THE OFFSHORE HYDROCARBON RELEASES (HCR) DATABASE

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Following the Piper Alpha disaster in 1988, and the subsequent investigation by Lord Cullen, it was found that there was a scarcity of information on incidents resulting from hydrocarbon leaks or spills, which meant that the frequency, and hence the risk, of future incidents could not easily be predicted.
In his report, Lord Cullen recommended (Recommendation 39) that:
"The regulatory body should be responsible for maintaining a database with regard to hydrocarbon leaks, spills, and ignitions in the Industry and for the benefit of Industry."
This paper deals with the setting up of the HCR Database, and discusses the main features and benefits of the database.

KEY WORDS : Offshore Safety; Hydrocarbons Incidents; Leak Frequencies; Database; Cullen Recommendation;

INTRODUCTION

During his investigation of the Piper Alpha disaster, and in his subsequent report [ref.1], Lord Cullen wrote (Vol.II, Page 299, Section 18.43):
"I am convinced that learning from accidents and incidents is an important way of improving safety performance. I consider that it would be useful if there was a systematic means by which what could be learnt from incidents and near misses could be shared by all operators."

At the time of the Piper Alpha disaster (July, 1988) the sources of accident/incident data were such that there was a scarcity of information on incidents resulting from hydrocarbon leaks or spills. The main data sources in the public domain at the time either covered major accidents involving substantial loss and stoppages over 24 hours, or they only covered failures and breakdowns with no link to the consequences of the failure.

Figure 1 overleaf illustrates this situation, with the main data sources shown on the left of the triangle, and the severity of incidents covered by these sources shown on the right. The base of the triangle represents the many offshore failures and breakdowns occurring over a period of time. The further one progresses up the scale of severity, the less frequent the incidents become, until, at the peak of the triangle is the disaster resulting in loss of platform and major loss of life.

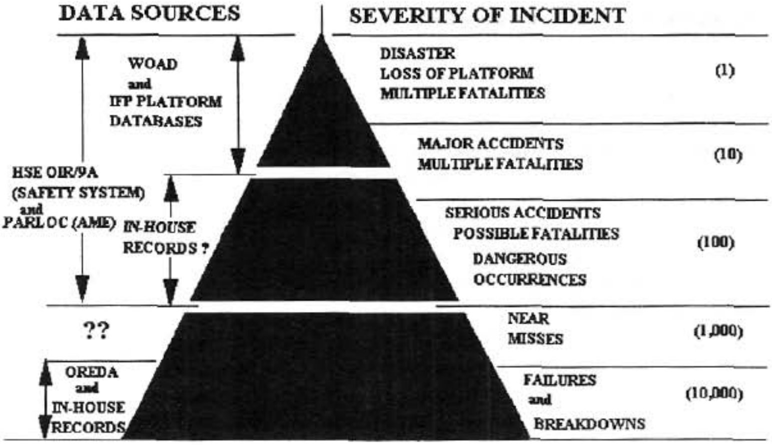


FIGURE 1

The numbers of occurrences also shown in the figure give an indication of the relative orders of magnitude for each incident type over a period of time. That is to say for every 10,000 failures there could be 1,000 near misses. For every 1,000 near misses, there could be 100 dangerous occurrences and/or serious accidents. For those 100 serious accidents, there could be 10 major accidents, and for every 10 major accidents there could be 1 disaster, such as Piper Alpha itself.

In 1988, the main accident data sources in the public domain, covering Offshore incidents in the North Sea, were WOAD [ref.2], IFP "Platform" [ref.3], and the Department of Energy "Brown Book" [ref.4] the statistics for which were extracted from the "Safety System" database containing all incidents reported to the regulatory body on OIR/9A forms. There was also a joint Industry project underway to gather incident data on "Pipelines And Risers Loss Of Containment", which has since been published as PARLOC '90 [ref.5]. The main source of data on offshore system and equipment failures was OREDA [ref.6].

Most accident data sources at the time shared a common criteria that "dangerous occurrences" involved stoppages of over 24 hours. This meant that "near misses" i.e. those hydrocarbon leaks, spills and ignitions resulting in a lower level of consequential stoppage or damage, were missing from the published data.

Lord Cullen identified this shortfall of data in his report, and one of his 106 recommendations dealt directly with the question of a Hydrocarbon Releases Database.

