Attachment 2

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Cell phones continue to be cited as causing fires at the pump in e-mails circulating on the Internet. So far we have been unable to document any incidents that were sparked by a cellular telephone.

Fires at Refueling Sites That Appear To Be Static Related – Summary

March, 2010

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BACKGROUND/STATEMENT OF THE PROBLEM:
Until September, 1999, the only motor vehicle refueling fires that the Petroleum Equipment Institute (PEI) was aware of were caused either by an open flame (smoking), lack of electrical continuity between the nozzle and the gasoline dispenser, or a spark from the engine compartment of a vehicle with its motor running. From September 1999 through January 22, 2000, 36 ignitions of gasoline vapors during the refueling process were verbally reported to me at PEI. All occurred during dry weather. There were no open flames and the engines were off. Continuity was verified between the nozzle and dispenser. People that investigated the cause of these accidents concluded that static electricity was the source of ignition in all cases.

HOW PEI GOT INVOLVED:
Although Americans pump gasoline into their cars between 11 and 12 billion times a year without incident, the fact that these fires were occurring in the first place—and with what appeared to be greater frequency—caused PEI to gather additional information about the circumstances surrounding the fires. We carried an article (Document A) in the January 25, 2000, issue of PEI's newsletter (*TulsaLetter*), asking readers to report to us all refueling fires presumably caused by static electricity. The same article and request appeared on PEI's Web site (www.pei.org) on January 23, 2000. An on-line report form accompanied the newsletter on the Web site (Document B).

WHAT PEI ASKED:
The newsletter asked readers to identify the make, model and year of the vehicle, the type of fuel used, type of tires and driveway finish, customer action while refueling, and any other information they believed would be useful. We promised that no oil company or PEI member names would be divulged. All responses were strictly confidential.

INFORMATION PEI INITIALLY RECEIVED:
PEI received 47 first-hand reports of refueling fires attributed to static electricity in response to our request in the newsletter. We also obtained 34 Vehicle Owner's Questionnaires (VOQs) from the National Highway Traffic Safety Administration's (NHTSA) database which strongly suggested that static electricity was the source of ignition. The reported fires occurred between 1993 and April 1, 2000, with more than half occurring from 1999 through April 1, 2000. A detailed report, similar to the one that follows, was posted on PEI's web site in May 2000.

INFORMATION PEI HAS RECEIVED THROUGH MARCH 2010:
PEI continued to receive reports of accidents/fires attributed to static electricity after we issued our report in May 2000, even though we did not actively solicit them in future newsletters. A detailed report listing all fires received and confirmed by PEI through March, 2010 contains the following information:

- Reports by Year
- Reports by Month
- Reports by State
- Injuries
- Damage to Station
- Damage to Vehicle

One hundred seventy-six reports (first-hand and NHTSA's VOQs) have been received from 39 states and Washington, D.C. In all the reports we were able to verify that no open flames, running motors, or electrical continuity problems were involved. The accidents occurred with conventional and vacuum-assist Stage II vapor recovery nozzles. There have been no accidents reported to PEI when balance system nozzles were used. Driveway surfaces included concrete, asphalt, stone, crushed rock and dirt. Fires occurred with many different types of nozzles, hoses, breakaways and dispensers. No cell phones were involved. A wide variety of clothes were worn by the refuelers. Rubber-soled shoes were worn by the refuelers in 94% of the accidents where footwear was identified. A summary of all the fire reports is also included in Document D.

WHY DOES THIS HAPPEN?
The author of this report is not an expert on static electricity. It does appear to many people in the industry, however, that electrostatic charging was the probable cause of the fires. In many of the reports we received, the refueler became charged prior to or during the refueling process through friction between clothing and the car seat to such an extent that electrostatic discharges to the vehicle body, fuel cap or dispensing nozzle occurred. Eighty-seven (87) fires occurred when the fueler returned to the vehicle during the refueling process and then touched the nozzle after leaving the vehicle. Thirty-nine (39) reports described fires before the refueling process began, when the fueler touched the gas cap or the area close to it after leaving the vehicle. Thirty (32) fires do not involve either of these two fact situations. In all but two of these cases the fueler was not the source of the electrical discharge and the source of ignition cannot easily be determined. We received insufficient information on seventeen (17) fires reported by NHTSA to confidently categorize them.

PEI has received five excellent articles (Documents E, 1-5) written over the last six years which attempt to explain these types of fires. Most were written in response to similar refueling fires in Germany, the United Kingdom and France from 1992 through 1997. Some offer very detailed explanations about why these refueling fires occur.

INFORMATION PEI DOESN'T HAVE:
Forty-five (45) fires have been verbally reported to us, but no written reports have been submitted. As a consequence, these 45 fires were not included in our report. The American Petroleum Institute (API) conducted a survey similar to PEI's in 2000 and identified 54 fires attributed to static electricity, most of which did not overlap with those collected by PEI. API's information is also not included in this report. API's February 2, 2000, report form (Document C) and its February 3, 2000, Consumer Advisory (Document F-5) are available from PEI.

RESPONSES:
Warnings have been issued by various companies and organizations since November 1999 (Documents F, 1-6).

WHERE DO WE GO FROM HERE?
PEI will continue to collect reports of fires, as well as theories and studies about why these fires happen. To contact the author of this report, refer to the numbers listed on the first page.

PEI and API joined together September 23, 2002, to remind motorists how to avoid potential problems with static electricity at the gas pump (Document G). The groups also listed tips on how motorists can follow safe refueling practices (Document H).

OTHER INFORMATION:
Information referenced throughout this summary is identified below. It is not included with this report because of the number of pages involved. We will mail a full set upon request. Contact PEI at the numbers listed on the first page for a copy of the referenced documents.

REFERENCED DOCUMENTS

A. PEI *TulsaLetter* – January 25, 2000

B. PEI Report Form – January 23, 2000

C. API Report Form – February 2, 2000

D. Summary of Fire Reports

E. Articles

1) German DGMK Project 508 – February 1996

2) Guidelines for the Control of Hazards Arising from Static Electricity – The Institute of Petroleum, London – March 1998

3) Electrostatic Ignitions of Fires and Explosions, Thomas H. Pratt, Burgoyne Inc., Marietta, Georgia (1997)

4) Report on Refueling Ignitions on Petrol Filling Stations in Europe – The Bulletin, Volume 35, August 1997

5) The Role of Static Electricity In Forecourt Fires In Europe – The Bulletin, Volume 38, February 2000

F. Warnings

1) Oil Company Alert: Static Electricity Discharge Explosion Hazards – November 24, 1999

2) Motor Vehicle Fueling Fires - Nebraska State Fire Marshal's Office – January 2000

3) BP Amoco Press Release – January 24, 2000

4) Flash Fire Alert – Alaska Army National Guard – February 2000

5) Gasoline Refueling Advisory and Safety Guidelines for Consumers – API – February 3, 2000

6) Three petroleum marketer warnings issued January-March 2000

G. PEI/API Joint Press Release (September 23, 2002)

H. Safe Refueling and Fuel Handling Guidelines for Consumers (September 23, 2002)

Fires at Refueling Sites that Appear to be Static Related—The Incidents—March 2010

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- Reports by **Year**
- Reports by **Month**
- Reports by **State**
- Report of **Injuries**
- Damage to **Vehicle**
- Damage to **Station**
- Incidents reported to **PEI**
- Incidents reported via **NHTSA Questionnaire**

Reports by Year

Year	Total	NHTSA Only
1992	1	
1993	1	1
1994	3	3
1995	8	7
1996	7	4
1998	10	3
1999	32	6
2000	24	1
2001	12	
2002	31	
2003	12	
2004	5	
2005	3	
2006	5	
2007	1	
2008	2	
2009	2	
2010	1	
Unknown	7	4
Total	176	34

Reports by Months

Month	Reports	Percent %
January	30	18
February	27	14
March	21	12
April	11	6
May	10	7
June	4	1
July	1	1
August	7	2
September	7	2
October	8	2
November	16	7
December	27	17
Unknown	7	7
Total	**176**	**96%**

Reports by State

State	Total	NHTSA Only
Nebraska	14	1
Texas	11	2
Colorado	10	3
Missouri	10	
Kentucky	9	
Pennsylvania	8	3
California	7	4
North Carolina	7	1
Oklahoma	6	
Kansas	6	
Michigan	6	1
Illinois	6	2
Virginia	6	
Minnesota	5	2
Tennessee	5	1
Louisiana	4	1
New Mexico	4	
Arizona	4	
Utah	4	
Ohio	4	1
Idaho	3	1
New York	3	2
Washington	3	
Maryland	2	2
Georgia	2	2
Wisconsin	2	1
Mississippi	2	
South Carolina	2	
Massachusetts	2	1
Montana	3	
Arkansas	2	1
Alabama	2	
Alaska	2	
Indiana	1	
Iowa	1	
District of Columbia	1	1
Florida	1	
Nevada	1	
New Jersey	1	
Oregon	1	
Canada	1	
Unknown	2	
Total	**176**	**34**

Injuries

Number	Description of Injury
26	Hair singed/Burned
8	First and Second degree burns
7	Burns to hand
4	Yes
5	First-degree burns
2	Burns to leg—treated and released
3	Burns to face
3	Second-degree burns—skin grafts
3	Badly burned
2	Minor scrapes
2	Clothing scorched
2	Treated for burns—released
1	Third-degree burns over 60& of body
1	Death-person
1	Death- Inhalation of heated gas fumes
1	Death—Dog
1	Back injury
1	Bruised leg from running away
1	Nerve damage

Damage to Vehicle

Number	Description of Damage
36	Totaled
15	Paint discolored; blistered
20	Under $1,000; minor
9	Melting around fill pipe
9	$1,000 to $8,000; moderate
4	Yes
2	Smoke
1	Burned rubber around gas tank door

Damage To Station

13	Damage to dispenser
10	Destroyed nozzle
10	Destroyed dispenser
8	Destroyed dispenser(s) and canopy
4	Destroyed canopy
3	Aboveground storage tank destroyed
2	Destroyed garage and nearby buildings
1	Nozzle splash guard
1	Destroyed dispenser(s), canopy, lighting
1	Smoke damage to cover above pump
1	Smashed fire extinguisher housing
1	Damage to fuel hose and canopy
1	Damage to gas tank and right quarter panel
1	Estimated $40,000

The Incidents - Details

87 Fires Reported to PEI Where the Vehicle Was Re-entered and the Nozzle was Touched During Refueling

Log #	Date	Yr./Make Vehicle	Description of Incident
1	10-99	Toyota Camry	The customer started fueling. She put it on automatic and returned to sit in the car. The nozzle shut off. She topped off the tank. As she grabbed the nozzle to remove it, a flash fire occurred.
2	1-00	1991 Plymouth Voyager	Started fueling the car with the automatic nozzle set. She reentered the car leaving the door open. She returned to the nozzle in order to stop the pump at the amount she wanted. After shutting off the nozzle manually she started to remove the nozzle; a fire started at the filler pipe of the car. When the fire started she removed the nozzle and threw it to the ground.
3	12-99	Mitsubishi Eclipse	Started fueling. Returned to car to write a check. Returned to the fueling site to stop fueling at $7.00. When she touched the nozzle, a flash fire followed.
4	12-99	1999 Ford Windstar	I shut off my engine before refueling my van. I got out of my van and began fueling. I set the pump to operate automatically while I sat in my car for a few minutes. While waiting in my car I called my husband on the cell phone and shut the phone off. After the pump had a little over $10 worth of gas, I grabbed a $20 bill and got out of the van to shut the gas off and pay. I got out and proceeded to pull the nozzle out of my vehicle. When I pulled the nozzle from my tank, a burst of flames shot out of my tank with the nozzle on fire. I jammed the nozzle back into the tank and ran from the vehicle.
6	1-00	1995 Mitsubishi Eclipse	I was letting it fill up and I got out of the car to go to stop the gas and when I reached down I felt a pop on my finger and I pulled back and the flames came up.
9	1-00	1995 Plymouth Voyager	Driver gets out of car to fuel. Returns to car. Dispenses $9 and gets out of car. Shuts door. Touches nozzle. Fire. Driver goes into store. Latch still on. Yanks the nozzle out to put out the fire. Gasoline comes out.
11	3-99	1996 Nissan Quest	Started dispensing fuel, got back in van, left door open. Jumped out to stop fueling and a static spark ignited the vapors as he reached for the nozzle.
12	Unknown	1999 Chevy Van	Started fueling. Got back in van. Got back out. Spark from hand to nozzle ignited vapors.
13	10-99	1997 Buick Regal	Operator was wearing cotton gloves. Started fueling and sat back in car waiting for nozzle to trip. Reached for nozzle after 11 gallons were dispensed. Flame came out. Turned off nozzle and dropped it on the ground. Attendant put out fire at fuel port.

Log #	Date	Yr./Make Vehicle	Description of Incident
15	1-00	1999 Ford F150 Pickup	Started fueling, went back to car, turned on power to view fuel gauge, turned off power. Left vehicle with door open. Touched nozzle and felt spark.
16	1-00	1992 Ford F150 Pickup	Engine on while refueling. Blocked nozzle open to "on" position with a rock. Climbed back into vehicle. Gauge at ¾ full, reached for nozzle to stop fuel flow, and saw flame shoot out from tank spout. Fire marshal said "a static discharge occurred."
18	5-99	Unknown	Customer sat in car while refueling. Turned key on to auxiliary. As the nozzle was pulled out, saw a flame.
19	3-97	1985 Buick Park Avenue	Chocked the nozzle open with the gas cap. Went into the car to talk to the children. Heard tank filling to top, got out of car, reached for the nozzle to turn off fuel flow. Sparking occurred at the nozzle-vehicle fill connection.
21	10-97	1985 Buick station wagon	After four gallons were dispensed, the driver opened the driver's side door, got in car and turned key to observe the gauge. She got out of the car, leaving the door open. She touched the nozzle to put more gas in her car and felt her hand getting hot. She looked down and saw fire coming from the fill spout of the gas tank. She jerked back and pulled the nozzle out, spraying some gasoline in (the door was open) and on the car. 7.28 gallons dispensed.
23	1-96	1996 Camaro	Put nozzle in car. Returned to car. Went back to nozzle. Bent down behind nozzle. Flash. Ran away but returned to car to remove nozzle.
25	1-99	1997 Chevy Silverado	Driver blocked nozzle open with gasoline cap. Sat in driver's seat with driver's side door open. Went back to nozzle as tank became full, touched the nozzle and vapors ignited. Started to run away but returned to remove nozzle and dropped it on the ground.
26	2-99	1993 Olds Cutlass Supreme	Started fueling. Sat back in car to return gas card to purse. Returned to rear of car to hold nozzle. Fire flared up as she reached for the nozzle.
29	11-99	1990 Nissan XS	Nozzle in car. Latch-open device on. Punched in I.D.# on card system. Sat in car with door open with one foot on the ground. Reached for nozzle to disengage, and saw a spark, flash and flame from filler neck. Removed nozzle and threw it down. Pushed car away.
30	1-98	1997 Ford Crown Victoria	Started fueling. Sat back in car. Nozzle clicked off. Touched nozzle to remove it. Flash fire.
32	1-99	1991 Chevy Lumina	Driver turned off ignition, turned on pump and began to refuel. She then opened the driver's side door and entered the car. Turned ignition switch to "on" (engine off) and watched the gas gauge. Got out of car and touched the nozzle to shut it off. Flames erupted.

Log #	Date	Yr./Make Vehicle	Description of Incident
36	12-99	Ford Pickup	Driver pulled up to an MPD, cleared the dispenser and placed the nozzle in the fuel tank. He was going to put $5 in the vehicle so he reentered the driver's seat and closed the door while the fueling was in operation. When the dispenser was at $4, he opened the door on the pickup, stepped down to get out, and reached back to touch the nozzle. When he touched the nozzle there was a flash fire.
72	1-00	1999 Ford Pickup	Owner put nozzle in fuel tank and began fueling. As he got back in the truck, he touched the door and got a shock. He got out of the truck while it was still pumping (he wanted $20), touched the nozzle and a fire resulted.
73	12-99	1994 Mitsubishi	Turned on accessory. Filled to $19 and nozzle clicked off. Got out of car, touched the nozzle (never the car), and it flashed. Dropped nozzle on ground.
75	2-99	1993 Ford Probe	Pumping gas. Set auto fill. Got in car to get keys. Reached for nozzle to top off car and fire resulted. Car was almost full of gasoline.
76	2-99	1993 Dodge Caravan	Driver started fueling and got back in car. Nozzle shut off. As she touched the nozzle, she felt a shock and fire ensued.
78	2-00	1997 Honda Accord	Lady drove in, started fueling, reentered car, got out of car, closed door, touched nozzle with right hand. Flash.
81	Unknown	1999 Dodge Durango	Started fueling. Got back into vehicle. Got back out, reached for nozzle and a spark jumped from hand to nozzle, igniting the vapors.
84	4-00	1995 Ford Windstar	Fueling van on automatic. Driver reentered van to talk to a friend. Opened door and doesn't remember if she shut it. Touched nozzle—or got close to it. Fire out fill neck. Turned off dispenser and ran to station to get extinguisher to put out flames.
88	3-00	2000 Chrysler Town & Country LX	Started fueling and left latch-open device on. Returned to van to get money. Shut door by grabbing window frame. Stood watching meter and touched nozzle. Flame went up left hand and continued for at least a minute. Shot out like a torch.
89	12-99	1998 Ford Mustang	Driver got out of vehicle, engine running, nozzle inserted. Walked back to vehicle to sit down. Left door open. Driver thought nozzle clicked off. Got out of vehicle. Two inches from nozzle saw a spark.
90	8-00	1995 Ford Escort	Turned off engine and exited vehicle, leaving door open. Removed nozzle from pump and placed in tank. Re-entered car to place credit card into wallet. Exited car to remove nozzle. Reached for nozzle. Entire nozzle was engulfed in flames. Fire followed hose to the dispenser.
91	4-92	1992 Chrysler Van	Fueling car. Sat in car as tank filled. Got out and reached for nozzle. Flash fire occurred, burning car and area on the ground around it.

