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Hazard Contributing Factors Classification for Petrol Fuel Station

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Abstract**—**Petrol Fuel Station (PFS) has potential hazards to the people, asset, environment and reputation of an operating company. Fire hazards, static electricity air pollution evoked by aliphatic and aromatic organic compounds are major causes of accident/incident occurrence at fuel station. Activities such as carelessness, maintenance, housekeeping, slips trips and falls, transportation hazard, major and minor injuries, robbery and snake bites has a potential to create unsafe conditions. The level of risk of these hazards varies according to location and country. The emphasis on safety considerations by the government is variable all around the world. Developed countries safety records are much better as compared to developing countries safety statistics. There is no significant approach available to highlight the unsafe acts and unsafe conditions during operation and maintenance of fuel station. Fuel station is the most commonly available facilities that contain flammable and hazardous materials. Due to continuous operation of fuel station they pose various hazards to people, environment and assets of an organization. To control these hazards, there is a need for specific approach. PFS operation is unique as compared to other businesses. For smooth operations it demands an involvement of operating company, contractor and operator group. This study will focus to address hazard contributing factors that have a potential to make PFS operation risky. One year data collected, 902 activities analyzed, comparisons were made to highlight significant contributing factors. The study will provide help and assistance to PFS outlet marketing companies to make their fuel station operation safer. It will help health safety and environment (HSE) professionals to arrest the gap available related to safety matters at PFS.

Keywords**—**Accident, Contributing factors, carelessness, fire, explosion, injuries.

I. Introduction

PETROL fuel station (PFS) store and sell flammable and hazardous material in close vicinity of urban and rural environment. Safety measures that requires for smooth operation not found similar at all PFS.

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Safety consciousness towards occupational health and safety aspects varies from industries to industries. Matters pertaining to safety issues also vary between countries [1]. It was noticed that attention towards safety principals is more in developed countries rather than developing countries. Developing countries prefer to give less focus on reporting occupational health & safety deficiencies therefore found to posses no record. Therefore very little room exists for improvement. On other side developed countries posses data base, record and history of their occupational health & safety statistics. By manipulating this data they can figure out the problem in a better position to resolve issues. Therefore safety records in developing countries are improving continuously. Takala (1999) elaborated occupational accidents estimates using World Bank divisions [2]. Table I listed the occupational accidents by continent in 1994, 1998 and 2001.

TABLE I
Occupational Accidents by Continent in 1994, 1998 and 2001

Continent	Fatal Accident per 1000			Accident causing greater than 3 days absence (average) per 1000	
	1994	1998	2001	1998	2001
Africa	62.6	612.3	593.3	467.3	45279.8
America	334	373.1	470.4	284.7	35904.3
Asia	212.7	222.7	223.4	170013.4	170494.5
Europe	233.2	231.1	203.7	17636.3	15550.8
Australia and Oceania	0.94	0.9	1.04	747.4	793.7
World	333.5	347.4	353.2	263606.6	268023.2

II. Literature Review

Consideration towards occupational health & safety (OHS) are growing very rapidly in all areas. PFS operators are also giving attention to adhere OHS rules at their outlets. Hazard contributing factors for every industry are different. Main cause of difference is the difference in working conditions that requires variable approach to handle the unsafe condition. Human unsafe behaviors also contribute at risk situations during working conditions [3]. Researchers classified them with different names such as hazard classification, hazard categorization, hazard identification and etc [4]. For PFS the terminology introduced here is named as “hazard contributing factors”. Many activities and processes observed in progress within close vicinity at PFS. These include; arrival and departure of various kinds of vehicles at PFS to buy fuel, filling of underground storage tanks, processing of various electrical components, public movement and customer dealing

at retail stores. Due to availability of flammable and hazardous materials every process generates variety of hazards. In addition, fuel station components are unique as compared to other facilities. It includes fuel system, fuel tanks, forecourt, car wash, tyre shop, oil suction machine, service bays, signage, equipments, restaurant, public toilets, truck parking shed and compressed national gas (CNG) Island. Every component creates different hazards for the smooth operation of PFS. Caltex is petrol fuel station retail outlet organization, operating in many countries around the world. According to Caltex environment report 2002 and 2003 the number of staff was 3,022 [5]. The total treated injury frequency rate (TTIFR) for employees fell from 21 per million hours worked in 2002 to 16 in 2003, and for contractors it fell from 30 in 2002 to 12 in 2003.

