present continuously or for long periods.

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Zone 1: An area in which an explosive gas atmosphere is likely to occur in normal operation.

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.

Indications of the frequency of the occurrence and duration may be taken from codes relating to specific industries or applications."

5.6.1.3 A definition of a non-hazardous area is given as:

" An area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of apparatus."

5.6.2 **Safety Principles**

5.6.2.1 It is stated that: "*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 the case of maintenance activities other than those of normal operation, the extent of the zone may be affected but it is expected that this would be dealt with by a permit-to-work system."

5.6.2.2 It is clear from this that matters concerning the maintenance and operation of installations are important considerations with respect to hazardous area classification.

5.6.3 **Normal Operation**

5.6.3.1 This is defined as the situation when the equipment is operating within its design parameters. It is noted that failures that involve urgent repairs, such as breakdown of

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pump seals or shut down are not to be considered as part of normal operation but that minor releases may be.

5.6.4 **Area Classification Objectives**

5.6.4.1 It is relevant to quote the IEC standard under this heading as follows:

"In most practical situation where flammable materials are used, it is difficult to ensure that an explosive gas atmosphere will never occur. It may also be difficult to ensure that apparatus will never give rise to a source of ignition. Therefore, in situations where an explosive gas atmosphere has a high likelihood of occurring, reliance is placed on using apparatus which has a low likelihood of creating a source of ignition. Conversely, where the likelihood of an explosive gas atmosphere occurring is reduced, apparatus constructed to a less rigorous standard may be used.

It is rarely possible by a simple examination of a plant or plant design to decide which parts of the plant can be equated to the three zonal definitions (zones 0, 1 and 2). A more detailed approach is therefore necessary and this involves the analysis of the basic possibility of an explosive gas atmosphere occurring".

This part of the standard is very relevant to the hazardous area classification of the DSTs as the intended use of the tanks, particularly in terms of the frequency and circumstances under which they might contain a hazardous atmosphere, is fundamental to the exercise.

5.6.5 **Area Classification Procedure**

5.6.5.1 The standard describes a procedure and schematic approach for establishing hazardous zone types. Every item of process equipment is considered to be a potential source of release of a flammable material. If an item does not contain a flammable material or if it does but cannot release it (for example an all welded pipe) then there is no source of release and there can be no hazardous area around the item. This leads to the assessment of the grade of any the release as continuous, primary, or secondary dependent on the nature of the opening and the frequency and duration of the release, which is assessed amongst other things on the basis of the

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type of opening. A secondary release for example is defined as one, which is not expected to occur in normal operation, and if it does occur, is likely to do so only infrequently and for short periods.

5.6.5.2 Once the grade of the release has been established the influence of the degree of ventilation is considered in order to arrive at the area classification. For example a continuous grade release from a zone 0 area into an area with a high degree of ventilation with good availability would be classified zone 0 negligible extent and equivalent to non-hazardous. On the other hand if the degree of ventilation were low it would be classified as zone 0. Therefore, this standard allows for adjacent areas to have differences in hazardous area classification of more than one division.

5.6.5.3 Finally it is to be noted that the standard makes a recommendation on the knowledge of those carrying out the area classification in the following terms: "The area classification should be carried out by those who have knowledge of the properties of flammable materials, the process and the equipment, in consultation, as appropriate, with safety, electrical and other engineering personnel."

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6. DST HAZARDOUS AREA CLASSIFICATION ACCORDING TO RINA RULES AND ASSOCIATED IEC STANDARDS

6.1 GENERAL

6.1.1 The question addressed in this section is, whether the hazardous area classification for the DSTs and the aft columns, on the basis of the planned use of the tanks as indicated in the documents and drawings provided to RINA for information and/or approval, was appropriate and complied with the RINA rules, including the MODU Code and supplemented as necessary by IEC standards.

6.2 DSTs

6.2.1 According to the definitions of zones,it would not have been reasonable to have classified the DSTs as zone 0 as it is clear that it was not planned that they were to be used in a way that gave rise to the likely presence of an explosive gas/air mixture continuously or for long periods.

6.2.2 The question is now addressed as to whether the DSTs should be classified as zone 1. It is necessary to establish whether an explosive gas/air mixture is likely to occur in normal operation. Whilst the RINA MODU Rules do not define normal in this context, the standard IEC 79-10 does (refer to 5.6.3 above) and this clarifies that valve failure, maintenance and emergency conditions should not be considered as part of normal operation. They could not contain an explosive gas/air mixture in normal operation since this does not by definition allow for failures or emergency situations. We therefore consider that the DSTs could not on this basis be considered as zone 1.

6.2.3 Now we turn to the question as to whether the DSTs might have been classified as zone 2. We have already established that an explosive mixture was not likely to occur in normal operation. If a flammable gas/vapour were to occur then this should only have been for a short period of time whether or not resulting from emergency, maintenance or valve failure. It is therefore considered that the DSTs could have been classified as zone 2 as they fell well into the definition of such a zone. We should also question whether they might also fall into the category of non-hazardous.

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6.2.4 As mentioned above, IEC79-10 suggests the use of operational procedures such as a permit-to-work system or isolation of unsuitable electrical equipment or shut down of process etc may be adopted to provide an acceptable level of safety in the case of maintenance or emergency conditions. As an explosive mixture should only have occurred very infrequently and outside normal operational parameters it may have been appropriate to have considered the DSTs as non-hazardous but only in the presence of operational procedures that were of a nature that would have provided an acceptable level of safety.

6.2.5 A further factor to be taken into account is the system fitted to the DSTs to introduce a flow of nitrogen into them as a purge. The purpose of doing so is to expel air (and hence oxygen) so that an explosive gas/air mixture cannot arise even if a flammable gas/vapour exists. Neither the RINA MODU rules nor IEC 79-10 provide guidance on how to account for the presence of a nitrogen purge in such circumstances. However the combination of infrequency of presence of flammable vapour in combination with the provision of a nitrogen purge might in our opinion have provided the necessary conditions for a classification of the tanks as non-hazardous.

6.2.6 Classification of the DSTs may also be assessed in accordance with the systematic approach according to IEC 79-10 (refer to 5.6.5 above). We first consider the sources of release into the tank. In normal operation of the process plant there should be no release of flammables into the DSTs. There may be a release in the unlikely event of a valve malfunction or resulting from maintenance or emergency conditions. The release into the tank in such circumstances would be graded as secondary. The hazardous area classification depends on not only the grade of the release but also on the degree/availability of ventilation. The purpose of ventilation in such circumstances is to reduce the likelihood of an explosive gas/air mixture by diluting/removing the gas/vapour. An alternative approach is to remove air/oxygen by the use of a nitrogen purge as described above. The IEC 79-10 standard provides that a secondary release into a space equipped with a high degree of ventilation, which has good or fair availability, would result in a classification of non-hazardous. If there were only a medium degree of ventilation the classification would be zone 2. The tanks are poorly ventilated but they were equipped with a nitrogen purge. Unfortunately IEC 79-10 does not provide guidance on the influence of a purge on classification. However applying a similar approach in relation to a nitrogen purge, in

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place of the influence of a high degree of ventilation, it would appear reasonable, in the presence of an effective nitrogen purge, to classify the tanks as zone 2 or even non-hazardous.

6.2.7 In summary we conclude that a reasonable hazardous area classification for the DST's on the basis of RINA MODU rules would have been zone 2 or alternatively non-hazardous.

6.3 THE COLUMN SPACES

6.3.1 Possible sources of flammable liquids/gas/vapour entering the column may be summarised as follows:

Leaks from DST discharge pumps as well as associated pipe flanges and valves.

Leaks from DST inlet pipe flanges and associated valves.

Leaks from vent pipe flanges (if any existed).

Leaks from sounding pipe flanges (if any existed).

6.3.2 A primary consideration in establishing the appropriate hazardous area classification is the likelihood of release of a flammable gas/vapour. In the case of the column spaces the likelihood of a release is very much smaller than for the DST's since a release into a column could only occur after a release into a DST followed by a further failure and release from the DST piping system to the column. On this basis it would be reasonable to classify the columns less stringently than the DSTs themselves. We have concluded above that the DSTs would not have been classified more stringently than zone 2. As a result it would have been reasonable to have taken the columns as un-classified.

6.3.3 Classification of the columns can also de judged by direct reference to the definition of zones. It is clear that zone 0 and zone 1 would not apply, as an explosive gas/air mixture would not be present in normal operation. Considering the infrequent use of the DSTs in the case of emergency or maintenance and the unlikelihood of a release from the discharge pump, valves or fittings, bearing in mind the infrequency that they

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would contain a hazardous liquid or gas/vapour combined with the good nature of ventilation of the space within the column, we consider that a non-hazardous classification would be reasonable. It would be important in such circumstances however that actual operating procedures were adhered to in the use of the DSTs for emergency or maintenance only.

É CÓPIA FIEL DO DOCUMENTO ORIGINAL

JOSÉ CARLOS PIMENTEL CUSMÃO
Diretor da Divisão de Serviços Corretivos

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7. APROVAL OF HAZARDOUS AREA CLASSIFICATION DRAWINGS

7.1 Hazardous Area Classification drawings prepared by AMEC such as DE-5400-9470-AMK-120, Rev. B "Hazardous Area Classification - Columns & Riser Platform EL 28956199 - EL 31955 A.B.C." (refer to appendix F) were approved by RINA.

7.2 The drawing labels the spaces in the column that were to become the DSTs as Base Oil Tanks in accordance with their original use. The drawing has indicated certain areas as hazardous but it has not identified the Base Oil Tanks (DSTs) or areas in the aft columns as hazardous.

7.3 When approving the plan, RINA made the following remarks concerning the classification of hazardous areas:-

"With ref. to your drwgs a.m. we point out that, according to IEC 61892-7 and MODU Code (see enclosures), the internal spaces of closed tanks are to be considered zone 0.

However, note that zone 1 includes, in outdoor or semi-enclosed locations, the area within 1,5m from boundaries of any openings to apparatus which is a part of the mud system (see 6.2.3.4 of MODU Code), while zone 2 is relevant to the areas 1,5m beyond the zone 1 areas specified in 6.2.3.4 of MODU Code and beyond the semi-enclosed locations specified in 6.2.3.2."

7.4 This remark appears to have been a general instruction to the designers that the hazardous area classification should extend to all those areas required by the MODU code and the IEC 61892-7 standard to be regarded as closed tanks. The remark was general but with regard to the DST's what was important was their intended use in accordance with the operating/operations manuals.

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8. GAS DETECTION

8.1 We understand that gas detectors were not fitted in the columns. This is consistent with areas adjacent to DST's as not having been classed as hazard areas. However, even if gas detectors had been fitted, it is clear that their presence could not have prevented the first mechanical explosion. With respect to the second chemical explosion, it is most uncertain that the presence of gas detectors in the column would have made any difference to events. The mechanical explosion and subsequent escape of gas, vapour and fluids under pressure was, in our view, almost certain to have caused the failure of any gas sensor in the vicinity. In any event, many gas alarms among those located on the upper decks were actually activated after the first mechanical explosion. It is therefore clear that the presence of gas was actually detected and that the presence of additional sensors and alarms are unlikely to have influenced events.

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9. CAUSES OF THE ACCIDENT

9.1 CONSEQUENCE ANALYSIS

9.1.1 A number of events (failures, defects and damages) have been identified in the ANP/DPC report as well as by other inquiry commissions as having a particular causal relationship to the casualty. In the Consequence Schedule at Appendix G we list the events and make a judgement on their contribution to the four major events leading to the casualty. These major events were:-

A. The first mechanical explosion

B. The second chemical explosion

C. Progressive flooding

D. Sinking

9.1.2 The schedule summarises the consequences of the absence of an event such as the blind flanging of the atmospheric vent pipe to the starboard DST on the major events listed above. It can be seen from the schedule that the absence of any of 14 (fourteen) events would have prevented the loss of the unit.

9.1.3 The question that may be asked is, had the DSTs or the column been provided with a more stringent hazardous area classification whether any of the major events leading to the casualty would have been avoided.

9.2 THE FIRST MECHANICAL EXPLOSION

9.2.1 The first mechanical explosion resulted from the over pressurisation of the starboard DST. This was caused directly by faulty maintenance activities and faulty operation of the port and starboard DSTs (refer to events 1 to 6 of the consequence schedule at appendix G). It is clear that this was not related to the hazardous area classification of the DSTs or the columns.

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9.2.2 Hazardous area classification assumes relatively minor accidental leakages. A catastrophic mechanical rupture of the sort that has been deduced to have occurred to the starboard DST is a far more severe failure than is anticipated might arise in normal circumstances. Thus the failure that occurred fell outside the ambit of hazardous area classification.

9.2.3 It is important to recognise that the mechanical explosion led not only to a massive escape of flammable gas but it also led directly to extensive damage to equipment and systems within the fourth level of the starboard column because of the explosion itself and particularly because of the consequential flooding of the column. Thus even if the columns had been fitted with gas detectors, which apparently they were not, the probability is that they would have been made inoperative by the mechanical explosion in any event.

9.3 SECOND CHEMICAL EXPLOSION

9.3.1 The rupture of the starboard DST was a catastrophic failure that resulted in the release of a large volume of flammable gas/vapour that vastly exceeded any quantity than would be entertained when assessing whether or not an area was hazardous. In simple terms, the catastrophic failure of the tank resulted in the certainty that an explosive gas/air mixture would develop within he column and in the hull above the column, thereby providing a very high risk of explosion. This has been demonstrated by the gas dispersion analysis carried out by MTL Engineering Ltda on behalf of PETROBRAS. Thus the main factor in the cause of the chemical explosion was the first mechanical explosion, which as we have stated above was not related to hazardous area classification. The massive over-pressurising and rupturing of the tank structure was a catastrophic failure. Such an event is not taken into consideration when assessing whether an area should be designated as hazardous. The adequacy of the response of the unit's personnel to the first mechanical explosion is also open to question with respect to the cause of the chemical explosion.

9.3.2 Despite the massive volume of release of flammable gas the chemical explosion would not have occurred in the absence of a source of ignition. Thus, it is not reasonable to assume that a more stringent hazardous area classification of the

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column spaces would have resulted in a different outcome. From evidence available, it is not possible to establish either the origin or location of the ignition. As an example, if the source of ignition was outside the column or was a mobile source within the column such as fireman's tools, portable equipment left in the area, etc. then a different hazardous area classification within the column or the DSTs would have had no influence.

9.3.3 Taking all the above into consideration, it is impossible to say with any certainty whether or not the second chemical explosion would have occurred had the DSTs or column been classified more stringently as a hazardous area. However, bearing in mind the very large magnitude of the gas dispersion that resulted in areas outside the column as a result of the mechanical explosion, we consider it as likely that there would have been no difference in outcome.

9.3.4 The flooding was, in our opinion, primarily a consequence of the first mechanical explosion, which resulted in the rupture of the seawater pipe at the fourth level and the consequent flooding of the column. The second chemical explosion did not cause the hull of the unit to flood and was clearly therefore insufficient in itself to have caused the loss but may have, amongst other things, caused damages to watertight doors/hatches at the upper levels of the column and /or other equipment. However, the sinking would have not occurred without other deficiencies / failures that prevented action being taken to restrict the rate of or further flooding of the unit.

9.4 <u>OPERATION AND MAINTENANCE OF THE UNIT AND ITS CLASSIFICATION STATUS AT THE TIME OF THE CASUALTY</u>

9.4.1 According to information provided in the various investigation reports, the unit was being operated in a manner that contravened the Operating Manual. In addition a number of the unit's essential systems and equipment were out of order or under repair, including:

(a) Frequent manoeuvres of the DSTs

(b) DST suction pump removed for repair;

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(c) Valves which were leaking;

(d) Air vent of the starboard DST blind flanged;

(e) Two pumps feeding the seawater ring removed for repair;

(f) Watertight dampers of the ventilation system out of use and relevant valves probably blocked open;

(g) Cracks in the stability box of the starboard column and compartments left open for ongoing repairs.

9.4.2 **DST Manoeuvres**

According to evidence available, it appears that the DST's were used frequently for the storage of fluids, such as water contaminated with oil. The source of the fluids that were held in the tanks has not been stated. The use of the tanks in this way was not something that was anticipated in the Operating Manual. Such a change of use of the tanks should have been confirmed to RINA and was not. RINA were not informed, as they should have been according to their Rules, that the tanks were being used in the way that they apparently were. Had RINA been informed they would have had the opportunity to carry out a survey and to make recommendations consequent to the change of use of the DSTs.

9.4.3 **DST Suction Pump**

In the ANP/DPC report it is stated that the pump of the starboard DST was removed for repair (on 10 February 2001) and the suction and delivery piping to the pump had been blind flanged. In another source of information it is stated that it was the second time that the pump was sent to repair. In addition, according to the ANP/DPC report, the suction pump of the port DST had also experienced problems at the time of the accident, delaying the start of discharge of the port DST and thereby causing the flooding of product / gas into the starboard DST through the production manifold.

In our view the removal of the starboard DST pump for repairs for such a long period of time cannot be considered a normal maintenance operation. Without the suction

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pump, the tank could not be emptied, so it had to be excluded from the closed drains system and put out of service.

9.4.4 Valves

According to witness statements, it was common for valves to leak. Looking at the sequence of alleged events leading to the casualty, the inlet valve V 535 to the starboard DST was leaking or was left partially open, causing the inflow of liquid into the starboard DST and consequent over pressurisation. The Operating Manual requires that both port and starboard EDT inlet valves be closed when pumping out. A history of leaking valves should have alerted a responsible person to check for such a failure prior to any pumping operation. In this instance it is clear that either the valve was leaking in which case proper checks were not carried out or it was not properly closed. RINA was not informed of these occurrences.

9.4.5 Air Vent of the Starboard DST

The DSTs were designed to store liquids at normal atmospheric pressure and temperature. They were not designed as pressure vessels. In the ANP/DPC report, it is stated that the air vent of the starboard DST was flanged to prevent a counter flow of water in the DST through the air vent system. This action substantially altered the tank's design characteristics:

a) It created the possibility of the tank being subjected to an over or under pressure. The tank was designed to operate at near atmospheric pressure and temperature. Such tanks should always be connected to an air or vent pipe/system commensurate with any possible means of filling or discharging the tank so as to prevent the development of a damaging positive or negative pressure. If a tank's vent pipe is closed off it is essential as a matter of principle to ensure that the tank cannot by any means become pressurised. This is a normal basic requirement in operating any ship or unit. By blanking off the vent pipe without also blanking off the inlet pipe the tank was automatically exposed to the risk of being over pressurised, causing a mechanical explosion.

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b) It caused the nitrogen purge to that tank to be inoperative.

c) It caused the tank level measuring system to be inoperative. Having blanked the vent pipe it was no longer possible to monitor how much fluid was in the tank or to detect fluids entering

The flanging of the vent pipe and the consequent alteration of the tanks characteristics is without doubt something that should have been reported to RINA and was never reported. We are of the firm opinion that had it been reported RINA would have recommended the tank be totally isolated by blanking off all inlet and outlet pipes. It is inconceivable to us that given that such an action is normal and routine basic safety practice that they would not have insisted on it.

9.4.6 Pumps Feeding the Seawater Ring

It is reported that two of the four pumps used for feeding the seawater ring, namely the forward and aft pumps in the port side pontoon, were out of order. This is another matter that should have been reported to RINA and was not reported.