Cullen Recommendation 39 states that :

" The regulatory body should be responsible for maintaining a database with regard to hydrocarbon leaks, spills and ignitions in the Industry and for the benefit of Industry.

The regulatory body should:

(i) discuss and agree with the Industry, the method of collection and use of the data;

(ii) regularly assess the data to determine the existence of any trends and report them to Industry;

(iii) provide operators with a means of obtaining access to the data, particularly for the purpose of carrying out quantified risk assessment (QRA)"

As a result of other Cullen Recommendations (Nos.23-26) the Health and Safety Executive, Offshore Safety Division (HSE-OSD) took over the responsibility for offshore safety from the Department of Energy, in April, 1991.

As the new Regulatory Body, HSE-OSD therefore also assumed responsibility for the setting up of the Hydrocarbon Releases (HCR) Database in line with Cullen Recommendation 39.

The remaining sections of this paper are concerned with the setting up of the HCR Database, with examples of the Outputs and Trends information likely to be produced, and with the likely benefits to be gained from their use by Industry, for example in QRA.

DATA COLLECTION

Since item (i) of Cullen Recommendation 39 required that the regulatory body should " discuss and agree with Industry, the method of collection and use of the data", it was necessary to set up the formal lines of communication required to achieve this.

A Joint Working Party (JWP) with Industry on Failure Rate Data (FRD) was formed , and an inaugural meeting was held in April, 1992. Initially, the membership of the JWP comprised three representatives from the United Kingdom Offshore Operators Association (UKOOA) ; one member representing the joint interests of the International Association of Drilling Contractors (IADC) and the British Rig Owners Association (BROA) ; and four members from HSE-OSD including the Chair and Secretariat. This was later augmented by one coopted member representing the Exploration and Production (E & P) Forum, and another one member representing Offshore Risk Consultants via the Affiliates of the Safety and Reliability Society (SaRS).

Releases Data

Before setting about gathering the required data on hydrocarbon leaks, spills and ignitions, however, it was recognised that the existing scheme for reporting offshore incidents [ref.7] would need to be amended. The first thing to be done, therefore, was to discuss and agree revisions to the existing definitions for dangerous occurrences. These definitions appear on the OIR/9A reporting form, which is the official form issued by HSE-OSD for the reporting of all offshore incidents covered by the regulations.
The main definition regarding hydrocarbon releases, now reads :
"Any release of petroleum hydrocarbon resulting in the stoppage of plant; the suspension of work; a flash fire; a continuous fire; an explosion; the operation of a smoke, flame, fire or gas detector at or above the lowest action point; or any specific action to prevent the possibility of a fire or an explosion; and/or any release resulting in or having the potential to cause death or serious injury to any person".

It was felt that this revised definition would have the effect of lowering the reporting threshold, thus covering the near misses and leaks,spills and ignitions discussed in the Cullen Report.

At the same time, a new voluntary reporting scheme was set up. This scheme requires the operator to provide further details, on a voluntary basis, of the hydrocarbon released. These details would be provided on a new "Hydrocarbon Release Report Supplementary Information" form (OIR/12) and would include :

- Date, time and geographical location of incident, including Installation details
- Hydrocarbon type, including density/gravity, Gas to Oil Ratio (GOR), level of H_2S
- Quantity released, and Duration of leak
- Location of leak, including an itemised check list indicating system and equipment involved
- Hazardous area classification
- Equivalent hole diameter, based on hydraulic equivalent hole, $d = 4A/p$ where A = Actual cross-sectional area of hole and p = wetted perimeter.
- Module Ventilation and Weather Conditions
- System Pressure, maximum allowable and actual at time of release
- Total (isolatable)Hydrocarbon Inventory in system
- Means of Detection, i.e. type(s) of detector activated and/or sight/sound/smell indications
- Extent of dispersion/accumulation
- Cause of Leak, including an itemised check list indicating any failure in design, equipment, operational, and/or procedural aspects, plus operational mode in the area at the time
- Ignition details , including delay time (if any) and sequence of events, plus ignition source
- Emergency actions taken, with tick list for shutdown, blowdown, deluge, CO_2/Halon, call to muster stations/lifeboats.

Many other details were discussed, e.g. maintenance data including tag numbers, methods of repair, criticality, etc., but these were discounted mainly in the interests of anonimity and of brevity (The OIR/12 form is currently 6 pages long !).