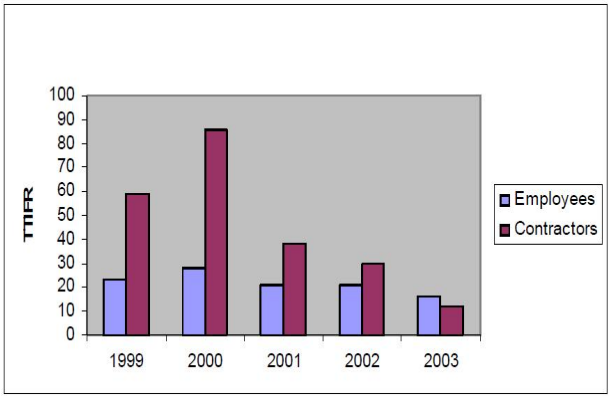

Fig. 1 Caltex's total treated injury frequency rate year 2002 & 2003 [5]

More accidents are recorded due to negligence or human errors [6]. Many studies also shows that more accidents are attributable to weaknesses in technical components [7]-[8]-[9]. Marketing and media plays important role in petrol fuel retail outlets business. Occurrences of even one incident pose significant loss to company [10]. Integration of people with the outlets facility creates a homogeneous safety culture for a short time period but in a regular sequence. Therefore during operation and maintenance safety matters considerations is of vital significance. The importance of addressing cultural aspects has been highlighted by recent well publicized major loss events such as Chernobyl group I.N.S.A., 1988 [11], Piper Alpha [12], the Kings Cross fire [13] and the inquiry into the 1999 Ladbroke Grove rail accident [14]. The recognition that there is a relationship between organizational culture and safety performance has spawned an increased interest in identification of methods that allow measurement of organizational culture [15]-[16] - [17]-[18]. In 2002 there were three (03) fires each causing damage exceeding $2,000. The loose Safety Management System and shortcoming in standard operating protocols creates hurdles in safety improvement [19].

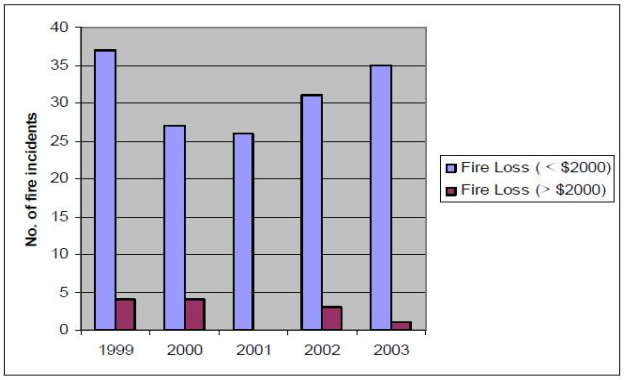

Fig. 2 Fire incidents at Caltex [5]

Contractors responsible to manage safety measures at PFS found satisfied whilst safety auditors think vise versa. Fuel stations are primarily operating by client and contractors, as PFS are widely available so the places where contractors are not agree to take the charge, clients normally hire locals / petty contractors to operate PFS. Therefore, safety considerations become more reduced. Majority PFS contractors accepted that safety considerations at their site are acceptable and they are improving it with time. However, monitoring authorities noticed so many gaps in the overall safety system.

TOTAL has more than 200 retail outlets stations all over the Pakistan. In environment and society report 2009 TOTAL mentioned that they experience too many fatalities, especially related to transportation by road. In 2009 TOTAL experience a succession of unusual and distressing serious accidents in France. Investigations were conducted to understand the specific circumstances of each and learn from them [20]. It was reported that 9 fatalities occurred during site operation, 8 fatalities in product transportation by road, 2 fatalities in employee travel by road and 2 fatalities during a seminar activity.

TABLE II
ACCIDENT STATISTICS OF TOTAL [20]

	Unit	2007	2008	2009
Lost time injury rate (TOTAL +contractor employees) - LTR	Number	2.4	2.1	1.9
Of which: Exploration & Production		0.8	0.6	0.6
Gas & Power		1.8	2.1	1.00
Refining & Marketing		2.58	2.5	2.4
Chemicals		4.17	3.6	3.1
Total recordable injury rate (TOTAL + contractor employee) - TRIR	Number	4.2	3.6	3.1
Of which: exploration & Production		2.4	2.2	1.9
Gas & Power		2.7	2.1	1.8
Refining & Marketing		3.2	2.9	2.9
Chemicals		7.7	6.5	5
Fatalities	Number	15	8	21
Fatalities per million worked (TOTAL + Contractor employees)		0.034	0.018	0.046

According to Pakistan State Oil (PSO) report, the company achieved 27.21 million safe operational man–hours without any lost work day from July 2002 to June 2007. The incident rate remained 0.669% for the year 06–07.

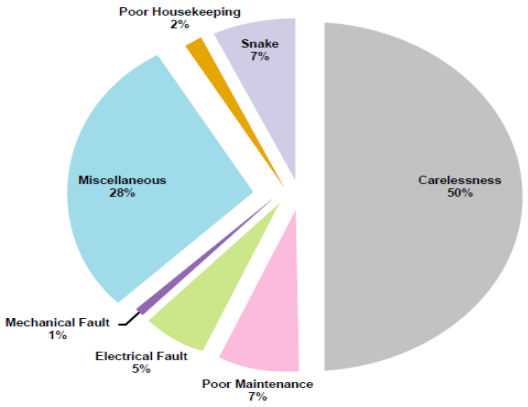

Fig. 3 PSO Incident cause analysis [21]