According to the Operating Manual, at least two seawater pumps were required for normal services while one of the remaining pumps was to be on stand-by; this condition was not satisfied with two of the four pumps out of order. Moreover, if a fire had caused the main electrical generator to stop, only the emergency generator would have remained in operation. In this case because the port aft pump was out of operation only one pump instead of the required two pumps would have been running to supply water to the seawater ring. This would have been an insufficient condition for fire fighting purposes and not in compliance with the MODU Code or classification rules.

9.4.7 Watertight Valves and Dampers of the Ventilation System

According to the ANP/DPC report, the actuators to the watertight valves on the ventilation system were experiencing operational difficulties. The valves in the starboard column that should have closed so as to prevent water flowing from one watertight compartment to another failed to close allowing the entire column to flood.

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There is witness evidence to suggest that the watertight dampers were known to be defective and that PETROBRAS were replacing them with different arrangements.

The watertight integrity of the bulkheads sub-dividing the unit is a primary safety matter and if there was a defect particularly if it influenced a number of watertight bulkheads,as it appears that it did in this case, the classification society should without doubt have been informed. Similarly if it had been planned to replace any of the dampers RINA should have been informed and requested to attend to approve the work. RINA were not informed or asked to attend the unit.

9.4.8 **Cracks in the Stability Box of the Starboard Column**

According to the ANP/DPC report, some cracks in the welding were detected in the stability box 61S of the starboard column and manholes of tanks 62S (ballast tank) and 26S had been left open for inspection and ongoing repairs. These cracks had been previously patched from the outside by divers without the knowledge or approval of RINA.

Such cracks to the hull plating of the unit should have been viewed as a serious defect requiring that RINA was immediately informed the moment they were discovered. This is because such cracks have the potential to seriously affect the safety of the unit by allowing flooding of compartments, thereby compromising stability and by causing a structural weakness. It was essential that RINA were given the opportunity to evaluate the nature and cause of the cracks in order that they could be in a position to assess the consequences in terms of the unit's safety and to assess the type of repairs that were necessary. It is without doubt worldwide industry standard practice to keep the classification society informed of any such structural defect. The fact that they were not informed demonstrates in our opinion a disregard by the unit's operators to proper procedures relating to a primary safety issue.

RINA should have been informed of these cracks, their planned inspection and repairs. It is clear that by opening up the tank the operator was placing the unit at risk to flooding. This was not a routine inspection of a tank but to one known to be cracked. In our opinion there was consequently a duty on the operator to take special

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precautions to minimise the risk to the unit's safety. Carrying out this inspection at a time when two of the four main sea water pumps were out of action and when the watertight dampers were inoperative would certainly not in our view have met with the approval of RINA had they been consulted as they should have been.

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10. CONCLUSIONS

10.1 Investigations have shown that there were numerous defects, damages and alterations arising from maintenance/operational failures that should have been reported to RINA and were not. They were matters directly related to the loss.

10.2 These failures led directly to the first mechanical explosion, which was not in any way related to the hazardous area classification of the unit. Had the DSTs or indeed the column been more stringently classified, we have concluded that this would not have prevented the first mechanical explosion.

10.3 We are of the opinion that the main factor causing the second chemical explosion was the first mechanical explosion. The catastrophic rupture of the starboard DST and the consequent dispersion of a large volume of gas resulted in the certainty that an explosive gas/air mixture would develop in the column and in large areas of the hull above the column thereby providing a very high risk of chemical explosion. The first mechanical explosion would probably have damaged and made inoperative gas detectors in the column had they been fitted. The adequacy of the response to the first mechanical explosion is also open to question.

10.4 The source of ignition for the second chemical explosion may well have been at second deck or tank top level which are above the level of the column. These areas were most remote from the DSTs in the columns and would not have been influenced by a more stringent classification. We are of the opinion therefore that it is very likely that it would have made no difference had the classification been more stringent.

10.5 The second chemical explosion had catastrophic consequences to the surrounding areas but was insufficient in itself to have caused the loss as was the first mechanical explosion. We have concluded that many failures of a) to properly maintain the unit's process plant and safety systems and b) to properly operate the unit led directly to the first mechanical explosion, to the second chemical explosion and ultimately to the loss. If any one of these failures had not occurred, the loss would not have resulted.

10.6 The hazardous area classification of the DSTs and the aft columns was made correctly according to the applicable rules, based on the MODU Code and IEC

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standards, which in our view were entirely appropriate in the circumstances. They could have been non hazardous or at the most Zone 2

10.7 In any event the catastrophic rupture of the starboard DST that resulted in the widespread dispersion of a large volume of gas within the hull and legs is a far more pessimistic scenario than is normally considered when assessing whether areas should be classified as hazardous.

For and on behalf of
London Offshore Consultants

.....
A J SQUIRE, BSc., CEng., FRINA, MIMarEST.

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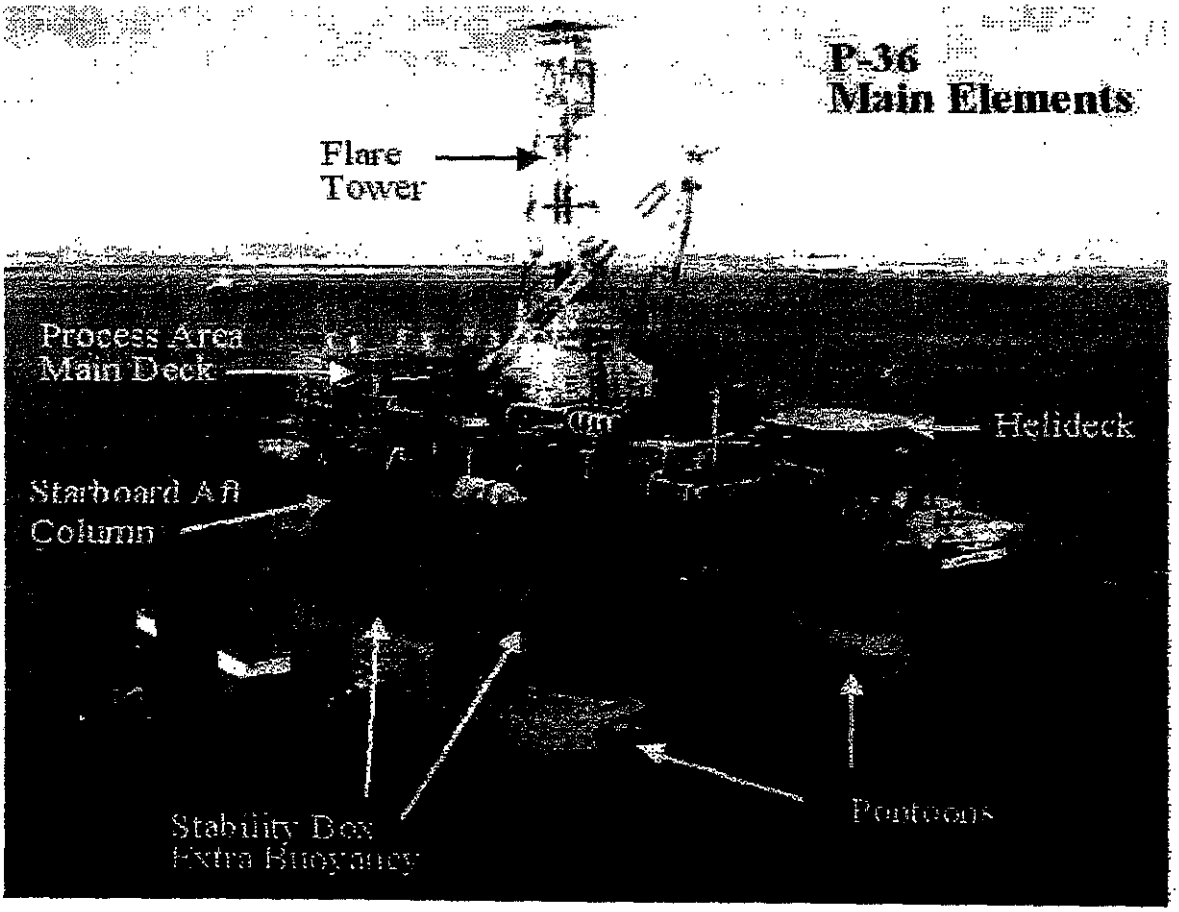

Figure 1 - The Platform P36

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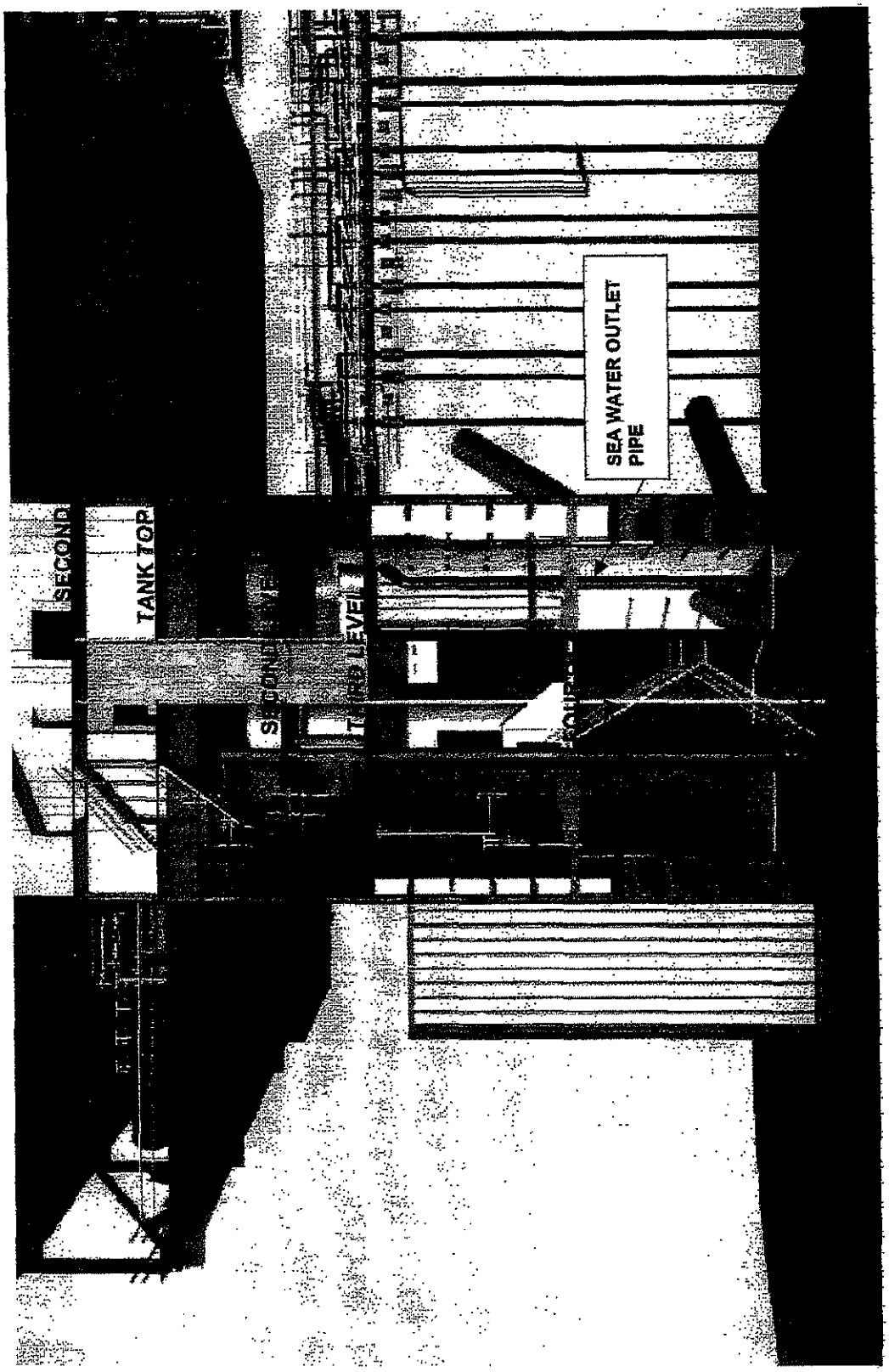

Figure 2 – Lower part of the aft starboard column

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Figure 3 – Upper part of the aft starboard column

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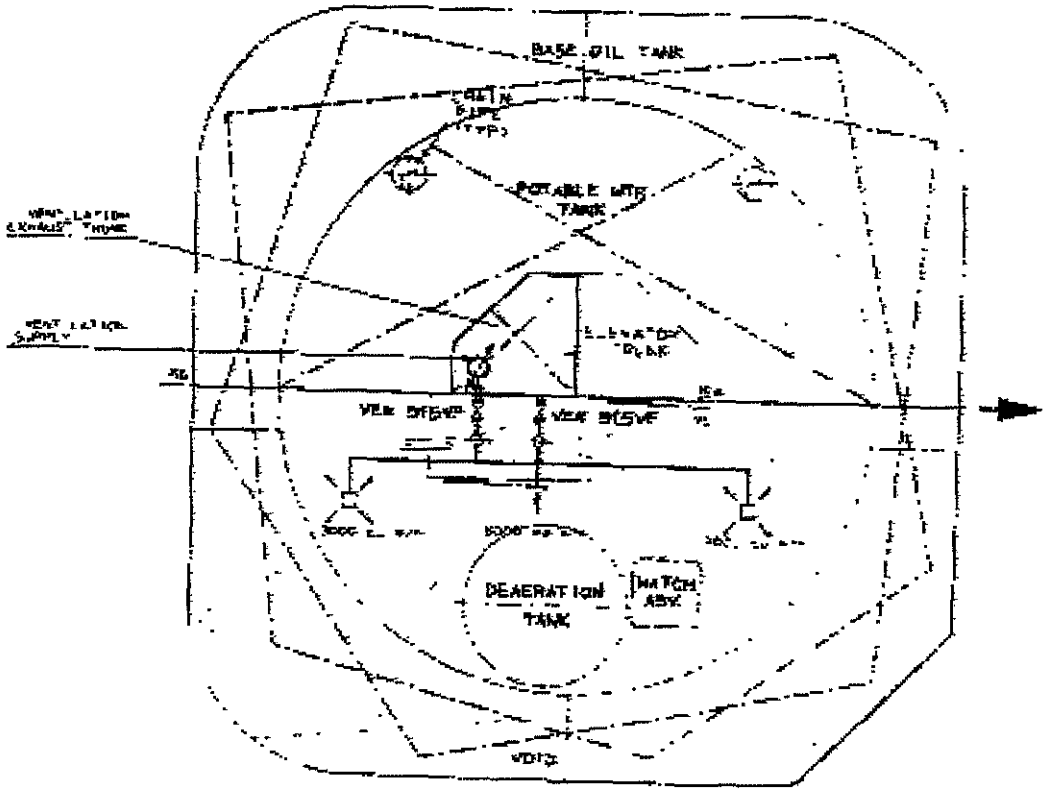


Fig. 4 - Particular of the drawing no. A51633080,

"Hull Ventilation System – One line diagram, ver. G"

3288

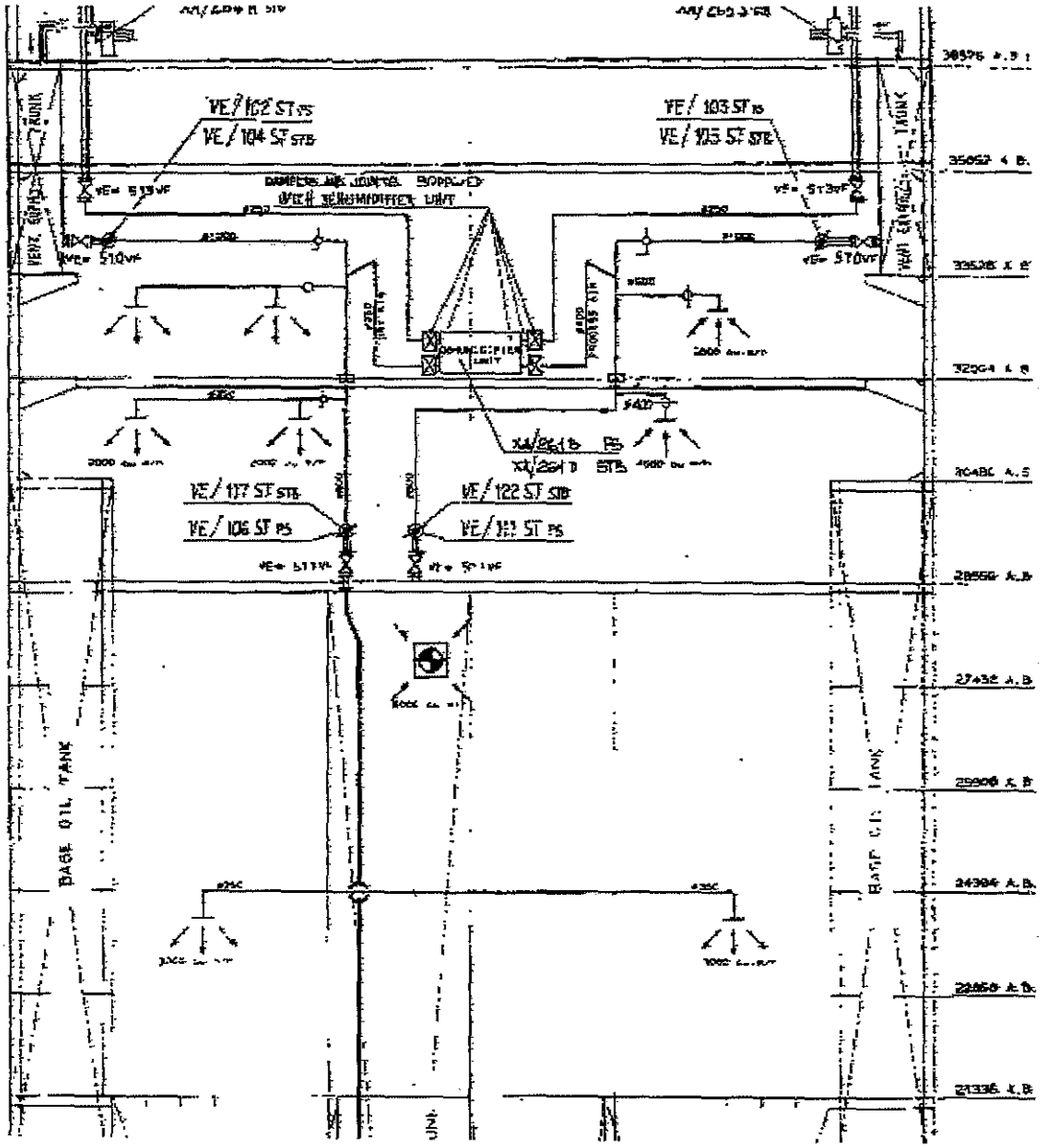


Fig. 5 - Particular of the drawing no. A51633080

"Hull Ventilation System – One line diagram, ver. G"