Log #	Date	Yr./Make Vehicle	Description of Incident
93	11-99	2001 Chevy S-10	Began fueling. Returned to car to put credit card away. Got back out. As hand got close to the pump, heard the fire ignite. Fire burned hair and eyelashes.
99	8-01	1995 Chevy Lumina	Fueler set auto nozzle latch open. Entered back seat to see about baby buckled in car seat. While attempting to remove nozzle from tank blaze occurred at nozzle area.
100	9-01	1999 Dodge Durango	Put nozzle in vehicle and set for self-fill. Returned to vehicle to write check. While grabbing handle to remove nozzle, flames shot out and up the side of car.
103	2-02	1996 Z71 Chevrolet	Driver unscrewed gas cap and put nozzle into tank. Got back into vehicle to put credit card away. Got out and attempted to touch the nozzle. Saw a large spark come out of the gas tank, fire ignited - it was a huge burst of flames.
104	3-02	1991 GMC Safari Van	Started fueling. Got back into vehicle to write a check. Got back out to manually finish pumping fuel. Left door open to hear two young children in vehicle. As soon as I grabbed nozzle flames were all around me.
105	3-02	1994 Geo Tracker	Driver started fueling on auto-cut-off. During fueling at passenger side rear of vehicle, he returned to driver’s side, entered car and returned without closing door to fueling side. When he removed nozzle from tank a fire ball erupted.
106	3-02	2001 Nissan Pathfinder	Driver got back into car to put something away. Got out to stop pump from fueling. Driver felt a shock and a whoosh sound. Flames were coming out of gas tank.
107	6-02	1996 Toyota Corolla	Started pumping gas. Got back into car because it was cold. Got out of car, reached for handle and felt a buzz. Saw a spark and a fire ignited at the entrance to the fuel line.
110	10-99	1995 Chevy ½ ton	Sitting inside vehicle while fueling. Stepped out of truck and immediately grabbed for handle to take out of tank. Fire shot out of gas tank.
113	8-01	Nissan Pathfinder Van	When fueling vehicle driver sat down in vehicle. When dispenser clicked off he returned to dispensing nozzle. Driver grabbed nozzle, felt static go up arm. Fire started coming out of fill hole by nozzle.
114	1-02	Not known	Driver started fueling and returned to vehicle. After fueling, she pulled nozzle out of car and fire started.
115	5-02	1987 Pontiac Firebird	Customer entered store to prepay for fuel. Driver returned to vehicle, put nozzle in tank and set auto-clip. She returned to vehicle, sat down in driver’s seat and left door open. As she went to remove nozzle there was a flash.
116	2-02	1999 Chevrolet Venture	Driver put gas in van and returned to vehicle because it was cold. As she pulled nozzle out, flames shot out of tank on to van, nozzle and ground.

Log#	Date	Yr./Make Vehicle	Description of Incident
117	11-00	1993 Subaru Legacy	Driver began filling tank and then engaged hold-open clip. She returned to car to put away debit card and then grabbed nozzle to disengage clip and continue filling. Driver felt a static spark as she grabbed nozzle and heard "whoosh" sound as fumes ignited.
118	10-99	Honda	Driver pumped gas, sat in car because it was cold, touched nozzle to release automatic and felt spark and saw flames.
120	1-02	1997 Ford F150	Customer paid clerk $20. Started nozzle pumping and got back into truck because it was cold. She noticed pump had passed $20 and jumped out to grab nozzle to stop gas. Vapors burst in a big fireball.
121	3-99	1991 Olds. Silhouette	Driver put nozzle in tank and set auto-fill. She returned to van to write a check and get out of cold and wind. Driver reached down to remove nozzle, saw a spark and fire came out of tank.
122	4-02	1994 Nissan Altima	Driver set nozzle to self-pump and returned to car. When fueling was complete driver returned to pull nozzle from tank. Flash of fire occurred around opening of gas tank.
127	3-01	1988 Chevy S-10	Customer sitting in vehicle during refueling process. When fueling complete, he exited vehicle and returned to nozzle. Felt shock when touching the pump. Truck caught fire.
131	9-02	1972 Chevrolet P/U	The victim was with a friend and both were filling their vehicles at the same time after a trip. He began filling his vehicle and walked to his friends pickup at the next pump. He had agreed to pay for the gas in the pickup. The owner of the pickup placed the nozzle in the fill opening located behind the driver's door. He then stepped back from the vehicle. The victim stood in the open doorway of the driver's side and reached in to retrieve his wallet. He had his wallet in the palm of his left hand as he placed his hand on the truck's fabric seat cover. He then touched the cab of the truck close to the fill opening. He heard a "whoosh" sound as the fire occurred.
133	1-98	1995 Toyota 4-Runner	Driver began fueling and returned to drivers seat. Automatic shutoff had not occurred yet when he exited the vehicle. Reached for nozzle and static discharge occurred. Vapors ignited.
134	10-02	1992 Dodge Caravan	Customer started the fueling process and then got back inside the vehicle and sat down in the seat. Driver then got out of the vehicle and reached for the nozzle. Vapors around her ignited, catching the vehicle on fire.
135	10-02	2001 Chevy Tahoe	Owner of a private fuel tank began fueling vehicle. Returned to front seat to log mileage. Returned to rear of vehicle to remove nozzle. As owner reached for the nozzle the gasoline fumes ignited totaling vehicle, tank, stand, hose and nozzle.

Log#	Date	Yr./Make Vehicle	Description of Incident
136	10-02	Plymouth Voyager	Driver started fueling process and returned to vehicle. Driver returned to manually finish fueling vehicle. Fire started.
138	5-19-01	1992 Olds Cutlass	Driver activated nozzle and used hold-open device. Returned to driver's seat with door open. Driver exited vehicle and touched nozzle. Felt shock on hand and saw fire from nozzle.
139	4-02	1997 Buick 4-door	Driver left ignition turned to accessory, exited vehicle, inserted nozzle into fill pipe and put gas cap in handle to keep gas flowing. Went to driver position to watch gauge. Exited vehicle to return to fuel area. Flames erupted.
141	11-02	1998 Chevy Suburban	Driver began fueling. Placed nozzle on automatic. Returned to car. Reached for nozzle to stop fueling and fire erupted.
144	12-02	1997 Jeep Wrangler	Driver got into car after pumping gas. He returned when pump shut off and touched the dispenser. A small fire erupted.
145	12-02	2000 Mitsubishi Eclipse	Motorist began fueling and then reentered vehicle front seat. Driver exited vehicle and proceeded to rear of car. When she reached filler spout with hose in it, she leaned over to listen to see if fuel was flowing into the fuel tank. There was an instantaneous flash fire.
146	12-02	2000 Toyota 4-Runner	Driver started pumping gas and went back inside the vehicle. Driver exited vehicle and touched nozzle. Fire started.
147	12-02	Dodge Caravan	Driver started pumping gas and returned to vehicle. When pump showed almost $10 driver jumped out and grabbed nozzle. Spark occurred and fire erupted from tank fill port.
148	1-03	1991 Subaru Legacy	Customer began filling car with gas. Got back in car, got out and grabbed nozzle, felt shock and saw flames.
149	1-03	1990 Cadillac Eldorado	Gasoline station attendant put hose in gas tank and proceeded to fill the tank. Customer upset because cap was placed on top of trunk of vintage Cadillac, got out of car to remove it and place it on the door to the gas tank. When driver placed the cap on the door cover, he felt a shock which produced flames at the fill pipe.
151	1-03	1994 Ford Escort Wagon	Customers niece started fueling vehicle. She got back into car. When nozzle clicked off she got out of car and touched the nozzle. She saw a spark and fire started.
152	11-00	1997 Buick LeSabre	Driver sat down in car while fueling vehicle. Driver then touched nozzle while fuel was still dispensing. Fumes ignited.
154	4-03	1996 Dodge Gr. Caravan	Driver started fueling, got back in car, got out, touched nozzle to remove. Flames.
156	12-01	1997 Chevy Van	The driver exited the car, began fueling and returned to vehicle due to cold weather. Driver exited for the second time and removed the gas nozzle after filling up. The spark from her hand to the nozzle started the fire.

Log#	Date	Yr./Make Vehicle	Description of Incident
157	10-98	1996 Chevy Pickup	Driver inserted hose to begin fueling. Driver returned to sit on seat with door open and legs resting on running boards. When gauge approached full, driver stepped out and attempted to pull nozzle out. Static popped off fingers and a ring of flames formed around nozzle.
159	11-03	2000 Nissan Pathfinder	Driver fueling car. Returned to vehicle because it was cold. When fueling was finished driver exited car and touched nozzle. Nozzle sparked and a fire ball occurred.
160	11-03	2003 Ford Expedition	Driver started fueling, got back in vehicle, got out to remove nozzle, flash fire occurred.
162	1-04	SUV	While driver inside vehicle, the nozzle overflowed. Driver tried to grab the handle and flames shot out.
163	12-03	1998 Ford Ranger	Driver started fueling process and returned to car to wait while the vehicle fueled. When driver returned and attempted to reach the nozzle she felt a charge from her palm and saw an explosion.
164	12-03	1996 Chevy Pickup	Driver exited vehicle to start fueling. Driver returned to truck to sit down. When fuel reached $29, driver got out, touched the nozzle and saw fire.
165	1-04	1994 Honda Civic	Driver inserted nozzle to fuel car and returned to car to wait for fueling. After fueling completed, driver exited car and touched handle of pump. After flame occurred driver removed handle and ran to station to report fire.
167	2-04	Unknown	Driver exited vehicle, removed gas cap and put nozzle in fuel port to begin fueling. Driver got back into vehicle and sat down. Driver then exited vehicle and attempted to remove the nozzle. As soon as driver touched the nozzle, flames erupted.
169	5-04	1996 Isuzu Trooper	Driver placed nozzle into vehicle and returned to the car to sit with son. As fuel approached the $30 mark, she slid out of the car and reached for the nozzle. Driver saw a spark leap from her hand to the nozzle, which ignited in flames.
171	2-24-06	Unknown	A lady was fueling her car. She opened the door to put her purse back inside her vehicle. When she returned, the pump caught fire.
175	12-8-06	Pickup	Driver started fueling and got back in vehicle. After fueling, driver exited truck and removed nozzle. When he reached for nozzle, sparks ignited.
176	11-12-06	Van	Driver got back in car, came back out of vehicle prior to flash fire/vapor flash.
178	2-5-05	SUV	Driver began to pump gas into the vehicle. Driver got back into vehicle. Once the pump stopped, she got out of the car and approached the fuel dispensing nozzle, which resulted in a fire in and around the car and damage to the pump.
179	1-25-07	1998 Ford Ranger	Started pumping, got back into truck. Got out of truck, on cell phone and fire ignited.
180	1-08	1999 Ford Ranger	Driver got out of vehicle to begin fueling. She engaged the hold-down clip to fill automatically and

			returned to sit in the vehicle. When the tank was full she got out of the vehicle and reached for the nozzle. Felt a shock and fire came out of the tank.
181	1-18-08	Minivan	Driver got out of vehicle to begin fueling. He got back in his car, to warm up. When he returned and touched the nozzle, the vehicle and gas pump burst into flames.
182	12-15-09	Car	Driver left the car running and was talking on cell phone as he started the gas pump. Police said static electricity generated by the man getting in and out of his car likely sparked the fire.

52 Fires Reported to PEI Where Refueler Did Not Reenter the Vehicle and/or Touch the Nozzle During Refueling

Log#	Date	Yr./Make Vehicle	Description of Incident
7	11-99	Dodge Caravan	Customer got in car and saw flames shooting out of the filler neck.
8	11-99	Geo Prizm	It was chilly that morning and the driver got out of his truck and put on a nylon jacket. He held the nozzle and fire traveled up the driver's arm.
10	2-00	1998 Pontiac Sunbird	Customer began fueling, returned to inside of the car, got out of the car and flash occurred as she approached the right quarter panel. She never touched the nozzle. This is on video.
14	6-99	1984 Ford Bronco II	Fueler was standing between the pump and vehicle when he noticed flames at eye level.8 ½ gallons were dispensed.
17	1-00	1999 Ford F-150	Began fueling, got back into vehicle, saw dispenser was near amount she wanted to purchase, jumped out of vehicle to shut off the nozzle and said, "It is on fire."
20	10-97	1991 Chevy Lumina	Driver was sitting in her vehicle when the nozzle shut off and the fire occurred. She saw it in her rear view mirror.
24	7-98	1997 Dodge Ram Pick-up Truck	Placed nozzle, attached to aboveground storage tank, in fuel port of car and started fueling. Went into the shop to consult colleague. Noticed smoke and then a fire. No sign of spilled fuel.
31	12-99	Honda Accord	Popped the lid to her gas tank before getting out of the car, then walked over to fill port and flipped the lid open with her key. The gas cap was never opened. Flames engulfed her car.
33	12-99	1994 Dodge Pickup	Customer began to fuel at #4 dispenser and fire erupted. Customer pulled back, put nozzle away, and went into store. Clerk hit E-Stop. Fire went out.
34	4-99	1999 Dodge Dakota	Started fueling and set the hold-open latch. Returned to cab to check purse for money. Remained outside the vehicle. Returned to fill port and shut off nozzle. Noticed flames as soon as the nozzle was released.

37	5-98	1989 Ford 70 passenger school bus	Bus pulled up beside dispenser, driver turned dispenser on and as soon as nozzle was opened, flash occurred.
71	1-00	1999 Ford Expedition SUV	Inserted nozzle. Started pump. One hand on vehicle and one on nozzle. Looked at dispenser. Arm holding nozzle got warm. 3 to 5 foot flame.
74	1-00	1988 Chevy Silverado	Turned truck off. Nozzle in truck. Got inside vehicle and put on accessory to listen to radio. Dispensed $6 and saw fire coming from side of truck.
77	2-00	1987 Honda Civic	The customer removed the gas cap and the fumes ignited.
79	5-96	1992 Honda Accord	My son went from the rider's side of the car, opened the fuel door, and unscrewed the cap. Took the nozzle from the dispenser and put it in car. Before dispensing began, flames shot out like a dragon shooting out fire.
80	2-00	1999 or 2000 Honda CRV	A woman was in the process of refueling her Honda CRV. She put $10 in when a flashback occurred.
83	Winter 1999	1994 Dodge Caravan	I put the nozzle in tank, clicked it to pump itself, and sat back down in van. I stepped out of my van and turned toward the nozzle and there was fire coming out of the end of the nozzle and flames were shooting over the top of the van. I never touched the nozzle the second time before the fire.
85	2-00	Unknown	Motorist got out of car and touched gas cap. Explosion and fire.
86	3-00	SUV	Fueling with hold-open clip on. During the process, she was petting her small dog which had just returned from groomers. Put dog down, touched nozzle and fire started.
92	4-95	1987 Mazda Pickup	While fueling, heard popping sound and fire started coming out of nozzle.
94	8-00	2000 Toyota Sienna Van	Started fueling vehicle. Driver cleaned windows then reached for nozzle to take off automatic. Fire started.
95	2-01	2000 Nissan Maxima	Driver noticed static shock when getting out of car. When he removed gas cap, flames shot out.
96	2-01	1997 Mazda Protégé	16 year old girl began to fuel car. Got back in and sat down. Got out and shut door. Stood against car watching the dispenser. Grabbed the nozzle. It was too hot to hold. Dropped nozzle and gasoline spilled. Caught fire and burned the car.
97	2-01	1992 Chevy Lumina	Driver set auto-fill on nozzle. Started to get back in vehicle and flames appeared.
98	2-01	1999 Ford Windstar	Customer was pumping fuel, heard spark and flames appeared.
101	1-02	1991 Suzuki Sidekick	Upon removal of gas cap, fire shot out.
102	2-02	1996 Toyota Corolla	Driver opened fuel door, turned gas cap and a flash fire occurred.
108	6-02	1996 Ford Contour	Removed gas cap prior to going in to pay. Driver leaned against car while fueling. Fire started after 10 gallons were pumped.
109	2-01	1994 Toyota Maxima	Vapors ignited while pumping fuel.
111	3-99	1994 Chevy Camaro	Flash from fuel port. When nozzle was pulled out fuel went everywhere and caught fire.
119	3-02	2000 Honda Odyssey	Driver turned off the motor. While removing the gas cap, a flame of fire burst out of tank.
123	5-02	1992 Subaru Legacy	Driver reached for gas cap when static spark jumped from finger to area around gas cap. Small flame ignited around gas cap.

124	8-02	1993 Dodge Caravan	Driver got out of van and turned gas cap ¼ to ½ turn. Flames shot out around gas cap.
125	4-02	Ford Aerostar	Driver filled up car. While driving away, noticed gas cap still lying on seat of car. Stopped car, got out to put cap back on. Gas tank erupted in fire.
126	11-97	1994 Nissan Altima	Driver pulled up to pump, pulled the lever inside the vehicle that opens the lid and got out of the vehicle. Driver quickly untwisted the plastic gas cap, heard air rush out, and placed the plastic cap in the inside lid holder. Fire ignited from the car.
128	5-98	1990 passenger car	Driver exited vehicle and unscrewed gas cap. Fire 4 inches high started around gas port.
129	2-02	Mid-size sedan	Driver got out of car. Vapors ignited when gas cap was removed.
130	2000	1993 Subaru Legacy	As driver unscrewed the gas cap fire flashed flames about a foot.
132	9-02	2001 Honda Civic EX	Driver turned the gas cap to begin fueling and saw a flame.
137	11-96	1996 Pontiac Firebird	Passenger got out of vehicle and removed gas cap to begin fueling. He was standing between pump and vehicle with right hand near nozzle when flames shot up from fuel port.
140	9-02	Subaru	Fire occurred when customer removed fuel cap.
142	12-00	Nissan Altima	Driver pumping gasoline and heard a sound like a strong wind. Flames were coming from gas tank.
143	12-02	2001 Ford F-250	After placing nozzle in the fuel fill port and locking it in the open position, driver opened driver's door to get in due to cold weather. While exiting the vehicle he noticed a small fire around fuel intake port and nozzle.
150	1-03	1990 Honda Accord	Driver proceeded to twist off gas cap. Fire came shooting out and stayed lit until put out with a fire extinguisher.
153	6-03	2000 Honda Civic	Driver was unscrewing gas cap 1/4 turn. Small blue flame came out from around the cap.
155	2-03	1997 Ford F-150 Truck	Driver exited the vehicle and observed fire at the gas filler to the gas tank. Driver did not touch the nozzle. Continuity was verified on the dispensing equipment.
157	2-02	1994 Chevy Lumina	Fueled car. Fire occurred as pump handle was removed from car. Flames shot out.
161	12-03	Unknown	Driver exited car and opened door to fill pipe. As she removed gas cap a fire four to five feet erupted.
170	1-05	Honda CRV	Driver felt a small shock when removing the gas cap. Flames started coming out of the refueling hole. Flames shot out about 8 inches.
172	3-05	Cat Excavator	Lifted nozzle to check for flow. The tank was near empty. Vapors rising from the tank. Flash fire occurred.
173	1-06	93 Mazda Protege	Driver backed up to the pump. Turned off ignition. Popped gas tank lever and got out of the car. Turned the gas tank lid 1/4 turn. Fire blazed out of tank.
174	9-00	Unknown	Came out of station. Fire started out the side of my car. When I pulled the nozzle out, it sprayed gas all over the car.