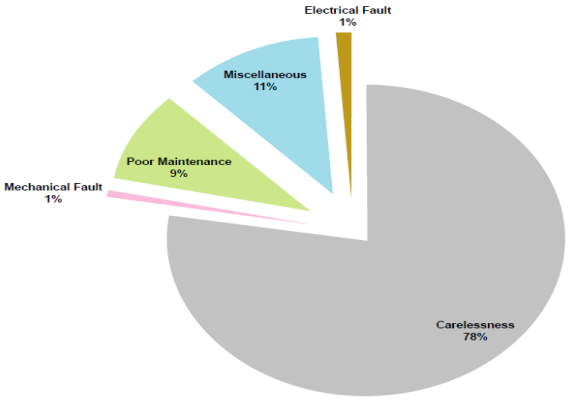

Fig. 4 Contractor Incident Cause Analysis [21]

172 and 130 incidents were reported by the contractors and PSO respectively. Root cause was identified as carelessness [21]. Many factors that contributes for the creation of hazardous situations during PFS operation such as housekeeping, hazard due to transportation, slips, trips and falls, carelessness, fire risks, electrical fault, miscellaneous cases and medical treatment cases. The activities recorded noticed that most of unsafe conditions and unsafe acts are occurring due to human behaviors. Reduction in occurrences of these unsafe events can be improved with modification of human behaviors. Researcher proposed safety instruments that incorporate human behavior change for reduction in accident/incident causation. The noticeable improvements recorded with change of human unsafe behaviors with safe behaviors. Some researchers have found that the higher the safe performance the lower the accident rate [22]-[23]-[24]. There are number of major sources of pollution release at petrol filling station to the air, soil, and water [25].

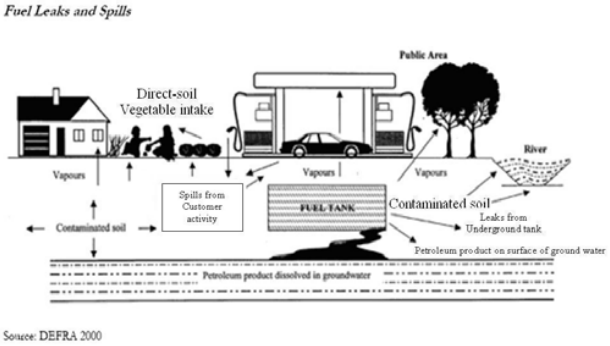

Fig. 5 Impacts of releases due to PFS on environment

Petrol fuel stations have hazardous effects on workers as well as occupants residing close to them. Workers and occupants exposed to gasoline, vapor emissions and motor vehicle exhausts for a long duration therefore found to have high elevated volatile organic compounds (VOC's) level. Study conducted by [26] demonstrated that PFS workers exposed to higher VOCs levels than workers who not in direct contact with VOCs. The health risk assessment conducted shows that PFS has lifetime cancer risk due to high level of benzene and 1-3 butadience. VOCs associated with gasoline vapor emissions and motor vehicle exhaust, are pollutants of concern because of their toxicity reported in studies conducted by [27]-[28]. Other studies conducted on occupational exposure to VOCs from gasoline vapor emissions are [29]-[30]-[31]-[32]-[33].

III. Hazard Contributing Factors

Petrol fuel station is a unique facility that contains, store and sell flammable and hazardous material in a close vicinity of rural and urban areas. Many studies conducted as highlighted in literature review demonstrated that researchers considered the effects of hazardous substances on human health and surrounding area. It proof by the studies results that PFS are not safe and contains harmful effects on human and environment. No study found that highlight other harmful potential scenarios associated with PFS. One year data collected and 902 unsafe acts and unsafe conditions were recorded during operation and maintenance of PFS. The activities recorded were analyzed by using three ways. In 1st classification unsafe acts and unsafe conditions recorded were divided into eight main categories such as;

1. House Keeping
2. Transportation Hazards
3. Slips, trips and falls
4. Carelessness
5. Fire Risks
6. Electrical Fault
7. Miscellaneous Cases (Manual Handling, Maintenance and Mechanical problems)
8. Medical Treatment Cases

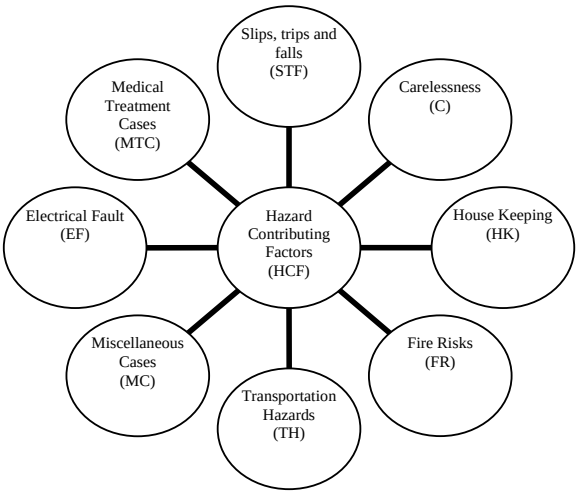

Fig. 6 Distribution of hazard contributing factors among eight components

In 2nd classification they were divided into four main categories. Same activities were grouped into fatality, accident, incident and near miss cases.