JOSÉ CARLOS PINTO PEIXOTO
Diretor da Divisão de Serviços Técnicos

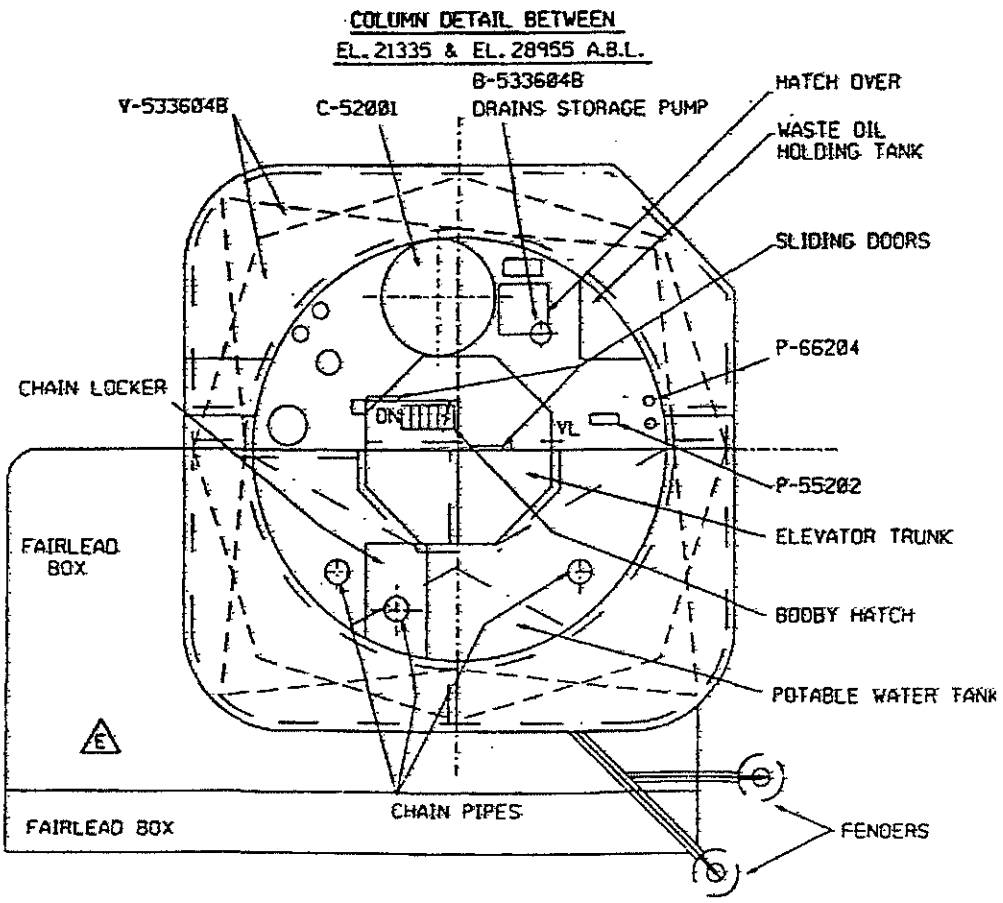


Fig. 6 - Particular of the drawing no. DE-3010.38-1200-200-AMK-117, rev. E

JOSÉ CARLOS PEREIRA DE CUSMÃO
Diretor da Divisão de Serviços Centrais

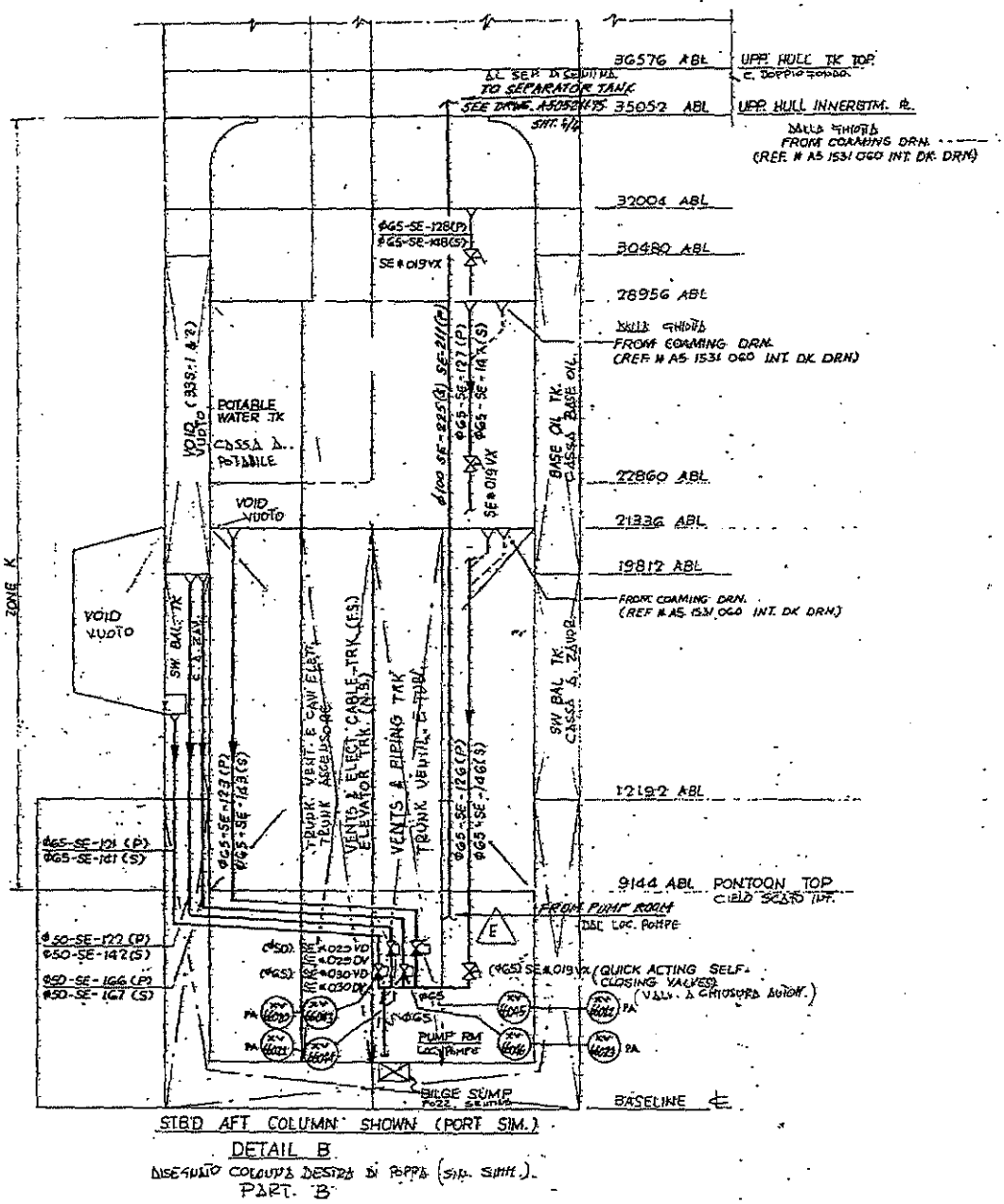


Fig. 7 - Particular of the drawing Fincantieri no. A50521175 rev. N

APPENDIX A

DOCUMENTS CONSIDERED

Costas CIPANAVE 02/2001 dated July 2001.

Presentation of Petrobras Inquiry Commission. Presentation dated 22 June 2001.

Translation of report of Rio de Janeiro Harbour Master's Office dated 13 July 2001.

ANP/DPC Investigation Committee Report dated July 2001.

Gas Dispersion Analysis dated June 2000.

Report of CREA-RJ Commission dated 4 September 2001.

Operations Manual Volume 1, 3 and 7.

Operating Manual System: Oil Production.

Bundles of design drawings.

ABS Certificate RJ 67901 dated 17 May 2000.

RINA Survey Report, Quebec dated 28 October 1998.

Charges by Brazilian Navy Attorneys Office dated 26 October 2001.

CD of Presentation given at Petrobras Workshop, Rio de Janeiro, August 2001.

Defences of Petrobras and its employees with relevant supporting documents.

Translation of official record of statement of thirty-seventh witness.

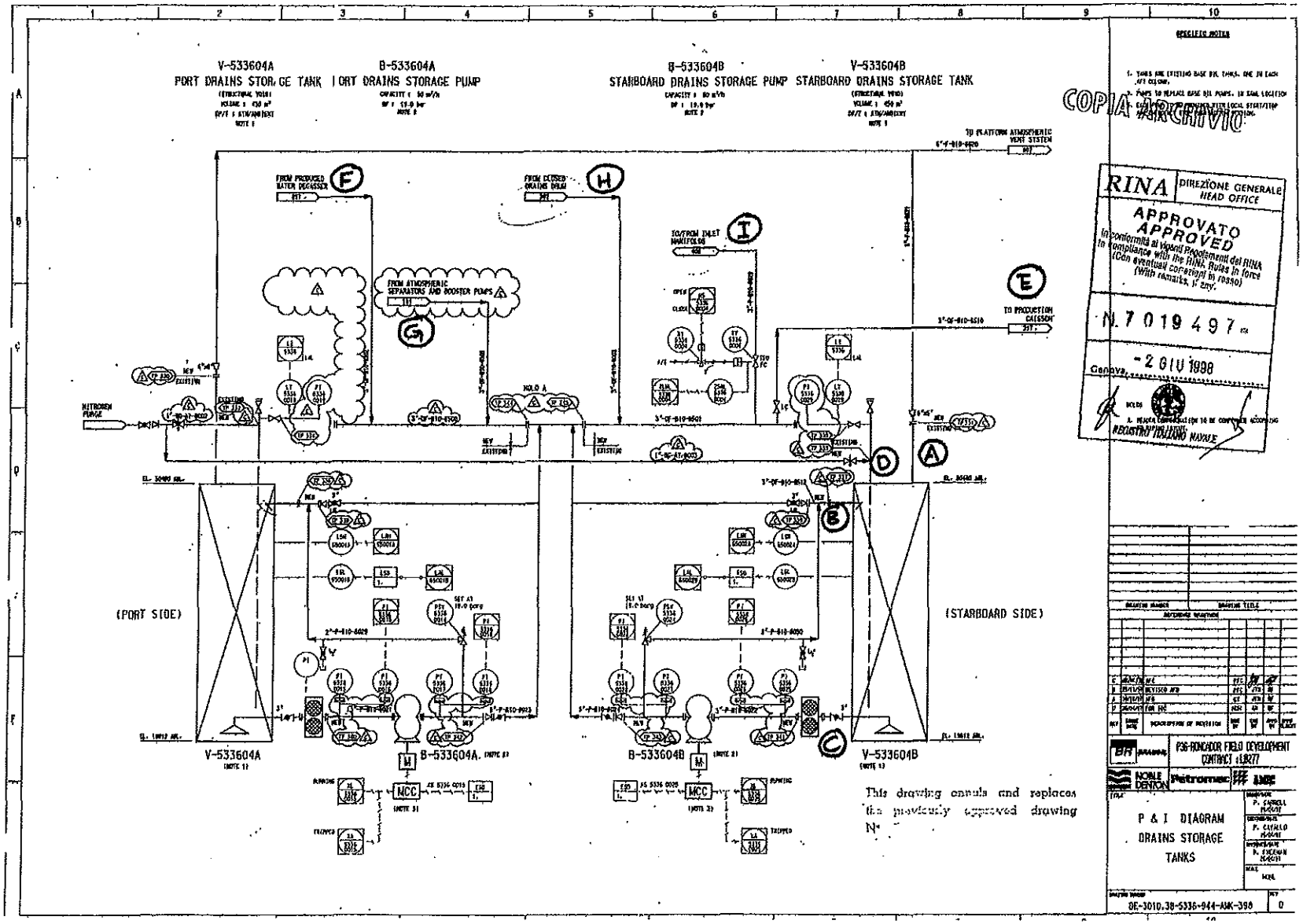
APPENDIX B

P and I Diagram

Drains Storage Tanks

No. DE-3010.38-5336-944-AMK-398

Rev. C



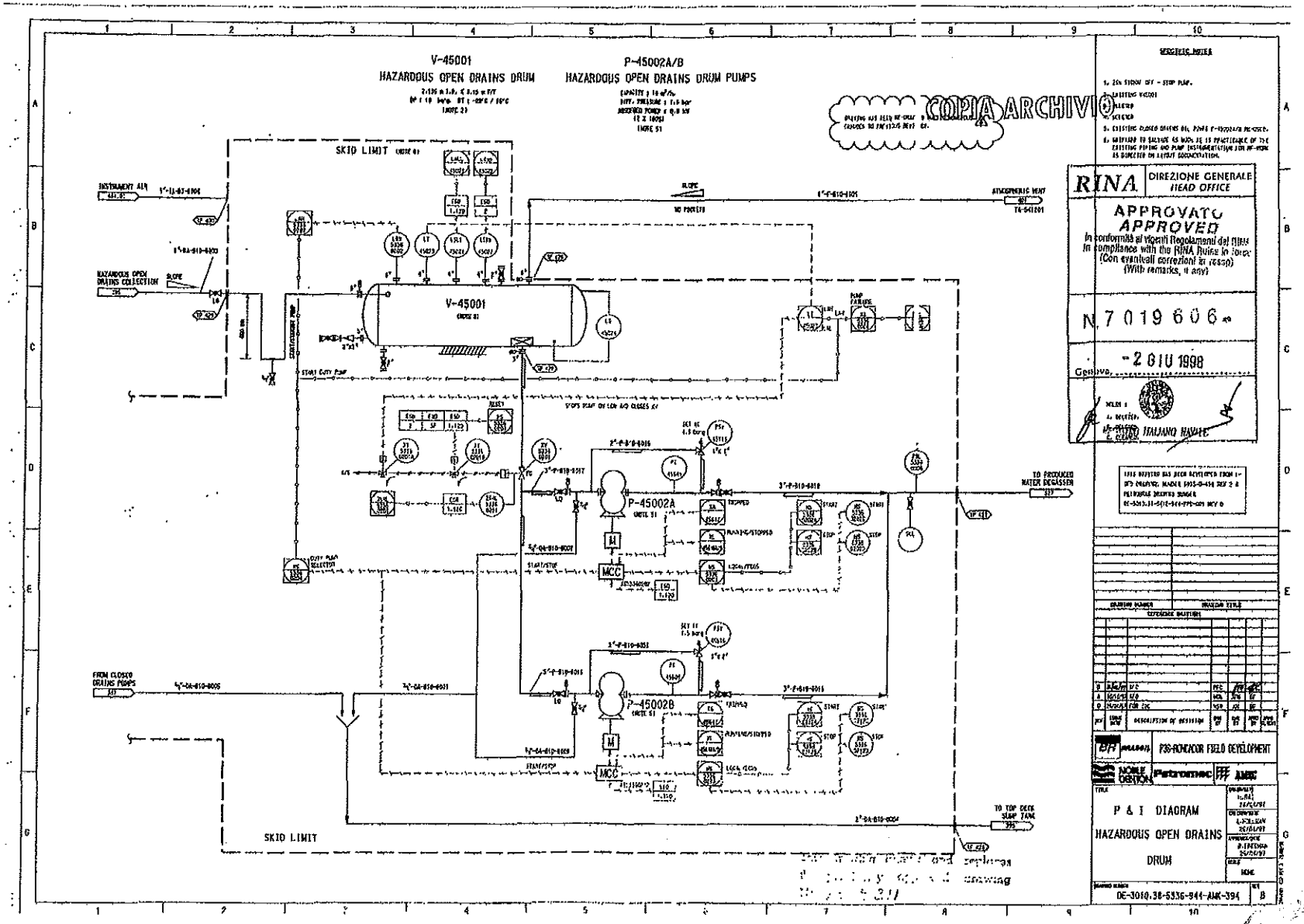
APPENDIX C

P and I Diagram

Hazardous Open Drains Drum

No. DE-3010.38-5336-944-AMK-394

Rev. B


V-45001
HAZARDOUS OPEN DRAINS DRUM
P-45002A/B
HAZARDOUS OPEN DRAINS DRUM PUMPS
SKID LIMIT
V-45001
P-45002A
P-45002B
MCC
TO PRODUCED WATER DEGASSER
TO TOP DECK SUMP TANK
FROM CLOSED DRAINS PUMPS
SKID LIMIT
COPIA ARCHIVIO
RINA
DIREZIONE GENERALE
HEAD OFFICE
APPROVATO
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P&I DIAGRAM
HAZARDOUS OPEN DRAINS
DRUM
DE-3010.38-5336-944-AAK-394
B

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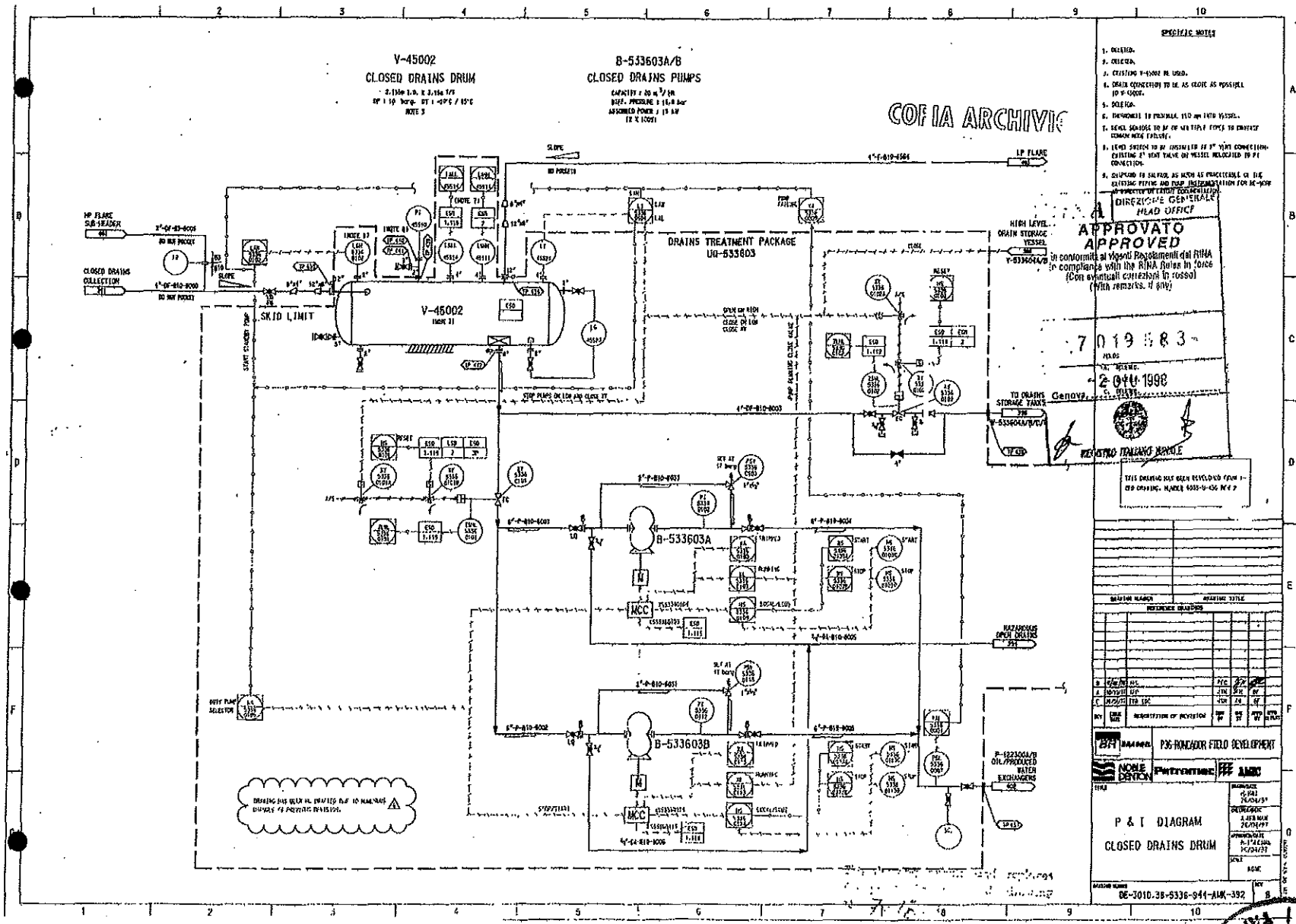
APPENDIX D