Fires Reported by Respondents to the National Highway Traffic Safety Administration Vehicle Owner's Questionnaire (VOQ)

Thirty-Four (34) Vehicle Owner's Questionnaires (VOQs) from the National Highway Traffic Safety Administration's database contained enough pertinent information to be included in this compilation. Seventeen (17) VOQs described fires that occurred before, during or immediately after the gas cap was removed and before fueling began. Although technically not a refueling fire, they are included because they describe fires that occurred during the first step of the refueling process. Descriptions of events leading up to the 17 fires are included under the sheet entitled NHTSA'S GAS CAP FIRES.

The other 17 fires described in the VOQs are all refueling fires and appear to have fact patterns similar to those received by PEI. We have not been able to verify that the cause(s) of these 17 fires were not due to smoking, an engine on, or lack of electrical continuity between the nozzle and dispenser. This is because incomplete information was contained in the VOQs and we were unable to contact the victims to "fill in the blanks," since the VOQs do not identify those who submitted the reports. Descriptions of the fire events can be found under the sheet entitled NHTSA'S 17 OTHER REFUELING FIRES. The reader of this report can decide the relative value of this information to the overall study.

NHTSA'S GAS CAP FIRES

Log #	Date	Yr./Make Vehicle	Description of Incident
46	5-23-97	1997 Dodge Caravan	I was going to put gas in and as I was taking the gas cap off flames were coming out from under the gas cap. They were orange and blue.
49	11-25-98	1991 Toyota Camry	About to put gas in vehicle, gas tank seemed to result in combustion, and flames came out of tank. No fuel leak.
50	3-1-94	1993 Subaru Legacy	Owner took gas cap off, heard a hissing sound and a few seconds later there were flames shooting out of the vehicle.
52	2-2-95	1994 Mazda Protégé	Turned the gas cap and flames shot out from tank.
53	3-30-95	1993 Mazda Protégé	After turning the gas cap, the gas tank opening ignited. The cap had only been turned slightly before it ignited.
54	12-16-96	1993 Mazda Protégé	Flames were coming out of the fuel tank when the cap was removed.
56	4-3-97	1997 Honda Civic	When taking the gas cap off of the fuel tank, flames were coming out of the tank around the filler neck.
57	2-3-94	1991 Toyota Corolla	Owner took gas cap off to get gas and flames shot out of truck. Fire department said it was a short in the fuel pump.
58	9-26-93	1993 Toyota Corolla	1/8 full. Fire inside the tank when the cap was removed.
59	11-15-98	1996 Toyota Corolla	I turned the gas cap to remove it before filling the car, flames shot out of the gas tank (full description provided).
61	3-2-95	1993 Toyota Previa Truck	Removed gas cap to fill, flames burst out of gas tank.
62	4-12-97	1992 Toyota Previa	When opening fuel filler tank cap, a flame shot out.
63	5-18-94	1991 Toyota Truck Land Cruiser	While unscrewing the gas cap to pump gas, the gas tank burst into flames at a gas station.
66	2-27-99	1999 Jeep Wrangler	I took the gas cap off to fill up, noticed a fire in the gas tank and in an instant, flames shot out (full

			description provided).
67	Unknown	1995 Isuzu Trooper Truck	Upon removing pressure vacuum relief filler cap, flames spewed out of the filler neck.
68	Unknown	1991 Toyota Truck-Previa	Upon unscrewing pressure vacuum filler cap, flames spewed from filler neck for 5-7 seconds.
69	2-24-99	1992 Toyota Camry	When removing the gas cap at the gas station, a flame shot out of the tank after one turn of the cap.

17 Fires While Removing Gasoline Cap – NHTSA

Make and Model of Vehicles Involved

2	Toyota Camry (1991, 1992)
3	Toyota corolla (1991, 1993, 1996)
3	Toyota Previa (1991, 1992, 1992)
1	Toyota Land Cruiser (1991)
3	Mazda Protégé (2-1993, 1994)
1	Dodge Caravan (1997)
1	Subaru Legacy (1993)
1	Honda Civic (1997)
1	Jeep Wrangler (1999)
1	Isuzu Truck Trooper (1995)

NHTSA'S 17 OTHER REFUELING FIRES

Log #	Date	Yr./Make Vehicle	Description of Incident
42	4-15-95	1994 F150 Ford Truck	While fueling gas tank, flames/fire suddenly appear from gas tank hole. Static discharge caused gas flames to ignite from gas tank, resulting in a fire.
44	3-1-97	1996 Chevy Suburban	Consumer was filling the vehicle with fuel and there was some type of electrical static and the vehicle caught fire around the filler neck.
5	11-99	1999 Ford Windstar	Started fueling. Went back into car to get money. During that time the automatic nozzle clicked off. Went to pump more and it sparked between the nozzle and her hand.
38	11-30-99	1992 Dodge Caravan	While filling the fuel tank, a fire erupted due to the fumes coming from the tank, possibly from static electricity. The Dodge distributor suggested I let them install a ground strap on the fuel filler neck of the fuel tank.
39	2-23-99	1991 Geo Prizm	As I stopped at a gas station and attempted to fill up with gas, my jacket sleeve caught on fire from flames coming out from the tank.
40	4-20-95	1994 Geo Prizm	Flames around opening of gas tank.
43	8-9-96	1996 Ford Taurus	Pulled into gas station, filled tank, as hand touched pump nozzle fuel tank burst into flames.
45	11-21-98	1997 Chevy Cavalier	While filling gas tank the check engine light is on,

			vehicle caught fire in fuel tank, which caused injuries.
47	12-9-95	1996 Dodge Caravan Truck	Fire ignited inside or outside of tank while filling tank; flames started shooting out of gas tank, gas nozzle caught fire, thrown to ground, ground caught fire.
48	2-3-96	1996 Dodge Caravan	I started to fill up at the pump. I saw a flash as I put the tip of the gas hose into the opening of the tank. Not a second later, flames came from out of the tank. I immediately removed the hose from the tank, even though the tip of the hose still had flames in it. Pulling the hose out as fast as I could, gas spilled on the ground near the van and other pumps, and caught the ground on fire.
51	3-12-97	1995 Pontiac Transport	After filling the vehicle with fuel and removing the nozzle, the vehicle caught on fire around the filler neck.
55	11-16-99	1999 Honda Odyssey	While filling the van with fuel, it caught fire and burned.
60	8-3-99	1996 Toyota Corolla	Fire occurred at gas nozzle, which was 3-5 seconds into the fueling process.
64	11-12-96	1994 Dodge Caravan	When refueling vehicle at the fuel filler pipe neck, a spark occurred, causing a fire.
65	9-30-95	1995 Dodge Neon	Fuel tank filler pipe caught fire when filling up the tank.
70	Unknown	1996 Audi S6	While refueling with the engine off, a flame shot out of the gas tank.
85	3-8-00	2000 Ford F150 Truck	Vehicle experienced a fire while consumer’s son was filling the fuel tank at a gas station. Local fire department arrived and extinguished the fire. Fire Department informed consumer that static electricity may have been cause of fire.

Attachment 3

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

STAYING SAFE AT THE PUMP

Static electricity-related incidents at retail gasoline outlets are extremely unusual, but the potential for them to happen appears to be the highest during cool or cold and dry climate conditions. In rare circumstances, these static related incidents have resulted in a brief flash fire occurring at the fill point. Consumers can take steps to minimize these and other potential fueling hazards by following safe refueling procedures all year long.

Most important, motorists should not get back into their vehicles during refueling. It may be a temptation to get back in the car for any number of reasons. But the average fill-up takes only two minutes, and staying outside the vehicle will greatly minimize the likelihood of any build-up of static electricity that could be discharged at the nozzle.

A build-up of static electricity can be caused by re-entering a vehicle during fueling, particularly in cool or cold and dry weather. If the motorist then returns to the vehicle fill pipe during refueling, the static may discharge at the fill point, causing a flash fire or small sustained fire with gasoline refueling vapors.

Motorists who cannot avoid getting back into the vehicle should always first touch a metal part of the vehicle with a bare hand, such as the door, or some other metal surface, away from the fill point upon exiting the vehicle.

Here Are Additional Consumer Refueling Safety Guidelines That Will Help Keep You And Your Family Safe When Refueling Your Vehicle Or Filling Up Gasoline Storage Containers:

- Turn off your vehicle engine. Put your vehicle in park and/or set the emergency brake. Disable or turn off any auxiliary sources of ignition such as a camper or trailer heater, cooking units, or pilot lights.
- Do not smoke, light matches or lighters while refueling at the pump or when using gasoline anywhere else.
- Use only the refueling latch provided on the gasoline dispenser nozzle. Never jam the refueling latch on the nozzle open.
- Do not re-enter your vehicle during refueling. If you cannot avoid re-entering your vehicle, discharge any static build-up BEFORE reaching for the nozzle by touching something

metal with a bare hand -- such as the vehicle door -- away from the nozzle.)
- In the unlikely event a static-caused fire occurs when refueling, leave the nozzle in the fill pipe and back away from the vehicle. Notify the station attendant immediately.

Portable Containers

- When dispensing gasoline into a container, use only an approved portable container and place it on the ground to avoid a possible static electricity ignition of fuel vapors. Containers should never be filled while inside a vehicle or its trunk, the bed of a pickup truck or the floor of a trailer.
- When filling a portable container, manually control the nozzle valve throughout the filling process. Fill a portable container slowly to decrease the chance of static electricity buildup and minimize spilling or splattering. Keep the nozzle in contact with the rim of the container opening while refueling.
- Fill container no more than 95 percent full to allow for expansion.
- Place cap tightly on the container after filling - do not use containers that do not seal properly.
- Only store gasoline in approved containers as required by federal or state authorities. Never store gasoline in glass or any other unapproved container.
- If gasoline spills on the container, make sure that it has evaporated before you place the container in your vehicle.Report spills to the attendant.
- When transporting gasoline in a portable container make sure it is secured against tipping and sliding, and never leave it in direct sunlight or in the trunk of a car.

Additional Safety Guidelines

- Do not over-fill or top-off your vehicle tank, which can cause gasoline spillage.
- Never allow children under licensed driving age to operate the pump.
- Avoid prolonged breathing of gasoline vapors. Use gasoline only in open areas that get plenty of fresh air. Keep your face away from the nozzle or container opening.
- Never siphon gasoline by mouth nor put gasoline in your mouth for any reason. Gasoline can be harmful or fatal if swallowed. If someone swallows gasoline, do not induce vomiting. Contact a doctor or and emergency medical service provider immediately.
- Keep gasoline away from your eyes and skin; it may cause irritation. Remove gasoline-soaked clothing immediately.
- Use gasoline as a motor fuel only. Never use gasoline to wash your hands or as a cleaning solvent.

Attachment 4

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Wayne TAP™ Contactless/NFC Reader

TAP into the future of Wayne innovation.

The **Wayne TAP™ Contactless/NFC Reader** is the future of payment at your fuel dispenser. No swiping. No sliding. No contact at all. Just mobile wallet and contactless technology that replaces conventional credit card payment. A wave of a mobile device can help you build stronger customer relationships and attract new business through fast and easy customer transactions.

Attract Customers With Convenience

More convenience for customers means more business for you. The Wayne TAP reader helps enable fast, easy, and safe payment transactions right where your customer needs them: your forecourt. By supporting emerging NFC mobile wallets, as well as mag-stripe and EMV® contactless credit cards, the Wayne TAP reader helps take your store beyond simple mobile transactions to realize the full benefits of mobile commerce.

Take Control Through Innovation

The technology behind the Wayne TAP reader allows you to improve security at the dispenser over that of traditional mag-stripe payment processing. Built on the Wayne iX Pay™ secure payment platform, the reader adapts effectively and efficiently to security regulations while enabling greater marketing capabilities.

Elevate Your Brand Experience

Provide an experience that can help put your convenience store on the map. The Wayne TAP reader not only helps you transact payments, but also helps increase customer loyalty and retention by providing technology to support brand rewards programs. It also allows for additional retailer marketing opportunities and the ability to promote new brand/retail offers through mobile wallet, such as coupons. With the Wayne TAP reader, you can build, strengthen, and sustain better customer relationships.

Explore more at Wayne.com

Wayne
FUELING SYSTEMS

Experience convenience on TAP.

Technical Specifications

Standards

- ISO 14443 type A/B
- NFC: ISO 18092
- Visa Paywave® (MSD, qVSDC)
- MasterCard® Paypass™ (MagStripe, M/Chip)
- Discover® Network Zip
- American Express® ExpressPay
- Interac® Flash™

Availability

- New Dispensers*
  - Wayne Ovation,™ Ovation™2 Fuel Dispensers
  - Wayne Helix™ Fuel Dispensers
  - Wayne 4/Vista™ Fuel Dispensers
- Retrofit Kits for Existing Dispensers*
  - Wayne Ovation Fuel Dispensers
  - Wayne Vista Fuel Dispensers

Features

- Large contactless landing zone identifier
- 4 LED sequence indicators
- Audible buzzer
- Device firmware programmable with upgrade capability
- Compact size

Wayne Vista™

Wayne Ovation™

Wayne Helix™

Wayne Ovation™2

Explore more at Wayne.com

Austin, Texas, USA | Malmö, Sweden | Rio de Janeiro, Brazil | Shanghai, China

Wayne FUELING SYSTEMS

*Dispensers require the Wayne iX™ Pay secure payment platform.

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Attachment 5

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Wayne iX Pay™ T5 and T7 Secure Payment Terminal

Imagine

Wayne
FUELING SYSTEMS

Just imagine.

One simple EMV® solution for bringing legacy fuel dispensers in America today into the America of tomorrow.

One. That's it. Regardless of original equipment manufacturer (OEM), Wayne iX Pay™ secure payment terminal helps do it all. Forget about multiple vendors, endless comparisons and exploring options.

All you need is the iX Pay secure payment terminal from Wayne that is an EMV-compliant retrofit which fits legacy dispensers from different OEMs already in the field throughout the U.S.

Is it secure? ***Yes.***

Is it the latest technology? ***Yes.***

Is it compact, flexible, and upgradeable? ***Yes. Yes. And yes.***

Will it simplify your business and help move it forward? ***Absolutely.***

wayne.com

Just imagine.

A world with no speed bumps. And no red lights.

With the iX Pay secure payment terminal, nothing will slow you or your customers down. When it comes to security, it's as good as it gets. From supporting the latest EMV and PCI security standards to dispenser secure access to point-to-point encryption, this product helps meet and even exceed the highest security standards, protecting your customers' data and you from fraud.

The iX Pay secure payment terminal is also Underwriters Laboratory (UL)-Certified, allowing you to deploy this product without approval concerns. It's easy to install and the flexible service model allows for replacing individual components or the entire terminal minimizing site downtime.

Business can be tough. Margins are slim, customers are demanding, and it costs a fortune to keep up with ongoing industry changes. But Wayne can help remove one of your road blocks with the iX Pay secure payment terminal.

Just imagine.

A terminal that's with you down the road. Way down the road.

The iX Pay secure payment terminal doesn't just solve your EMV-compliance issues, it offers important value-added features designed to extend the life of your equipment. It can help fix the "now" and also give you technology tools designed to change and grow with your business.

The iX Pay secure payment terminal is designed to meet the latest published security standards and be adaptable to future payment changes. And in some cases, a simple software update is all it will take.

The terminal features a large 7" Widescreen VGA display, a touchscreen user interface, media capabilities, a state-of-the-art secure keypad, enhancing the customer experience and offering a wide range of marketing opportunities. It's also ready for what's next in payment with the ability to process contactless cards, mobile payments, Apple Pay™, and more.

iX Pay Solution

Imagine an easy ride towards EMV.

You have to do this. We get that. But you might as well make it as simple as possible, and get the best return on your investment. The iX Pay secure payment terminal is a single solution for EMV-compliance, and it comes loaded with value-added features that can help you better serve your customers and be prepared for future industry changes.

For more information, visit *wayne.com*

Highest Security Standards

→ EMV Level I and EMV Level II Compliant
→ PCI PTS 4.0
→ Point-to-Point Encryption (P2PE) Capable
→ UL-Certified, Approved, and Listed

Compact Universal Design

→ Single Solution Compatible with Different OEM Dispensers and POS/EPS
→ Flexible Service Model
→ Small and Compact
→ Printer in Terminal, Not a Separate Item

Value-Added Technology

→ 7" Widescreen VGA Display
→ Touchscreen User Interface
→ Secure Keypad with Configurable Function Keys
→ Wayne TAP™ Contactless/NFC Reader
→ Wayne SCAN™ 2D Barcode Reader
→ Dispenser Secure Access

Supported Wayne Solutions

→ inOvationTV™ Media Platform
→ Wayne iX Media™ Platform
→ Wayne iSense™ Remote Monitoring with Diagnostic Interface
→ Wayne Connect™ IP-485® Network Solution

Austin, Texas, USA | Malmö, Sweden | Rio de Janeiro, Brazil | Shanghai, China

Wayne
FUELING SYSTEMS

Attachment 6

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

GILBARCO VEEDER-ROOT
Technology with a human touch.

Home › Products › Forecourt Payment › Payment Options › Mobile Payment

MOBILE PAYMENT AT THE C-STORE

Mobile Payment

GET PRODUCT PRICING!

Mobile Payment

As the retail petroleum technology leader, Gilbarco is committed to bringing the latest technologies to the retail petroleum industry, allowing our broad customer base to remain at the forefront of retail technologies.

Mobile payment is being touted as the next big thing in retail payment technology. With contactless payment options quickly gaining popularity amongst smartphone savvy users, you can now leverage the power of mobile payment at the pump and give your customers a simple and effective way to pay for fuel and other in-store items.

The intuitive mobile communication channel also helps incentivize the sales process and helps you grow and maintain a regular stream of repeat customers.

With technologies like Near Field Communication (NFC) and cloud based network interaction, mobile payments are extremely easy to setup and integrate, allowing secure and seamless integration between mobile devices and a point of sales system.

Mobile payments at the c-store not only allow your customers make transactions in a safe and secure manner, but also adds a lot of value to your operations including media and marketing message integration such as issuing electronic coupons and receipts.

store sales, look no further than sstore upselling solutions. Solutions such as the Impulse™ brings the power of suggestion to your company strategy by making use of the c-store suggestive selling technology that helps improve cashier performance and boost upsell conversion rates.