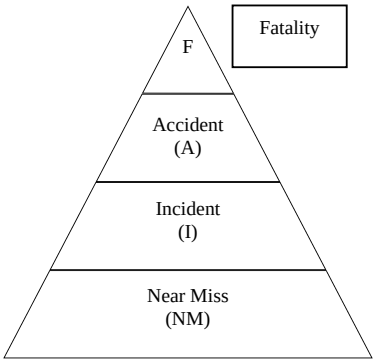

Fig. 7 Division of hazard contributing factors in four classifications

In 3rd third classification activities were classified based upon their impacts on property, environment and human.

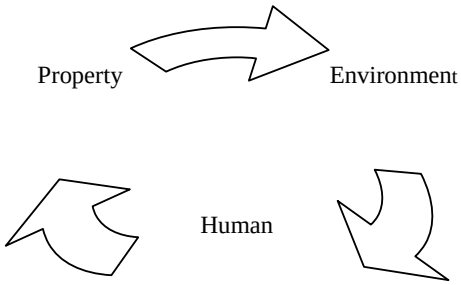

Fig. 8 Link of hazard contributing factors on property, environment and human

These factors have harmful impacts on human, environment and property. The proposed hazard classification can be applied in integration with other respective processes such as risk assessment, development of standard operating procedures, hazard operability study (HAZOP) and hazard identification and risk assessment (HIRA) and in isolation as well. It equally helps safety professionals to predict the upcoming hazards at their PFS. PFS are hazardous workplaces. During study 902 events recorded and grouped into eight hazard contributing factors. They are also the root causes for occurrences of fatality, accident, incident and near misses cases. Hazard contributing factors are grouped under eight main classifications.

A. House Keeping

Housekeeping encompasses all activities related to the cleanliness of facilities, materials, equipment and the elimination of nonessential materials and hazardous conditions. Good housekeeping practices have many advantages such as;

- Minimizes environmental impacts of the activities
- Reduces costs incur due to slips, trips and falls
- Prevent fire incidents
- Maintain a good and pleasant workplace

Elements of good housekeeping are ventilation, lighting, waste removal, floors and walls, aisles, space, storage and materials handling. The standard of housekeeping found unsatisfactory to control risks at PFS. Good housekeeping practices helps to prevent fire, tripping and contact hazards. Incidents reported during operation and maintenance of PFS related to housekeeping includes, slips, trips and falls, articles dropping from above, slippery-greasy-wet-dirty surfaces, striking against poorly stacked or misplaced material and fire hazards. Racking items stacked on the floor cause tripping hazard and blocking fire escape routes. In addition, to the racking that is provided found overloaded and unstable. Serious injuries can happen if the racking collapsed.

The toilet and hand washing area found in dirty state and requires urgent cleaning and redecoration. It was also noted that there is no provision for storage and changing of clothing, for rest and taking meals for workers.

Fig. 9 Unsafe storage of material in racks

Fig. 10 Housekeeping of tank zone was found poor

Scrap material found unattended outside the scrap yard. Some cases reported in which due to high wind pressure trees fallen on ground and creates hindrances in movement of vehicles and blocked the passage. Due to heavy wind blown trees swing and touch the high voltage electricity cables. It causes occurrences of fire and generation of electromagnetic waves. Due to unawareness practices of housekeeping workers throw the cotton rags on ground. It causes unhealthy effects to the environment. In underground storage tanks stairs hornet hive's was found. Growth of bushes under the fire water pipe lines also reported. Stairs found wet, slippery and oily. Platform of gantry found slippery.

B. Transportation Hazards

Occurrences of road accidents involving tank lorries (T/Ls) were recorded most common during operation and maintenance of PFS. PFS operating companies have vital role of transportation network in smooth operation of their business activities. Transportation of fuel via T/Ls is quite common everywhere in the world. Hazards and accidents related to this mode of transportation were found more frequent. It happens due to many factors such as conditions of vehicles, driver's attitude, driver's education level, company safety culture, road conditions, time of journey, allowable speed limits, climatic conditions, traffic congestions on road and etc. The principal factor in majority of accidents is the failure of driver and it can be controlled. The following accidents were reported by the fuel station owners. They agreed that there is no system of safety management issues presently available at PFS.

1. A T/L was parked under parking shed at depot. A driver was reversing his T/L without looking at the back mirror. A worker was standing just behind the T/L. He was hit by the T/L and badly injured.
2. During routine transportation operation a T/L was overtaking a bus and violated speed limits. Suddenly it hit the cyclist on road. A T/L passed over a cyclist. A cyclist died on spot.
3. A driver was sleeping in between two T/Ls. There was a very hot season and he was sleeping under the shed among the T/Ls. A T/L driver starts engine without observing nearby. While he was taking out his T/L, a sleeping driver between two T/Ls crushed. Death occurred on spot.
4. A T/L driver parked his T/L at depot just below the high tension wires and he slept on the roof of T/L. When he woke up in the morning, as he was sleepy so did not noticed the high tension electric wires. Once he woke up and stands he makes contact with electric cables and died.

