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A STATISTICAL REVIEW OF FIRES AND EXPLOSION INCIDENTS IN THE GULF OF MEXICO 1980 -1990

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SUMMARY

A statistical review has been made of the offshore fire and explosion incidents in the Gulf of Mexico from 1980 to 1990. This review generally indicates that most incidents (78.7%) are shown to be from the loss of process piping or equipment integrity or from miscellaneous causes and which result in minor losses. Over half of the ignition sources are from hot surfaces of equipment or exhaust gases of internal combustion processes or various miscellaneous sources. Major loss of life has generally occurred as a result of drilling activity blowouts or helicopter transport operations. The major financial risks for these facilities are property losses precipitated by blowout incidents. The early part of the decade accounts for approximately three-fourths of the incidents, while recent years have seen a considerable decline in the number of incidents.

INTRODUCTION

A comprehensive review has been made of fire and explosion incidents, as recorded by the U.S. Minerals Management Service (MMS), that have occurred in the Gulf of Mexico in the period from 1980 to 1990[1]. A total of 539 incidents occurred during this period, accounting for 60 fatalities and 246 injuries. This document uses the latest published historical listing of the MMS as the basis of the review which encompasses Gulf of Mexico incidents occurring from 1956 to 1990. In order to ensure relevancy of the data to current management and technology of offshore installations, only incidents occurring from 1980 to 1990 are included.

246 injuries occurred as a result of 140 separate incidents (26%), while 60 fatalities were the result of 20 separate incidents (4%). 43 explosions (8% of total) were also identified as having occurred in this period. There was no damage, injuries or environmental pollution in 154 (28%) of the reported incidents.

WORST FATAL INCIDENTS

The five worst fatal incidents are briefly described below; most are associated with helicopter and blowout incidents.

1. Helicopter struck leg of platform, 14 fatalities (Forest Oil - 1987);
2. Helicopter struck platform, 6 fatalities (Exxon - 1980);
3. Cut into pipeline containing hydrocarbons, 7 fatalities (Arco - 1989);
4. Blowout, 6 fatalities (Pennzoil - 1980);
5. Blowout, 5 fatalities (Cities Service - 1980).

33.3% of the fatalities during the period are attributed to helicopter incidents, while 18% are attributed to blowouts.

WORST PROPERTY LOSS INCIDENTS

Some of the major property loss incidents are briefly described below; almost all are associated with blowout incidents.

1. Blowout, total platform destroyed, (Pennzoil - 1980);
2. Blowout, jackup rig suffered catastrophic damage (Cities Service - 1980);
3. Blowout, major damage to rig and submersible barge (Placid - 1981);
4. Blowout, jackup rig and derrick destroyed (Shell - 1982);
5. Blowout, drilling rig and quarters destroyed (Chevron - 1982);
6. Blowout, extensive damage to two rigs and platform (Union - 1982);
7. Blowout, $15 million damage to drilling rig (Conoco - 1984);
8. Cut into pipeline containing hydrocarbons, platform destroyed, 6 pipelines involved (Arco - 1989).

Immediate Cause of Death

60 fatalities occurred in the Gulf of Mexico and were related to offshore oil and gas production. The immediate cause of death for these incidents is shown in Table 1.

Immediate Cause	Number of Incidents	Number of Fatalities	Percentage
Helicopter Crash	2	20	33.3%
Blowout (Fire & Explosion)	5	18	30.0%
Explosion Impact	5	5	8.4%
Perforating Gun Inadvertent Activation	2	3	5.0%
Burns	2	2	3.3%
Drowning	1	2	3.3%
Unknown (during major fire/explosion incident)	3	10	16.7%

Table 1. Immediate Cause of Death

Helicopter incidents and blowouts account for the major portion (63%) of the incidents associated with fatalities. The helicopter incidents account for the highest amount and single cause of death. They were the result of two separate incidents in which each helicopter struck the facility. They were not the result of failure of the helicopter itself, but of human error of the pilot in flying the aircraft during operations in close proximity to the facility. One of these incidents accounted for the highest life loss in the entire review period—14 fatalities. The other incident accounted for 6 fatalities.