Go for the best and the latest in retail payment technology and see how s innovative and future proof solutions can make a difference to your business.

Press Release: Gilbarco Veeder-Root working with PayPal to simplify payment at the pump.

PayPal Blog Post: PayPal: Coming to Neighborhood Gas Station Near You.

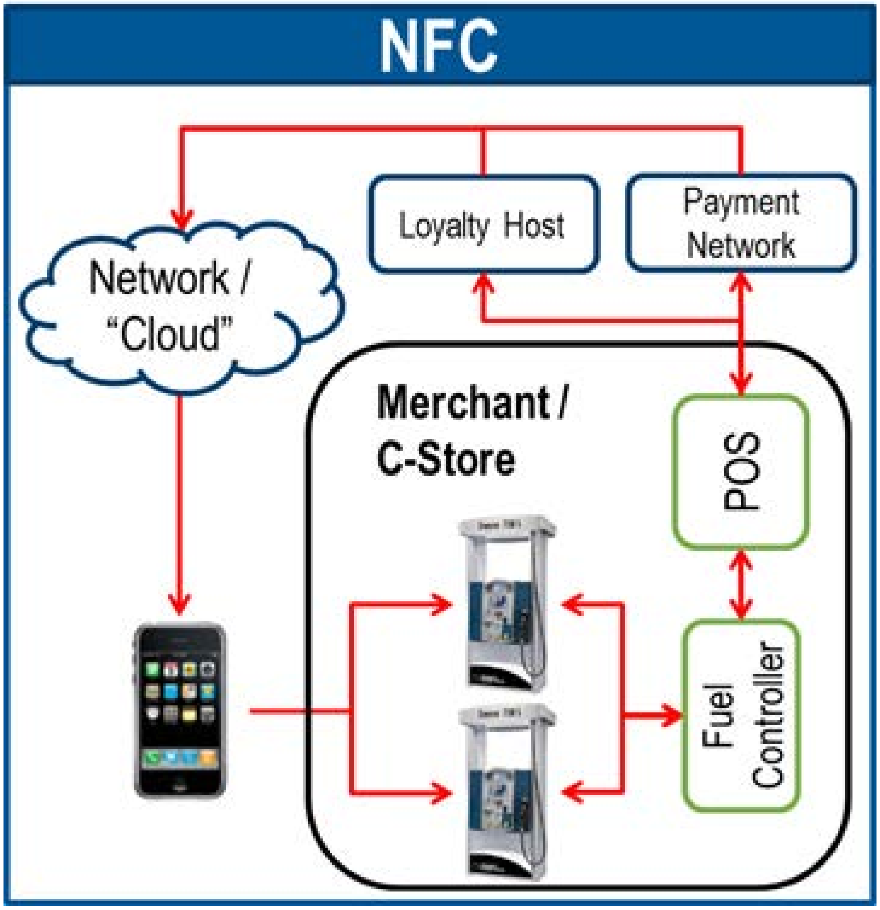
Implementation:

Two technologies are typically referenced in mobile payment discussions: Near Field Communication (NFC) or Cloud (network)-based interaction.

1. Near Field Communication:

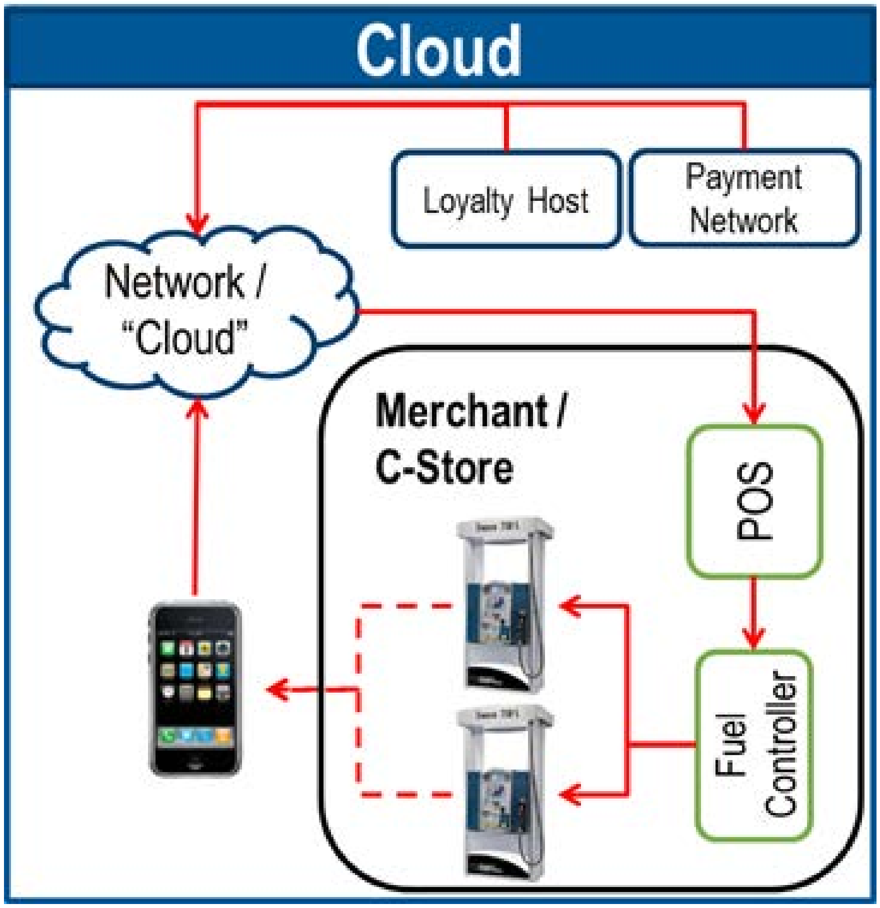
- Payment, Loyalty, and Coupons transmitted from phone to POS via contactless chip
- Uses EMV contactless reader
- Required POS integration work

L1	> Payment only > Based on ISO 14443 spec	Current Contactless Installed Base
L2	> Payment + Loyalty + Coupons > Based on ISO 14443 spec with software app	
L3	> 2-way interactivity functionality > Based on ISO 18092 specification	



2. Cloud-based (network):

- (QR-code or unique transaction ID)
- Payment, Loyalty, and Coupons exchanged in the 'cloud'
- Mostly POS development work



Mobile Payment Benefits

- Adds value to the transaction
- Enhanced loyalty / media integration with targeted messaging
- Electronic coupons and receipts

Gilbarco remains committed to providing these latest technologies to our customer partners. Please check back often for additional content. Visit our blog for more information about Mobile Payment.

Attachment 7

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Encore® 700 S Dispensers

Secure your competitive advantage and increase profits with Gilbarco® Veeder-Root's Encore 700 S – your best dispenser investment for today and tomorrow. Highly secure, powerful CRIND® electronics build a flexible and innovative platform for your changing forecourt marketing and payment needs. Enjoy peace of mind with a leading foundation that is highly secure today and upgradeable to meet the payment security and technology needs of tomorrow.

Encore 700 S delivers:

- **EMV Readiness** – Encore 700 S is the cornerstone of Gilbarco's suite of EMV technology.
- **Reliability** – Gilbarco's proven quality provides durable construction for lower cost of ownership.
- **Flexibility** – Encore 700 S offers the most configurations and options to fit your forecourt.
- **Marketing Capability** – Gilbarco's future-ready electronics platform, FlexPay™ IV, supports technologies such as Applause pump media to drive in store traffic.
- **Security** – Enhanced features minimize potential for fuel loss and payment fraud.

Options. Uptime. Reliability.

Proven design guarantees uptime.

You get the best of Gilbarco's field-proven Encore® 700 S series:

> Familiar ATM-style customer interface
> Full range of alternative fuel options
> Industry's most comprehensive warranty

Enhanced, upgradeable security.

You'll benefit from Gilbarco's global EMV® leadership and experience, including the largest installed base of EMV® fueling pay points in North America. The Payment Card Industry and EMV® certified platform in Encore 700 S include:

> FlexPay™ Encrypting PIN Pad (EPP) to protect PIN data
> FlexPay™ Hybrid (Chip and Magnetic Stripe) Card Reader
> EMV® certification
> PCI-UPT certification
> Secure Controller to protect the entire electronics platform

Superior merchandising improves profits.

Encore® 700 S gives you field-proven tools to inform, persuade, and motivate your fuel customers to come inside your store and buy higher-margin goods, through:

> Flexible content management options, with the industry leading Applause merchandising system
> Superior image clarity, resolution and video performance
> 5.7" color screen as standard for clear, effective communication
> 10.4" color upgrade option for maximum impact

Platform for continued growth.

Encore® 700 S provides a strong foundation for growth with powerful, future ready electronics to support your innovation needs, such as mobile payments, enhanced loyalty, expanded merchandising and other applications:

> Enhanced applications processor for future growth
> Enhanced CRIND® memory for improved application speed
> CAT-5 connectivity for ultimate flexibility

Encore® 700 S Specifications

Regulatory / Governmental Approvals:
> UL, cUL
> Measurement Canada, Weights & Measures, FCC
> PCI PED 4.x
> EMV® Compatible

Environmental:
> – 30°C to +70°C Operating Temperature
> A cabinet or keypad heater option is available to avoid ice accumulation.

Processor:
> Up to 400-MHz ARM A9 Core for enhanced CRIND applications speed
> Secure processor for data encryption and tamper responsiveness
> Memory: > NAND Flash: 512 MB > DDR SRAM: 256 MB > eMMC: 4GB

Component Options:
> 5.7" QVGA (10.4" VGA upgrade option available)
> NFC Contactless Reader
> 2D Barcode Scanner
> Door switches to notify the POS to limit access and prevent tampering*
> Key components that self-disable in the event of tampering
> High Speed Graphic Thermal Printer
> Encrypted Pulser (optional)

*POS Dependent

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Attachment 8

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Important safety information

WARNING: Failure to follow these safety instructions could result in fire, electric shock, injury, or damage to iPhone or other property. Read all the safety information below before using iPhone.

Handling Handle iPhone with care. It is made of metal, glass, and plastic and has sensitive electronic components inside. iPhone can be damaged if dropped, burned, punctured, or crushed, or if it comes in contact with liquid. Don’t use a damaged iPhone, such as one with a cracked screen, as it may cause injury. If you’re concerned about scratching the surface of iPhone, consider using a case or cover.

Repairing Don’t open iPhone and don’t attempt to repair iPhone yourself. Disassembling iPhone may damage it or may cause injury to you. If iPhone is damaged, malfunctions, or comes in contact with liquid, contact Apple or an Apple Authorized Service Provider. You can find more information about getting service at www.apple.com/support/iphone/service/faq/.

Battery Don’t attempt to replace the iPhone battery yourself—you may damage the battery, which could cause overheating and injury. The lithium-ion battery in iPhone should be replaced only by Apple or an authorized service provider, and must be recycled or disposed of separately from household waste. Don’t incinerate the battery. For information about battery service and recycling, see www.apple.com/batteries/service-and-recycling/.

Distraction Using iPhone in some circumstances can distract you and may cause a dangerous situation (for example, avoid using headphones while riding a bicycle and avoid texting while driving a car). Observe rules that prohibit or restrict the use of mobile phones or headphones.

Navigation Maps, directions, Flyover, and location-based apps depend on data services. These data services are subject to change and may not be available in all areas, resulting in maps, directions, Flyover, or location-based information that may be unavailable, inaccurate, or incomplete. Some Maps features require Location Services. Compare the information provided on iPhone to your surroundings and defer to posted signs to resolve any discrepancies. Do not use these services while performing activities that require your full attention. Always comply with posted signs and the laws and regulations in the areas where you are using iPhone and always use common sense.

Charging Charge iPhone with the included USB cable and power adapter, or with other third-party “Made for iPhone” cables and power adapters that are compatible with USB 2.0 or later, or power adapters compliant with applicable country regulations and with one or more of the following standards: EN 301489-34, IEC 62684, YD/T 1591-2009, CNS 15285, ITU L.1000, or another applicable mobile phone power adapter interoperability standard. An iPhone Micro USB Adapter (available separately in some areas) or other adapter may be needed to connect iPhone to some compatible power adapters. Only micro USB power adapters in certain regions that comply with applicable mobile device power adapter interoperability standards are compatible. Please contact the power adapter manufacturer to find out if your micro USB power adapter complies with these standards.

Using damaged cables or chargers, or charging when moisture is present, can cause fire, electric shock, injury, or damage to iPhone or other property. When you use the Apple USB Power Adapter to charge iPhone, make sure the USB cable is fully inserted into the power adapter before you plug the adapter into a power outlet.

Lightning cable and connector Avoid prolonged skin contact with the connector when the Lightning to USB Cable is plugged into a power source because it may cause discomfort or injury. Sleeping or sitting on the Lightning connector should be avoided.

Prolonged heat exposure iPhone and its power adapter comply with applicable surface temperature standards and limits. However, even within these limits, sustained contact with warm surfaces for long periods of time may cause discomfort or injury. Use common sense to avoid situations where your skin is in contact with a device or its power adapter when it's operating or plugged into a power source for long periods of time. For example, don't sleep on a device or power adapter, or place them under a blanket, pillow, or your body, when it's plugged into a power source. It's important to keep iPhone and its power adapter in a well-ventilated area when in use or charging. Take special care if you have a physical condition that affects your ability to detect heat against the body.

Hearing loss Listening to sound at high volumes may damage your hearing. Background noise, as well as continued exposure to high volume levels, can make sounds seem quieter than they actually are. Turn on audio playback and check the volume before inserting anything in your ear. For more information about hearing loss, see www.apple.com/sound/. For information about how to set a maximum volume limit on iPhone, see Music settings.

To avoid hearing damage, use only compatible receivers, earbuds, headphones, speakerphones, or earpieces with iPhone. The headsets sold with iPhone 4s or later in China (identifiable by dark insulating rings on the plug) are designed to comply with Chinese standards and are only compatible with iPhone 4s or later, iPad 2 or later, and iPod touch 5th generation.

WARNING: To prevent possible hearing damage, do not listen at high volume levels for long periods.

Radio frequency exposure iPhone uses radio signals to connect to wireless networks. For information about radio frequency (RF) energy resulting from radio signals and steps you can take to minimize exposure, go to Settings > General > About > Legal > RF Exposure or visit www.apple.com/legal/rfexposure/.

Radio frequency interference Observe signs and notices that prohibit or restrict the use of mobile phones (for example, in healthcare facilities or blasting areas). Although iPhone is designed, tested, and manufactured to comply with regulations governing radio frequency emissions, such emissions from iPhone can negatively affect the operation of other electronic equipment, causing them to malfunction. Turn off iPhone or use Airplane Mode to turn off the iPhone wireless transmitters when use is prohibited, such as while traveling in aircraft, or when asked to do so by authorities.

Medical device interference iPhone contains components and radios that emit electromagnetic fields. iPhone also contains magnets and the included headphones also have magnets in the earbuds. These electromagnetic fields and magnets may interfere with pacemakers, defibrillators, or other medical devices. Maintain a safe distance of separation between your medical device and iPhone and the earbuds. Consult your physician and medical device manufacturer for information specific to your medical device. If you suspect iPhone is interfering with your pacemaker, defibrillator, or any other medical device, stop using iPhone.

Not a medical device iPhone and the Health app are not designed or intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease.

Medical conditions If you have any medical condition that you believe could be affected by iPhone (for example, seizures, blackouts, eyestrain, or headaches), consult with your physician prior to using iPhone.

Explosive atmospheres Charging or using iPhone in any area with a potentially explosive atmosphere, such as areas where the air contains high levels of flammable chemicals, vapors, or particles (such as grain, dust, or metal powders), may be hazardous. Obey all signs and instructions.

Repetitive motion When you perform repetitive activities such as typing or playing games on iPhone, you may experience discomfort in your hands, arms, wrists, shoulders, neck, or other parts of your body. If you experience discomfort, stop using iPhone and consult a physician.

High-consequence activities This device is not intended for use where the failure of the device could lead to death, personal injury, or severe environmental damage.

Choking hazard Some iPhone accessories may present a choking hazard to small children. Keep these accessories away from small children.

Attachment 9

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Health and Safety

This safety information contains content for mobile devices. Some content may be not applicable to your device. To prevent injury to yourself and others or damage to your device, read the safety information about your device before using the device.

Warning: Failure to comply with safety warnings and regulations can cause serious injury or death.

Do not use damaged power cords or plugs, or loose electrical sockets

- Unsecured connections can cause electric shock or fire.

Do not touch the power cord with wet hands or disconnect the charger by pulling the cord

- Doing so may result in electrocution.

Do not bend or damage the power cord

- Doing so may cause electric shock or fire.

Do not use your device while it is charging or touch your device with wet hands

- Doing so may cause electric shock.

Do not short-circuit the charger or the device

- Doing so may cause electric shock or fire, or the battery may malfunction or explode.

Do not use your device outdoor during a thunderstorm

- Doing so may result in electric shock or device malfunction.

Use manufacturer-approved chargers, accessories, and supplies

- Using generic chargers may shorten the life of your device or cause the device to malfunction. They may also cause a fire or cause the battery to explode.
- Use only Samsung-approved charger specifically designed for your device. Incompatible battery and charger can cause serious injuries or damage to your device.
- Samsung cannot be responsible for the user's safety when using accessories or supplies that are not approved by Samsung.
- Do not drop or cause an impact to the charger or the device

Handle and dispose of the device and charger with care

- Never dispose of the device in a fire. Never place the device on or in heating devices, such as microwave ovens, stoves, or radiators. The device may explode when overheated. Follow all local regulations when disposing of used battery or device.
- Never crush or puncture the device.

- Avoid exposing the device to high external pressure, which can lead to an internal short circuit and overheating.

Protect the device and charger from damage

- Avoid exposing your device to very cold or very hot temperatures.
- Extreme temperatures can damage the device and reduce the charging capacity and life of your device and battery.
- Never use a damaged charger.

Do not store your device near or in heaters, microwaves, hot cooking equipment, or high pressure containers

- The battery may leak.
- Your device may overheat and cause a fire.

Do not use or store your device in areas with high concentrations of dust or airborne materials

- Dust or foreign materials can cause your device to malfunction and may result in fire or electric shock.

Do not bite or suck the device

- Doing so may damage the device or result in an explosion or fire.
- Children or animals can choke on small parts.
- If children use the device, make sure that they use the device properly.

Do not insert the device or supplied accessories into the eyes, ears, or mouth

- Doing so may cause suffocation or serious injuries.