C. Slips, trips and falls

Slips trips and falls recorded major causes of medical treatment cases and lost time injury cases. Injuries reported on legs, arms and heads during PFS operation to the workers. Root causes reported in most of the cases were carelessness. Tools fallen down during working at height causes injuries to the workers and pedestrians passed nearby. Falling of workers during cleaning from height contains higher severity during working. PFS considers being a small facility, less consideration was observed during working at height. Wooden ladders found in a highly dangerous state with three damaged rungs. Using the equipment in this condition could result in a very serious injury. Overall condition of ladders found worst and it considers being the main component of working at height. Slippery conditions at filling gantry due to minor leakages of oil make working area slippery. It contributes to slips, trips & falls. When workers climb up to the T/Ls to check the level of T/L after filling they become slipped from ladders and received major injuries on legs and arms. Workers fall from roof reported major and minor injuries. 202 slips, trips and fall cases reported during data collection period. Fig. 11 shows the gap in design conditions. It indicates permanent gap in design and fix cause of occurrences of slips trips & falls.

Fig. 11 Diesel dozing pipe has become a trip hazard

D. Carelessness

Carelessness happens because of lazy way out. The supervisor or safety inspector can not eliminate the chances of carelessness from workers but he can give constant reminding and refresh tool box talks regarding severe outcomes of carelessness. Major causes of carelessness cases recorded due

to workers found violating in following areas;

1. Not following work instructions
2. Not following set disciplinary rules and regulations
3. Not using safe work methods
4. Not paying attention to job they are carrying or to the operating equipment
5. Improper use of personnel protective equipment
6. Posses insufficient skills required for the work performing
7. Improper use of tools and equipment
8. Eyes are not on task
9. Bad safety attitude

Carelessness found to be the main element to contribute hazard during operation and maintenance of PFS. Various cases observed related to carelessness at PFS. Such as unsatisfactory use of personnel protective equipment (PPE), improper use of tools and equipments (conditions of tools recorded deteriorated), inadequate use of signage's and instructions, missing signage's at desirable locations, use of cell phone in tank zone, not using seat belts while driving, emergency number plates with outdated contact numbers, medicines in first aid box was found insufficient, suddenly application of brakes on transportation lorries and other vehicles.

E. Fire Risks

Fire hazard exists where housekeeping is poor. Numbers of fire hazards were present due to unsatisfactory working conditions. Many fire exits were reported blocked, which could prevent an emergency evacuation. Occurrences of fire events can be minimized by following considerations;

- Good floor surface
- Keeping area clean and free of loose material
- By keeping working area free of oil, grease, etc
- Keeping floors area free of scrap & unnecessary articles
- Keeping workplace free of obstructions
- Safe and free passage to fire-fighting equipment and fire exits
- Providing safe and free access to staff with clear instructions
- Keeping equipments free from unnecessary dripping of oil or grease
- Maintaining area around machines cleaned and free of rags, paper, etc
- Providing well ventilation
- Providing appropriate guards
- Keeping first-aid facilities and equipment fully stocked and in clean condition
- Performing work area inspections
- Keeping tool rooms and racks cleaned

Fig. 12 Emergency exits blocked due to improper storage of excess drums

Fig. 13 Tank Lorry rolled over from road and caught fire [35]

F. Electrical Fault

Retail outlet contains display boards and other signages. Cleaning is essential on regular basis to maintain beautification. Electrical shock cases (9) reported during cleaning of these signage's. Electrical faults causes damage to electrical equipments, property loss and hazard to the operating workers. Very less awareness in relation to hazards of electrical equipments was noticed at PFS. Electrical faults causes generation of fire and total loss of electrical equipment. Electrical fixtures, switch boards, electrical panel, control panel, sky links, electrical hooters, dispenser units, generators, electrical wiring, electrical heaters are the main components of PFS.

Fig. 14 Electric cable trench was found uncovered

Fig. 15 Unsafe electric heaters being used at retail outlet

Electrical failure has potential to stop the whole sales operation at PFS. Therefore, compatibility of electrical appliances is viable. It was noticed that in canopy the electrical fixtures and bulbs used for lighting was not appropriate. Normal lighting system was used. It requires special lighting configuration so that lighting system does not affect by VOCs emissions and other hazardous substances.

G. Miscellaneous Cases

Miscellaneous cases comprised of hazard contributing factors fall under following classification;

- Oil spillages
- Water leakages
- Snakebite cases
- Minor damages
- Maintenance issues
- Robbery
- Theft
- Natural disasters/wind storms
- Law and order situation

Due to lack of safety awareness by staffs many unsafe practices were noted, including failure to clear oil spillages, unsafe manual handling practices and the storage of fuel samples in unmarked mineral water bottles. This indicates poor supervision and lack of training.