P and I Diagram

Hazardous Closed Drains Drum

No. DE-3010.38-5336-944-AMK-394

Rev. B



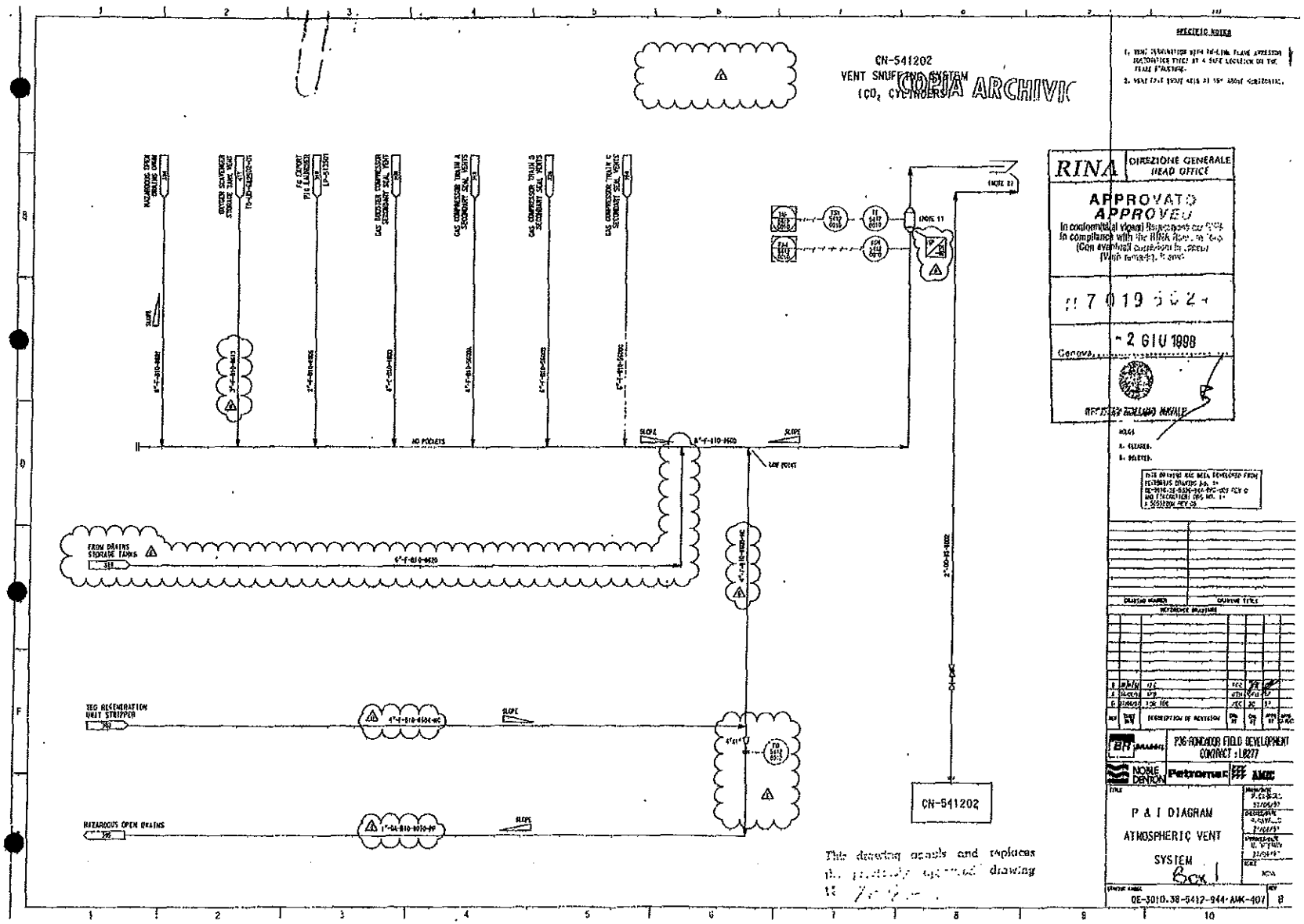
APPENDIX E

P and I Diagram

Atmospheric Vent System

No. ET-3010.38-1200-941-AMK-924-14

Rev. 0



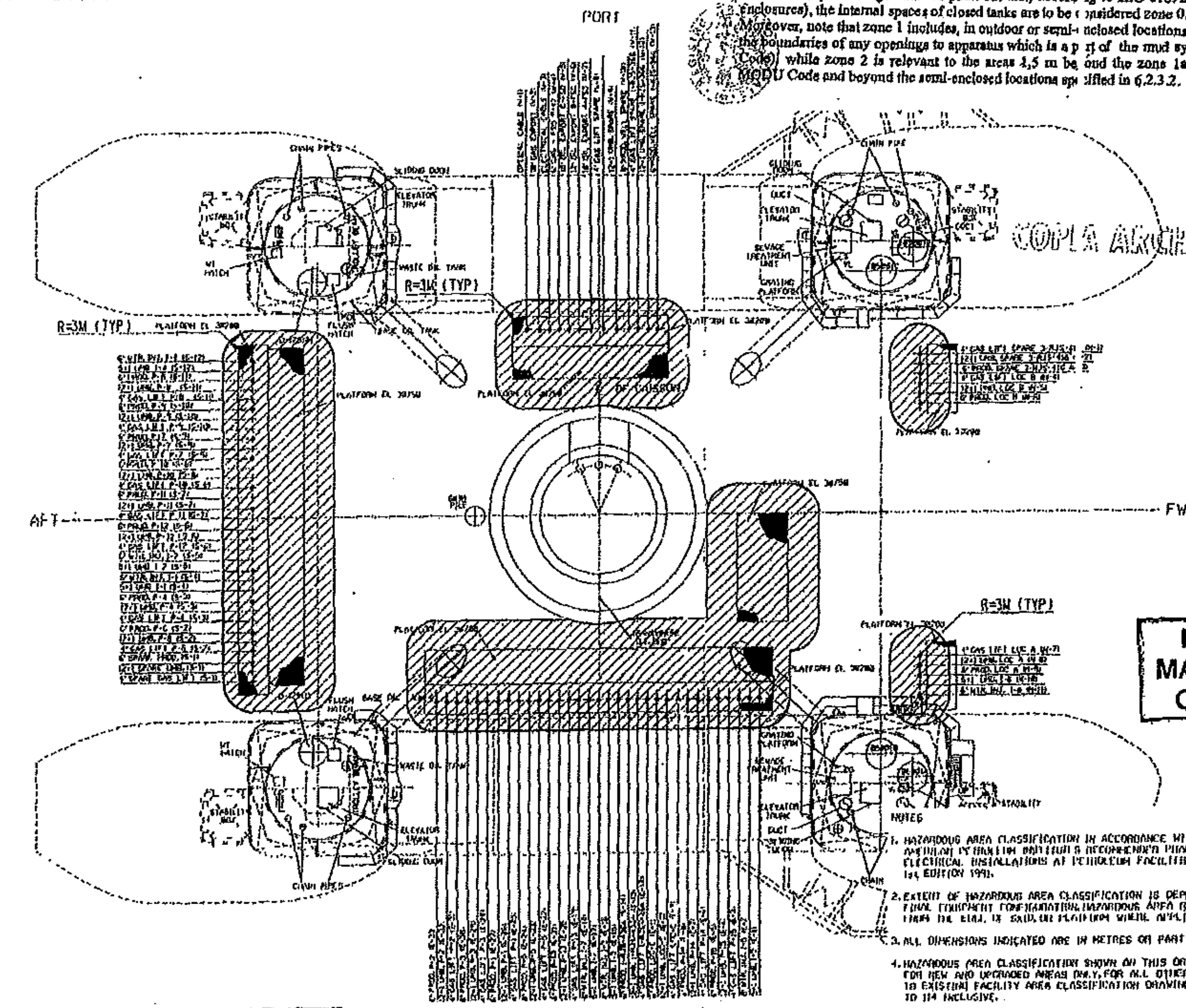
APPENDIX F

Hazardous Area Classification - Columns & Riser Platform EL 28956199 - EL 31955 A B C

No. DE-5400-947-AMK-120

Rev. b

With ref. to your drwgs a.m. we point out that, according to IEC 61892-7 and M.O.D.U. code (see enclosures), the internal spaces of closed tanks are to be considered zone 0.
Moreover, note that zone 1 includes, in outdoor or semi-enclosed locations, the area within 1,5 m from the boundaries of any openings to apparatus which is a part of the mud system (see 6.2.3.4 of MODU Code) while zone 2 is relevant to the areas 1,5 m beyond the zone 1 areas specified in 6.2.3.4 of MODU Code and beyond the semi-enclosed locations specified in 6.2.3.2.



PLAN ON CENTRAL CAISSON & COLUMNS
EL28956-EL31955 AFL

THIS DRAWING IS TO BE USED FOR STATED PURPOSE ONLY. REFER TO PLOT PLAN LATEST REV FOR PLANT LAYOUT

NOTES

1. HAZARDOUS AREA CLASSIFICATION IN ACCORDANCE WITH THE AMERICAN PETROLEUM INSTITUTE RECOMMENDED PRACTICE FOR ELECTRICAL INSTALLATIONS AT PETROLEUM FACILITIES, RP 500, 1st EDITION 1991.
2. EXTENT OF HAZARDOUS AREA CLASSIFICATION IS DEPENDENT ON FINAL EQUIPMENT CONFIGURATION. HAZARDOUS AREA RADII START FROM THE EDGE OF SKID OR PLATFORM WHERE APPLICABLE.
3. ALL DIMENSIONS INDICATED ARE IN METRES OR PART THEREOF.
4. HAZARDOUS AREA CLASSIFICATION SHOWN ON THIS DRAWING ARE FOR NEW AND UPGRADED AREAS ONLY. FOR ALL OTHER AREAS REFER TO EXISTING FACILITY AREA CLASSIFICATION DRAWINGS : GB35-X-110 TO 114 INCLUSIVE.
5. ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS TO BE CERTIFIED IN ACCORDANCE WITH RP 500 FOR GAS GROUP D AND TEMPERATURE CLASS T3 (EUROPEAN EQUIVALENT GAS GROUP IIA AND TEMPERATURE CLASS T3).
6. ABBREVIATIONS USED ON THESE AREA CLASSIFICATION DRAWINGS AS DEFINED IN API RP 500 : L = HORIZONTAL HAZARD RADIUS, R = HAZARD RADIUS, Q = VERTICAL HAZARD RADIUS.

DCC MASTER COPY

EXISTING EQUIPMENT

DESCRIPTION
DEAERATOR TOWER
DEAERATOR TOWER
TANKS (NOT USED)
AERATED LIFT PUMPS

DIREZIONE GENERALE / HEAD OFFICE

APPROVATO
APPROVED
In conformità ai vigenti Regolamenti del RINA
In compliance with the RINA Rules in force
(Con eventuali correzioni in rosso)
(With remarks, if any)

N.7017711

Genova, - 3 AGO 1999

REGISTRO ITALIANO NAVALE

LEGEND

- CLASS 1., DIVISION 1.
- CLASS 1., DIVISION 2.
- UNCLASSIFIED (SEE NOTE 4)

P36-RONCADOR FIELD DEVELOPMENT CONTRACT : L0277

NOBLE DENTON — Petromec — AMEC

UNIT P36, HAZARDOUS AREA CLASSIFICATION COLUMNS & RISER PLATFORM EL28956-EL31955 A.B.L.

22-09-97
16-09-97
1:200

OE-3010.38-5400-947-AMK-120 B

APPENDIX G

Consequence Schedule

CONSEQUENCE SCHEDULE

		MAIN EVENT			
Event	**Description**	**A**	**B**	**C**	**D**
1	Filling of DSTs by overflow	1	1	1	1
2	Removal of starboard DST pump	0	0	0	0
3	Closing of the vent pipe to starboard DST	1	1	1	1
4	Decision to pump to process inlet manifold rather than production caisson	1	1	1	1
5	Delayed operation of port DST pump	1	1	1	1
6	Leaking or improperly closed inlet valve to starboard DST	1	1	1	1
7	Rupture of starboard DST (First Mechanical Explosion)	1	1	1	1
8	Rupture of riser in starboard column	0	1	1	1
9	Opening of doors to level 4 compartment from upper hull	0	1	1	1
10	Failure of watertight valve on vent pipes in column to close	0	1	1	1
11	Second Chemical Explosion	0	1	1	1
12	Non-availability of portside seawater pumps (two port pumps removed for maintenance)	0	0	1	1
13	Leaving open of openings to compartments 26S and 61S	0	0	1	1
14	Decision to ballast unit reducing list	0	0	0	0
15	Progressive flooding	0	0	1	1
16	Sinking			0	1

Key: 1 = in absence of event, main events A, B, C or D would not have occurred (i.e. absence of event = change of outcome)

0 = in absence of event, main events would have occurred (i.e. absence of event = no change of outcome)

A = First mechanical explosion

B = Second chemical explosion

C = Progressive flooding

D = Sinking

CONTRACT NO. PETROMEC - 04/97

CONTRACT FOR THE PROVISION OF

THE AGREEMENT BETWEEN

PETROMEC INC.

AND

REGISTRO ITALIANO NAVALE

INDEX

Clause

THIS AGREEMENT is made the 2nd day of July 1997 BETWEEN:

1) Petromec Inc. whose address is The Tropical Isle Building, PO Box 438, Road Town, Wickhams Cay - Tortola, British Virgin Islands, (hereinafter referred to as the "Company"); and

2) Registro Italiano Navale, whose address is Via Corsica, 12 I-J6128 - Genova, Italy (hereinafter referred to as the "Contractor").

In the event of any inconsistency or discrepancy between this Agreement and the Appendices, this Agreement shall take precedence.

In consideration of the Contractor performing the Scope of Services contained in Appendix 'A' hereof (the "Services"), and of the Contractor performing its obligations, the Company shall pay to the Contractor compensation as set forth in Appendix 'B' in accordance with this Agreement.

The Contract shall commence on or about 8th July 1997 or as determined by the Company for a period necessary to complete the work as described herein, or as may be adjusted in accordance with Clause 23.

Except as may be described elsewhere in this Contract, the Contractor shall be given access to the whole or part of the Jobsite as may be required to enable the Contractor to proceed with the Services in accordance with the agreed programme for the execution of the Services.

This Contract (as defined hereinafter) shall constitute the entire Contract between the parties as to the Services to be performed in accordance with this Contract and shall supersede and take the place of all documents, minutes of meetings, letters or notes, which may be in existence at the date hereof and all statements, representations and warranties which may have been made by or on behalf of any of the parties hereto.

1. DEFINITIONS AND INTERPRETATIONS

1.01 In these General Conditions and all other documents which form part of this Contract:

In this Agreement the following terms shall have the following meaning:

(a) "Petromec Associated Parties" shall mean all or any of the following parties:

(i) Petromec Inc.

(ii) Maritima Petróleo e Eugenharia Ltd.

(iii) Petromec - Società Armamento Navi Appogio Spa

(iv) Each of its respective subcontractors, affiliates and employees, invitees and servants.

(b) The "Contract" means this Agreement together with Appendices attached hereto.

(c) The "Services" means all work to be performed by the Contractor as described in Appendix 'A' or incidental thereto and includes materials, articles or substances provided hereto.

(d) "Regulatory Bodies" means organisations or individuals having authority established by legislation or industry custom and practice to require or request actions of the Company.

(e) "Contract Price" means the total of all moneys as described in Appendix 'B' to be paid to the Contractor for performance of the Services in accordance with the requirements of this Contract.

(f) "Subcontractor" means any person or persons, firm, partnership, corporation or combination thereof engaged by the Contractor for the performance of the Services or any part thereof.

(g) "Jobsite" means any location where the Services are performed.

(h) "Facility" means 'Spirit of Columbus' which is to be converted into 'P36'.

(i) "Company Representative" means the senior designated person as appointed by the Company.

2. RELATIONSHIP OF PARTIES

2.01 The Contractor's status shall be that of an independent contractor, and the relationship of the parties shall in no event be construed to be that of principal and agent or master and servant. The Contractor shall exercise the control, management and direction of the Services to be carried out. The presence of a Company Representative or inspector at the site of the Services shall not relieve the Contractor from the Contractor's obligations for the proper execution of the Services or at law.

3. COMPLIANCE WITH LAWS

3.01 The Contractor shall comply with, and shall require its Subcontractors to comply with, all laws, regulations, standards and codes of any government in the performance of the Services.

4. CONTRACTOR TO INFORM ITSELF FULLY

4.01 The Contractor shall be deemed to have satisfied itself as to drawings, plans, specifications and other documents and as to all conditions and circumstances applicable to the Services to be carried out under this Contract. The information which the Company may give to the Contractor shall be the best information available to the Company. The Company shall not be liable for claims from the Contractor for additional payments, in excess of the Contract Price, on account of conditions, circumstances and costs which the Contractor should have determined and understood in advance save for those occasions on which the Company stops the work for operational reasons.

4.02 Any part of the Services not expressly detailed in the drawings or documents furnished to the Contractor nor mentioned in the Contractor's tender proposal, but necessary for the proper completion of the Services according to the provisions of this Contract and necessary to meet properly the requirements for which the Services are intended, shall be carried out by the Contractor at the Contractor's expense just as if such Services or part of the Services had been specifically mentioned or shown in the drawings or documents.

5. PERMITS AND LICENCES

5.01 Unless otherwise specified, the Contractor shall obtain at its own risk and expense from the appropriate authorities all necessary permits and licences for the performance of the Services.

6. COMPANY'S REPRESENTATIVE

6.01 The Company shall designate a Representative who shall have authority to act for and on behalf of the Company in all matters connected with this Contract. The Contractor shall comply and procure that its employees, servants and agents comply with all instructions of the Company's Representative in relation to the Services.

6.02 Whilst on board the Facility the Contractor's personnel or any of its subcontractors and their respective employees shall be under the Company Representative's control.

7. CONTRACTOR'S REPRESENTATIVE

7.01 The Contractor shall designate a Representative who shall have full authority to act on behalf of the Contractor in relation to matters arising from this Contract.

8. CONTRACTOR'S PERSONNEL

8.01 The Contractor shall engage, at its sole expense, all personnel necessary to carry out the Services. The Contractor's personnel shall be fully qualified and trained, instructed and supervised, for their respective trades and callings and for carrying out the Services. The Contractor's personnel shall, as a minimum, be in possession of all offshore survival and fire fighting certificates required by the current Company training standards.

8.02 The Company shall have the right to require the Contractor, by notice in writing specifying the reason, to remove from the Services and/or replace any member of the Contractor's personnel who, in the Company's opinion, is incompetent in the performance of his duties or is guilty of misconduct or who is medically unfit. Any costs associated with such removal and/or replacement will be paid by the Contractor. The Contractor shall replace such person or persons as soon as possible, after obtaining approval from the Company, with other suitably qualified and medically fit person or persons.

8.03 The Contractor shall, at its sole cost and expense, ensure that prior to performing any of the Services under this Contract/Agreement all personnel employed by the Contractor, both directly and indirectly, submit to a medical examination to the current Company standard. The Contractor shall also ensure that such personnel subsequently submit to periodic medical examinations in accordance with the current Company standard.

8.04 The Contractor shall ensure that any incident of ill health or personal injury occurring to the Contractor's personnel during the course of the Services or which subsequently arises at any time after termination of the Contract and which is apparently related to the Jobsite is notified forthwith to the Company in writing.

9. CONTRACTOR'S RESPONSIBILITIES

9.01 The Contractor shall perform its obligations hereunder in a diligent and efficient manner and in accordance with good oilfield practice.