Do not handle the device if the Lithium Ion (Li-Ion) battery is damaged or leaking

- For safe disposal of your Li-Ion battery, contact your nearest authorized service centre.

Caution: Failure to comply with safety cautions and regulations can cause injury or property damage

Do not use your device near other electronic devices

- Most electronic devices use radio frequency signals. Your device may interfere with other electronic devices.
- Using an LTE data connection may cause interference with other devices, such as audio equipment and telephones.

Do not use your device in a hospital, on an aircraft, or in an automotive equipment that can be interfered with by radio frequency

- Avoid using your device within a 15 cm range of a pacemaker, if possible, as your device can interfere with the pacemaker.
- To minimize possible interference with a pacemaker, use your device only on the side of your body that is opposite the pacemaker.
- If you use medical equipment, contact the equipment manufacturer before using your device to determine whether or not the equipment will be affected by radio frequencies emitted by the device.
- On an aircraft, using electronic devices can interfere with the aircraft's electronic navigational instruments. Make sure the device is turned off during takeoff and landing. After takeoff, you can use the device in flight mode if allowed by aircraft personnel.
- Electronic devices in your car may malfunction, due to radio interference from your device. Contact the manufacturer for more information.

Do not expose the device to heavy smoke or fumes

- Doing so may damage the outside of the device or cause it to malfunction.

If you use a hearing aid, contact the manufacturer for information about radio interference

- The radio frequency emitted by your device may interfere with some hearing aids. Before using your device, contact the manufacturer to determine whether or not your hearing aid will be affected by radio frequencies emitted by the device.

Do not use your device near devices or apparatuses that emit radio frequencies, such as sound systems or radio towers

- Radio frequencies may cause your device to malfunction.

Turn off the device in potentially explosive environments

- Turn off your device in potentially explosive environments instead of removing the battery.

- Always comply with regulations, instructions and signs in potentially explosive environments.
- Do not use your device at refueling points (petrol stations), near fuels or chemicals, or in blasting areas.
- Do not store or carry flammable liquids, gases, or explosive materials in the same compartment as the device, its parts, or accessories.

If you notice strange smells or sounds coming from your device, or if you see smoke or liquids leaking from the device, stop using the device immediately and take it to a Samsung Service Centre

- Failure to do so may result in fire or explosion.

Comply with all safety warnings and regulations regarding mobile device usage while operating a vehicle

- While driving, safely operating the vehicle is your first responsibility. Never use your mobile device while driving, if it is prohibited by law. For your safety and the safety of others, use your common sense and remember the following tips:
- Get to know your device and its convenience features, such as speed dial and redial. These features help you reduce the time needed to place or receive calls on your mobile device.
- Position your device within easy reach. Make sure you can access your wireless device without taking your eyes off the road.
- Suspend calls in heavy traffic or hazardous weather conditions. Rain, sleet, snow, ice, and heavy traffic can be hazardous.
- Do not take notes or look up phone numbers. Jotting down a “to do” list or flipping through your address book takes attention away from your primary responsibility of driving safely.
- Dial sensibly and assess the traffic. Place calls when you are not moving or before pulling into traffic. Try to plan calls when your car will be stationary.
- Do not engage in stressful or emotional conversations that may be distracting. Make the person you are talking to aware that you are driving and suspend conversations that could potentially divert your attention from the road.

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Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

self-operated device may be equipped with cumulative indicating or recording elements, provided that it is also equipped with a zero-return indicating element.

(b) It shall not be possible to return primary indicating elements, or primary recording elements beyond the correct zero position.

(Amended 1972)

S.1.6.4. Display of Unit Price and Product Identity.

S.1.6.4.1. Unit Price.

(a) A computing or money-operated device shall be able to display on each face the unit price at which the device is set to compute or to dispense.

(b) Except for dispensers used exclusively for fleet sales, other price contract sales, and truck refueling (e.g., truck stop dispensers used only to refuel trucks), whenever a grade, brand, blend, or mixture is offered for sale from a device at more than one unit price, then all of the unit prices at which that product is offered for sale shall meet the following conditions:

(1) For a system that applies a discount prior to the delivery, all unit prices shall be displayed or shall be capable of being displayed on the dispenser through a deliberate action of the customer prior to the delivery of the product. It is not necessary that all of the unit prices for all grades, brands, blends, or mixtures be simultaneously displayed prior to the delivery of the product.
[Effective and Nonretroactive as of January 1, 1991]

(2) For a system that offers post-delivery discounts on fuel sales, display of pre-delivery unit price information is exempt from (b)(1), provided the system complies with S.1.6.8. Recorded Representations for Transactions Where a Post-Delivery Discount(s) is Provided.

(Added 2012)

Note: When a product is offered at more than one unit price, display of the unit price information may be through the deliberate action of the customer: 1) using controls on the device; 2) through the customer's use of personal or vehicle-mounted electronic equipment communicating with the system; or 3) verbal instructions by the customer.

(Added 2012)

(Amended 1989, 1997, and 2012)

S.1.6.4.2. Product Identity.

(a) A device shall be able to conspicuously display on each side the identity of the product being dispensed.

(b) A device designed to dispense more than one grade, brand, blend, or mixture of product also shall be able to display on each side the identity of the grade, brand, blend, or mixture being dispensed.

S.1.6.5. Money-Value Computations.

(a) A computing device shall compute the total sales price at any single-purchase unit price (i.e., excluding fleet sales, other price contract sales, and truck stop dispensers used only to refuel trucks) for which the product being measured is offered for sale at any delivery possible within

either the measurement range of the device or the range of the computing elements, whichever is less.
[Effective and Nonretroactive as of January 1, 1991]

(b) The analog sales price indicated for any delivered quantity shall not differ from a mathematically computed price (quantity × unit price = total sales price) by an amount greater than the value in Table 1. Money-Value Divisions and Maximum Allowable Variations for Money-Value Computations on Mechanical Analog Computers.

(Amended 1984, 1989, and 1993)

S.1.6.5.1. Money-Value Divisions, Analog. – The values of the graduated intervals representing money values on a computing type device shall be no greater than those in Table 1. Money-Value Divisions and Maximum Allowable Variations for Money-Value Computations on Mechanical Analog Computers.

(Amended 1991)

Table 1.
Money-Value Divisions and
Maximum Allowable Variations for Money-Value
Computations on Mechanical Analog Computers

Unit Price		Money-Value Division	Maximum Allowable Variation	
From	To and including		Design Test	Field Test
0	$0.25/liter or $1.00/gallon	1¢	± 1¢	± 1¢
$0.25/liter or $1.00/gallon	$0.75/liter or $3.00/gallon	1¢ or 2¢	± 1¢	± 2¢
$0.75/liter or $3.00/gallon	$2.50/liter or $10.00/gallon	1¢ or 2¢	± 1¢	± 2¢
$0.75/liter or $3.00/gallon	$2.50/liter or $10.00/gallon	5¢	± 2½¢	± 5¢

S.1.6.5.2. Money-Value Divisions, Digital. – A computing type device with digital indications shall comply with the requirements of paragraph G.S.5.5. Money-Values, Mathematical Agreement, and the total price computation shall be based on quantities not exceeding 0.05 L for devices indicating in metric units and 0.01 gal intervals for devices indicating in U.S. customary units.

(Added 1980)

S.1.6.5.3. Auxiliary Elements. *– If a system is equipped with auxiliary indications, all indicated money-value divisions of the auxiliary element shall be identical with those of the primary element.*
[Nonretroactive and Enforceable as of January 1, 1985]

S.1.6.5.4. Selection of Unit Price. – A system shall not permit a change to the unit price during delivery of product. When a product or grade is offered for sale at more than one unit price through a computing device, the following conditions shall be met:

(a) Except for a system only capable of applying a post-delivery discount(s), the selection of the unit price shall be made prior to delivery through a deliberate action of the customer to select the unit price for the fuel delivery.
[Nonretroactive as of January 1, 1991]

(b) For a system only capable of applying a post-delivery discount(s), the selection of the unit price shall be made through a deliberate action of the customer to select the unit price for the fuel delivery.

(Added 2012)

Note: When a product is offered at more than one unit price, selection of the unit price may be through the deliberate action of the customer: 1) using controls on the device; 2) through the customer's use of personal or vehicle-mounted electronic equipment communicating with the system; or 3) verbal instructions by the customer.

(Added 2012)

The provisions in (a) and (b) do not apply to dispensers used exclusively for fleet sales, other price contract sales, and truck refueling (e.g., truck stop dispensers used only to refuel trucks).

(Added 1989) (Amended 1991, 1992, 1993, 1996, and 2012)

S.1.6.5.5. Display of Quantity and Total Price. *– Except for aviation refueling applications, when a delivery is completed, the total price and quantity for that transaction shall be displayed on the face of the dispenser for at least five minutes or until the next transaction is initiated by using controls on the device or other customer-activated controls.*
[Nonretroactive as of January 1, 1994]

(Added 1992) (Amended 1996 and 2007)

S.1.6.5.6. Display of Quantity and Total Price, Aviation Refueling Applications.

(a) The quantity shall be displayed throughout the transaction.

(b) The total price shall also be displayed under one of the following conditions:

(1) The total price can appear on the face of the dispenser or through a controller adjacent to the device.

(2) If a device is designed to continuously compute and display the total price, then the total price shall be computed and displayed throughout the transaction for the quantity delivered.

(c) The total price and quantity shall be displayed for at least five minutes or until the next transaction is initiated by using controls on the device or other customer-activated controls.

(d) A printed receipt shall be available and shall include, at a minimum, the total price, quantity, and unit price.

[Nonretroactive as of January 1, 2008]

(Added 2007)

Attachment 11

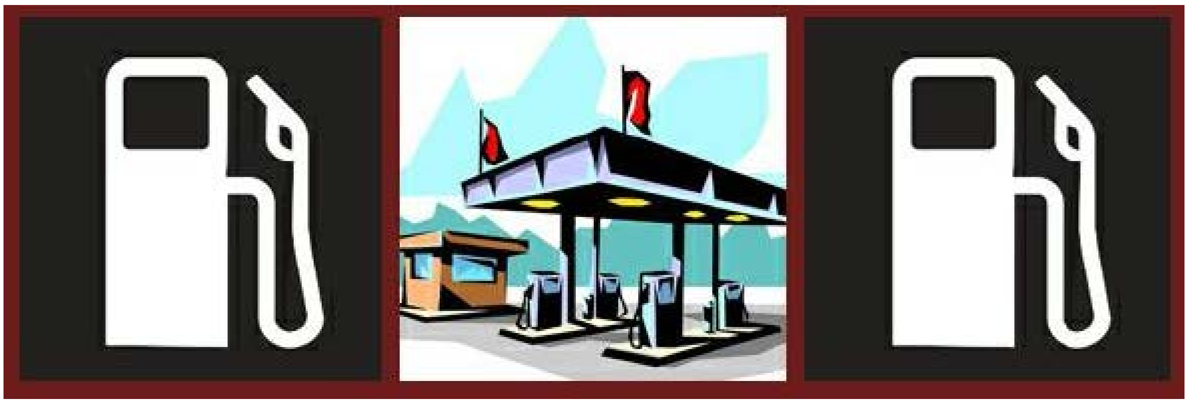
Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Fact Check > Automobiles > Highway Hazards

Fuelish Pleasures

Does the use of cellular phones pose a danger of touching off explosions at gas stations?

David Mikkelson
From the Archive



Claim: The use of cellular phones poses a danger of touching off explosions at gas stations

FALSE

Examples:

[Collected on the Internet, 1999]

Cell Phones

In case you do not know, there was an incident where a driver suffered burns and his car severely damaged when gasoline vapors ignited an explosion while he was talking on his mobile phone standing near the attendant who was pumping the gas. All the electronic devices in gas stations are protected with explosive containment devices, (intrinsically safe) while cell phones are not. READ YOUR HANDBOOK!

Mobile phone makers Motorola, Ericsson, and Nokia, all print cautions in their user handbooks that warn against mobile phones in "gas stations, fuel storage sites, and chemical factories." Exxon has begun placing "warning stickers" at its gasoline stations. The threat mobile phones pose to gas stations and their users is primarily the result of their ability to produce sparks that can be generated by the high-powered battery inside the phone. Please pass this on.

[Collected on the Internet, 1999]

*** PASS THIS ON TO ALL YOUR FAMILY AND FRIENDS ***

Mobile phones an explosive risk at gas stations. Switch off your mobile phone while filling your car. This is the latest advice for mobile phone users and gas station attendants alike from the Chinese Petroleum Corp. (CPC), which has recently informed all its affiliates to be on alert for people chatting on mobiles while pumping gas, a practice it asserts can cause explosions. "There have been several explosions in Southeast Asia and Europe and we hope similar tragedies can be avoided in Taiwan," said David Tung from CPC's main engineering division.

According to a report released by Shell Chemicals, a driver in Indonesia suffered burns and his car was severely damaged when petrol vapor exploded after being ignited by static electricity from the mobile phone he was using.

Apparently, the driver had been talking on a mobile phone as a gas station attendant filled his car with petrol. When the driver bent down close to the petrol tank to check whether it was full, the vapor exploded. In Belgium, customers have been prohibited from using mobile phones within 10 meters of gas stations and warnings are posted everywhere to remind people of the danger, according to a Belgian newspaper.

The threat mobile phones pose to gas stations and their users around the world is largely due to their ability to produce sparks. These can be generated by the high-powered battery inside the phone, which is itself, a possible cause of fire. But the electromagnetic waves emitted by the phone are more than sufficient to create considerable static electricity that heats the surrounding air and if the flammable vapor is concentrated enough, causes an explosion. But other electronic devices installed in the gas stations are safe. "All the electronic devices in gas stations are protected with explosive containment devices, while cellular phones are not," Tung explained. Mobile phone makers Motorola, Ericsson and Nokia, all print cautions in their user handbooks that warn against mobile phones in "gas stations, fuel storage sites and chemical factories."

But the danger is still being ignored by many users who continue to talk on their cellular phones while filling up at gas stations. "Asking them to turn off the phone is the only thing we can do now, but not all the users like to : some of them even get mad with me," one attendant at a gas station complained. In fact, if danger is to be avoided, all transmitting devices - not just mobile phones - should be switched off near gas stations and locations housing flammable substances. Mobile phones should also be switched off near sensitive electronic equipment, in places such as hospitals and airports for public safety reasons.

Taken from 'The China Post' by Chris Lang.

Origins: Warnings about the dangers of using cellular phones in the presence of gasoline fumes began circulating on the Internet in 1999. Though both versions of the original Internet warning alluded to an accident in Indonesia wherein a driver was burned and his car badly damaged as a result of such an explosion, no reports ever surfaced in the news media to confirm the incident. Moreover, nothing turned up about similar explosions in other countries. If sparks from cell phones were touching off conflagrations at gas pumps around the world, as suggested at the time, the phenomenon escaped the media's notice. Such rumors were furthered in May 1999 when a lengthy article appeared in the Bangkok Post supporting this warning. It mentioned "a recent report in the China Post newspaper" and from there proceeded to parrot the warning given in the longer example quoted above, complete with reference to the report by Shell Chemicals on the injuries suffered by the man in Indonesia and the Chinese Petroleum Corporation's instructions to filling stations to get drivers to switch off their phones while fueling.

Okay, so the bit about a guy in Indonesia being turned into a human fireball didn't stand up. But what about persistent rumors concerning another supposed victim, this time an Australian man, supposedly done in by using his mobile phone as he refueled?

Although in 1999 oil companies told the South China Morning Post they had heard reports of an Australian man being blown up recently when his phone rang as he was filling his car with gasoline, fire service heads in Australia insist the incident never happened. As for incidents elsewhere in the world, after several reports were circulated in the United States claiming mobile phones had been blamed for fires at gas stations, both the Cellular Telecommunications Industry Association (CTIA) and the American Petroleum Institute issued statements denying the risk. The CTIA said, "There is no evidence whatsoever that a wireless phone has ever caused ignition or explosion at a station anywhere in the world. Wireless phones don't cause gas stations to blow up. Warnings being posted in petrol stations simply perpetuate the myth." The American Petroleum Institute said, "We can find no evidence of someone using a cellphone causing any kind of accident, no matter how small, at a gas station anywhere in the world."

In June 2002 another authoritative-sounding warning on this subject began circulating on the Internet:

> The Shell Oil Company recently issued a warning about three incidents where Mobile Phones have ignited fumes while being answered or ringing during fueling operations. What specifically happened
>
> Case 1
> The phone was placed on the car's trunk lid during fueling, it rang and the ensuing fire destroyed the car and the gasoline pump.
>
> Case 2
> An individual suffered severe burns to their face when fumes ignited as they answered a call while refueling their car.
>
> Case 3
> An individual suffered burns to the thigh and groin as fumes ignited when the phone, which was in their pocket, rang while they were fueling their car.
>
> What should you learn from this?
>
> It is a misconception that Mobile Phones are intrinsically safe and can't ignite fuel/fumes. Mobile phones that light up when switched on, or when they ring, have enough energy released to provide a spark for ignition. Mobile phones should not be used in filling stations, or when fueling lawn mowers, boats etc.
>
> Mobile phones should not be used around other materials that generate flammable or explosive fumes or dust (i.e. solvents, chemicals, gases, grain dust etc.). Mobile phones should be turned off before entering an area where other materials that generate flammable or explosive fumes or dust is located.
>
> Please share this with employees who do not have access to email, family members and friends to help keep everyone safe.

Though we looked long and hard, we never found documentation confirming any of the three incidents described in the that warning. Moreover, Shell denied having issued a warning of this nature:

We understand that there is an email, purportedly official Shell communication, circulating which describes various incidents that are supposed to have occurred as a result of mobile phones ringing while at a retail station.

Please be advised that the email in question does NOT originate from Shell Malaysia and we are unable to confirm any of the incidents quoted.

There was a warning memo which originated at a Shell loading station in California, but it was issued only to caution employees about the potential dangers of static-related hazards at fueling stations; it said nothing about cell phones touching off fires. (The "three incidents" e-mail quoted above was teamed with a separate warning about the hazards posed by static electricity, a topic covered on our Static Quo page.)

Okay, so it hasn't happened yet. Is there still a potential, as yet unrealized risk in using cell phones while refueling?