The first completed OIR/12 forms were received in HSE-OSD in early October, 1992, and so it was decided to make the start date 1 October, 1992 for all data in the HCR Database.

The receipt of correctly completed OIR/12 forms is important to ensure good output data from the database, and so "Guidance on the Reporting of Offshore Hydrocarbon Releases" [ref.8] was issued to Industry in August, 1993. The guidance contained in this document was aimed at consistency in completion of both the statutory (OIR/9A) form and the voluntary (OIR/12) form. Copies of both forms are contained in the guidance document , which may be obtained from HSE Information Services in Sheffield.

Population Data

Cullen Recommendation 39 also mentions the determination of trends and the use of data for the purposes of carrying out QRA (items (ii) and (iii) respectively).

To validate trends, once determined, it is necessary to know the size of the affected population. For example, 5 leaks from a population of 100 equipment items, can be seen to be more significant than 5 leaks from a population of 10,000 such items.

Leak frequencies are a prerequisite for the QRA of hydrocarbon incidents, for example as initiating events in event trees, or as base data in fault tree analyses, and these are expressed in terms of "per equipment year" or "per activity"(e.g. per well drilled).

To facilitate the calculation of trends and leak frequencies it was decided that systems and equipment population data would need to be obtained and be input into the Hydrocarbon Releases (HCR) Database.

Proposals for a Population Data Gathering Project were discussed by the JWP on FRD, and a questionnaire was drawn up.
The questionnaire was in three parts :
Part 1 comprised details of the type of Installation involved, e.g. Fixed or Mobile, plus details of drilling and workover activities carried out in the past year (if any).
Part 2 comprised a count of the types of systems involving hydrocarbons on the Installation.
Part 3 comprised a count of the equipment components contained in each system type.
The questionnaire also contained integrated guidance which included definitions of the systems and equipment involved.

A Pilot Study was then carried out to test the effectiveness of the questionnaire and the guidance, to obtain information on the likely accuracy of the population data produced, and to give an indication of the resources necessary to complete the overall exercise.

The Pilot Study was carried out between June and August, 1993 and involved one large Northern North Sea Oil and Gas Platform , one medium Central North Sea Oil and Gas Platform , a Southern Sector Gas Production complex (three platforms), one Not Normally Manned Southern North Sea Gas Platform, and one semi-submersible Mobile Drilling Unit (MODU).

The value of the exercise was justified, in that the Pilot Study confirmed that the required accuracy of data was achievable. However, the collection of the data was seen to be resource intensive, and so Industry and HSE discussed various options for taking this exercise forward.

The ideal approach to obtaining the required population data would be to go out to every Installation with the full questionnaire with a request to provide all of the data, using whatever techniques were at their disposal e.g. P & I.D's, CAD, etc. This would then enable all release information gathered on OIR/12 reports to be "matched" with the relevant population data to produce the required trends and leak frequencies information. Other options considered were gathering "systems only" data, or "systems only" data together with estimates for equipment data based on agreed estimating methods for the different types of Installation.

It was eventually proposed to ask Industry to select a preferred method of estimation for equipment data from an agreed menu supplied as part of the guidance. The remainder of this paper has been written with that approach in mind for completion of the full questionnaire.

DESIGN OF THE HCR DATABASE

The HCR Database was designed so that the OIR/12 reported system and equipment details could be linked with the appropriate population data as and when required.
It was decided to use an existing Sun® minicomputer to house the Hydrocarbon releases data, and that the HCR Database itself would be ORACLE® - based with one dedicated 386 PC fitted with an ORACLE® card and 8Mb RAM as the initial "stand alone" system. The 386 was later upgraded to a 486 to improve the database performance.

It was decided to carry out the design of the database in two phases:
Phase 1 would enable the input, storage and interrogation of the OIR/12 hydrocarbon release reports data, with a limited output capability; and
Phase 2 would allow the addition of, storage of, and link-ups with the population data, such that the required leak frequencies could be determined.

The database design is also windows-based to allow flexibility in using other applications for data manipulations e.g. graphs, pie-charts, etc. thus obviating the need for in-built graphics.

Phase 1 of the design was completed and tested by 31 May, 1993, and the input of hydrocarbon releases data (reported since 1 October, 1992) commenced in June, 1993.