There were 13 blowout incidents recorded and were generally the result of equipment failures. About one-third of these resulted in fatalities. No blowouts occurred from 1987 to 1990. Some of the typical causes of these incidents are listed below.

Blowout Causes:

1. Gas diverter valve improperly set and diverter hose ruptured;
2. Annular preventer failed, pipe rams closed, casing ruptured at 7,200 psi below the BOP (Blowout Preventer) rams;
3. Fill up line opened to release trapped gas, closed pipe ram, unable to close fill up line, well blew out through swivel neck;
4. Kelly hose burst during well control procedure, Kelly cock and in-line safety valve could not be closed;
5. Annular preventer leaked, after well "kicked;"
6. Diverter line ruptured after 35 minutes of gas diversion;
7. Drilling string safety valve leaked at stem;
8. Port side of diverter line ignited.

Cause of Incidents

A review of the causes of fire and explosion incidents are presented in Table 2.

The primary causes are the result of hydrocarbon gas or fluid releases (approximately 32), equipment failures - mechanical or electrical (21%), hot work activities (12%), and miscellaneous causes (individually 4% or less, but accounting for the remaining 35% of the incidents).

Equipment Initially Involved in the Incident

The equipment initially involved in the incidents was reviewed to determine the most prevalent items. These incidents can be grouped in the following categories:

1. Equipment which contains mechanical actions such as compressors, engines, turbines, generators, and pumps (39%);
2. Piping, valves, and tanks (15%);

Cause	No. of Incidents	Percentage
Gas release (leak, vent, etc.)	120	22.2%
Hot work	66	12.2%
Mechanical failure	53	9.8%
Fluid release (leak, spill, etc.)	51	9.5%
Electrical short/insulation failure	49	9.1%
Engine or gearbox oil leak	20	3.7%
Rupture	14	2.6%
Process upset	13	2.4%
Blowouts	13	2.4%
Exhaust gases in proximity of combustible materials	13	2.4%
Lighting	11	2.0%
Open flame use	10	1.8%
Engine or compressor backfire	10	1.8%
Vibration induced failure	8	1.5%
Improper use or incorrect type of cleaning fluid in use	7	1.3%
Mechanical impact	6	1.1%
Improper procedure	6	1.1%
Internal compressor or engine explosion	5	0.9%
Fuel gas used as a utility gas (impact tools, starting gas, etc.)	5	0.9%
Major collision (Boat/helicopter)	4	0.7%
Ether used to start engine/comp.	4	0.7%
Static	3	0.5%
Override of safety device or wrong setting	3	0.5%
Smoking	2	0.3%
Improper storage of combustibles	2	0.3%
Improper installation of equipment	1	0.2%
Vessel capsized	1	0.2%
Chemical reaction	1	0.2%
Unknown	40	7.4%
Total	539	100%

Table 2. Cause of Ignition

3. Process vessels (11%);
4. Electrical components (11%);
5. Drilling equipment (5%);
6. Miscellaneous and unknown (19%).

Table 3 provides a summary of these occurrences.

Ignition Sources

The source of ignition identified in the data is provided in Table 4.

Hot surfaces and welding are the most concern (58%). The hot surfaces are usually the exhaust system piping of an engine or turbine driver. In two cases, the exhaust gases were directed on combustible materials in the immediate area causing fires. A further review of welding (and acetylene cutting) causes was undertaken