H. Medical Treatment Cases

Medical treatment cases reported in all eight hazard contributing factors. Severe cases reported during transportation of fuel from distribution center to the petrol fuel outlet. The gantry used for filling of T/Ls was observed very narrow and more than fifty (50) cases reported at that particular position. Injuries reported on head, arms and legs. First aid treatment at the retail outlet was provided to the workers on immediate basis while in case of any serious injury the patient shifted to the nearby hospital.

IV. Monthly Distribution of Hazard Contribution Factors

During year 2009, 902 unsafe acts and unsafe conditions recorded during operation and maintenance of PFS. The activities classified into eight main contributing factors. These are housekeeping (HK), transportation hazard (TH), slips trips and falls (STF), carelessness (C), fire risk (FR), electrical fault (EF), miscellaneous cases (MC) and medical treatment cases (MTC).

Table IV shows monthly distribution of 902 hazard contributing factors into three ways. 902 events divided into eight hazards contributing factors.

TABLE III
Description and Legends

No	Description	Legends
1	Housekeeping	HK
2	Transportation hazard	TH
3	Slips trips and falls	STF
4	Carelessness	C
5	Fire risk	FR
6	Electrical fault	EF
7	Miscellaneous cases	MC
8	Medical treatment cases	MTC
9	Fatality	F
10	Accident	A
11	Incident	I
12	Near Miss	NM
13	Environment	E
14	Human	H
15	Property	P

TABLE IV
MONTHLY DISTRIBUTION OF HAZARD CONTRIBUTING FACTORS

No	Legend	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HK	9	0	3	7	7	6	1	2	2	5	0	0	42
2	TH	31	24	27	17	17	11	14	11	15	15	8	1	191
3	STF	33	37	53	15	10	16	7	11	11	4	5	0	202
4	C	17	7	11	11	10	6	4	7	7	9	6	2	97
5	FR	3	0	1	2	1	2	1	0	1	3	1	1	16
6	EF	18	7	13	9	1	5	3	2	4	3	3	1	69
7	MC	36	30	26	19	14	13	18	12	14	9	6	1	198
8	MTC	15	9	21	11	4	3	7	4	3	6	3	1	87
	Total	**162**	**114**	**155**	**91**	**64**	**62**	**55**	**49**	**57**	**54**	**32**	**7**	**902**
No	**Legend**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1	F	0	0	0	0	0	0	1	0	0	0	0	0	1
2	A	10	5	9	5	10	10	9	11	12	12	8	0	101
3	I	35	25	48	23	14	10	22	10	21	15	9	6	238
4	NM	117	84	98	63	40	42	23	28	24	27	15	1	562
	Total	**162**	**114**	**155**	**91**	**64**	**62**	**55**	**49**	**57**	**54**	**32**	**7**	**902**
No	**Legend**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1	E	22	20	16	17	12	15	8	9	7	8	5	1	140
2	H	58	46	70	33	18	20	17	14	14	12	9	1	312
3	P	82	48	69	41	34	27	30	26	36	34	18	5	450
	Total	**162**	**114**	**155**	**91**	**64**	**62**	**55**	**49**	**57**	**54**	**32**	**7**	**902**

Table V shows the relationship between hazard contributing factors with fatality "F", accident "A", incident "I" and near miss "NM" cases.

TABLE V
RELATIONSHIP BETWEEN HAZARD CONTRIBUTING FACTORS WITH FATALITY, ACCIDENT, INCIDENT AND NEAR MISS CASES

Legend	Fatality												Accident											
	Months Number												Months Number											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
HK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TH	0	0	0	0	0	0	1	0	0	0	0	0	10	5	9	5	10	6	9	11	12	9	7	0
STF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
EF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
MC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MTC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**10**	**5**	**9**	**5**	**10**	**10**	**9**	**11**	**12**	**12**	**8**	**0**
Legend	**Incident**												**Near Miss**											
	Months Number												**Months Number**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
HK	0	0	0	0	0	0	0	0	0	0	0	0	9	0	3	7	7	6	1	2	2	5	0	0
TH	2	1	6	4	3	0	2	0	3	4	1	1	19	18	12	8	4	5	2	0	0	2	0	0
STF	11	14	18	2	4	3	4	1	7	2	2	0	22	23	35	13	6	13	3	10	4	2	3	0
C	1	0	0	1	0	0	2	2	1	0	0	1	16	7	11	10	10	6	2	5	6	9	6	1
FR	3	0	1	2	1	2	1	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
EF	2	0	1	0	0	1	0	2	3	2	1	1	16	7	12	9	1	0	3	0	1	1	2	0
MC	1	2	3	3	2	1	6	1	3	1	2	1	25	28	23	26	12	12	12	11	11	8	4	0
MTC	15	8	19	11	4	3	7	4	3	4	2	1	0	1	2	0	0	0	0	0	0	0	0	0
Total	**35**	**25**	**48**	**23**	**14**	**10**	**22**	**10**	**21**	**15**	**9**	**6**	**107**	**84**	**98**	**73**	**40**	**42**	**23**	**28**	**24**	**27**	**15**	**1**
Main Total	**152**	**114**	**155**	**101**	**64**	**62**	**55**	**49**	**57**	**54**	**32**	**7**												

Table VI shows the relationship between environments "E", human "H" and property "P" with fatality "F", accident "A", incident "I" and near miss "NM" cases.