9.02 The Contractor shall submit to the Company its written statement of the Safety Policy which shall include the Contractor's organisation and arrangements for ensuring health and safety and welfare of any person who may be affected by the Services of the Contractor and shall ensure that the Policy is applied.

The Contractor should be aware of and work to the Company's Safety Policy.

9.03 Contractor shall inform itself of the activities performed by RINA and support these providing all required assistance.

9.04 The Contractor shall not at any time provide alcoholic beverages, narcotics or any prohibited substance in any form on the Facility or furnish such to any person thereon or to any person travelling to the Facility.

9.05 The Contractor shall be responsible for the transportation of its personnel to the Jobsite.

9.06 The Contractor shall ensure it is fully aware of Petromec/Brasoil operating policies, standards and procedures and shall advise all its employees of these prior to their being appointed to the Contract. The relevant Contract conditions should also be advised to employees of the Contractor to ensure they comply fully with the Contract terms and conditions.

9.07 The Contractor shall inform the Company in writing and in good time of any control measures by way of but not restricted to plant, equipment or procedure which the Company needs to take to ensure the health, safety and welfare of its personnel during the course of the Contractor's Services.

9.08 The Contractor shall inform the Company in writing and in good time of any Occupational Health Surveillance or Workplace Hygiene monitoring which is required by statutory requirement or by recommendation or guidance from any Regulatory Bodies in connection with the Services.

9.09 The Contractor shall maintain records of any Occupational Health Surveillance or Workplace Hygiene monitoring which the Contractor undertakes in connection with the Services and keep the records available for access by the Company for a period of thirty (30) years from the termination of the Contract.

9.10 The Contractor shall maintain and keep the Company advised of a contact point within the Contractor's organisation which is available twenty-four (24) hours a day for the Company to notify any emergency involving the Contractor's personnel or services to the Contractor. The Contractor's written procedures for response to any emergency shall be deposited with the Company prior to performing any of the Services under this Contract/Agreement.

9.11 Any additional labour or substitute labour to be provided by the Contractor, at the Company's request, shall be approved by the Company prior to its commencing the provision of the Services under this Contract.

9.12 The Contractor agrees not to remove the labour from the performance of this Contract except as indicated in Subclause 8.02 detailed above.

10. CONTRACTOR'S SOFTWARE TO BE SUPPLIED

10.01 The Contractor, at its expense, shall supply all the software and corresponding equipment necessary to carry out the Services, except only in so far as the Company shall have expressly agreed in writing to supply any of these items. The Contractor must obtain the prior written consent of the Company to any proposed substitution of or modification to materials and equipment as specified or referred to in this Contract.

11. COMPANY'S RESPONSIBILITIES

11.01 The Company shall provide at its sole cost and expense:

(i) meals for the Contractor's personnel whilst offshore on the Facility;

(ii) sleeping accommodation for the Contractor's personnel whilst offshore on the Facility;

(iii) sick bay facilities for the Contractor's personnel whilst offshore on the Facility;

(iv) full laundry service for the Contractor's personnel whilst on the Facility;

(v) onshore Company emergency response facilities including twenty-four (24) hour communications and Company Duty Manager.

11.02 The Company shall provide transportation to and from the Offshore Jobsite for all the Contractor's personnel, and shall provide transport in the event of a medical evacuation which shall be at the Contractor's cost.

12. PRICE AND PAYMENT

12.01 The Company shall pay the Contractor for the Services or interim portions thereof at the price or prices set out in Appendix 'B' hereof. The Contractor shall invoice the Company when the Services or interim portions thereof have been completed to the satisfaction of the Company together with such supporting evidence as the Company may reasonably require. Payment of invoices shall be made by the Company by the 45 days after receipt of the same.

12.02 The Company and Contractor shall endeavour to settle any such dispute at the earliest possible date and any agreed adjustment shall be made as promptly as possible following the date of such settlement.

12.03 Neither the presentation nor payment of any invoice shall in itself constitute settlement of any dispute, or otherwise waive or affect the rights of the parties thereunder.

12.04 The Company shall be entitled to set off any sums due and payable by the Contractor to the Company under or pursuant to this Contract against sums due and payable by the Company to the Contractor under or pursuant to this Contract.

13. AUDIT AND RECORDS

13.01 The Company reserves the right, which shall continue for a period of five (5) years after termination of the Contract, to audit all the Contractor's records in connection with operations under this Contract and shall, upon request, have access to any detailed cost data necessary for that purpose and be entitled to copies of such data and supporting documents and information.

14. ASSIGNMENT AND SUBCONTRACTING

14.01 The Contractor shall not assign this Contract or any part thereof or any benefit or interest therein or thereunder without the written consent of the Company. The Company shall have the right to assign this Contract to any person or company not in competition with the Contractor, upon giving notice in writing to the Contractor.

14.02 The Contractor may make such subcontracts with other companies as it deems necessary for the performance of auxiliary services to be performed hereunder, subject to the approval of the Company which shall not unreasonably be withheld, provided that the Contractor shall discharge any Subcontractor whose competence, capability or performance, in the Company's opinion, is unsatisfactory. In making any subcontracts hereunder the Contractor shall not be relieved of any of its obligations under this Contract.

15. LIABILITY AND INDEMNITY

15.01 Indemnity by Contractor

The Contractor shall, save as is otherwise herein specifically provided, indemnify and hold harmless the Petromec Associated Parties and Brasoil from any and all claims, liabilities, costs, damages and expenses of every kind and nature with respect to sickness, injury or death of any person employed directly or indirectly by the Contractor, and damage to or destruction of any property or equipment of the Contractor, its subsidiaries or affiliates or their subcontractors or their respective employees arising during and as a result of the performance of this Contract from any cause whatsoever including but not limited to the negligence of the Petromec Associated Parties and Brasoil.

15.02 Indemnity by Contractor for Third Parties

The Contractor shall be responsible for indemnifying and holding harmless the Petromec Associated Parties from all claims, liabilities, costs, damages and expenses of every kind and nature resulting from:

(a) personal injury including fatal injury and disease to, and/or

(b) loss or damage to property of

third parties arising out of or in connection with the performance of the Contract whether or not the negligence or breach of duty of the Petromec Associated Parties caused or contributed to such personal injury or loss or damage.

15.03 Indemnity by the Company

The Company shall indemnify and hold harmless the Contractor from any and all claims, liabilities, costs, damages and expenses of every kind and nature with respect to sickness, injury or death of any person employed directly or indirectly by the Petromec Associated Parties, its subsidiaries or affiliates or any of their contractors (other than the Contractor) and damage to or destruction of any property or equipment of the Company, its subsidiaries, affiliates and contractors and their respective employees arising directly or indirectly during and as a result of the performance of this Contract from any cause whatsoever including but not limited to the negligence of the Contractor, its Subcontractors and their respective employees.

15.04 Liability for Contractor's Equipment

The Contractor shall be responsible at all times, including while in storage or in transit, for damage to or destruction of the Contractor's equipment regardless of how, when or where such loss, damage or destruction occurs and the Company shall be under no liability to reimburse the Contractor for any such loss or damage.

15.07 Consequential Loss

Notwithstanding any other provision of the Contract neither the Petromec Associated Parties nor the Contractor shall bear any liability to the other under this clause (and each party hereby agrees to indemnify the party relying on this provision) for loss of production, or consequential damages arising during and/or as a result of the performance or non-performance of the Contract regardless of the cause thereof including but not limited to the negligence of the party seeking to rely on this provision.

15.08 Continuing Effect

Notwithstanding anything to the contrary in this Contract the liabilities and obligations of the parties under this Clause 15 shall survive the termination of this Contract.

16. GUARANTEE

16.01 The Contractor undertakes and warrants that the Services shall be performed in accordance with the Contract in a competent and workmanlike manner with all skill, care and due diligence and in accordance with good, sound engineering and oilfield practices to the satisfaction of the Company and the Company Representative.

16.02 If the Contractor re-performs any portion of the Services, the provisions of this Contract shall apply to the portion of the Services so re-performed. Any such re-work will be to the cost of the Contractor.

17. INSURANCE

19.01 Insurance of Contractor

With respect to and for the duration of this Contract the Contractor shall, for liabilities assumed by the Contractor hereunder, procure and maintain with insurance underwriters, and on terms reasonably acceptable to the Company, appropriate insurance coverage including but not limited to the following:

(i) Employers' Liability insurance in the customary form of unlimited liability and Workmen's Compensation (if applicable) for the statutory legal limit of liability in the country or in the respective countries where the Service is to be performed including but not limited to the UK Employers' Liability (Compulsory Insurance) Act of 1969 and any amendments thereto or by the law of any area in which the Contractor may become legally obligated to pay benefits including but not limited to United States Jones and Admiralty Acts. Such insurance shall include occupational disease and sickness and to be effective with an insurer authorised to transact business in the United Kingdom;

(ii) Personal Accident insurance cover for all Contractor's employees with coverage on a sliding scale up to a minimum of £20,000 for death. This cover to include loss of limb(s), eye(s) and permanent total disablement;

(v) Third Party and Passenger Liability insurance as may be required by statute or similar regulation in the country(ies) of use with respect to motor vehicles used by the Contractor in connection with the performance of this Contract. The Contractor shall ensure that its Subcontractors maintain such insurance in respect of motor vehicles used by them or their employees.

(vi) the above coverage shall contain a waiver of subrogation in favour of the Petromec Associated Parties;

(vii) the Contractor shall furnish to the Company certificates of all insurance required by this clause giving evidence of the types and scope of each insurance cover;

(viii) policies shall be issued by insurers approved by the Company.

17.03 General Insurance Requirements

(a) Neither failure to comply nor full compliance with the insurance provisions of this Agreement shall limit or relieve the Contractor of its liabilities and obligations under this Agreement and in particular from the Contractor's obligation to hold harmless the Petromec Associated Parties in compliance with the indemnity provisions of this Contract.

(b) All policies shall contain a clause to the effect that such insurance policies shall not be modified or terminated without thirty (30) days prior notice in writing to the Company and, in addition, shall name, in respect of Clause 19 where applicable, the Petromec Associated Parties as additional assureds.

(c) All policies shall contain a clause to the effect that insurers have sighted and acknowledge this Agreement and waive all rights of subrogation against the Petromec Associated Parties.

18. TAX REQUIREMENTS

18.01 The Contractor shall pay and shall use its best endeavours to procure that any Subcontractor employed in connection with this Contract shall pay all Income and Corporation Taxes properly and duly assessed on the profits accruing to the Contractor or such Subcontractors (as the case may be) from the operation of this Contract and the Contractor shall (subject as hereinafter mentioned) indemnify and hold harmless the Company against any expense, liability, costs, claims or proceedings howsoever arising in connection with the liability of the Contractor or Subcontractors of any such taxes levied by any country or political subdivision thereof.

18.02 In the event of the Company being accountable (including without limitation pursuant to the provisions of the Finance Act 1973) to the United Kingdom Inland Revenue or to the Canadian or Italian and Brazilian Tax Authorities for any unpaid tax assessed on the Contractor or on any Subcontractor performing services for the Contractor (in relation to the operations hereunder) and where such tax is in respect of profits and gains from the performance of such Services the Company will, within fifteen (15) days of receiving a notice from the Inland Revenue or Canadian and Brazilian Tax Authorities, provide the Contractor and any Subcontractors concerned with a copy of such notice and of any document accompanying the same. Within seven (7) days of receiving from the Company such copies as aforesaid, the Contractor will pay the Company the amount required to be paid by the Company under that notice. In the event that any delay in the Company making payment to the Inland Revenue or to the Canadian or Italian and Brazilian Tax Authorities occurs by reason of the Contractor not paying to the Company, then any interest or penalty payable in respect of such delay shall be borne by the Contractor.

18.03 Contractor shall consider the company or resident abroad for all matters associated with AT, local taxes in the UK, in Italy in Canada and Brazil.

18.04 The Contractor shall defend, indemnify and hold the Company harmless from any taxes on income, wages, salaries, profits or gain imposed by any governmental authority upon the Contractor or the Company in respect of any payment to or earned by the Contractor or the labourer.

If required by the laws of any country having jurisdiction, the Company shall have the right to withhold payments at the withholding rate specified by such laws from the compensation payable for the Service performed by the Contractor hereunder and any such amounts paid over by the Company to a government authority, pursuant to such laws, shall to the extent of such payment be deducted from the amounts owing to the Contractor hereunder.

18.05 Notwithstanding anything to the contrary written in this Contract the liabilities and obligations of the Company and Contractor under this clause shall survive termination or completion of this Contract.

19. FORCE MAJEURE

19.01 If and to the extent that either party is hindered, or prevented by circumstances not now reasonably foreseeable and not within its reasonable ability to control, from performing any of its obligations under this Contract and promptly so notifies the other party giving full particulars of the circumstances in question, then the party so affected shall be relieved of liability to the other for failure to perform such obligations but shall nevertheless use its best endeavours to resume full performance thereof without avoidable delay and, pending such resumption, shall permit and shall use its best endeavours to facilitate any efforts the other party may make to procure alternative supplies or services.

19.02 If either party is unable to perform its obligations under this Contract for the reasons specified in Subclause 19.01, for a period exceeding seven (7) days, then the Company shall be entitled to terminate this Contract forthwith by written notice.

20. TECHNICAL INFORMATION AND CONFIDENTIALITY

20.01 The Company will provide such technical data and drawings necessary for the performance of this Contract subject always to:

(i) all specifications, drawings, tracings, design calculations, geological or any other data and information supplied directly or indirectly by the Company to the Contractor in connection with this Contract shall remain the property of the Company and together with depths, formations penetrated, casing depths, testing and surveying and any other like information obtained by the Contractor either by word of mouth, visual observation, derivation or any other way shall be kept in secrecy and treated as confidential and shall not be used other than for the purpose of this Contract nor be divulged to any third party without the written consent of the Company provided, however, that this shall not prevent the divulgence of information to the Contractor and the designated employees or assignees of the Contractor in the normal course of carrying out this Contract. Furthermore, the Contractor shall return to the Company all printed matter, including drawings and specifications supplied by the Company, as soon as reasonably possible on completion of this Contract or on termination of this Contract for whatever reason;

(ii) no design or drawing development under this Contract shall be reproduced in whole or in part by the Contractor for any purpose not related to this Contract without the prior consent of the Company.

20.02 The Contractor shall ensure that its personnel and its assignees and their personnel shall comply with all instructions issued by the Company to maintain the security of confidential information.

20.03 The obligation of Subclauses 20.01 and 20.02 above shall not apply to any information which:

(i) is or becomes within the public domain other than by breach by the Contractor of the obligations imposed by this Clause 22; or

(ii) was in the possession of the Contractor prior to its acquisition or development pursuant to this Contract; or

(iii) was lawfully acquired by the Contractor from a third party not under a similar obligation to the Company in respect thereof.

It shall be the responsibility of the Contractor to demonstrate that the information comes within the exceptions aforesaid.

20.04 The Contractor shall not publish any information concerning the performance of this Contract, including the fact of the existence of the Contract itself, for any promotional, advertising or other reason, without first obtaining the written permission of the Company.

21. SUSPENSION, EXTENSION AND TERMINATION

21.01 Where the Company extends the duration of the Services referred to in the Contract or requests additional labour or materials, the Contract shall be extended by mutual agreement of the Company and the Contractor. Such extensions shall be documented by a formal contract amendment duly approved by both parties.

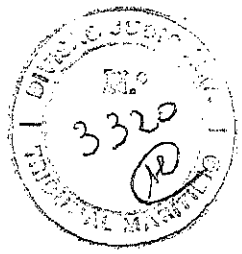
21.02 The Company may, at its absolute discretion, suspend or terminate the Services at any time and where the Contractor is not in default hereunder the Company agrees to pay the Contractor for all work done and all materials furnished, pursuant to this Contract, up to the time of suspension or termination.

21.03 The Company shall be entitled to terminate this Contract with immediate effect and without further compensation by notice in writing if:

(a) the Contractor or labour shall have committed any serious breach or repeated or continued (after warning) any material breach of its or his obligations hereunder or shall have been guilty of conduct tending to bring itself or himself or the Company into disrepute; or

(b) if the Contractor is unable to pay its judgement debts as they fall due or a petition is presented or a meeting convened for the purposes of winding up the Contractor (except for the purposes of reconstruction) or if the Contractor enters into liquidation or compounds with its creditors generally or has an administrative receiver appointed over all or a substantial part of its assets.

21.04 No failure or omission by either the Contractor or the Company to carry out or observe any of the stipulations, conditions or obligations to be performed hereunder shall give rise to any claim against the other party or be deemed to be a breach of Contract if such failure or omission arises from a cause reasonably beyond the control of the party claiming force majeure.



22. CERTIFICATION, QUALITY ASSURANCE AND AUDITS

22.01 The Contractor shall provide all quality assurance documentation, as required under the Scope of Work.

22.02 The Contractor agrees that delivery will not take place and payment will not be made until the provisions of Clause 22 are satisfied.

23. SAFETY

23.01 The Contractor agrees to maintain the highest standards of protection of persons and property during the Contractor's performance hereunder and the Contractor agrees to comply with the Company's Health, Safety and Environment Policy during the Contractor's performance hereunder and to provide its personnel with adequate information, instruction, training and supervision to ensure compliance with the Company's policies and all statutory requirements or written recommendations or guidance of any Regulatory Bodies.

23.02 The Contractor agrees to provide and maintain an up to date written assessment of the Services. The assessment to contain a detailed description of the hazards and risks presented by the Services and the control measures which are to be applied.

24. GENERAL

24.01 Time being of the Essence

In the performance of this Contract it is recognised that time is of the essence.

24.02 Waiver

No failure or failures on the part of either party to enforce from time to time all or any portion of the terms or conditions of this Agreement shall be interpreted as a waiver of such terms or conditions.

24.03 Previous Statements

Save as expressly incorporated herein, any and all oral or written statements or agreements given by or made between the Contractor as a whole and the Company as a whole prior to the date hereof are hereby excluded.

24.04 Changes to the Contract

(i) No amendments or changes to the Contract shall be made except where the Company agrees in writing;

(ii) when agreement has been reached between the Contractor and the Company as to the net effect of a change to the Contract then the Contractor and the Company shall execute a document which will become a binding Agreement supplementing and included by references into the Contract and shall be

termed an Addendum to the Contract and all the relevant terms and conditions of the Contract shall become applicable thereto.

25. NOTICES

25.01 Any notice given under this Contract shall be in writing and may be delivered by hand or may be sent by registered mail, postage prepaid, or by letter or by facsimile transaction. Notice to either party shall be given at such address or addresses as such party shall specify from time to time by written notice to the other. In the absence of such notice to the contrary, notice to the Company shall be properly addressed to:

Petromec Inc.
c/o AMEC Process and Energy Limited
1 Golden Lane
LONDON
EC1Y 0RR

Attention:	Domingos D'Arco
Telephone:	(0171) 894-4099
Facsimile:	(0171) 894-4055

and notices to the Contractor shall be properly addressed to:

Attention:	Ing Cesare Murgia
Telephone:	(00 39 6) 488-5580/ 488-2243
Telex:	-
Facsimile:	(00 39 10) 538-5570

Any such notice shall be effective:

(i) if delivered by hand, at time of delivery;

(ii) if sent by facsimile, at time of dispatch unless sent outside normal business hours when it shall be deemed received at 1000 hours (addressee's local time) the next succeeding business day;

(iii) if sent by registered mail, three (3) days after the date of mailing provided always that intention of mailing such notice is given by telephone or in writing.