Type of Equipment	Number of Occurrences	Percentage
Engine, turbine or gearbox	112	21%
Compressor	78	14%
Piping (including drains)	37	7%
Tank	36	7%
Reboiler	31	6%
Generator or Electric Motor	27	5%
Pump	22	4%
Incidental Combustibles	20	4%
Drilling Equipment	19	4%
Electric Panel or Switchgear	17	3%
Heater Treater	13	2%
Sump Pump or Tank	11	2%
Storage Bottles or Drums	10	2%
Separator	9	2%
Electrical Wiring	9	2%
Control Panel	8	1%
Scrubber	8	1%
Shale Shaker or Mud Tank	8	1%
Flare or Overboard Vent	8	1%
Helicopter or Boat	5	<1%
Valve	4	<1%
Crane	4	<1%
Mechanical Hand Tools	4	<1%
Burner (for cuttings)	3	<1%
Perforating Gun	3	<1%
Wellhead	3	<1%
Scraper Trap	2	<1%
Space Heater	2	<1%
Antenna/radio Equipment	2	<1%
Heat Exchanger	2	<1%
Oil Slick on the Sea	2	<1%
LACT Unit	1	<1%
Living Quarters	1	<1%
Clothes Drier	1	<1%
Air Conditioner	1	<1%
Unknown	15	3%
Total	539	100%

Table 3. Type of Equipment Involved

Source	No. of Incidents	Percentage
Hot Surface or Exhaust (e.g., engine, compressor or reboiler)	190	35.2%
Welding or Cutting	99	18.4%
Electrical Short	53	9.8%
Open Flame	25	4.6%
Ordinary Electrical Component	25	4.6%
Rotating Mechanical Equipment	20	3.7%
Lightning	12	2.2%
Static Discharge	6	1.1%
Major Impact or Collision	5	0.9%
Minor Impacts (hand tools, parts, etc.)	5	0.9%
Smoking	4	0.7%
Grinding	3	0.5%
Spontaneous Combustion	2	0.4%
Chemical Reaction	2	0.4%
Electrical Space Heater	2	0.4%
Pump Packing Overheating	1	0.2%
Clothes Drier	1	0.2%
Sandblasting	1	0.2%
Unknown	83	15.2%
Totals	539	100%

Table 4. Ignition Sources

Sub-Category	No. of Incidents	Percentage
Hydrocarbon gas leaking or in the immediate area	26	26.2%
Slag falling to other areas	24	24.2%
Cut into tank, vessel or line apparently containing hydrocarbons	18	18.2%
Combustible materials in the immediate area	10	10.1%
Hydrocarbon fluids in the immediate area due to spills, leaks, etc.	7	7.1%
Welding tarpaulin caught on fire	4	4%
Welding electrical lead shorted	4	4%
Leaking acetylene hose	2	2%
Acetylene cylinder exploded	1	1%
Excess welding gas released	1	1%
Unknown	2	2%
Total	99	100%

Table 5. Welding and Cutting Operations

and is presented in Table 5. Flammable or combustibles in the immediate work area (or inside the equipment to be handled) and hot materials (slag) falling to areas outside the designated work environment, are the prevalent issues associated with these incidents.

Method *	No. of Times Used	Percentage
Manual fire fighting - Portable Dry Chemical Extinguisher	214	38%
Extinguished (method not stated)	132	24%
Use of "Water"	34	6%
Work, Standby or Fireboat sprayed water	19	3%
ESD - Platform Level	15	3%
Fixed Fire Protection System	13	2%
Blow-Out Preventer (BOP) Valves Activated (i.e., closed)	11	2%
Fuel Supply Valve Closed	10	2%
Manual Fire Hose or Utility Hose	9	2%
ESD - Unit Level (equipment shutdown)	9	2%
Power Disconnected	6	1%
Fixed Halon fire suppression system	5	1%
Well Bridged (Relief well drilled)**	5	1%
Let Burn Out**	5	1%
CO_2 System	3	<1%
Foam System	3	<1%
Portable CO_2 Fire Extinguisher	3	<1%
Nitrogen System Activated	1	<1%
Fuel Drained from Hazard	1	<1%
Portable Halon Fire Extinguisher used	1	<1%
Portable Equipment Used (type not designated)	1	<1%
Unknown	55	10%
Total	555*	100%

Table 6. Fire Suppression Methods Utilized

*In some cases more than one method was used
**Technically not a direct fire suppression method

Method of Fire or Explosion Suppression

Various methods have been employed to control and suppress fire or explosion incidents. Manual fire fighting efforts play a key role at offshore facilities. Although the data is not highly explicit in some instances, it would appear that the majority of fire incidents are suppressed with portable fire fighting equipment (fire extinguishers or hoses) used by the workers in the immediate area. A summary of the methods used is provided in Table 6.