According to some experts, there is a danger that using a mobile phone near gas pumps could touch off an explosion, but not only have we found no real-life instances of such an explosion occurring, we don't know anyone who has demonstrated experimentally that it's even possible (including the folks at The Discovery Channel's Mythbusters program). Even so, gas pumps in Australia bear stickers cautioning motorists to turn off their phones while refueling; Shell in Malaysia has affixed similar stickers to each of its gas pumps; numerous pumps in the U.S.A. are similarly adorned; Canada's major gas pump operators have banned customers from using mobile phones while at the gas pump; and in 1999 the city of Cicero, Illinois, passed the first law in the USA banning the use of cellular phones at gas stations. All of this activity was in the nature of CYA cautions rather than a response to a documented hazard.

Cellular phone manufacturers Nokia and Ericsson have said the risk is very small that something will happen when one uses a cell phone at a gas station, but since there is a risk, it should be counted. Nokia also said that the company has been recommending for a long time that mobile phones should be turned off while the car is being refueled. What it is about a cellular phone that could possibly trigger an explosion is difficult to fathom, however. The claim that the batteries used in a cellular phone can ignite gasoline seems specious, since cellular phone batteries are the same voltage as automobile batteries (12V D.C.) but deliver far less current. Likewise, the claim that a "cellular phone ringer uses more than 100 volts for excitation" is a curious artifact of the "regular" telephone era: cellular phones don't have ringers; they produce audio tones that simulate the sound of a ringing telephone.

News reports routinely attribute gas pump fires to cell phone use whenever a fire occurs at a service station where such a phone was in use at the time, and police and firefighters at the scene often simply assume the connection between the two to be valid. Later investigations, however, have always shown in such cases that the press reports were wrong, that something else (usually a discharge of static electricity) touched off the fires, and the presence of cell phones was coincidental rather than causal.

Barbara "gasoline alley oops" Mikkelson

Last updated: 25 August 2014

Attachment 12

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Cellular Phones in Class I, Division 2/Zone 2 Hazardous Locations

Paper No. PCIC-4

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Abstract - The risk associated with using a portable cellular phone in a Class I, Division 2 or Zone 2 hazardous location is evaluated. Experimental trials were performed on a representative sample of commercial grade cellular phones using the guidelines provided in ISA-RP12.12.03-2002 *"Recommended Practice for Portable Electronic Products Suitable for Use in Class I and II, Division 2, Class I Zone 2 and Class III, Division 1 and 2 Hazardous (Classified) Locations"* [1]. The ignition risks are subsequently classified according to a framework ranking system for ignition sources developed by Rew and Spenser (1997)[2]. The results are used to construct a probability model that estimates the risk of a cell phone igniting a flammable atmosphere in a Class I, Division 2 or Class I, Zone 2 hazardous location.

All cell phones evaluated did not meet the ISA-RP12.12.03-2002 requirements for a PEP 2 (Portable Electronic Product) device and therefore could not be considered *"incapable of causing an ignition under normal operating conditions"* as per the PEP definition. Additional testing and analysis of the high risk cell phone components indicated a very low probability of ignition even under ideal conditions. A Monte Carlo simulation of the probability model estimated the odds of a cell phone causing a fire or explosion in a Class I, Division 2 or Class I Zone 2 hazardous location as being 1.16E-06; or one in a million.

Index Terms – Cellular mobile cell phones, Hazardous locations, Ignition probability model.

I. INTRODUCTION

In recent years, the cell phone has become the most widely used technology media for voice communications. In North America alone, there are estimated to be 180 million mobile phones in use; with on average 1 mobile phone for every two persons. Their convenience and portability make it an ideal means of communication within a petrochemical facility. This convenience must be weighed against the risk of a fire or explosion inadvertently caused by the use of a cell phone within a hazardous location.

The purpose of this paper is to estimate the risk associated with using a standard commercial grade cellular phone in a Class I, Division 2 or Class I, Zone 2 hazardous location. Class I, Division 2 and Zone 2 locations were selected as the basis for the study since 95% of all hazardous locations within North America are assigned this classification. It should be cautioned that the risk of using commercial grade cell phones in a Class I, Division 1 or Class I, Zone 1 hazardous location is an order of magnitude higher and is not addressed within the scope of this paper.

Results from previous research studies are examined and the current industry regulations related to cell phone use in hazardous locations is reviewed. An industrial user survey is conducted to determine the extent of cell phone use by petrochemical operations and how their use is monitored in hazardous locations.

To estimate the probability of a cell phone igniting a flammable atmosphere, a series of tests are performed on a sample cross section of cellular phones. The results are summarized and incorporated into a probability model that approximates the risk of a cell phone igniting a flammable mixture within a Class I Division 2/Zone 2 hazardous location.

II. OVERVIEW OF CELL PHONE TECHNOLOGY

A cell phone is essentially a radio transmitter/receiver operating in the 800 Mhz and 1900 Mhz frequency spectrum. A cell phone communicates to a network of base stations which in turn are linked to the telephone network.

Cell phone technology has evolved over a number of product generations to where it is today. In 1981, the 1st generation mobile phone began operation with the introduction of analog cellular service called AMPS (Advanced Mobile Phone Service). The 1G cell technology allowed users to place calls and converse seamlessly as they moved from cell to cell locations. A typical 1G handheld mobile phone was large, heavy and expensive and required 6 watts of power to transmit and receive.

The 1G was rendered obsolete in the early 1990's with the introduction of the 2nd generation based on digital cellular technology. Digital cellular technology increased the number of simultaneous phone conversations for the same range of radio spectrum and allowed for services beyond simple voice communications. As cellular phones incorporated additional features such as personal digital assistants, text messaging, cameras, internet browsers and email capability, a 2.5G generation of mobile phone technology emerged. The majority of mobile phones in use today are 2.5G.

A 3rd and 4th generation of cellular phone technology is currently in development. As with all microprocessor technologies, each generation reduces the size, weight, cost and power consumption while improving the features, reliability and the ease of manufacture.

Fig. 1 provides a simplified block diagram of a 2.5G mobile phone.

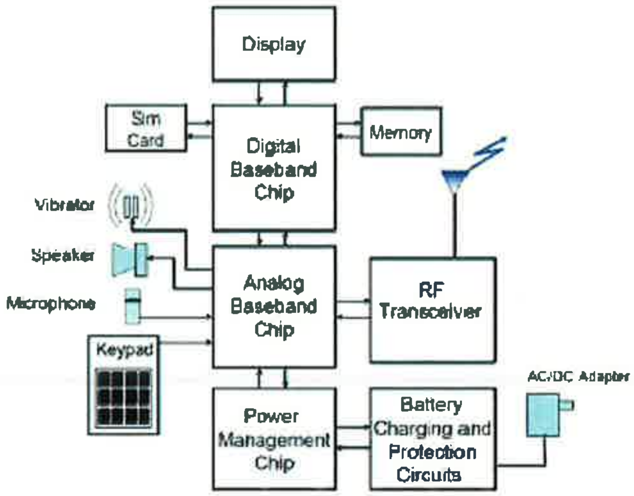

Fig. 1 Mobile Phone Block Diagram

III. SUMMARY OF PREVIOUS RESEARCH STUDIES

The majority of documented cases where a cell phone was identified as a potential ignition source are in retail gasoline operations. Within the petroleum and chemical industry, only one incident was identified where a cell phone was considered a potential source of ignition. The majority of research to date has focused exclusively on retail gasoline operations.

Self-service gasoline pumping operations requires the public (unknowingly or otherwise) to perform activities within a Class 1, Division 2/Zone 2 hazardous location. In several cases where a gasoline fire resulted during filling operations, a cellular phone was identified as possible source of ignition. Widespread media coverage led to the growth of an urban legend where cell phones were quoted as being the primary source of ignition in these events.

In response to public awareness, several retail gas operators issued directives to their staff to post warning signs and monitor the use of cell phones near fuel dispensers. If a customer was observed to be using a cell phone while pumping fuel, the operator was to cease filling operations. Mobile phone manufacturers also responded by incorporating warnings in their user manuals as illustrated in Fig. 2.

Following the accident investigations, a number of formal studies were commissioned to objectively assess the danger of using a cellular phone during filling operations. All studies concluded that it was highly unlikely that a cell phone was the primary source of ignition and that static electricity as the most probable cause. Several formal statements were issued as follows:

The University of Oklahoma Center for the Study of Wireless Electromagnetic Compatibility study (August 2001); Investigation of the Potential for Wireless Phones to Cause Explosions at Gas Stations, concluded that "*...research into the cell phone – gas station issue provided virtually no evidence to suggest that cell phones pose a hazard at gas stations. ...While it may be theoretically possible for a spark from a cell phone battery to ignite gas vapor under very precise conditions, the historical evidence does not support the need for further research.*"[3]

Exponent Failure Analysis Associates, Menlo Park, California (December, 1999) study, Cell Phone Usage at Gasoline Stations, concluded that "*...the use of a cell phone at a gasoline filling station under normal operating conditions presents a negligible hazard and that the likelihood of such an accident under any conditions is very remote.*" The report also noted "*automobiles (which have numerous potential ignition sources) pose a greater hazard... Finally, other potential ignition sources are present, such as static discharge between a person and vehicle.*" [4]

The Institute of Petroleum hosted a technical seminar entitled "Can mobile phone communications ignite petroleum vapour?" (March 2003) issued a press announcement stating "*The seminar showed the findings of research undertaken to date demonstrating that although the majority of mobile phones are not specifically designed and constructed to prevent them igniting a flammable atmosphere (in accordance with standards for 'protected equipment) the risk they present as a source of ignition is negligible.*" [5]

Potentially Explosive Atmospheres

Turn off your radio product prior to entering any area with a potentially explosive atmosphere, unless it is a radio product type especially qualified for use in such areas as "Intrinsically Safe" (for example, Factory Mutual, CSA, or UL approved). Do not remove, install, or charge batteries in such areas. Sparks in a potentially explosive atmosphere can cause an explosion or fire resulting in bodily injury or even death.

NOTE: The areas with potentially explosive atmospheres referred to above include fueling areas such as below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles, such as grain, dust or metal powders, and any other area where you would normally be advised to turn off your vehicle engine. Areas with potentially explosive atmospheres are often but not always posted.

Fig. 2 Excerpt from a Mobile Phone Users Manual

In contrast to the large number of filling station fires where a cell phone was listed as a possible ignition source, only one industrial incident was noted. The incident involved a flash fire on an offshore platform in the Gulf of Mexico. A contract panel specialist was working on an open panel that used fuel gas for instrumentation. The contractor's cell phone rang and was activated by flipping it open. A flash fire occurred and the contractor received second degree burns to his forearms and face. The incident prompted the US Department of the Interior to issue Safety Alert No. 5 in March of 2002 cautioning the use of portable electronic devices in hazardous locations. The bulletin recommended the use of hot work permits, intrinsically safe devices or third party approved devices in hazardous locations [6].

The US Department of Interior Mineral Management Service (MMS) Division followed up with a formal investigation. The cellular phone involved in the incident was sent to a third party testing agency for a battery of tests in a controlled laboratory environment. On conclusion of the investigation, the Department of Interior issued the following statement:

> *"Based on this information and MMS's investigation, we were unable to conclusively identify the ignition source of the fire. However, we have not ruled out the possibility that the fire could have been ignited by static electricity, a spark from the metal master control panel door coming into contact with a metal handrail, or a wrench striking metal inside the control panel."*[7]

Although the investigation concluded that it was highly unlikely that the cell phone was the primary source of ignition, the advisory cautioning against the use of cellular phones in hazardous locations remained in place.

IV. INDUSTRY REGULATIONS AND PRACTICES

A. *Government Regulations*

Government regulations related to cell phone use in hazardous locations vary in scope and detail. In the US, the NEC does not make a direct reference to the use of cellular phones but implies they fall under the general classification of electrical and electronic equipment. NEC Article 500.8 [8] requires that all electrical and electronic equipment be approved for use in hazardous locations and shall be identified by any of the following:

1) *Equipment listing or labeling*
2) *Evidence of equipment evaluation from a qualified laboratory or testing agency*
3) *Evidence acceptable to the authority having jurisdiction such as a manufacturer's self evaluation or an owner's engineering judgment.*

In Canada, the Canadian Electrical Code requires that all electrical equipment used in hazardous locations be subject to the rules of section 18. A note in the CEC appendix specifically addresses battery powered equipment including *"transceivers, paging receivers and battery or voice powered telephones"* and requires such devices be approved by a third party certification authority for use in a hazardous location [9].

The CEC requirements are further reinforced by a suggested change to the 2005 Occupational Health and Safety Regulations that specifically requires cellular telephones used in hazardous locations be certified.

In Europe, ATEX 94/9/EC directive requires all equipment used in potentially explosive atmospheres be certified for the appropriate gas group, temperature classification and be suitably labeled [10].

B. *Recommended Practices*

From a regulatory perspective, it would appear that cellular phones, unless certified for use, shall not be used in a Class I hazardous location. This clarity was somewhat contradicted by the ISA publication ISA-RP12.12.03-2002 *"Recommended Practice for Portable Electronic Products Suitable for Use in Class I and II, Division 2, Class I Zone 2 and Class III, Division 1 and 2 Hazardous (Classified) Locations"*

ISA-RP12.12.03-2002 was written as a guideline for the safe use of general purpose battery powered portable equipment in hazardous locations. It was developed to address situations where portable and battery powered equipment was required, but unavailable as listed for use in a classified location. This may be due to rapidly changing technology, or the need for time consuming and expensive third party certifications for products with a limited market.

ISA-RP12.12.03-2002 describes the minimum precautions required for using a portable electronic device in a classified location. In Class 1 Division 2/Zone 2 locations, a product may be listed, or used with a gas free work permit, or when the product meets the design and performance criteria for a PEP (Portable Electronic Product) as specified in the document.

A PEP product is defined as a *"battery powered or photovoltaic cell powered apparatus that can be hand-held or that is intended for use while worn on a person's body."* Certain PEPs may be suitable for use in hazardous locations if they are deemed *"incapable of causing an ignition under normal conditions."*

PEPs are further broken down into PEP 1 and PEP 2 product categories. A PEP 1 device does not require labeling or permitting for use in a hazardous location. In contrast, a PEP 2 device requires a PEP 2 marking stating the evaluating company name and the supporting document reference number or code.

Examples of PEP 1 products include electronic wrist watches and hearing aids. Examples of PEP 2 devices include calculators, hand held testers and *"some cell phones"*.

C. *Industry Practice*

To determine the extent of cell phone use in hazardous locations, an on-line survey was conducted. The survey targeted firms in the oil and gas industry who were operators of large scale petrochemical facilities. Results of the survey indicated that cell phones are in general use by Operations personnel, however, they are not the primary means of communication in classified areas. All companies responding restricted the use of cell phones in hazardous locations with 60% banning them outright. Where cell phones were permitted, they were required to be listed and approved by a third party certification authority. Appendix A summarizes the results of the survey.

V. REQUIREMENTS FOR IGNITION OF A FLAMMABLE ATMOSPHERE

To further examine this issue, a basic understanding of the ignition process is required.

To ignite a flammable atmosphere:

a) An ideal flammable mixture must be present in sufficient quantity to create a hazard
b) An active ignition source must be present
c) The ignition source must have sufficient energy to ignite the flammable atmosphere

A. Requirements for an Ideal Flammable Gas Mixture

For an ideal flammable mixture to exist, the flammable material must be in the vapor or gaseous state; the vapor to air mixture concentration must be between the lower flammable limit (LFL) and the upper flammable limit (UFL) and the temperature must be below the auto-ignition temperature of the flammable material. The flammable region, as illustrated in Fig. 3 is the area where the presence of an external ignition source may potentially cause a fire or explosion.

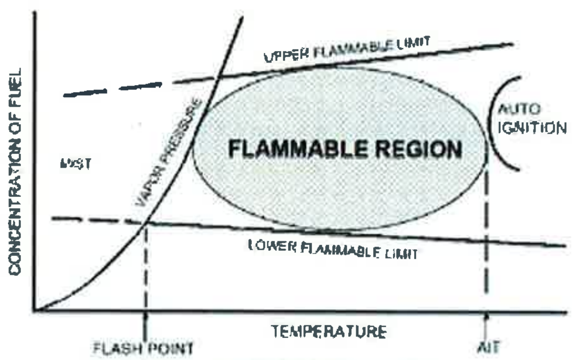

Fig. 3 Flammability Relationships

The probability of an ideal flammable gas vapor-air mixture being present at any given time is influenced by a number of material and environmental factors. The flashpoint of the flammable material, the material's density relative to air, the source, rate and geometry of release and the quantity of air movement all influence the degree and the extent of the hazard. To assess if a hazard exists at any given time requires quantifying these variables. This is often very difficult to do in practice.

The purpose of a hazardous area classification is to subjectively assess the probability of a flammable mixture being present within an area at any given time. Facilities within North America may be classified using the Division or Zone method of area classification. Class I, Division 1 locations are areas where there is *likely* to be ignitable concentrations of flammable gases or vapors. Class I, Division 2 areas are locations where ignitable concentrations of hazardous materials are *unlikely* to exist; and should they exist will do so for a very short time.

The Zone method of area classification divides hazardous locations into three risk categories. A Class I, Zone 0 location is where a flammable concentration of a gas or vapor is expected to exist on a continuous basis. Class I, Zone 1 areas are locations where a flammable atmosphere is *likely* to exist; and a Class I, Zone 2 location is where a flammable atmosphere is *unlikely* to exist. It should be noted that these subjective probabilities are based on normal operating conditions. Catastrophic failure events are not considered.

API RP 505 provides additional guidance in defining a hazardous area classification based on the theoretical presence of a hazardous mixture as illustrated in Table I.

TABLE I
Relationship between Zone Classification and the Presence of Flammable Mixtures (API RP 505) [11]

Zone	Flammable Mixture Present	*% of time per year*
0	1000 hrs or more per year	> 10%
1	> 10hrs and < 1000hrs per year	0.1% - 10%
2	> 1hr and < 10 hrs per year	0.01% - 0.1%
Unclassified	< 1hr per year	< 0.01%

B. Requirements for an Active Ignition Source

For a device in intermittent use, the probability of the device becoming an ignition source in the presence of a flammable gas is a function of how often and for what duration the device is used. A cell phone can be considered an intermittent use device and is deemed 'active" when it is in the process of transmitting and receiving radio frequencies.

To conserve power, a cell phone will operate in a "sleep" mode awaiting an incoming signal or activation by the User. While the cell phone is in sleep mode, power levels are reduced to a minimum and the risk of ignition is negligible. Once the cell phone receives an incoming call or is activated by the User, it may be exposed to a flammable atmosphere and has the potential to become an ignition source.