26. GOVERNING LAW

26.01 This Contract shall be governed by and construed in accordance with the laws of England and the parties hereby agree that any action by either party against the other in respect of or arising out of this Contract shall be commenced only in a court of competent jurisdiction and each of the parties hereby submits to the non-exclusive jurisdictions of the English Courts.

IN WITNESS WHEREOF this Agreement has been executed on behalf of the parties hereto the day and year first above written.

SIGNED BY
for and on behalf of
PETROMEC INC.

ALBERTO J. PADILLA LIZALDO
CONSTRUCTION DIRETOR.

SIGNED BY
for and on behalf of
REGISTRO ITALIANO NAVALE

REGISTRO ITALIANO NAVALE
F. Ziliotto

É CÓPIA FIEL DO DOCUMENTO ORIGINAL

JOSÉ CARLOS PIMENTEL GUSMÃO
Diretor da Divisão de Serviços Cartoriais

Appendix 'A'

Scope of Work

Scope of Work

The semi-submersible mobile "Spirit of Columbus" will be upgraded for processing 180,000 bbl/day of crude oil, to be installed in the Roncador Field, Campos Basin, offshore the North Coast of State of Rio de Janeiro, Brasil, for gas and oil production.

Contractor shall maintain the present class of the whole vessel including topside facilities (Process system), mooring system and risers during the upgrade and after, according to the following documents (attached) which are an integral part of the scope of work:

1. Brasoil specification: ET-3010.38-1200-940-PPC-001 Rev A
2. Annex X of the Upgrade Contract: Deviations
3. (Rina's specific Rules)?
4. Metocean data: ET-3010.56-1200-941.PPC-001

The scope of work on lump sum basis, comprises but not limited to the following items:

- Design appraisal, technical review of the upgrading documents originated by Brasoil, MSR (OTD) AMEC and Noble Denton.
- Survey in Canada during the yard's upgrading work by a resident surveyor.
- Offshore attendance during inclining ballast tests and final process facilities testing/ commissioning and the release of final class certificates.
- General co-ordination with Purchaser and Sub-contractors (i.e. AMEC; Noble Denton; Davie Industries and Sub-Suppliers)
- The Contractor shall issue and present to the Company a monthly report showing the development of the works in charge of the contractor.
- The Contractor shall attend a monthly meeting with the company and Brasoil where will be discussed technical issues and the development of contractor's work.
- The Contractor shall liaise with ABS Europe to obtain from them all meters that Rina needs to maintain the present class notation during the upgrade and after.

Appendix 'B'

Compensation

COMPANY shall pay the Contractor during the continuance of the Contract and according to its terms and the amounts from time to time due and calculated as provided in this Contract. No other payments shall be due by COMPANY other than those specifically mentioned in this Contract. The Rates hereunder shall be fully inclusive of all the Contractor's costs, overheads and profits incurred by the Contractor in the performance of this Contract and in fulfilment of the Contractor's obligations and liabilities thereunder including but not limited to direct labour costs, overtime, payroll burdens, bonuses paid for handling materials and goods, repairs and maintenance costs, taxes, training, insurances, financing costs and import and export duties and shall be payable per day or pro rata thereof. The Rates herein shall be fixed for the duration of the Services.

Prices/Milestones

A)	Design Review	US $	38,000.00
B)	Survey in Canada (considered 12 months)	US $	442,000
C)	Offshore Attendance (estimated 21 pays)	US $	25,000

Payment Terms

Engineering Lump Sum - Item A above

- 10% upon issue of purchasing order and receipt of acknowledgement form duly signed.
- 20% three months after commencing engineering review/appraisal.
- 50% upon completion of engineering phase.
- 20% upon submission of all documentation/approval.

Survey Lump Sum - item B above

- 10% upon issue of purchase order and receipt of acknowledgement duly signed.
- 25% after 3 months the rig enters the yard
- 25% after 6 months the rig enters the yard
- 20% after the rig sails away from the yard
- 20% upon completion of all activities and release of final reports in Canada.

Offshore attendance Lump sum - item C above

- 10% upon issue of purchase order and receipt of acknowledgement duly signed.
- 90% upon completion of all activities and release of final reports.

Appendix 'C'

Schedule

ORIGINAL

CONTRACT NO. PETROMEC - 04/97

THE AGREEMENT BETWEEN

PETROMEC INC.

AND

REGISTRO ITALIANO NAVALE

ADDENDUM NO. 2

3328

ADDENDUM NO. 2

CLIENT:
Petromec Inc.

CONTRACTOR
Registro Italiano Navale

This document is issued as an Addendum to Contract 04/97 between Petromec Inc. And Registro Italiano Navale in accordance with the requirements of clause 24.04 (ii) of the Contract.

The changes below referenced RINa's fax ITO - 042942/RRO and Petromec's fax Ref: QUE.GE.1781 from which the conclusion are as follows:

- The Parties agreed to have an extension of the contract related to the RINa survey, beginning on November 1st, 98.

- The Parties agreed that RINa has to have a monthly compensation to provide the activities related to the above mentioned survey for the amount of US$33,150.00.

In witness whereof, this Addendum No.2 has been executed on behalf of the parties hereto on the date written below.

Signed by:

for and on behalf of

PETROMEC INC.

Dated:

Signed by:

REGISTRO ITALIANO NAVALE
C. Murgia

for and on behalf of

REGISTRO ITALIANO NAVALE

Dated: 16th of DECEMBER of 1998

CONTRACT NO. PETROMEC - 04/97

THE AGREEMENT BETWEEN

PETROMEC INC.

AND

REGISTRO ITALIANO NAVALE

ADDENDUM NO. 1

In witness whereof this Addendum No. 1 has been executed on behalf of the parties hereto on the date written below.

Signed by: _____

for and on behalf of _____

PETROMEC INC. _____

Dated _____

Signed by: _____

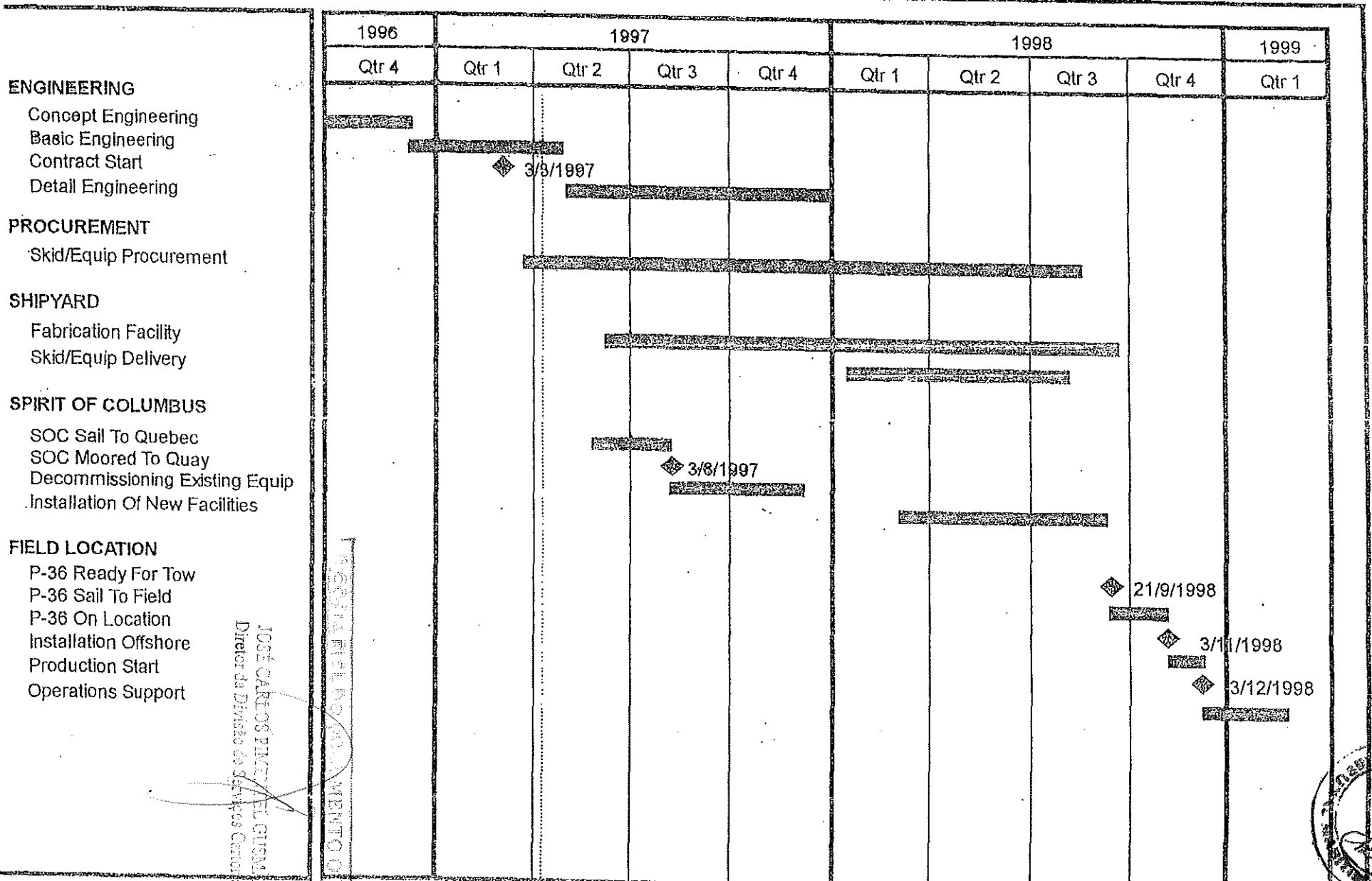
for and on behalf of _____

REGISTRO ITALIANO NAVALE _____

Dated _____

MASTER SCHEDULE

UPGRADING OF THE SPIRIT OF COLUMBUS TO PETROBRAS P-36 FOR THE RONCADOR FIELD



APPENDIX 1

SCOPE OF WORK

SPIRIT OF COLUMBUS UPGRADE

Contents

Attachments:

i.) Spirit of Columbus Equipment Layout - As built

ii) Spirit of Columbus Equipment Layout - P36, South Marlin

iii) Equipment List - Redundant Equipment

iv) Equipment List - New Equipment

Directives:

v)	Annex II	-	Design Basis, extracts.
vi)	Annex IV	-	Construction and Assembley
vii)	Annex VI	-	Planning and Control
viii)	Annex VII	-	Quality Assurance
ix)	Annex VIII	-	Commissioning and Pre-Operations
x)	Annex IX	-	Facilities for BRASOIL supervisors
xi)	Annex X	-	Deviations of Basic Design

xii) Noble Denton Basic Engineering Feasibility

1. Introduction

The Spirit of Columbus is a new build semi-submersible currently equipped as a Floating Production and Drilling Unit. The vessel has been selected to be installed as a Production Unit in the Petrobras P36, South Marlim Field. The vessel will require additional process related equipment to suit the field specific needs, as expressed within the project directives and specifications.

The upgrade will be progressed within the following phases:

Phase 1	Basic Design
Phase 2	Detailed Engineering
Phase 3	Procurement
Phase 4	**Yard workscope**
Phase 5	Offshore delivery

The following description provides a brief summary of the Phase 4 requirements, the BRASOIL Directives will form the basis for any contractural agreement.

2. Overview

The SoC will be delivered with essential life support, marine and utility systems in service. The production system is currently equipped with a level of core facilities. The upgrade workscope will be progressed within three distinct areas:

i. Removal of redundant equipment, deck preparation.

ii. Installation and hook-up of new, fully outfitted, packaged equipment

iii. Upgrade of existing facilities to comply with project specifications

The upgrade yard shall be responsible for all works associated with the removal and storage of redundant equipment and the receipt, installation and hook-up of the Field Specific Equipment (FSE) packages. The FSE packages will be delivered fully outfitted with valves and instrumentation, piped and cabled to skid edge interfaces. In addition, the yard will be responsible for the provision of all necessary installation materials and consumables, to be supplied in compliance with the applicable Project specifications. The work will include for the modification of existing Core Equipment and utilities, as defined in the Workpacks. The upgrade yard will be required to develop detailed planning and fabrication documents, as described within the Directives.

The upgrade yard shall be responsible for the testing and on-shore commissioning pursuant to the issue of the System Acceptance Certification described within Annex VIII - Directives for Commissioning and Pre-operations.

The upgrade yard shall be responsible for adherence with the Directives, prevailing regulatory standards and codes of practice, together with the established principles of good oilfield practice, in achieving the safe and efficient completion of the work.

3. Equipment Receipt and Storage

The yard will be required to receive and store the FSE packages, prior to installation. Upon delivery the equipment shall be inspected, against the specification, for completeness and damage. Any shortfall or damage shall be noted by the yard, with a report issued to the Company and the supplier. The yard will arrange for suitable storage, preservation, care and maintenance, in accordance with the recommendations of the supplier.

Yard supplied materials and consumables shall be stored and controlled in accordance with a recognised international quality control standards i.e. BS5750 or equivalent.

Redundant equipment removed from the SoC shall be stored in suitable conditions as required by the Company, in readiness for future deployment.

4. Installation

The yard will be provided with a detailed Engineering Design package which will include:

- Process and Utility Flow Diagrams (P/UFD) and Piping and Instrument Diagrams (P&ID).
- Project equipment, installation and commissioning specifications.
- Schedule of interfaces.
- Equipment lists, weights and dimensions.
- Structural steelwork scantlings.
- Equipment layouts.
- Equipment specifications and data sheets.
- Piping Line Lists and cable schedules.
- Project quality plan.
- Current "as built" electrical/controls documentation.
- Project Procurement Plan.

The yard will be responsible for the development of the following:

- Quality assurance / quality control procedures.
- Final material take-offs.
- Fabrication detail documents including structural, pipework, cable traywork and equipment mounting supports.
- Pipe supports and stress analysis.
- Lifting and rigging arrangements.

- Routing and distribution of small bore pipework.
- CA approved Welding and NDT/hydrotest procedures.
- Electrical/controls cable routing and interconnection drawings.
- Function test and onshore commissioning procedures.
- Company supplied documents to be modified to "as-built" status.
- Vendor document control.
- Fire protection/detection system integration.

The installation shall include all necessary skills and resources to complete the work, which will include manpower [supervisory, technical, inspection, trades and labour] together with machinery, equipment, tools, scaffolding and consumables as required.

The following list is indicative of the general areas and types of activities currently envisaged during the upgrade:

- Monitor and control progress.
- Remove redundant equipment.
- Complete structural modifications e.g. aft deck extension steelwork.
- Prepare existing pipework and support systems.
- Lift and install FSE packages.
- Complete process system package installation and connection to the existing pipework and support systems.
- Complete integration of safety and control system equipment.
- Equipment calibration and function testing
- Complete marine system modifications.
- Install, gland, terminate and dress electrical cables, as required by the activities above.
- Install and connect all small bore pipework and tubing, as required by the activities above.
- Make good and repair any damage to the existing equipment.
- Make good and repair paintwork and protective coating systems.
- Generate work outstanding punchlists.
- Provide supervisory, inspection and quality control services (radiography, NDT, hydrotest etc.).

5. Function Testing and Onshore Commissioning

The vessel will be delivered to the upgrade yard with existing marine and safety systems functional and in service. The upgrade yard will be required to provide continued care and maintenance for the existing systems. The upgrade yard shall complete detailed system function testing and on-shore commissioning for all systems added to, or modified during the upgrade. The procedures shall be effected in accordance with the Directives to the satisfaction of the Company Representative(s).

Completion of the testing and commissioning shall be evidenced by the progressive acceptance of the Certifying Authority and the Company representatives.

Completion of the systems requiring either hydrocarbons or access to deepwater, for final commissioning shall be taken as far as is reasonably practicable.

The yard shall be responsible for the satisfactory completion of Surveys, Statutory and otherwise, and any related functional and performance testing that may be required by the Certifying Authority.

6. Spirit of Columbus Background

6.1 Summary Vessel Description

The Spirit of Columbus is a 'state of the art' Floating Exploration and Production Facility, capable of drilling and oilfield production activities across a wide range of water depths. The vessel is based on Friedman and Goldman 'Trendsetter' class semi-submersible mobile drilling rig design, and has been designed to be suitable for a wide range of field operating conditions worldwide.

The basic design incorporates all the marine systems, utilities, services and drilling facilities, plus core production equipment. The core production equipment is designed to cater for a wide range of operating conditions, but it may be necessary to add 'field development equipment' to meet the requirements of a specific field (gas:oil ratio, pressure, temperature, export requirements etc.) Space, payload and utilities have been allocated to cater for such equipment.

The Spirit of Columbus is provided with drilling facilities capable of development drilling, which also provide full workover capability. The core process equipment is designed to handle up to 100,000 bopd, 120,000 bwpd for water injection and up to 100 mmscf/d of compressed gas, with oil exported via an offshore tanker loading system up to 3km away. Facilities for gas export, gas lift, gas injection and oil export via pipeline can be added as field development equipment, .

The FPF is designed and constructed in accordance with the requirements for Production Operations in the North Sea as laid down by the UK Department of Industry and the UK Health & Safety Executive. Lloyds Register will issue a certificate of compliance to this effect. The vessel is Classified by both Lloyds and the Italian authority RINa.

Dimensions

The main dimensions of Spirit of Columbus are:

Length overall	112.8m
Beam overall	77.8m
Height (keel to top of main deck)	42.7m
Height (keel to top of derrick)	95.3m
Operating Draft	24.4m
Transit Draft	15.0m

Upper Hull length overall	70.1m
Upper Hull Beam overall	68.6m
Upper Hull Depth overall	7.7m

Note: The transit draft above should be taken as the maximum expected draft of the vessel at the completion of the proposed outfitting, with thrusters fitted. With the thrusters removed, the equivalent draft would be 10.3m. The minimum expected draft during outfitting is 9.5m.

6.2 Detailed Vessel Description

Drilling Systems

The Dynamic derrick is 160 feet high with a 40ft by 40ft base, rated at 1,000,000lbs, static hook load. The Drill String Compensator is 600,000lbs capacity with 25ft stroke and an integral 500 ton travelling block. The vessel has a 2000hp drawworks fitted with 1.5" wireline suitable for nominal 6560m (20,000ft) drilling depth, a 4 9 ½" rotary table independently driven by 1000hp dc motor, with a 59ft kelly and 500 ton swivel. The Riser Tensionning is achieved with a 6 x 80,000 lb riser tensioner system.

There is a 500 psig diverter with a single 16" divert line, 10,000 psig choke and kill manifold, mud/gas separator, 50 barrel capacity trip tank and pump. A 193 ton rail mounted BOP transporter is fitted, with 2 x 22 ton overhead maintenance cranes. The Subsea BOP hydraulic control system with master control unit, accumulators, duplicate hose reels and pods, drillers control panel and electric mini control panel.

The vessel is fitted with 2 x 2950 cu ft bulk cement storage tanks and 1 x 480 cu ft staging tank. There are also 2 x 2950 cu ft barites tanks with 2 x 1100 cu ft storage tanks and 1 x 40 cu ft surge tank. Fluidisation and conveying by 60psi compressed air system. Cementing is by twin diesel driven cement pumps rated at 10,000psig complete with liquid additive proportioning tanks, displacement tanks, cement mixing system, discharge manifold, with dual high pressure lines to drill floor cement manifold and connection to choke and kill manifold.

For Mud Storage/Mixing, there is an Active/reserve tank capacity of 2760 barrels, two 6 x 5 mixing pumps, two 700 gpm hoppers, low pressure and high pressure mud guns. There are two 1600hp triplex mud pumps fed by two 6 x 5 charge pumps to supply high pressure mud at up to 5000 psig. Mud Return and Processing is by 4 double deck shakers with 2 x 8 cone desilter banks over one shaker, and a 1000 gpm vacuum type degasser.