TABLE VI
RELATIONSHIP BETWEEN HAZARD CONTRIBUTING FACTORS WITH FATALITY, ACCIDENT, INCIDENT AND NEAR MISS CASES

Legend	Fatality												Accident											
	Months Number												Months Number											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2	1	0
P	0	0	0	0	0	0	0	0	0	0	0	0	10	5	8	5	10	10	9	10	12	10	7	0
Total	0	0	0	0	0	0	1	0	0	0	0	0	10	5	9	5	10	10	9	11	12	12	8	0
Legend	Incident												Near Miss											
	Months Number												Months Number											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
E	1	3	2	4	2	1	3	1	1	0	2	1	21	17	14	13	10	14	5	8	6	8	3	0
H	28	20	31	13	7	6	10	5	9	6	4	1	30	26	38	20	11	14	6	8	5	4	4	0
P	6	2	15	6	5	3	9	4	11	9	3	4	66	41	46	30	19	14	12	12	13	14	8	1
Total	35	25	48	23	14	10	22	10	21	15	9	6	117	84	98	63	40	42	23	28	24	26	15	1
Main Total	162	114	155	91	64	62	55	49	57	53	32	7												

Table VII shows the relationship between eight main contributing factors such as housekeeping "HK", transportation hazard "TH", slips trips and falls "STF", carelessness "C", fire risk "FR", electrical fault "EF", miscellaneous cases "MC" and medical treatment cases "MTC" with environments "E", human "H" and property "P".

TABLE VII
RELATIONSHIP BETWEEN HAZARD CONTRIBUTING FACTORS WITH ENVIRONMENTS, HUMAN AND PROPERTY YEAR 2009

Legend	Environment												Human											
	Months Number												Months Number											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
HK	7	0	2	5	6	0	1	1	1	4	0	0	2	0	0	0	1	0	0	1	1	0	0	0
TH	0	1	0	0	0	0	0	0	0	0	0	0	5	6	4	3	0	1	1	1	0	0	0	0
STF	1	2	2	1	1	0	0	2	1	0	0	0	26	23	35	13	8	13	5	8	7	4	4	0
C	0	0	1	1	0	0	0	0	0	1	1	0	7	5	5	6	5	3	2	0	3	2	2	0
FR	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
EF	0	1	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0	0	0
MC	14	16	11	9	5	0	7	6	5	3	4	1	1	2	2	0	0	0	2	0	0	0	0	0
MTC	0	0	0	0	0	0	0	0	0	0	0	0	15	9	21	11	4	3	7	4	3	6	3	1
Total	22	20	16	17	12	1	8	9	7	8	5	1	58	46	70	33	18	20	17	14	14	12	9	1
Legend	Property																							
	Months Number																							
	1	2	3	4	5	6	7	8	9	10	11	12												
HK	0	0	1	2	0	0	0	0	0	1	0	0												
TH	26	17	23	14	17	10	13	10	15	15	8	1												
STF	6	12	16	1	1	2	2	1	3	0	1	0												
C	10	2	5	4	5	2	2	7	4	6	3	2												
FR	2	0	1	1	1	1	1	0	1	3	1	1												
EF	17	5	10	9	1	5	3	2	4	3	3	1												
MC	21	12	13	10	9	7	9	6	9	6	2	0												
MTC	0	0	0	0	0	0	0	0	0	0	0	0												
Total	82	48	69	41	34	27	30	26	36	34	18	5												
Main Total	162	114	155	91	64	48	55	49	57	54	32	7												

V. RESULTS AND DISCUSSION

902 hazard contributing factors were recorded in the year 2009. They were studied in detail by using three approaches. In first approach they were classified into eight hazard contributing factors. Fig. 16 shows the distribution of 902 hazard contributing factors for the year 2009.

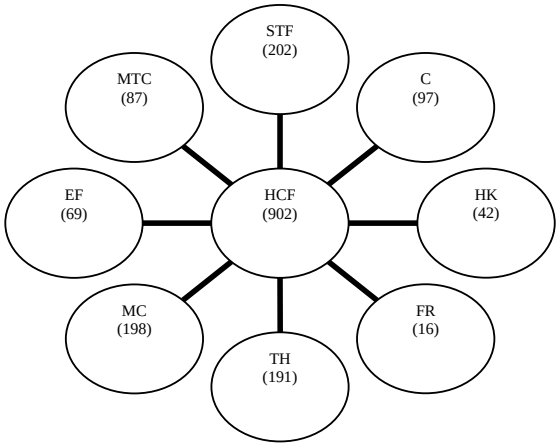

Fig. 16 Distribution of hazard contributing factors for the year 2009

For the year 2009 top four hazard distribution factors were slips trips & falls (202), miscellaneous cases (198), transportation hazards (191) and carelessness (97). The availability of miscellaneous cases and transportation hazard in top four hazard contributing factors is quite obvious because miscellaneous cases is a combination of cases including oil spillages, water leakages, snakebite cases, minor damages, maintenance issues, robbery, theft, natural disasters/wind storms and laws & order situations. Little proportion of all these events makes miscellaneous cases in top four contributing factors. Transportation hazard is ranking in top four ranking because petrol fuel station operation involves extensive use of road network. Transportation of fuel is normally carried out by using tank lorries (T/Ls). During transportation T/Ls covers 1000 to 1200 km distance in a day. Hazards pertaining to transportation also comprised of many factors such as drivers medical conditions, road configurations, condition of vehicle, climatologically conditions, safety culture of company and many other factors. If in initial safety improvement these four hazard contributing factors can be minimized then petrol fuel stations could become much safe.