The HCR Database is modular in design, with five main modules in total, one for Log-on/Log-off (Figure 2, overleaf) and one each for Data Input, Population Data, Reporting, and Administration respectively (Figure 3, overleaf).

The functions of each module were rigorously tested to ensure that the database would perform as required. This included the insertion of test data to check the accuracy of unit conversions and output reports.

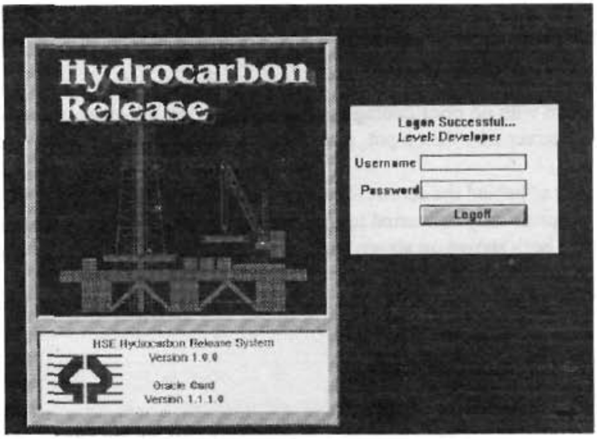


FIGURE 2
LOG-ON/LOG-OFF SCREEN

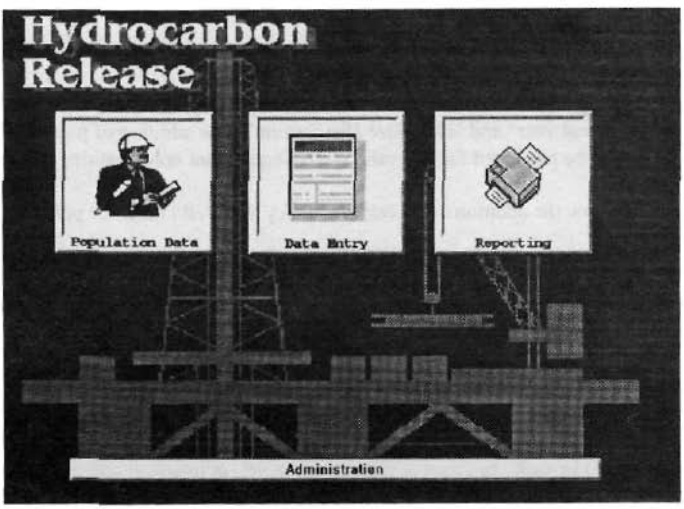


FIGURE 3
MAIN MENU

Data Input Module

The screens in this module emulate the OIR/12 form such that the administrator can input the data straight from the form with no prior coding necessary. With one half-page of the OIR/12 form per screen, there are 11 screens for data input, including one screen for administrative data.

The module includes a "behind the screen" conversion facility so that the units reported on the OIR/12 form are automatically converted to the preferred (usually SI) units. The given unit and the converted values are both shown on screen and are both stored to enable auditing to be carried out.

The facility allows input of new records and update/interrogation of single previously recorded incidents.

Population Data Module

This module allows input of the details of all registered Installations in U.K.waters, including whether Fixed or Mobile, type of Installation (e.g. Production, Drilling, Quarters) etc..

Phase 2 design will also allow input of all the data obtained from each questionnaire for each Installation, and these will be summed as necessary to give the overall population per system and/or equipment year, or on a per well or per workover basis as required.

Reporting Module

Currently, the Phase 1 design provides only two standard reports, and these are "Leak Frequency per System and/or Equipment year" and "Hole Size Distribution". The addition of population data will enable these reports to be produced for any valid system/equipment combination.

Phase 2 design will allow the addition of "Leak Frequency per Well Drilled or per Well Workover".

An "Ad-hoc" reporting facility is also available, using ORACLE "Data Browser"®, for developing complex queries for in-depth database interrogation. Examples of the outputs produced by this facility are shown later in this paper.

Administration Module

As it's name suggests, this module is intended for Database Management and Administration, and allows revisions to be made to features such as user roles, conversion codes, and key words as and when necessary.

OPERATION OF THE HCR DATABASE

So, having obtained all this data on releases (and population data) what do we do with it ? Well, as described above, the reporting module will provide certain outputs from the database, and, using the ad-hoc reporting facility, the database can be further interrogated for trends etc.