There is an 18 3/4" 10,000psig BOP stack consisting of 1 x 5,000 psig annular, 4 x 10,000 psig ram preventers, flexible joint well connector, 21" OD riser with 10,000 psig choke and kill lines, integral boost line and telescopic joint. There is a full pipe handling set plus a downhole drill string and complete set of drilling tools.

A central hydraulic unit powers BOP handling and maintenance system, piperacking system, various drill floor tools and minor users. Utilities are supplied to the drilling equipment from integrated vessel systems.

Provision has been made in the design of the drilling facilities for the installation of crown mounted compensator, Derrick mounted top drive unit, third 1600hp triplex mud pump, riser tensioner system capable of expansion to 12 x 80,000lbs system, and high speed and low speed centrifuges for deweighting and fines removal.

Production Systems

The core Oil/Gas separation system comprises one train of 2 stage separation. A test separator (3 phase) operating at least at 2nd stage separator pressure is also provided. The test and 2nd stage separators have sandwashing facilities and sand collection trays. Crude heating is provided at the inlet of both the test and 2nd stage separators. Provision has been made for installation of a 1st stage separator, as part of further field development.

Oil is exported by 3 motor driven crude booster pumps. There is a single gas compression train. The Export and HP compressors are driven by a common turbine. Space is available for a possible second export, or reinjection compressor. A glycol dehydration package is provided downstream of the HP compressor and inlet separator in order to provide dry gas to the final compression stage and for fuel. Dewpoint control equipment after the glycol contactor is designated as a field specific development since the required dewpoint specification will be field dependent.

The hydrocarbons produced are metered to fiscal standards in compliance with the Department of Energy (UK) guidelines prior to export. Crude oil will be metered using 3 x 50% parallel turbine meter runs, with a bi-directional prover loop to calibrate the meter runs. The gas is metered by 3 parallel orifice plate runs, using differential pressure transmitters for flow measurement.

Dry fuel gas is supplied from downstream of the glycol contactor tower through a pressure reduction system. Liquids are separated and the gas superheated by heating medium. Fuel gas is supplied at two different pressures. Facilities have been provided for the gas turbines to operate during start-up with fuel gas taken directly from the LP Compressor discharge.

Seawater Injection Facilities comprise 2 trains each with 2 seawater feed pumps, coarse filtration, high flux multi-media fine filtration, vacuum deaeration, 2 motor driven water injection booster pumps, and 2 motor driven water injection pumps. The feed pumps take their suction directly from dedicated seachests in the pontoons and supply seawater through the filtration system into the deaerator column. Filtered and de-oxygenated water is taken from the bottom of this column via the booster pumps to the main seawater injection pumps.

Process Seawater is supplied by the FPF saltwater system for the process/utilities users. A heating medium system, based on heat recovery from the exhaust of the gas turbine generators provides heat for the crude heater, test heater and fuel gas heater. The heating medium is pressurised glycol/water. Waste heat recovery units are installed at two of the three electrical generators. Produced water separated

from the well fluid is treated by a coalescer system. Hydrocyclones may be fitted upstream and in series with the coalescer.

Facilities are provided for methanol injection at various points in the gas stream. Methanol is also be available for injection into the wells upstream of the choke valves during start-up and blowdown. Production chemicals are supplied in transportable tanks or drums. Metering pumps are used to transfer the chemicals to the required point of injection.

Safety Systems

There is a firewater deluge to external process and drilling areas, and halon, carbon dioxide or sprinkler protection to internal areas supplemented by portable extinguishers, and hand held fire fighting appliances. There is gas detection in the process and drilling areas, and all HVAC air intakes and other areas where there is a possibility of flammable gas accumulating. An automatic alarm system is fitted. A manual fire alarm system is also fitted, with stations positioned on main escape routes throughout the installation. The vessel is also fitted with a fire detection system, and an integrated production, a marine ESD system, and a duplicated PA system.

There are lifeboats and rafts, and the usual miscellaneous safety equipment in the form of lifejackets, survival suits, protective clothing, helicopter crash rescue equipment, breathing apparatus, and medical equipment.

Internal and External Communications and Navigation

The Spirit of Columbus is provided with INMARSAT system, Lifecraft radios and EPIRBS, Telephone System, Facsimile and Telex, Drillers Intercom System, Intercom Systems, Entertainment System, Cinema, Crane Radios, Marine Radios, Aeronautical Radios, NDB System, Environment Monitoring System, Marine Radar Systems, Direction finding and navigation systems, and Telecomms power supplies (UPS's). Provision has been made for the installation of, Speech and data communication by satellite, Closed circuit TV monitoring, and Line of sight telemetry.

Accommodation

The accommodation is designed for a complement of 126 in single and twin bedrooms. The helideck will be designed for operating a Sikorsky S61 type helicopter.

Utility Systems

Main electric power is generated by three LM 1600 gas turbine generators at 6.6KV 3 phase 60hz, each is rated for approximately 11.5 MW. There is also one diesel driven generator at 440V 3 phase 60Hz, 2.25 MW power output. There is provision for a fourth main generator. There are four diesel transfer pumps, and one diesel oil service pump.

Potable water is produced from seawater by reverse osmosis units as part of the vessel utility systems. The fresh water cooling requirements for the FPF equipment are supplied by two fresh water cooling pumps and two plate coolers.

The helicopter refuelling system consists of two transportable tanks, two transfer pumps, a hand operated pump and a dispensing unit.

Marine Systems

A ballast system is installed with remotely operated ballast pumps to permit the filling or emptying of any of the seawater ballast tanks. A ballast pump of 570 m^3/hr capacity is fitted in each of the four pump rooms, one room being located at either end of each pontoon. Each pump room has a cross-over connection both fore and aft and an aft port to starboard cross-over. An automatic priming system is fitted for all ballast pumps.

The ballast system is interconnected with the seawater service and bilge system for standby operation. The ballast system valves are remotely operated from the control console in the central control room and each tank is provided with a remote reading tank level gauge. A separate tank stripping system is installed in each of the aft pontoon pump rooms and cross connected to the forward pump room ballast system.

There are two thrusters installed, each driven by 2 x 2250Kw 6.6 KV electrical motors mounted vertically, one on top of the other. There is provision for two additional thrusters. The thrusters are controlled from a central control console located on the bridge. The vessel is equipped with twelve hydraulic chain windlasses. There is a central control console located on the bridge and local control consoles (4-Total) in each control cabin. The vessel is outfitted for the future installation of two further thrusters should operational requirements dictate them. In this configuration the vessel would also have dynamic positioning capability.

Two cranes are installed, one starboard and one port. The starboard (50te) crane has been designed predominantly for lifting and moving tubulars on the facility and to and from supply boats and may also be used for plant maintenance and replacement lifts. The port (22te) crane has been designed for maintenance and replacement lifts and transferring equipment to and from supply boats.

Four totally enclosed lifeboats are installed each of 65 man capacity. Two are located forward and facing away from the vessel while the remaining two are installed port and starboard also facing away. Five 25 man davit launched liferafts are installed at various locations on the vessel. A rescue boat, fully equipped to meet the regulatory requirements is installed and launched from a single point davit.

Control Systems

Overall control and monitoring of the FPF is managed from a central control room and bridge continuously manned at all times. Control and monitoring equipment in this room provide the operator interface to the various systems which control the field equipment. The major control and monitoring systems in the central control room and bridge include:

- Production control system;
- An integrated marine and production ESD system;
- Monitoring of electrical generation and distribution system;
- Firewater pump monitoring system;
- An integrated Fire and Gas detection system;
- Sounding of all FPF alarms - fire, gas, man overboard, abandon FPF via public address (PA) system;
- Oil metering and export/loading system;
- Bridge control console (propulsion & navigation);
- Mooring winch control system;
- Position reference systems;
- Environmental data systems;
- Ballast and fluids control console;
- Vessel automation system;
- Watertight integrity panel;
- Helicopter/marine supply boat communications.

Control is effected via VDU/keyboards dedicated to specific areas of the overall control and monitoring function. A dual redundant data highway carries signals to and from the central system to outstations located in safe areas. These outstations are hard-wired to field equipment and are capable of performing closed loop control functions at the various equipment items and packages.

Provision has been made within the configuration and space allocation of the control and monitoring system for easy integration of the following field specific systems:

- Gas metering system;
- QC/DC riser control system;
- Subsea control system.

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1	Document		Rev	Issued by	Issue Date		Approved by Client			Approved by C.A.			Progress	Update
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3														
4														
5		REPORTS												
6														
7		DESIGN BASIS	A	PR	23-May-97									
8			0	PR										
9		PROJECT QUALITY MANUAL	A	PR	23-May-97									
10			0	PR										
11		PROJECT QUALITY PLAN	A	PR	23-May-97									
12			0	PR										
13		PROJECT WEIGHT CONTROL MANAGEMENT AND PROCEDURE	A	PR	23-May-97									
14			0	PR										
15		WEIGHT REPORT	A	PR	26-Jun-97									
16			B	PR	26-Jul-97									
17			C	PR	25-Aug-97									
18			D	PR	24-Sep-97									
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28			N	PR	21-Jul-98									
29			O	PR	20-Aug-98									
30			P	PR	19-Sep-98									
31														
32		FORCE AND MOTION ANALYSIS REPORT	A	NA	28-May-97									
33			0	NA										
34		ANALYSIS OF RISER SYSTEM REACTIONS ON PLATFORM	A	NA	03-Jun-97									
35			0	NA										
36		MOORING ANALYSIS REPORT	A	NA	03-Jun-97									
37			0	NA										
38		ANCHORING ANALYSIS REPORT	A	NA	04-Jul-97									
39			0	NA										
40		STABILITY ANALYSIS	A	NA	16-Jun-97									
41			0	NA										
42		OPERATIONS MANUAL UPDATE	A	NA	30-Sep-98									
43			0	NA										
44		HULL MODIFICATIONS - STRUCTURAL DESIGN REPORT	A	ST	18-Aug-97									
45			0	ST										
46		HULL MODIFICATIONS - STRUCTURAL ANALYSIS REPORT	A	ST	09-Jun-97									
47			0	ST										
48		HULL MODIFICATIONS - MTO LIST	A	ST	09-Jun-97									
49			0	ST										
50		AFT DECK EXTENSION - STRUCTURAL DESIGN REPORT	A	ST	21-Jul-97									
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52		AFT DECK EXTENSION - MTO LIST	A	ST	09-Jun-97									
53			0	ST										
54		MAIN DECK MODIFICATIONS - STRUCTURAL DESIGN REPORT	A	ST	11-Aug-97									
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56		MAIN DECK MODIFICATIONS - MTO LIST	A	ST	11-Jul-97									
57			0	ST										
58		MAIN DECK PACKAGES - STRUCTURAL DESIGN REPORT	A	ST	28-Jul-97									

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	RISER SUPPORT STRUCTURES - MTO LISTS	A	ST	28-Jul-97									
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	RISER PULL-IN EQUIPMENT - DESIGN REPORT	A	ST	18-Aug-97									
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	RISER PULL-IN EQUIPMENT - WINCHES TECHNICAL SPECIFICATION	A	ST	23-Jul-97									
		0	ST										
	RISER PULL-IN EQUIPMENT - SHEAVES/RIGGING TECHNICAL SPECIFICATION	A	ST	23-Jul-97									
		0	ST										
	RISER PULL-IN EQUIPMENT - STRUCTURAL MTO LIST	A	ST	23-Jul-97									
		0	ST										
	UPGRADE OF MOORING EQUIPMENT -STRUCTURAL DESIGN	A	ST	04-Jul-97									
		0	ST										
	MODIFICATIONS OF FAIRLEADS -STRUCTURAL DESIGN	A	ST	18-Aug-97									
		0	ST										
	MODIFICATIONS OF FAIRLEADS - MTO LIST	A	ST	21-Jul-97									
		0	ST										
	MOORING SYSTEM - TECHNICAL SPECIFICATION FOR FIBRE ROPES	A	NA	07-Jul-97									
		0	NA										
	MOORING SYSTEM - TECHNICAL SPECIFICATION FOR CONNECTIONS	A	NA	07-Jul-97									
		0	NA										
	MOORING SYSTEM - TECHNICAL SPECIFICATION FOR CHAIN	A	NA	07-Jul-97									
		0	NA										
	MOORING EQUIPMENT - FILEADS/WINCHES/CHAINSTOPPERS TECHNICAL SPECIFICATION	A	ST	16-Jun-97									
		0	ST										
	UPGRADE OF MOORING CONTROL SYSTEM -TECHNICAL SPECIFICATION	A	ST	16-Jun-97									
		0	ST										
	FENDERING SYSTEM DESIGN	A	ST	11-Jun-97									
		0	ST										
	WORK PLATFORMS AND LADDERS -STRUCTURAL DESIGN	A	ST	18-Aug-97									
		0	ST										
	WORK PLATFORMS AND LADDERS - MTO'S	A	ST	04-Sep-97									
		0	ST										
	FENDERING SYSTEM - TECHNICAL SPECIFICATION	A	ST	18-Jun-97									
		0	ST										
	COLUMN PADEYES -STRUCTURAL DESIGN	A	ST	23-Jun-97									
		0	ST										
	COLUMN PADEYES - MTO LIST	A	ST	23-Jun-97									
		0	ST										
	CRANE BOOM RESTS 22T & 50T - STRUCTURAL DESIGN	A	ST	21-Jul-97									
		0	ST										
	CRANE BOOM RESTS 22T & 50T - MTO LISTS	A	ST	21-Jul-97									
		0	ST										
	DRAWINGS												
	RISER SUPPORTS AND PLATFORMS	A	ST	18-Aug-97									
		0	ST										
	EXTENSION OF CENTRAL CAISSON	A	ST	18-Aug-97									
		0	ST										
	EXTENSION OF FAIRLEAD BOXES	A	ST	HOLD									

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Document		Rev	Issued by	Issue Date		Approved by Client			Approved by C.A.			Progress	Update
2	Number	Document Title			Scheduled	Actual	Transmittal No	Comment by	Status	Transmittal No	Comment by	Status	% Complete	
3														
114			0	ST										
115		FENDERS	A	ST	18-Aug-97									
116			0	ST										
117		COLUMN PADEYES	A	ST	18-Aug-97									
118			0	ST										
119		FAIRLEADS	A	ST	18-Aug-97									
120			0	ST										
121		CRANE BOOM REST - 22T	A	ST	21-Jul-97									
122			0	ST										
123		CRANE BOOM REST - 50T	A	ST	21-Jul-97									
124			0	ST										
125		AFT MAIN DECK EXTENSION	A	ST	21-Jul-97									
126			0	ST										
127		MAIN DECK - PRODN/TEST/GAS LIFT MANIFOLD SUPPORT	A	ST	11-Aug-97									
128			0	ST										
129		MAIN DECK - OIL SEPARATION PACKAGE TRAIN A SUPPORT	A	ST	11-Aug-97									
130			0	ST										
131		MAIN DECK - OIL SEPARATION PACKAGE TRAIN B SUPPORT	A	ST	11-Aug-97									
132			0	ST										
133		MAIN DECK - OIL SEPARATION HEATING PACKAGE SUPPORT	A	ST	11-Aug-97									
134			0	ST										
135		MAIN DECK - MAIN OIL PUMP PACKAGE SUPPORT	A	ST	11-Aug-97									
136			0	ST										
137		MAIN DECK - COMPRESSOR UNIT TRAIN A SUPPORT	A	ST	11-Aug-97									
138			0	ST										
139		MAIN DECK - COMPRESSOR UNIT TRAIN B SUPPORT	A	ST	11-Aug-97									
140			0	ST										
141		MAIN DECK - COMPRESSOR UNIT TRAIN C SUPPORT	A	ST	11-Aug-97									
142			0	ST										
143		MAIN DECK - COMPRESSION PROCESS PACKAGE TRAIN A SUPPORT	A	ST	11-Aug-97									
144			0	ST										
145		MAIN DECK - COMPRESSION PROCESS PACKAGE TRAIN B SUPPORT	A	ST	11-Aug-97									
146			0	ST										
147		MAIN DECK - COMPRESSION PROCESS PACKAGE TRAIN C SUPPORT	A	ST	11-Aug-97									
148			0	ST										
149		MAIN DECK - INLET SEPARATOR PACKAGE SUPPORT	A	ST	11-Aug-97									
150			0	ST										
151		MAIN DECK - GLYCOL REGENERATION UNIT SUPPORT	A	ST	11-Aug-97									
152			0	ST										
153		MAIN DECK - TEG CONTACTORS SUPPORT	A	ST	11-Aug-97									
154			0	ST										
155		MAIN DECK -HEATING MEDIUM EXPANSION VESSEL SUPPORT	A	ST	11-Aug-97									
156			0	ST										
157		MAIN DECK - WATER INJECTION FILTER PACKAGE SUPPORT	A	ST	11-Aug-97									
158			0	ST										
159		MAIN DECK - WATER INJECTION MANIFOLD PACKAGE SUPPORT	A	ST	11-Aug-97									
160			0	ST										
161		MAIN DECK - COOLING MEDIUM PACKAGE SUPPORT	A	ST	11-Aug-97									
162			0	ST										
163		MAIN DECK - GAS BOOSTER COMPRESSION UNIT MODIFIED SUPPORT	A	ST	11-Aug-97									
164			0	ST										
165		MAIN DECK - GAS BOOSTER/SAFETY GAS PROCESS SKID MODIFIED	A	ST	11-Aug-97									
166			0	ST										
167		MAIN DECK - CHEMICAL INJECTION PACKAGE (WI) RELOCATED SUPPORT	A	ST	11-Aug-97									
168			0	ST										

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Document		Rev	Issued by	Issue Date		Approved by Client			Approved by C.A.			Progress	Update
2	Number	Document Title			Scheduled	Actual	Transmittal No	Comment by	Status	Transmittal No	Comment by	Status	% Complete	
3														
69		MAIN DECK - CHEMICAL INJECTION PACKAGE (PRODUCTION) RELOCATED SUPPORT	A	ST	11-Aug-97									
70			0	ST										
71		MAIN DECK - FUEL GAS HEATER/UPGRADED PREHEATER/EXCHANGER PACKAGE SUPPORT	A	ST	11-Aug-97									
72			0	ST										
73		MAIN DECK - SWIMMING POOL - STRUCTURAL DETAILS	A	ST	HOLD									
74			0	ST										
75		MAIN DECK - SPORTS COMPLEX STRUCTURAL DETAILS	A	ST	HOLD									
76			0	ST										
77		MAIN DECK - ACCOMODATION UNITS STRUCTURAL DETAILS	A	ST	HOLD									
78			0	ST										
79		RISER PULL-IN SYSTEM - LAYOUT	A	ST	18-Aug-97									
80			0	ST										
81		MOORING SYSTEM - LAYOUT AND ANCHOR PATTERN	A	NA	07-Jul-97									
82			0	NA										
83		MOORING LINES - COMPONENT DETAILS	A	NA	07-Jul-97									
84			0	NA										
85		CHAINBOXES/CHAINPIPES - STRUCTURAL DETAILS	A	NA	18-Aug-97									
86			0	NA										
87		MOORING SYSTEM CONTROL/INSTRUMENTATION - P&ID's	A	NA	11-Aug-97									
88			0	NA										
89		HATCHES - STRUCTURAL MODIFICATIONS	A	ST	04-Sep-97									
90			0	ST										
91		MAIN DECK - WORKING PLATFORMS AND LADDERS - AFC	A	ST	04-Sep-97									
92			0	ST										
93		RISER SUPPORT STRUCTURES - WORKING PLATFORMS AND LADDERS - AFC	A	ST	03-Oct-97									
94			0	ST										
95														
96	PR	PROJECT												
97	NA	NAVAL ARCHITECTURE												
98	ST	STRUCTURAL												