Fig. 17 shows results of accident causation triangles. It indicates maximum numbers of cases recorded pertaining to near miss cases. 562 near miss cases recorded in year 2009. Safety conscious companies take near miss importantly. Near misses are not less serious; they are often deadly. These companies always encourage reporting of near miss cases. Immediate action need to be taken to prevent occurrences of a similar near miss cases. Obey safety rules decreases the number of near misses. Near misses are warnings that something or someone is not performing the job correctly.

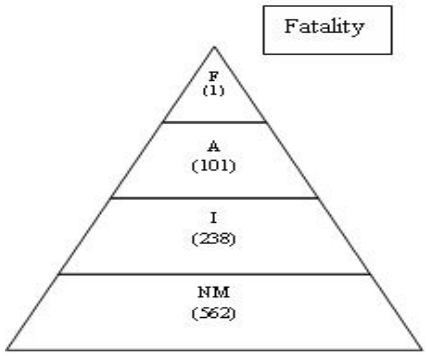

Fig. 17 Accident causation triangle results for the year 2009

Reading triangle from bottom to top is also helpful for clear understanding. Such as if occurrences of near miss cases can be reduced, the other associated parameters including accident, incidents and fatality cases can be minimized by accordingly.

In third classification impacts of PFS on human, environment and company assets were determined. Fig. 18 shows the contributing of hazard contributing factors on human, environment and property. The impacts on company assets were recorded as top priority.

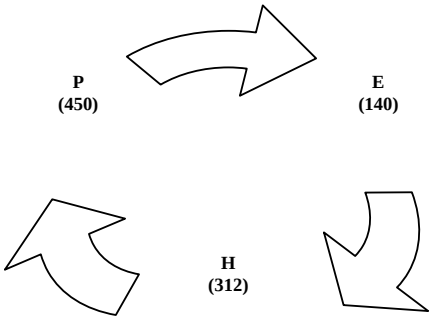

Fig. 18 Impacts of hazard contributing factors on human, environment and company assets for the year 2009

VI. Recommendations

Petrol fuel stations are widely available. The value of safety measures in rural and urban areas is of equal importance. Accident, incidents occurrences during operation and maintenance of PFS can be prevented by good management practices, by people taking personal responsibility and by acquiring necessary competence. Improvements in following features during operation and maintenance, activities at PFS can help to create better safety performance;

1. Commitment by management to occupational health & safety
2. Drivers training programs
3. Trainings and development on hazard contributing factors awareness and management
4. Training of employees
5. Communication, supervision and instructions
6. Issue resolution procedure

7. Use of appropriate signage's
8. Establish safety rules or formal work practices
9. Equipment maintenance
10. Protective equipment and safeguards

By considering above mentioned recommendations, safety conditions during operation and maintenance of PFS can be improved significantly.

Further research on hazards related to PFS operation is still in progress. Successful implementation of safety management system during operation and maintenance of fuel stations also found very help to reduce occurrences of hazard contributing factors [36]. Many parameters to make PFS more safe and workable are under review. Two important parameters i-e change of roof design and construction of facilities such as shopping arcade and other office building structures by constructing multi level floors on PFS facility is under study stage. This can be achieved successfully if hazard contributing factors pertaining to PFS can be minimized to an acceptable level. This could be more helpful to generate revenue, utilization of space/area in more appropriate manner, reduce effects of high winds/storms on PFS and etc. Underground storage tank (UGST) is considered main source of hazard at PFS. If it can be shifted away from PFS and connected to retail outlet via piping than it would be very helpful to reduce the major source of hazard as well as encourage the space utilization in a better way. If the UGST located away from outlet than it could be possible that PFS located in close vicinity can use the same fuel supply source to the outlet. Studies on these aspects are at final stages and results would be publishing soon.

VII. Conclusion

Hazard contributing factors classification shows that there is little attention paid to maintaining good standards of health and safety performances at petrol fuel station. 902 activities recorded by collecting one years data and detailed reviewed by using three approaches. Monthly classification of activities was carried out. In first classification, 902 unsafe acts and unsafe conditions divided into eight factors these are housekeeping, transportation hazard slips trips and falls, carelessness, fire risk, electrical fault, miscellaneous cases and medical treatment cases. In second classification their impacts on fatality, accident, incident and near miss causation were studied and finally impacts on human, environment and company assets were highlighted.

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