The remainder of this paper covers the type of output reports currently available from the database, and examples of the trends information which may be given in the future.

Standard Output Reports

On selecting "Standard Reports" in the Reporting Module , a standard screen is displayed which allows the user to obtain Leak Frequency data on a selected system and/or equipment (see Figure 4 overleaf), in terms of equipment (or system) years.

There is a choice of "systems", "equipment" or "both", and the user can either type in the system and/or equipment number directly if known, or may select the required system and/or equipment item from menus or picklists provided.

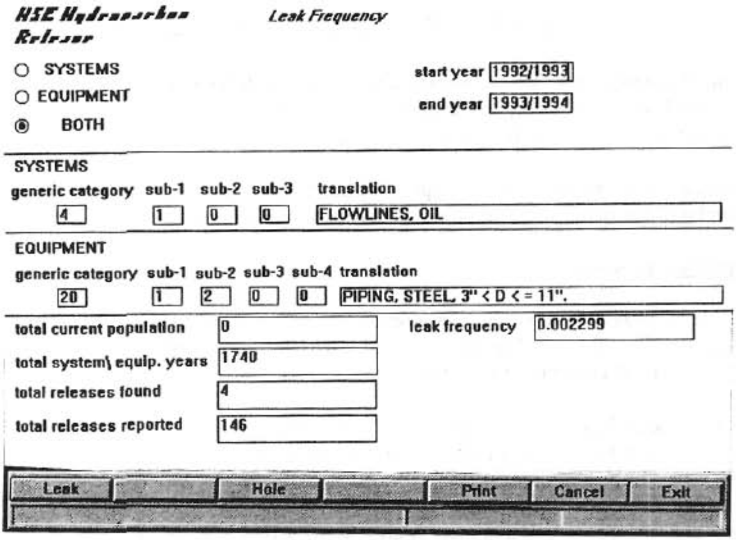
If "system" is selected, the leak frequency is given for that type of system only.
If "equipment" is selected, the leak frequency for that piece of equipment is given, regardless of system type.
If "both" is selected (per sample shown), the leak frequency for that equipment item as part of that system type is given. The period over which the frequency is to be calculated must also be entered as start year and end year.

On selecting the "Leak" button, the user is then given the appropriate details of Current Population, Total System/Equipment Years, Total Releases Found, and Total Releases Reported (i.e the total number of releases in the database for that period.) The leak frequency is calculated by dividing the total releases found by the total system/equipment years, and appears on the right hand side as shown in Figure 4.
It is important to note that the figure shows test data, and is for illustrative purposes only.

By then selecting the "Hole" button, the user is switched to the "Hole Size Distribution" screen, which shows how the total releases found are distributed within the Size Bands shown (see Figure 5) It is expected that the distribution will become more defined after several years of data are gathered. It is important to note that the figure shows test data and is for illustrative purposes only.

Ad-Hoc Reports

This facility enables the "Data Browser" package, which allows the user to interrogate the database by building up a query using the various look-up tables contained in the database design. By building queries in this way, it is possible to obtain output from the database on trends and other statistical information, examples of which are given in the following section of this paper.



HSE Hydrocarbon Releases — *Leak Frequency*

○ SYSTEMS
○ EQUIPMENT
◉ BOTH

start year 1992/1993
end year 1993/1994

SYSTEMS

generic category	sub-1	sub-2	sub-3	translation
4	1	0	0	FLOWLINES, OIL

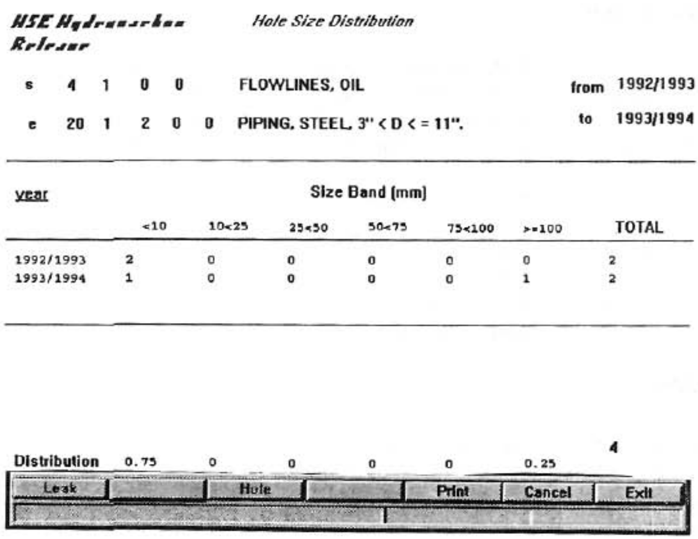
EQUIPMENT

generic category	sub-1	sub-2	sub-3	sub-4	translation
20	1	2	0	0	PIPING, STEEL, 3" < D < = 11".