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Document		Rev	Issued by	Issue Date		Approved by Client			Approved by C.A.			Progress	Update
2	Number	Document Title			Scheduled	Actual	Transmittal No	Comment by	Status	Transmittal No	Comment by	Status	% Complete	
3														
169		MAIN DECK - CHEMICAL INJECTION PACKAGE (PRODUCTION) RELOCATED SUPPORT	A	ST	11-Aug-97									
170			0	ST										
171		MAIN DECK - FUEL GAS HEATER/UPGRADED PREHEATER/EXCHANGER PACKAGE SUPPORT	A	ST	11-Aug-97									
172			0	ST										
173		MAIN DECK - SWIMMING POOL - STRUCTURAL DETAILS	A	ST	HOLD									
174			0	ST										
175		MAIN DECK - SPORTS COMPLEX STRUCTURAL DETAILS	A	ST	HOLD									
176			0	ST										
177		MAIN DECK - ACCOMODATION UNITS STRUCTURAL DETAILS	A	ST	HOLD									
178			0	ST										
179		RISER PULL-IN SYSTEM - LAYOUT	A	ST	18-Aug-97									
180			0	ST										
181		MOORING SYSTEM - LAYOUT AND ANCHOR PATTERN	A	NA	07-Jul-97									
182			0	NA										
183		MOORING LINES - COMPONENT DETAILS	A	NA	07-Jul-97									
184			0	NA										
185		CHAINBOXES/CHAINPIPES - STRUCTURAL DETAILS	A	NA	18-Aug-97									
186			0	NA										
187		MOORING SYSTEM CONTROL/INSTRUMENTATION - P&ID's	A	NA	11-Aug-97									
188			0	NA										
189		HATCHES - STRUCTURAL MODIFICATIONS	A	ST	04-Sep-97									
190			0	ST										
191		MAIN DECK - WORKING PLATFORMS AND LADDERS - AFC	A	ST	04-Sep-97									
192			0	ST										
193		RISER SUPPORT STRUCTURES - WORKING PLATFORMS AND LADDERS - AFC	A	ST	03-Oct-97									
194			0	ST										
195														
196	PR	PROJECT												
197	NA	NAVAL ARCHITECTURE												
198	ST	STRUCTURAL												

JOSÉ CARLOS PIMENTEL GUSMÃO
Diretor da Divisão de Serviços Cartoriais

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Noble Denton Europe Ltd
P36-RONCADOR
WS: 7/14/2134

DRAFT

12/05/97

DIVISÃO JUDICIÁRIA
N.º 3349
TRIBUNAL MARÍTIMO

CERTIDÃO

CERTIFICO que, nesta data decorreu o prazo para PROVAS sem que o(s) representado(s) Hélio Galvão de Mendonça, Evanildo S. Santos, Carlos José M. Azeredo, Joel Mendes Renno, José Coutinho Barbosa, Sebastião Henriques Villarinho, Carlos Eduardo Sardenberg Bellot e Luiz Eduardo G. Barreiro ——

se manifestassem.

O referido é verdade e dou fé.

Aos 26 de maio de 2003.

RRB.

CONCLUSÃO

Aos 27 de maio de dois mil e três faço estes autos conclusos ao Exm°(ª) Sr(ª). Juiz(ª) Relator —

Do que lavrei este termo para constar.

RRB.

REINALDO ROCHA BARAUNA
Assistente

É CÓPIA FIEL DO DOCUMENTO ORIGINAL

JOSÉ CARLOS PIMENTEL GUSMÃO
Diretor da Divisão de Serviços Cartoriais

Defiro a produção de prova testemunhal requerida em fls. 3021 para três testemunhas, a saber: JOSÉ ANTONIO DE FIGUEIREDO, ANTONIO CARLOS JUSTI e ALBERTO JESUS PADILLA LISONDO.
Designo o dia 09/07/2003 às 09:00 horas para audiência.
Indefiro quanto ao depoimento pessoal do Sr. EDUARDO COSENTINO DA CUNHA, por tratar-se de autor da representação de parte e já ter juntado aos autos sua sustentação.
Publique-se.
Intime-se.

Defiro o requerido às fls. 3025 a 3027. Junte-se aos autos.
Publique-se.

Defiro a produção de prova testemunhal requerida às fls. 3052.
Para as testemunhas CARLOS ALBERTO SAMPAIO e GILBERTO DUQUE DE OLIVEIRA, deverá ser efetuado preparo e apresentado rol de quesitos. Prazo: 5 dias.
Para as testemunhas CARLOS JOSÉ DO NASCIMENTO TRAVASSOS e JOSÉ ANTONIO HENRIQUES DA COSTA, designo o dia 23/07/2003 às 09:00 para audiência.
Publique-se.
Intime-se.

Em relação ao requerido em fls. 3055, as palestras e demais documentos requeridos encontram-se juntados aos autos às fls. 1362, sendo que a fita e o CD estão com o Juiz-relator. Quanto ao material distribuído ou gravado em outros workshops realizados no Brasil e no exterior, por ser de caráter genérico, poderá ser trazido aos autos pelo requerente no curso da Instrução.
Publique-se.

Em 04/06/2003.

Sergio Cezar Bekel
Juiz - Relator

Defiro a produção de prova testemunhal requerida às fls. 3057, 3063, 3065, 3067 e 3069, devendo ser apresentada qualificação das testemunhas pelo requerente. Para as testemunhas que residirem fora da área da Cidade do Rio de Janeiro, deverá ser efetuado preparo e apresentado rol de quesitos. Prazo: 5 dias. As testemunhas que residem no exterior deverão comparecer a audiência independente de intimação, cabendo ressaltar que para os estrangeiros deverá ser providenciado pelo requerente intérprete/tradutor juramentado.
Publique-se.

Indefiro o requerido às fls. 3059, tendo em vista que o requerente poderá, nesta fase da instrução, apresentar laudo técnico que substituirá com maior celeridade a prova requerida.
Publique-se.

Defiro a produção de prova testemunhal requerida às fls. 3061.
Para as testemunhas SEBASTIÃO FRANCISCO DE SOUZA FILHO, EDUARDO RODRIGUES DA COSTA e LUIZ MARIO LINHARES DE AZEVEDO, deverá ser efetuado preparo e apresentado rol de quesitos. Prazo: 5 dias.
Para as testemunhas MARCOS ANTONIO CAHU LAURIA, ARTUR CESAR HECHT e HÉLIO GALVÃO DE MENEZES, designo o dia 30/07/2003 às 09:00 horas para audiência.
Publique-se.
Intime-se.

Defiro o requerido às fls. 3071, 3072 e 3073. Junte-se aos autos itens a, b e c e oficie-se à Petrobrás quanto ao item d, efetuando-se preparo.
Publique-se.

RJ 04/06/2003

Sergio Cezar Bokel
Juiz - Relator

RECEBIMENTO

Aos 04/06/03, em Secretaria, recebi os presentes autos do Juiz Relator

Do que lavrei este termo para constar.

RMB

CERTIDÃO

CERTIFICO que, nesta data foi expedido despacho de fls 3350/3351 para publicação no DJ. O referido é verdade e dou fé.
Aos 09 de junho de 2003.

CERTIDÃO

CERTIFICO que, nesta data foi publicado no DJ. número 110 de 11/06/03, súmula do despacho.
O referido é verdade e dou fé.
Aos 13 de junho de 2003.

RMB.

JUNTADA

Aos 13 de junho de 2003 em Secretaria junto aos presentes autos 1 NOTIFICAÇÃO AOS REPRESENTANTES **que adiante segue.**

Do que para constar lavrei este termo.

RMB

Processo nº 19.489/2001

NOTIFICAÇÃO

O JUIZ DO TRIBUNAL MARÍTIMO DA REPÚBLICA FEDERATIVA DO BRASIL, Dr. SERGIO CEZAR BOKEL, Relator do Processo nº 19.489/2001, referente ao acidente e fato da navegação com a plataforma "P-36", na bacia de Campos, RJ, em 15 de março de 2001, na forma da Lei, expede a presente N O T I F I C A Ç Ã O, por ele assinada e subscrita pela Diretora da Divisão Judiciária, ao Sr. JOSÉ ANTONIO DE FIGUEIREDO, com endereço na Avenida República do Chile nº 65, 18º andar, Centro, Rio de Janeiro, RJ, Cep: 20.031-170, para comparecer a este Tribunal, sob as penas da Lei, no dia 09 de julho de 2003, às 09h, a fim de prestar depoimento nos autos do processo supramencionado. **QUE SE CUMPRA NA FORMA DA LEI**. Dado e passado na sede deste Tribunal, Avenida Alfred Agache s/nº, nesta Cidade e Estado do Rio de Janeiro, aos 09 de junho de 2003. Eu, ANGELA CARNEVALE _____, Chefe da Seção de Processamento de Feitos, mandei datilografar e conferi. E eu, DINÉIA DA SILVA _____, Diretora da Divisão Judiciária, subscrevo.

SERGIO CEZAR BOKEL
Juiz-Relator

Processo nº 19.489/2001

NOTIFICAÇÃO

O JUIZ DO TRIBUNAL MARÍTIMO DA REPÚBLICA FEDERATIVA DO BRASIL, Dr. SERGIO CEZAR BOKEL, Relator do Processo nº 19.489/2001, referente ao acidente e fato da navegação com a plataforma "P-36", na bacia de Campos, RJ, em 15 de março de 2001, na forma da Lei, expede a presente N O T I F I C A Ç Ã O, por ele assinada e subscrita pela Diretora da Divisão Judiciária, ao Sr. ALBERTO JESUS PADILLA LISONDO, com endereço na rua da Assembléia nº 10, sala 2002, Centro, Rio de Janeiro, RJ, Cep: 20.011-000, para comparecer a este Tribunal, sob as penas da Lei, no dia 09 de julho de 2003, às 09h, a fim de prestar depoimento nos autos do processo supramencionado. **QUE SE CUMPRA NA FORMA DA LEI.** Dado e passado na sede deste Tribunal, Avenida Alfred Agache s/nº, nesta Cidade e Estado do Rio de Janeiro, aos 09 de junho de 2003. Eu, ANGELA CARNEVALE _____, Chefe da Seção de Processamento de Feitos, mandei datilografar e conferi. E eu, DINÉIA DA SILVA _____, Diretora da Divisão Judiciária, subscrevo.

SERGIO CEZAR BOKEL
Juiz-Relator

Processo nº 19.489/2001

NOTIFICAÇÃO

O JUIZ DO TRIBUNAL MARÍTIMO DA REPÚBLICA FEDERATIVA DO BRASIL, Dr. SERGIO CEZAR BOKEL, Relator do Processo nº 19.489/2001, referente ao acidente e fato da navegação com a plataforma "P-36", na bacia de Campos, RJ, em 15 de março de 2001, na forma da Lei, expede a presente N O T I F I C A Ç Ã O, por ele assinada e subscrita pela Diretora da Divisão Judiciária, ao Sr. ANTONIO CARLOS JUSTI, com endereço na rua General Canabarro nº 500, 7° andar, Maracanã, Rio de Janeiro, RJ, Cep: 20.271-201, para comparecer a este Tribunal, sob as penas da Lei, no dia 09 de julho de 2003, às 09h, a fim de prestar depoimento nos autos do processo supramencionado. **QUE SE CUMPRA NA FORMA DA LEI**. Dado e passado na sede deste Tribunal, Avenida Alfred Agache s/nº, nesta Cidade e Estado do Rio de Janeiro, aos 09 de junho de 2003. Eu, ANGELA CARNEVALE _____, Chefe da Seção de Processamento de Feitos, mandei datilografar e conferi. E eu, DINÉIA DA SILVA _____, Diretora da Divisão Judiciária, subscrevo.

SERGIO CEZAR BOKEL
Juiz-Relator

É CÓPIA FIEL DO DOCUMENTO ORIGINAL

JOSÉ CARLOS PIMENTEL GUSMÃO
Diretor da Divisão de Serviços Cartoriais

10 Jun

AC/DS/11

TRIBUNAL MARÍTIMO

RIO DE JANEIRO, RJ.

Nº 834

Em 10 de junho de 2003.

Do: Presidente
Ao: Exmº Sr. Diretor da Procuradoria Especial da Marinha

Assunto: audiência de instrução

Referência: processo nº 19.489/2001

1. Solicito a V. Exª seja dado conhecimento a Drª Tereza Cristina Bevilácqua que, pelo Juiz Sergio Cezar Bokel, Relator do processo em referência, foi marcada audiência de instrução para o dia 09/07/2003, às 09h, quando será realizada a oitiva das testemunhas José Antonio de Figueiredo, Antonio Carlos Justi e Alberto Jesus Padilla Lisondo.

POR ORDEM:

DINÉIA DA SILVA
Diretora da Divisão Judiciária

Cópias:
TM-10 1
TM-11.1 2
Arquivo 1

JUNTADA

Aos 13 de Junho de 2003 em Secretaria junto aos presentes autos NOTIFICAÇÃO DO DR. CONSENTINO E A DRA VANUZIA. — que adiante segue.
Do que para constar lavrei este termo.

pro

JOSÉ CARLOS PIMENTEL GUSMÃO
Diretor da Divisão de Serviços Cartoriais

De: DINEIA @ TRIBAR (Dinéia)
Data: 09-jun-2003 15:25:15 [R-09152515P/JUN/2003]
Para: mariorebello@uol.com.br
Assunto: depacho p-36

Senhor advogado informo a V.Sª que o MM. Juiz Relator exarou o seguinte despacho nos autos do processo nº 1489/2001:

Defiro a producão de prova testemunhal requerida em fls. 3021 para três testemunhas, a saber: JOSÉ ANTO O DE FIGUEIREDO, ANTONIO CARLOS JUSTI E ALBERTO JESUS PADILHA LISONDO.

Designo o dia 09/07/2003 às 09:00 horas para audiência.

Indefiro quanto ao depoimento pessoal do Sr. EDUARDO COSENTINO DA CUNHA, por tratar-se de autor d epresentação de parte e já juntado aos autos sua sustentação.

Publique-se.

Intime-se.

SERGIO CESAR BOKEL

Juiz relator

Reinaldo Rocha Barauna

É CÓPIA FIEL DE DOCUMENTO ORIGINAL

JOSÉ CARLOS PIMENTEL GUSMÃO
Diretor da Divisão de Serviços Cartorlais

De: DINEIA @ TRIBAR (Dinéia)
Data: 09-jun-2003 15:47:34 [R-09154734P/JUN/2003]
Para: tancredo@alternex.com.br
Assunto: Despacho Processo Nº19489/2001

Senhor Advogado informo a V.Sª que o MM. Juiz Relator exarou o seguinte despacho:
Defiro a producão de prova tstemunhal requerida em fls. 3021 para três testemunhas, a saber: JOSÉ ANTONIO DE FIGUEIREDO, ANTONIO CARLOS JUSTI E ALBERTO JESUS PADILHA ISONDO.
Designo o dia 09/07/2003 às 09:00 horas oara a audiência.
Indefiro quanto ao depoimento pessoal do Sr. EDUARDO CONSENTINO DA CUNHA, por tra se de Autor da Represetação de Parte e já juntado aos autos sua sustentação.
Publique-se.
Intime-se.
SERGIO CESAR BOKEL
Juiz-Relator

Reinaldo Rocha Barauna

É CÓPIA FIEL DO DOCUMENTO ORIGINAL

JOSÉ CARLOS PIMENTEL GUSMÃO
Diretor da Divisão de Serviços Cartoriais

De: tancredo@alternex.com.br ("Neya")
Data: 11-Jun-2003 17:28:31 [R-11172831P/JUN/2003]
Para: DINEIA@TRIBAR.MB
Assunto: Lidas: Despacho Processo N§19489/2001

É CÓPIA FIEL DO DOCUMENTO ORIGINAL

JOSÉ CARLOS FIUZA DE CUSMÃO
Diretor da Divisão de Serviços Cartoriais

DESTINATÁRIO DO OBJETO / DESTINATAIRE

NOME OU RAZÃO SOCIAL DO DESTINATÁRIO DO OBJETO / NOM OU RAISON SOCIALE DU DESTINATAIRE

ENDEREÇO / ADRESSE

Sr. ALBERTO JESUS PADILLA LISONDO
Rua da Assembléia, nº 10, sala 2002
Centro – Rio de Janeiro – RJ
20011-000
Notificação Proc. 19489/01

CEP / CODE POSTAL

PAÍS / PAYS

DECLARAÇÃO DE CONTEÚDO (SUJEITO A VERIFICAÇÃO) / DISCRIMINACION

O OBJETO FOI DEVIDAMENTE / L'ENVOI A ÉTÉ DÛMENT

☐ ENTREGUE / REMIS ☐ PAGO / PAYÉ

DATA DE RECEBIMENTO
12/6/03

CARIMBO DE ENTREGA
UNIDADE DE DESTINO
BUREAU DE DESTINATION

ASSINATURA DO RECEBEDOR / SIGNATURE DU DESTINATAIRE

Nº DOCUMENTO DE IDENTIFICAÇÃO DO RECEBEDOR

RUBRICA E MAT. DO EMPREGADO / SIGNATURE DE L'AGENT
Marcos A.R do Nascimento
Carteiro Motorizado
Matr. 8.956.414-6

VEJA, DO OUTRO LADO, O ENDEREÇO PARA DEVOLUÇÃO DESTE AR

* 7 5 2 4 0 2 0 3 - 0 *

7524-0203-0 FC0463 / 16 114 x 186 mm

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JOSÉ CARLOS PIMENTEL GUSMÃO
Diretor da Divisão de Serviços Cartoriais

DESTINATÁRIO DO OBJETO / DESTINATAIRE

NOME OU RAZÃO SOCIAL DO DESTINATÁRIO DO OBJETO / NOM OU RAISON SOCIALE DU DESTINATAIRE

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CEP CODE POSTAL | C | PAÍS / PAYS

DECLARAÇÃO DE CONTEÚDO (SUJEITO A VERIFICAÇÃO) / DISCRIMINACION

O OBJETO FOI DEVIDAMENTE / L'ENVOI A ÉTÉ DÛMENT

☐ ENTREGUE / REMIS ☐ PAGO / PAYÉ

DATA DE RECEBIMENTO 2/6/03

ASSINATURA DO RECEBEDOR / SIGNATURE DU DESTINATAIRE

Marcelo V. de Souza

Nº DOCUMENTO DE IDENTIFICAÇÃO DO RECEBEDOR 512130

RUBRICA DO CARTEIRO / SIGNATURE DE L'AGENT

VEJA, DO OUTRO LADO, O ENDEREÇO PARA DEVOLUÇÃO DESTE AR.

ENTREGA
UNIDADE DE DESTINO
BUREAU DE DESTINATION
DGRIN
13 JUN 2003
NÚCLEO PETROBRAS
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CERTIDÃO

CERTIFICO que nesta data foi encerrado o 15º **volume do processo nº 19.489/2001 com suas fls. nº** 3361 **dos autos.**
O referido é verdade e dou fé.
Aos 16 **de** Junho **de 2003.**

DRB.

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JOSÉ CARLOS PIMENTEL CUSMÃO
Diretor da Divisão de Serviços Cartorários