C. Ignition Source Energy Requirements

For an electrical ignition to occur an electric spark must arc across a contact gap that exceeds the minimum quench gap distance and the spark energy generated must exceed the minimum ignition energy requirements for the flammable material. Quenching refers to the "cooling" process that occurs when the heat energy of a spark or flame is transferred to an adjacent surface. The quench gap is the largest passage that can prevent propagation of a flame through a passage when it is filled with a flammable fuel-air mixture.

The size of a quench gap is experimentally determined and varies with the mixture composition, the surface geometry and the pressure and temperature of the surrounding atmosphere. A 2.0 mm quench gap distance is typically used for methane and 0.6 mm gap used for hydrogen.

The minimum ignition energy required to ignite a flammable mixture varies with the material composition and the air mixture ratio. Fig. 4 illustrates the minimum spark energy required to ignite methane and hydrogen as a function of % volume to air concentration. The ignition spark energy is at a minimum at the stoichiometric air mixture ratio. The energy required for ignition increases as the percent air/mixture ratio deviates from the stoichiometric ratio. Table II illustrates the material characteristics; minimum ignition energy and minimum quench gap distance required for the ignition of methane and hydrogen.

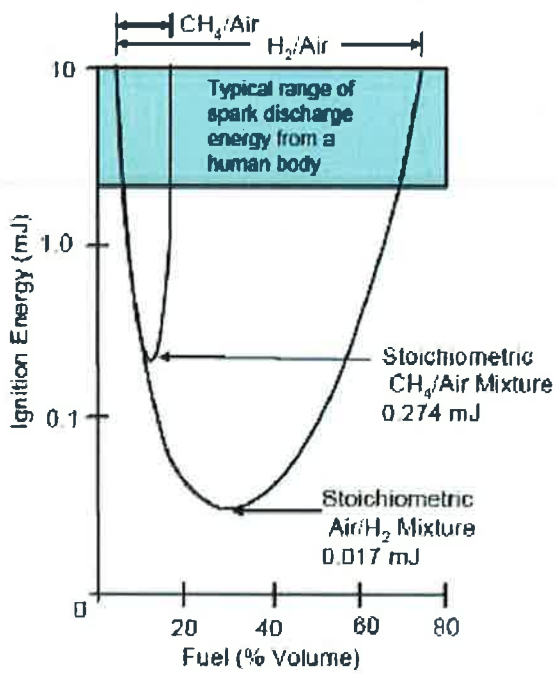

Fig. 4 Spark Energy Required to Ignite Methane and Hydrogen

TABLE II
Physical Properties of Hydrogen and Methane

	Hydrogen	Methane
Autoignition temperature	520° C	630° C
Lower flammable limit	4% by vol.	5.3% by vol.
Upper flammable limit	75% by vol.	17% by vol.
Stoichiometric mixture	29.5% by vol.	9.5% by vol.
Density relative to air at STP	0.07	0.55
Minimum ignition energy	0.017 mJ	0.274 mJ
Group Classification	Group B, IIC	Group D, IIA
Quench Gap Distance	0.66 mm	2 mm
Minimum ignition energy	0.017 mJ	0.274 mJ

VI. CLASSIFICATION OF IGNITION SOURCES

A number of statistical models have been developed for the purpose of classifying ignition sources. The framework developed by Rew & Spencer (1997) builds on the research done by a number of previous references including Cox, Lees and Ang [15]. The model provides a means of ranking ignition sources into various groups based on their ignition potential as illustrated in Table III. Ignition sources range from open flames that are assigned an ignition probability of 1.0 to intrinsically safe devices with an ignition probability of 0.0.

For reference purposes, a typical zone 2 approved equipment device would fall into the "weak" category with an ignition probability of 0.01[15].

TABLE III
Framework Ranking System for Ignition Sources
Rew & Spencer (1997) [2]

Category (Strength of Source)	Examples of Ignition Sources	Ignition Potential
Certain	Pilot Lights Fired Heaters Flares	$p = 1$
Strong	Hot Work Electrical Faults, Smoking	$p > 0.5$
Medium	Vehicles, Substations, Unclassified electrical equipment, Engines, Hot surfaces	$0.5 > p > 0.05$
Weak	Office Equipment, Electrical Appliances Mechanical Sparks Static electricity	$p < 0.05$
Negligible	Intrinsically safe equipment Radio Frequency Sources	$p = 0$

VII. EVALUATION OF A CELL PHONE AS AN IGNITION SOURCE

To evaluate and classify the ignition potential of a cell phone, the design criteria and test methods outlined in ISA-RP12.13.03-2002 for a PEP 2 device is used as a basis.

The PEP2 criterion applicable to a cell phone is as follows:

1) Radio frequency transmission energy is limited to a safe level
2) No sparks visible in normal operation
3) No power on-off switch that directly interrupts the battery current
4) No motors unless it can be demonstrated that the motor incorporates non-arcing technology
5) No external connections of accessories are used in the hazardous area
6) Exposed terminals (battery charging terminals) are recessed or diode protected to prevent a discharge caused by the accidental shorting of the terminals
7) No excessive temperatures in normal operation
8) Cell or battery is secured so it will not fall out in a specified drop test
9) No damage that exposes electrical/electronic circuitry as a result of the drop test

The ISA performance tests were applied to a representative sample of 8 cell phones from five different manufacturers. Upon completion, each cell phone was dismantled and examined for any components that might pose an ignition risk. Where a potential ignition hazard was identified, additional tests were done to further assess the ignition hazard.

Appendix B provides a complete summary of the test results. The following sections discuss the PEP 2 criterion and provide comment on the ignition risks identified.

A. Radio Frequency Energy

Radio devices that emit electromagnetic frequencies may create a spark hazard in the presence of an open circuit antenna loop as illustrated in Fig. 6. The extent of the hazard is related to the strength of the radio frequency radiation emitted while transmitting.

Fig. 6 Induced Spark Hazard from RF Radiation

The safe radio frequency energy transmission levels are defined in BS 6656 "*Assessment of inadvertent ignition of flammable atmospheres by radio-frequency radiation – Guide*" [12] and are used as a PEP performance criterion. The maximum RF energy that may be emitted from a PEP 2 device must be less than:

- 2 W maximum output averaged over 20 microseconds for Groups A and B and Group IIC
- 3.5 W maximum output averaged over 100 microseconds for Group C and Group IIB
- 6 W maximum output averaged over 100 microseconds for Group D and Group IIA

Under normal operating conditions, a 2.5G mobile phone radiates between several hundred milliwatts and 0.7 watts of RF energy depending on the signal strength to the base station (the weaker the signal the more power a mobile phone handset will send). This is well under the maximum 2 watts of radio frequency energy considered safe under all conditions and therefore eliminates RF energy as a potential ignition source.

B. Arcing/Sparking Components in Normal Operation

1) *Contacts and Switching Devices:* The potential for a cell phone to arc or spark in normal operations is related to the technology and energy switching levels used for keyboard and switching functions. All cell phones examined used a dome switch keyboard technology. The dome switch technology uses a hybrid of membrane and mechanical components to allow two circuit board traces to contact under a plastic "dome" or bubble.

One key advantage of the dome switch keyboard technology is that it effectively seals the switching contacts from the environment. While primarily designed to prevent liquid contamination of the keyboard, it also creates a vapor-tight barrier that effectively eliminates the keyboard as a potential source of ignition.

ISA-RP12.12.03-2002 requires only the on-off switch be examined for arcing-sparking potential. All cell phones in the test group used the same switch for on-off functions indicating an electronic circuit switch was used for power control. A dome membrane type switch was observed in all cases. On this basis, the ignition risk associated with switching and control functions was deemed negligible.

2) *Vibrator mechanism:* Seven of the eight cell phones in the test group incorporated a vibrate ring feature. The vibrator mechanism on a typical mobile phone consists of a DC micro-motor turning a counterweight. The spinning counterweight provides the vibration effect.

The micro-motor used for a cell phone vibrator mechanism incorporates a coreless motor design. A coreless motor replaces a rotating iron armature with a light weight copper coil. The copper coil then rotates around a stationary magnet system. Fig. 7 illustrates a coreless micro-motor design.

A typical vibrator pager micro-motor will have a voltage input of 1.25V and a running current of 120ma. Within the cellular phone circuitry, the vibrator motor is controlled by a micro motor driver chip that controls and protects the motor operation. The controller chip will provide a stabilized DC output and limits both the temperature and current to the motor.

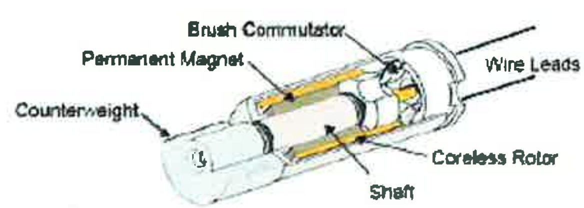

Fig. 7 Coreless Vibrator Micro-motor

The coreless micro-motor design requires a precious metal or graphite brush commutator system. A commutator system is an arcing sparking component by nature and must be considered a potential ignition source. To determine if the vibrator function might pose an ignition risk, micro-motors were removed from 5 of the 7 cell phones in the test group and placed in an explosion chamber with a Group IIC stoichiometric hydrogen mixture to simulate a worst case flammable mixture environment. The micro-motors were alternately energized for 10 seconds with a 1.5V DC power source to simulate a vibrator operation.

No ignition events were observed with any of the micro-motors tested. Based on these results, the probability of a cell phone micro-motor igniting a flammable atmosphere can be considered negligible.

C. Drop Tests

ISA-RP12.12.03-2002 requires a PEP2 certified product to be dropped from a height of 2 meters to a horizontal concrete surface. The device must survive without exposing any internal circuitry or the battery becoming disconnected. The test is repeated six times in a variety of orientations.

Within the test group, only one cell phone survived without the battery disconnecting on impact. In all other cases, the battery separated from the cell phone one or more times. In all cases, when the battery was reconnected, the cell phone worked properly with no physical or operational damage observed.

The probability of a spark being created as a result of the battery disconnect is difficult to assess. The more likely scenario would be the dropped object itself posing the ignition risk. In theory, an object the size of cell phone can discharge 10-20 mJ of energy under ideal conditions. This risk is common to all objects. Without conclusive results and given the remote likelihood of a battery disconnect or dropped object creating a spark hazard, the spark ignition potential of a dropped cell phone was given a weak rating in accordance with the Rew and Spencer (1997) model.

D. Battery circuit

Most modern cell phones use a Lithium Ion battery cell as a power source. The Li-Ion technology provides a low energy-to-weight ratio; do not suffer from a memory effect and have a very low self-discharge rate when not in use. There are however, some inherent risks associated with Li-Ion battery cells. An unprotected Li-Ion cell can easily rupture, ignite or explode if short circuited, over charged or exposed to high temperatures.

To minimize the risks associated with using Li-Ion cell technology, a built-in IC protection circuit is incorporated into the battery pack as illustrated in Fig. 8. The battery cell also incorporates a cell vent system designed to limit the internal pressure to a safe level should a fault occur.

There have been a number of recent incidents where a Li-Ion cell has exploded causing personal harm in the form of 2nd degree burns. The mobile phone industry responded by launching a large scale recall of the mobile phones involved. What was later discovered is that many of the battery units at fault were counterfeit cells manufactured by unauthorized third parties. The battery cells did not incorporate the battery protection circuits that all legitimate manufacturers use in their design.

To insure public safety and to promote standardization of Li-Ion cell protection systems, the IEEE is currently in the process of releasing IEEE P1725 "Standard for Rechargeable Batteries for Cellular Telephones" [13]. The standard provides specific recommendations designed to limit component failures that lead to hazards. The standard recommends the use of output current limiting devices, thermal protection circuits and at least two overcharge protection functions designed to prevent overcharging a battery cell. The standard also provides recommendations on connector/terminal arrangements designed to prevent accidental short circuits.

All cell phone manufacturers in the test group incorporated a battery protection circuit to prevent short circuits and with the exception of one cell phone, all incorporated recessed terminals. It should also be noted that despite the protection circuitry, all batteries were labeled with warnings that burns or injury could result from shorting the battery terminals with metal objects.

To determine the effectiveness of the protection circuitry, the battery terminals were shorted in a darkened environment to determine if any visible sparks could be detected. No sparks were observed throughout the test group. The test results were consistent with a similar study done in 1999 by the Center for the Study of Wireless Electromagnetic Compatibility, University of Oklahoma [3] on 3.6V Li-Ion cells. Based on these observed results, the ignition potential associated with shorting the battery terminals was considered negligible.

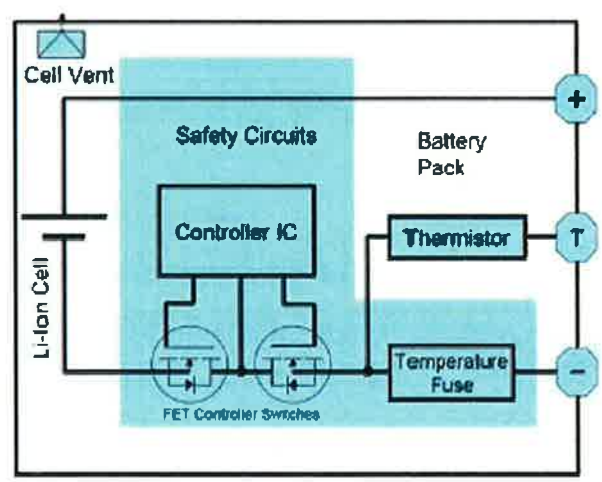

Fig. 8 Lithium-Ion Battery Protection Circuit

E. Excessive Temperatures in Normal Operation

In normal operation, the operating temperatures of cell phone components are well below the auto-ignition temperatures of all flammable materials.

Under abnormal conditions, the only component that could potentially act as a heat source is a short circuited battery. To determine if this was a potential risk, a test was performed to measure temperature rise under short circuit conditions. The surface temperature of the battery cell was measured prior to the battery terminals being shorted for a period of ten minutes. The temperature was again measured and compared to the original reading. In all cases, no measurable increase in temperature was noted. This implies that probability of a surface temperature reaching a flammable material autoignition temperature even under abnormal operating conditions is remote. The ignition risk associated with excessive temperatures was considered negligible.

F. *Static Electricity*

Although ISA RP12.12.03 does not specifically address the potential for static build-up on PEP, it is worth discussing as many of the incidents involving cell phones in a fire or explosion were eventually traced back to a static discharge.

For a static ignition to occur, a capacitive build-up of energy must occur on a non conductive surface. The energy stored on the charged surface must exceed the minimum ignition energy of the fuel mixture. The stored energy E on a part of capacitance C at a voltage V is based on the following relationship:

$$E = 0.5CV^2$$

The breakdown strength of air is around 6MV/m, therefore the minimum quench gap distance of 2mm corresponding to methane requires an ignition voltage of approximately 6kV. A stoichiometric mixture of methane requires 0.274 mJ of energy for ignition and thus requires an object to have a capacitance of at least 11pF. Similarly, a stoichiometric mixture of hydrogen requires 0.017 mJ of energy and therefore requires the object to have a capacitance of 0.94pF. Smaller objects require a higher voltage to provide the required ignition energy.

To determine if an object the size of a cell phone can build up a sufficient capacitance charge, the guidelines for enclosures provided in ANSI/ISA 12.00.01-2002 (IEC 60079-0 Mod) "Electrical Apparatus for Use in Class 1, Zone 0,1&2 Hazardous (Classified) Locations: General Requirements" [14] was used as a test criteria for cell phone enclosures.

By limiting the surface area of a plastic enclosure to less than 100 cm^2 for Group IIA (methane), and 20 cm^2 for Group IIC (hydrogen) an object can be considered inherently safe. The surface area dimensions for all cell phones in the test group ranged between 180 and 225 cm^2. Although the surface area exceeds the minimum no-test criteria, the surface area is minimal when compared to the surface area of a human body.

The male human body has a surface area of approximately 18,000 cm^2 and a capacitance in the range of 100-300 pF under ideal conditions. A human body charged to 6 kV stores around 3.6 mJ of energy; more than enough to ignite a hazardous mixture under ideal conditions. The ratio of charge build up by a cell phone compared to a human body is insignificant under these circumstances. In all likelihood, a static charge build-up would be the result of a human body static discharge rather than a static discharge from the cell phone itself.

It should be noted that a metallic object such a mobile phone case can act as an electrode and increase the risk of a static electric discharge from a charged human body.

Based on the analysis, the ignition risk resulting from a static build-up on the surface area of a cell phone was considered negligible.

G. *Test Results Summary*

None of the cell phones tested met the ISA RP12.13.03-2002 criteria for a PEP 2 device. The primary ignition risks noted were related to the risk of the battery separating from cell phone circuit or an impact spark discharge after being dropped. All other ignition risks were deemed negligible. Given the potential for a battery disconnect or spark impact discharge, the overall ignition source ranking for a cell phone best be described as a "weak" with an ignition potential of between 0.0 and 0.5 in accordance with the Rew and Spenser (1997) framework.

VII. COMPUTER MODELLING

As discussed in section V, the ignition of a flammable mixture requires an ideal flammable mixture and an active ignition source with sufficient energy to ignite the mixture. The relationship can be described in mathematical terms as follows:

$$\rho(FE)_t = \rho(FA) \times \rho(IGN) \times Ta/(Ta+Ti)$$

where:

$\rho(FE)_t$ = Probability of a Fire or Explosive Event at time t
$\rho(FA)$ = Probability of a flammable gas is present
$\rho(IGN)$ = Probability a spark ignition event of sufficient energy
Ta = Time a device is active
Ti = Time a device is inactive

All variables in the equation are subject to a range of probabilities which lends itself to a Monte Carlo statistical simulation analysis. A Monte Carlo simulation was applied to a range of different values for $\rho(FA)$, $\rho(IGN)$, *Ta* and *Ti* to generate a theoretical range of values for $\rho(FE)_t$. The simulation was run for 500 iterations using the following input models.

A. *$\rho(FA)$ - Flammable Atmosphere Present*

The probability of a flammable mixture being present within a Division/Zone 2 classified location at any given time was modeled as a uniform distribution as illustrated in Fig. 9. The distribution approximates the probability of a flammable gas being present of between 1 hour and 10 hours per year which is consistent with definition of Class I, Division 2 or Class I, Zone 2 hazardous location.