total current population 0
leak frequency 0.002299
total system\ equip. years 1740
total releases found 4
total releases reported 146

Leak | Hole | Print | Cancel | Exit

FIGURE 4
SAMPLE LEAK FREQUENCY REPORT



HSE Hydrocarbon Releases — *Hole Size Distribution*

s 4 1 0 0 FLOWLINES, OIL — from 1992/1993
e 20 1 2 0 0 PIPING, STEEL, 3" < D < = 11". — to 1993/1994

year	Size Band (mm)						
	<10	10<25	25<50	50<75	75<100	>=100	TOTAL
1992/1993	2	0	0	0	0	0	2
1993/1994	1	0	0	0	0	1	2
							4
Distribution	0.75	0	0	0	0	0.25	

Leak | Hole | Print | Cancel | Exit

FIGURE 5
SAMPLE HOLE SIZE DISTRIBUTION REPORT

Outputs and Trends Information

A few examples of the outputs obtained from the HCR Database are shown in the following tables and figures. It is important to note that these were produced using test data and are for illustrative purposes only.

Table 1 : Breakdown of Total Releases by Hydrocarbon Type

Hydrocarbon	Releases	Percentage
Non-Process	9	7.76
Oil	15	12.93
Condensate	10	8.62
Gas	72	62.07
2-Phase	10	8.62
Total:	116	100

A pie-chart was then created from the data, and this is reproduced in Figure 6 below.

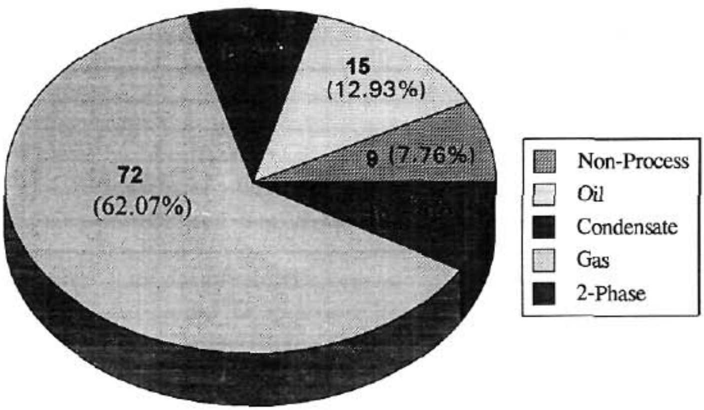


FIGURE 6
EXAMPLE PIE-CHART

Another illustration of the data held in the HCR database is the breakdown of incidents by system type, as shown in Table 2 below and Figure 7 overleaf.

Table 2 : Breakdown of Releases by System Type

System Type	Releases
DRILLING	15
WELL CONTROL	1
WELL, OIL PRODUCTION, SURFACE	7
WELL, OIL PRODUCTION, SUBSEA,	1
WELL, GAS PRODUCTION, SURFACE	4
FLOWLINES, OIL	10
FLOWLINES, GAS	10
MANIFOLD, GAS	2
SEPARATION, OIL TEST	3
SEPARATION, OIL PRODUCTION	5
SEPARATION, GAS TEST	1
PROCESSING, OIL, OIL TREATMENT,	7
PROCESSING, OIL, PROD. WATER TREATMENT,	2
PROCESSING, OIL, CHEMICAL INJECTION	1
PROCESSING, GAS, DEHYDRATION	3
PROCESSING, GAS, METHANOL (INJECTION)	1
PROCESSING, GAS, LPG/ CONDENSATE	4
UTILITIES, OIL, HELI-FUEL / JET FUEL	1
UTILITIES, OIL, DIESEL.	4
UTILITIES, OIL, POWER GEN. TURBINES.	1
UTILITIES, GAS, FUEL GAS,	11
UTILITIES, GAS, POWER GEN. TURBINES.	4
GAS COMPRESSION.	19
METERING, OIL,	2
METERING, GAS,	2
METERING, CONDENSATE,	2
EXPORT, OIL,	4
EXPORT, GAS,	1
EXPORT, CONDENSATE,	4
IMPORT, OIL,	2
IMPORT, GAS,	1
DRAINS, CLOSED,	2
DRAINS, OPEN,	5
FLARE, HP,	3
BLOWDOWN,	1
Total:	146