Incidents by Installation

Of the facilities reporting incidents to the MMS, most have only one incident over the period of study. Although one, two and possibly three incidents would be consid-

		Number of Incidents					
Platform	Operator	3	4	5	6	7	8
BM-3FF	Chevron	X					
EwB-305A	Conoco	X					
EC-245A	Chevron	X					
EC-338A	Sun	X					
EI-313B	Texaco	X					
EI-314B	Exxon	X					
EI-349A	Marathon	X					
GI-23T	Exxon	X					
HI-206A	Texaco	X					
MP-153B	Shell	X					
MP-306D	Marathon	X					
SMI-268A	Placid	X					
SoP-60B	Arco	X					
SS-182C	Tenneco	X					
SS-207	Placid	X					
SS-207B	Placid	X					
ST-26C	Shell	X					
ST-52A	Chevron	X					
ST-54A	Exxon	X					
V-76	Samedan	x					
V-261A	Tenneco	X					
WD-109A	Texaco	X					
GI-37R	Chevron		X				
HI-A570A	Exxon		X				
MP-305C	Marathon		X				
SS-114	ODECO		X				
SS-198H	Tenneco		X				
WC-648A	Sun		X				
WD-73C	Exxon		X				
ST-171D	Exxon		X				
SS-207A	Placid			X			
SS-214F	Kerr-McGee			X			
SoP-49A	Gulf				X		
V-331A	Marathon				X		
EC-321A	Marathon					X	
WD-73A	Exxon						X

Table 7. Multiple Incident per Installation

ered within the realm of historical accident rates for the facilities, most facilities had two incidents or less. Two installation groupings in particular stand out as having an unusually high number of incidents associated with them. SS-207, SS-207A and SS-207D listed 12 incidents. WD-73A, WD-73AD, WD-73, WD-73D reported 15 incidents. A summary of facilities with three or more incidents is provided in Table 7. Without further information of the facility, working environment, and operating methods, additional conclusions from these figures cannot be determined.

Incidents by Calendar Date

Overall, the general trend is that the time of the year is not a determining factor in the mishaps. Changes due to lower winter temperatures (October and January) may vary slightly and increase the accident frequency and is reported as a contributing factor in a few individual reports. January is reported as the highest month for accidents, while June is the lowest (50% of January). On the average, 45 incidents occur in a month. For the warmer months (April through September) the average is 42, while for the colder months (October through March) the average is 48. A summary of incidents by calendar month is provided in Table 8.

Month	No. of Incidents	Percentage
January	67	12.4%
February	47	8.7%
March	37	6.9%
April	34	6.3%
May	45	8.3%
June	33	6.1%
July	53	9.8%
August	43	8.0%
September	43	8.0%
October	58	10.8%
November	38	7.0%
December	41	7.6%

Table 8. Incidents by Month

Loss Trend

The number of incidents by year is presented in Table 9. The last five year period (1986 - 1990) accounts for only 27% of the accidents, while the earlier part of the decade (1980 - 1985) accounts for the remaining 73% of accidents. This may be correlated to the major activity in the Gulf of Mexico during the early part of the decade, with a relatively high decline in the activity with the recent years.

Year	No. of Incidents	Percentage
1980	53	9.8%
1981	56	10.4%
1982	68	12.6%
1983	75	13.9%
1984	74	13.7%
1985	67	12.4%
1986	45	8.3%
1987	37	6.9%
1988	28	5.2%
1989	18	3.3%
1990	17	3.2%

Table 9. Loss Trend for Decade

Summary of Findings

The cause of incidents can be grouped into four main categories:

1. Loss of integrity (gas or fluid release and mechanical failure, 41.5%0;
2. Various miscellaneous causes (24 categories with individual percentages of 4% or less, totaling 37.2%);
3. Hot work (12.2%);
4. Electrical short or insulation failure (9.1%).