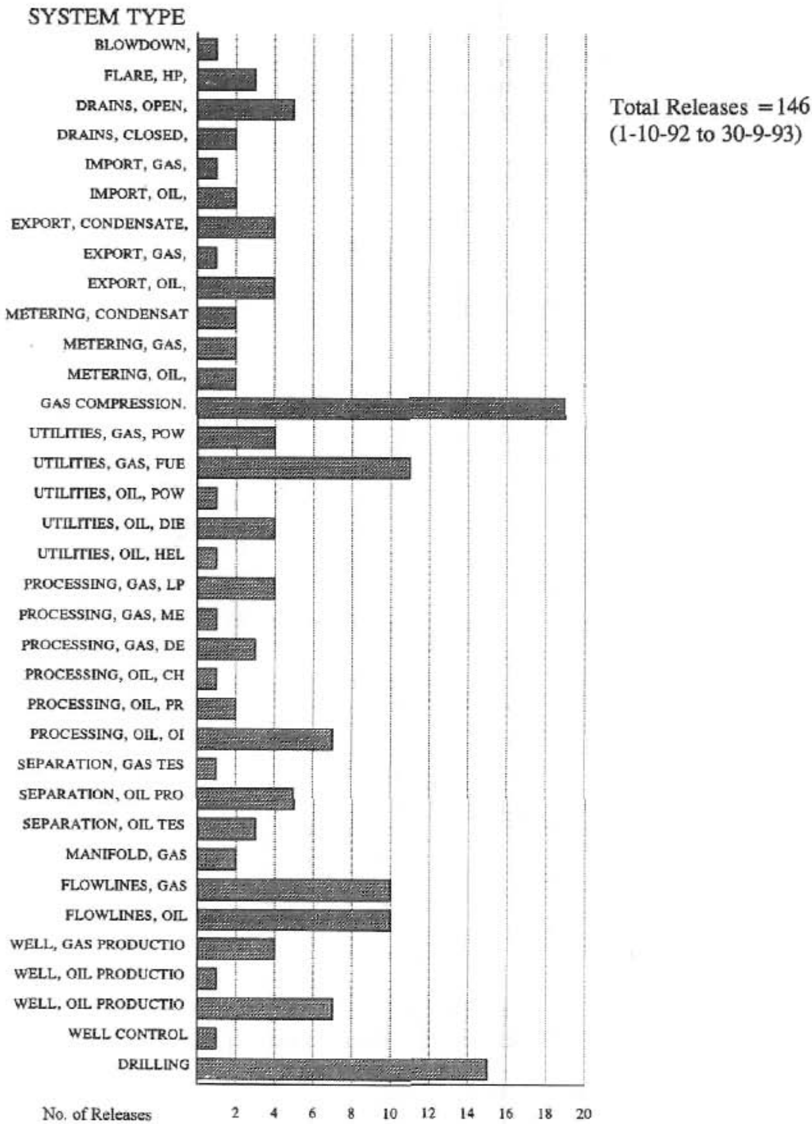


FIGURE 7
EXAMPLE BAR CHART

Finally, as an example of trends-type information, the graph in Figure 8 below shows the underlying trends for reporting of hydrocarbon releases for the reporting year 1 October, 1992 to 30 September, 1993. The chart shows the numbers reported on a quarterly basis for each type of hydrocarbon released , and also shows the totals reported over the same period. It is important to note that the figure shows test data and is for illustrative purposes only.