Thus, historically most incidents (78.7%) are shown to be from the loss of integrity or from miscellaneous causes.

The main ignition sources are grouped into five main categories:

1. Hot surface or exhaust gases (35.2%);
2. Miscellaneous causes (15 categories of 5% or less, totalling 21.4%);
3. Hot work (18.4%);
4. Unknown (15.2%);
5. Electrical short (9.8%).

Over one half of the ignition causes are from hot surfaces of equipment or exhaust gases of internal combustion processes or various miscellaneous sources.

Fire suppression methods are categorized into four areas:

1. Manual fire fighting - portable dry chemical extinguisher (38%);
2. Miscellaneous methods (20 categories, 6% or less each, totalling 28%);
3. Extinguished - method not stated (24%);
4. Unknown (10%).

Portable fire extinguishers and other available means for extinguishment are used frequently to control and suppress fire incidents.

Major loss of life has generally occurred as a result of drilling activity blowouts or helicopter transport operations. In both of these activities, personnel are grouped together in high concentrations due to the nature of the activity, more so than most routine operations offshore, *e.g.*, process operations, lifting activity and blowouts appear to be as a result of equipment failures while helicopter incidents appear to be human errors.

The results of this analysis shows similarity with studies previously conducted for accidents in the Gulf of Mexico for the late 1970's and early 1980's[2, 3]. In general similar causes, ignition sources and fire suppression methods and levels of occurrence were obtained. A study of the North Sea from 1979-1988[4] indicates helicopter activities account for a similar high percentage of fatalities (23% for U.K. and 33% for Gulf of Mexico); however the North Sea accounts for a much higher percentage of fatalities from production operations (53%) than from drilling operations (4%), as is the case with the Gulf of Mexico for drilling fatalities (30%).

Conclusions

Any high concentration of personnel activities may suffer a high fatality incident. Areas of concentratedpersonnel (such as offshore transportation, drilling activities, living quarters, muster points, and evacuation lifeboats) are all potential candidates where a "minor" mishap may result in considerable life loss. Where the equipment involved in these tasks is complex, the risk of an incident becomes greater. In order to reduce these risks, highly trained and experienced personnel and well maintained equipment must be made available. Human errors will result otherwise. This applies equally to drilling activities, production operations, or helicopter transportation.

Lack of system integrity has been shown to be one of the key points leading to an incident. Human surveillance (remotely or onsite) of the process, increased testing, inspection and maintenance, gas detection and vapor dispersion methods are all suitable measures to lessen the probability of an incident due to loss of integrity concerns. Ignition sources tend to be associated with either hot surfaces or miscellaneous causes. The prudent application of electrical area classification and insulation, arrangement and placement of engines, turbines and compressors in a practical manner from probable leakage points should be always analyzed. In particular, highly insulated, water cooled exhaust and effective dispersion/orientation of exhaust should be considered. Hot work practices should be improved. Consideration of habits for offshore hot work on producing platforms may be considered cost effective in view of the potential losses from an incident.

The first method of fire suppression for incipient fires should always be considered human intervention where personnel are adequately trained and equipment is provided. The statistical review demonstrates that human capabilities to react and control incipient fires offshore is a valid assumption. Portable fire extinguishers should be numerous and well placed. They should be particularly prevalent at all hydrocarbon-containing systems including fuel and lubrication lines to engines, turbines, and compressors.

Philosophy of Protection

All areas that have high concentrations of personnel may be subject to incidents where a high level of fatalities can occur. Large hydrocarbon incidents offshore are the result of the inability to isolate the source of large fuel inventory sources, such as wellheads and pipelines.

Small incidents that do not have several levels of isolation of fuel sources may be subject to escalation to larger incidents. Where large volumes of hydrocarbons may be involved such as pipelines (import or export) or wellheads, the potential escalation may result in higher levels of property damage or injuries that may otherwise occur.

The method to prevent these occurrences is to provide secondary and tertiary levels of isolation to the respective sources.

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Note: Information presented in this paper is the personal effort of the author and reflects his views only.