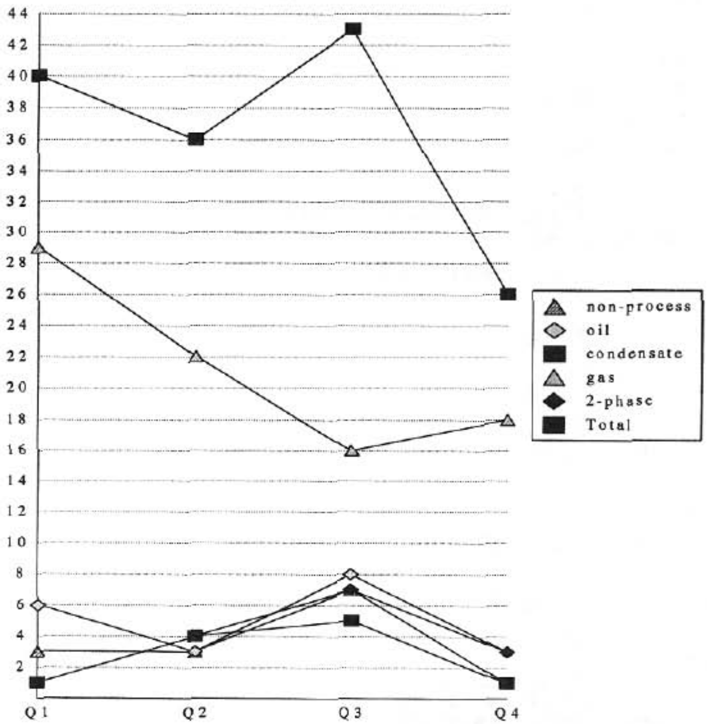


FIGURE 8
SAMPLE GRAPH SHOWING REPORTING TRENDS

From the data shown, it can be seen that the differing requirements for portraying trends and other outputs from the HCR Database can be readily catered for, and it is intended that these techniques will be used in the proposed "Outputs and Trends" report.

CONCLUSION

The Hydrocarbon Releases (HCR) Database is seen as a major advance in process safety offshore, since it will provide valuable data to the Offshore Industry which they will need for use in complying with the new goal-setting regulations currently being introduced.

The regulations governing the submission and acceptance of Offshore Safety Cases [ref.9], require that quantified risk assessment (QRA) be carried out on the risks associated with explosion, fire, heat, smoke, and toxic gas or fumes.

Through time, and with the addition of appropriate population data, the leak frequency and hole size distribution data generated by the HCR Database should prove beneficial to Industry, resulting in improved QRA calculations, and thus leading to greater confidence in the QRA for Offshore Safety Cases.

The proposed regulations governing prevention of fire and explosion, and emergency response (PFEER) on offshore installations[ref.10], which are at the consultative stages at the time of writing, call for a fire and explosion analysis to be carried out and for provisions to be taken against fire and explosion effects by means of prevention, control and mitigation.The draft regulations also call for an evacuation, escape and rescue (EER) analysis for establishment of suitable measures for EER.

The output data from the HCR Database is seen as a valuable aid in enabling the fire and explosion analyses to be carried out, and should also contribute towards data for the EER analyses.

The HCR Database will meet the requirements of Cullen Recommendation 39 by providing the data necessary to meet the current shortfall, and by aiding Industry in the quantification of offshore risks from hydrocarbons. It is hoped that this paper has demonstrated the substantial effort being directed by both Industry and HSE to meet Cullen Recommendation 39.

The initial "Outputs and Trends" report is due to be published in April, 1994, and at that time approximately 18 months data will be available for analysis. It is proposed to illustrate the findings by using the techniques shown earlier, and with the eventual addition of population data, later reports will also contain the required frequency data for each type of system and equipment involved with hydrocarbons offshore.

The use, by Industry, of the HCR database as a common data source should also greatly reduce the need for cross-checking of other data sources by HSE. Industry should also benefit from having the individual systems and equipment population data for each Installation, since this can also be used in QRA calculations for the specific Installation.

Trend reports should prove useful in highlighting areas of concern requiring immediate attention by Industry, thus also aiding HSE in it's regulatory role and in planning the inspection of offshore installations.

Finally, the main measure of success of the database will be the extent to which it is used by both HSE and Industry within the next few years, and the degree to which this contributes to the acceptance of Offshore Safety Cases, and to the overall improvement of safety offshore.

ACKNOWLEDGEMENTS

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However, it should be noted that the views and opinions expressed in the paper are those of the author, and do not necessarily represent those of the Health and Safety Executive.

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