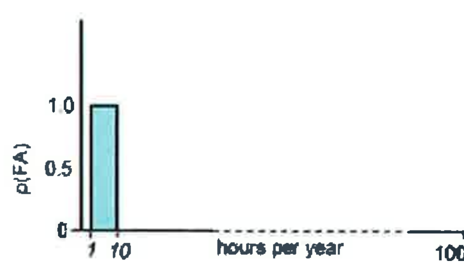

Fig. 9 Probability Distribution for a Flammable Gas being Present within a Class I Division/Zone 2 Area

B. p(IGN) - Spark Ignition Event of Sufficient Energy

To model the probability of ignition risk, a triangular distribution was selected with a range of values between 0.01 and 0.05 with a mode (most likely) value of 0.02. The probability distribution is illustrated in Fig. 10.

The value 0.01 was selected as the lower bound based on premise that a certified Class I, Division 2 or Zone 2 device has a theoretical ignition risk of 0.01. The 0.05 upper bound is based on the Rew and Spenser (1997) model for a "weak" ignition sources as illustrated in Table III. The most likely value (mode value) was set at 0.02 and reflects the very low number of potential ignition sources identified in the test group. The probability distribution selected is conservative and allows for the wide variety of cell phone configurations and technologies.

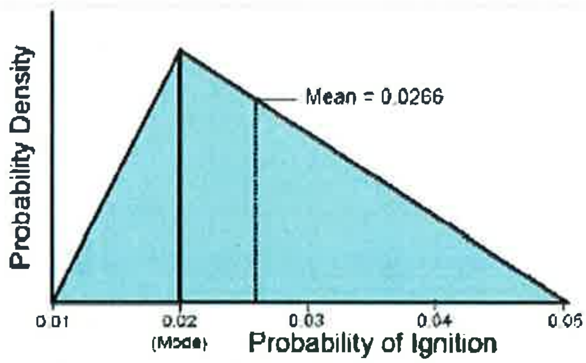

Fig. 10 Probability Distribution for an Ignition Event

C. Ta, Ti - Proportion of Time a device is Active and Inactive

The probability of a cell phone being active at any given time is given by the following relationship:

$$p(\text{Device Active}) = T_a / (T_a + T_i)$$

where:

Ta = Time device is active
Ti = Time device is inactive

A typical cell phone call lasts between 30 seconds and 20 minutes with an average duration of 3 minutes 15 seconds. For the purpose of the analysis, it is assumed that any conversations lasting longer than 20 minutes would likely be done in a non-hazardous area. The frequency of calls will vary with the individual and the model assumes the interval between calls varies between 3 minutes and 8 hours with the average being 20 minutes.

A triangular distribution was again used to model the values of Ta and Ti with the mode values of 3.25 minutes for Ta and 20 minutes for Ti. The probability distributions for Ta and Ti are illustrated in Fig. 11.

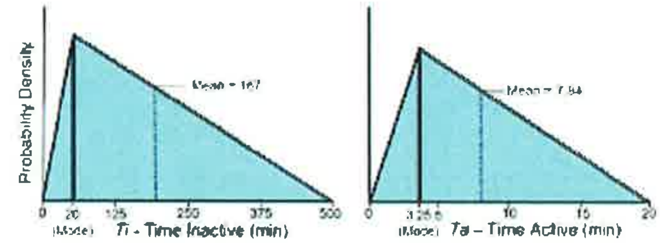

Fig. 11 Input Distributions for Ti and Ta

D. Probability Model Simulation

A Monte-Carlo statistical simulation using a Latin Hypercube sampling method was done for 500 iterations. The resulting output distribution was derived as illustrated in Fig. 12. The summary statistics associated with the simulation are provided in Table IV.

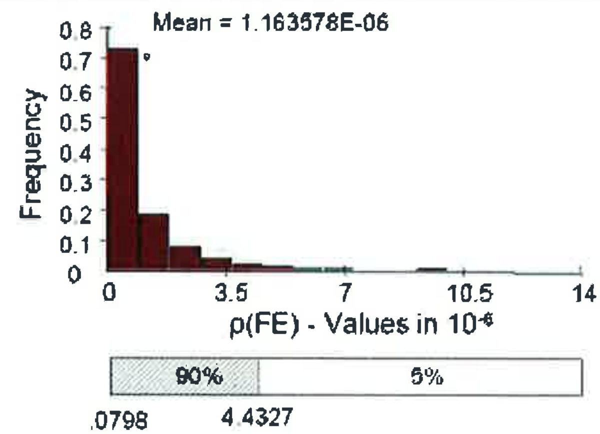

Fig. 12 Probability Distribution of a Fire or Explosion Resulting from an Ignition by a Cellular Phone

TABLE IV
Summary Statistics

Output Statistics - Fire/Explosion Probability							
Name	Min.	Mean	Max.	x1	p1	x2	p2
p(FE) =	2.73E-08	1.16E-06	1.37E-05	7.98E-08	5%	4.43E-06	95%

Input Parameters				
Name	Min.	Mode	Mean	Max.
p(FA) =	1.01E-04		5.50E-04	9.99E-04
p(IGN) =	1.06E-02	2.0E-02	2.67E-02	4.90E-02
Ta =	0.562	3.25	7.834	19.293
Ti =	6.956	20	167.688	471.013

The results indicate that the probability of a fire or explosion initiated by a cell phone is in the range of 0.0789E-06 and 4.4327E-06 with a 90% confidence level, with a mean value of 1.16E-06. This would imply that the probability of a cell phone causing a fire or explosion in a

Class I, Division 2/Zone2 hazardous location is in the range of approximately one in a million.

VIII. CONCLUSION

Cell phones are commonly used in petrochemical operations however; government regulations and company policies strictly limit the use of cell phones in hazardous locations. The representative sample of cell phones subjected to the ISA RP12.12.03-2002 design and performance criteria failed to pass the requirements for a PEP 2 device. This would imply that all cell phones in the test group posed an ignition risk in hazardous location.

Further testing and analysis indicated the greatest risk was associated with dropping a cell phone on a hard surface. The impact caused the battery to disconnect in the majority of cases and could potentially create an impact spark under ideal conditions. All other potential ignition risks were deemed negligible.

The Monte Carlo model simulation results estimated the probability of a fire or explosion resulting from the use of a commercial grade cellular phone in a Class I Division 2/Zone 2 hazardous location as negligible. This conclusion concurs with several previous studies where cell phones were deemed a negligible hazard in gasoline pumping operations.

While the research and conclusions of this paper indicate the probability of a cell causing an ignition in a Class I, Division/Zone 2 location are minimal, the authors do not suggest the potential hazard can be ignored. Mobile communication devices that are third party listed for use in hazardous locations are commercially available and serve to eliminate the risk of ignition. In all case, appropriate safety measures in accordance with Occupational Health and Safety (OH&S) regulations, electrical codes and other regulations must be observed.

IX. ACKNOWLEDGEMENTS

The Authors would like to acknowledge Dave Adams, P.Eng. and Greg Law from CSA International for their valued assistance and the use of their explosive testing facilities in Edmonton, Canada.

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[3] "Investigation of the Potential for Wireless Phones to Cause Explosions at Gas Stations." Center for the Study of Wireless Electromagnetic Compatibility, University of Oklahoma, Norman, Oklahoma USA. August 2001.

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[8] NFPA 70, 2002 National Electrical Code, Quincy, MA: NFPA

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[12] BS 6656:2002 'Assessment of inadvertent ignition of flammable atmospheres by radio-frequency radiation. Guide', British Standards Insititute, London, UK.

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[14] ANSI/ISA 12.00.01-2002 (IEC 60079-0 Mod) "Electrical Apparatus for Use in Class 1, Zone 0,1&2 Hazardous (Classified) Locations: General Requirements" Research Triangle Park, NC: ISA

[15] Institute of Petroleum, 'Model Code of Safe Practice – Part 15, Area Classification Code for Installations Handling Flammable Fluids' 3rd Edition, Energy Institute (2003), Portland Press.

H. VITA

Allan Bozek, P.Eng., MBA graduated from the University of Waterloo in 1986 with BASc in Systems Design Engineering and a MBA from the University of Calgary in 1999. He is a Principal with EngWorks Inc. providing consulting engineering services to the oil and gas sectors. Allan is a registered professional engineer in the provinces of Alberta, British Columbia, Saskatchewan and the Northwest Territories and Nunavut. He has been a member of the IEEE since 1989. Allan's areas of expertise include hazardous area classification, power systems, heat trace and digital control systems design for large scale industrial facilities.

Marty Cole has worked for Hubbell Canada for over 25 years and has been involved with hazardous locations for much of that time. He is a member of the Canadian Electrical Code (CEC) Part I - Section 18 Subcommittee and CSA's Integrated Committee on Hazardous Location Products. He was vice-chair of the task force that added the IEC Zone System to Section 18 and chaired the committee that adopted the IEC 60079 Series standards as CSA standards.

Marty is chairman of the Hazardous Location Products sub-section of Electro Federation Canada's (EEMAC) Wiring Products Section, a member of the Advisory Committee for the Objective Based Industrial Electrical Code (OBIEC), along with a number of other CSA Part 2 and IEC standards and technical committees. He has authored and co-authored a number of papers and articles on the subject of hazardous locations for the IEEE-PCIC, IEEE-IAS Magazine, EX Magazine and other industry publications.

Ken Martin graduated from the Southern Alberta Institute of Technology in 1982 in Electrical Engineering Technology and is an active member in The Alberta Society of Engineering Technology and received his C.E.T. in 1985. Presently after several years of selling in the petroleum/petrochemical community in Alberta he is an owner and technical sales representative for Brodwell Industrial Sales Ltd. in Calgary Canada. His primary focus is working with engineering firms and end users in the specifying of material for electrical equipment and controls in hazardous and non hazardous locations for over 18 years.

Appendix A
Survey of Major Producers Regarding Cell phone Use in Hazardous Locations

1. What is the primary means of communication for personnel working within a hazardous locations area?

Cell Phone		0%
Radio		80%
Land phone		0%
Other*		20%
	Total	100%

*Comments
1 - Talking via air waves - no electronic allowed

2. Does your company issue cell phones to operations personnel? (if yes answer question 3 otherwise go to question 4)

Yes		80%
No		20%
	Total	100%

3. Estimate the percentage of your operations personnel that routinely carry a mobile cell phone

0-10		0%
10-20		25%
20-40		50%
40-60		0%
60-100		25%
		100%

4. Does your company have a policy regarding the use of cell phones or two way radios in hazardous locations within their facilities? (if yes go to question 5, if no go to question 6)

Yes		100%
No		0%
	Total	100%

5. Does the policy permit the use of these devices in facilities with hazardous locations?

Yes		40
No		60
	Total	100%

6. Are there specific hazardous location rating requirements for the cell phones / radios for used in the facility?

Yes		80%
No		20%
	Total	100%

7. Has your company had any recorded incidents related to the use of cell phones or radios in hazardous locations?

Yes		0%
No		100%
	Total	100%

8. How does your company communicate their cell phone use policy to employees and visitors to their facilities?

Part of a safety orientation		0%
Safety handbook		25%
Permit practice		0%
Posted signs		0%
Other, Please Specify*		75%
	Total	100%

*Comments
1-all of above
2-All of the above
3-Orientation & posted signs

9. Does your company have a policy for operating cell phones in company vehicles while driving?

Yes		80%
No		20%
	Total	100%

10. How does your company communicate to visitors where areas classified as hazardous locations are?

Warning signs are posted in all areas		40%
Area Classification drawings in permit room		0%
No Policy in place		0%
Other, Please Specify*		60%
	Total	100%

*Comments
1-Orientation, signs and Operation escorts
2-Onsite safety training is mandatory before entry.

Appendix B

Cellular Phone Summary Test Results

Sample Number	1	2	3	4	5	6	7	8
Generation	2G	2.5G	2.5G	2.5G	2.5G	2G	2.5G	2.5G
Year of Manufacture	1999	1999	2001	2001	1996	2001	2001	2001
Form Factor	Clamshell	Bar	Clamshell	Bar	clamshell	Bar	Bar	flip phone
Surface area (cm^2)	198.48	204.5	179.6	186.04	179.6	204.5	223.1	189.28
Weight (grams)	156	142.5	151	108	125	142.5	133	125
Battery Type	Li-Ion	Li-Ion	Li-Ion	Li-Ion	Li-Ion	Ni-MH	Li-Ion	Li-Ion
Battery Capacity	1600 mAh	900 mAh	850 mAh	750 mAh	900 mAh	900 mAh	800 mAh	900 mAh
Battery Voltage	3.6V	3.6V	3.6V	3.6V	3.6V	3.6V	3.6V	3.6V
Hazardous Location Warning in Manual	yes	yes	yes	yes	yes	yes	yes	yes
Battery Short Circuit Hazard Warning	yes	yes	yes	yes	yes	yes	yes	yes

Visual Analysis								
Power On-Off Switch	electronic	electronic	electronic	electronic	electronic	electronic	electronic	electronic
Vibrator	yes	yes	yes	yes	yes	no	yes	yes
Micro Contacts	no	no	no	no	no	no	no	no
Battery Security Method	single latch	single latch	dual latch	single latch	single latch	single latch	dual latch	single latch
Battery Connections	spring terminal	spring terminal	spring loaded flat	plug connection	spring terminal	spring terminal	spring terminal	spring terminal
External Electrical Connections	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
External Battery Charging Connections	Yes	No	No	No	No	No	No	No

Tests								
Drop Test	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Pass
Visual Damage Inspection	none	none	none	none	exterior damage	none	none	none
Operational test after Drop test	operated	operated	operated	operated	operated	operated	operated	operated
Battery Short Circuit (Visual)	No Spark	No Spark	No Spark	No Spark	No Spark	No Spark	No Spark	No Spark
Battery Short Circuit (Temp Rise °C)	-3.6	-3	-0.5	-1	-0.8	-1.4	-0.7	-0.4
Vibrator Test (Test Chamber)	No Ignition	No Ignition	Not Tested	No Ignition	No Ignition	N/A	Not Tested	No Ignition

Attachment 13

Formal Interpretation Request - Use of Personal Electronic Devices for Payment Activities at Motor Fuel Dispensing Facilities

Cell Phone Usage At Gasoline Stations

Cell Phone Usage At Gasoline Stations

Prepared for

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December 1999

Doc. No. SF27489.000 B0T0 1299 CM03

Contents

Executive Summary

Exponent Failure Analysis Associates (FaAA) was retained by Motorola to investigate the potential hazards associated with the use of cell phones at gasoline service stations. Based on a review of literature concerning alleged fires of this nature, a review of standards and codes relating to electronic equipment at gasoline stations, the fundamental physics of combustion and ignition processes, and prior work on the ignition characteristics of equipment such as cell phones, FaAA has reached the following conclusions.

1. The use of a cell phone at a gasoline filling station under normal operating conditions represents a negligible hazard. Even at stations without vapor recovery systems, gasoline vapors will not collect in regions of expected cell phone operation. The small openings present in a typical cell phone casing act to limit the prospects for developing a combustible concentration at any site theoretically capable of acting as an ignition source, and may also act to quench flames and prevent their propagation if the vapors are ignited.

2. The possibility of abnormal operation of both the gasoline pump and the cell phone presents a potential hazard. Gasoline spills or sprays create larger flammable vapor volumes and the potential to initiate a fire of sufficient size and duration to ignite other combustible materials. The cell phone would still need to be within an area having a flammable mixture, for example lying on the ground near the filling operation or a spill. In addition, if the phone has no competent ignition source during normal operation, something would have to go wrong with the phone to provide a competent ignition source.

3. Published literature contains no credible evidence of cell phones igniting a fire at a gasoline station. Given the exposure (number of phones used at filling stations over the years throughout the world) and the lack of any confirmed incidents, the past performance of cell phones in this regard is outstanding. The likelihood of a cell phone starting a fire at a gasoline station is very remote. Automobiles (which have numerous potential ignition sources) pose a greater ignition hazard. Finally, other potential ignition sources are present, such as a static discharge between a person and a vehicle.

Introduction

Exponent Failure Analysis Associates (FaAA) was retained by Motorola to investigate the potential hazards associated with the use of cell phones at gasoline service stations. The following report describes the results of our investigation. It begins with a brief discussion of the relevant fundamental physics of combustion, ignition, and vapor propagation processes. This report then discusses the environment encountered at a gasoline station, including the physics accompanying tank filling, the relevant codes, and standards for electronic equipment at service stations, and the literature on alleged incidents at fueling stations. This report goes on to discuss the cell phone as a potential ignition source and concludes with a brief discussion, for comparison, of the potential ignition sources encountered with automobiles and drivers.

Physics of Combustion and Vapor Propagation

For combustion to occur four elements must be present: an oxidizer, a fuel, an ignition source, and free radicals to propagate the chemical reaction. In the environment of a gasoline station, the oxygen in the air acts as the oxidizer. Gasoline vapor, either emitted during the fueling process or evaporated from a spill, is the fuel. Competent ignition sources would be a spark or very hot surface. Free radicals will be present when gasoline vapors in air are ignited.

Not all fuel/air mixtures are ignitable, nor will all sparks or hot surfaces ignite all flammable mixtures. Whether a mixture will ignite and/or sustain a flame is determined by competition between the rate of heat generation where the air-fuel mixture is reacting (reaction zone), and the rate of heat transfer away from this reaction zone. If the rate of heat generation is higher, the temperature in the reaction zone rises and accelerates chemical reactions, ultimately resulting in a self-sustaining, propagating combustion zone or flame. If the rate of heat generation is lower than the rate of heat transfer away from the reaction zone, the reaction zone will cool, the chemical reaction rates will slow, and any reactions or flames will extinguish. The rates of heat generation and heat transfer are affected by numerous conditions including the fuel/oxidizer ratio (stoichiometry), the geometrical configuration of the system, and characteristics of the environment. These are discussed below in some detail.

Flammability Limits

Fuel/air mixtures have two flammability limits: a lower explosion limit (LEL) or lean limit, where the concentration of fuel is too low to allow flame propagation, and an upper explosion limit (UEL) or rich limit, where the concentration of fuel is too high and the available oxygen is too low to allow flame propagation. At each limit, the scarcity of one reactant results in a rate of heat generation that is just balanced by the rate of heat transfer away from the reaction zone. The flammability (explosive) limits of a fuel/air mixture are thus the prime measures for ascertaining whether a particular mixture is combustible. If the fuel concentration in a particular gas mixture is between the LEL and UEL, that mixture is ignitable if a competent ignition source is present. If the fuel concentration in a particular gas mixture is outside the range bounded by the LEL and UEL, then that mixture will not ignite.

Every fuel has unique flammability limits in a specific oxidizing atmosphere. These limits are determined by the fuel's specific combustion chemistry and the heat transfer properties of the surrounding atmosphere. Since detailed combustion chemistry can be very complex, flammability limits are determined empirically with standardized tests.[1] Gasoline is a mixture of hydrocarbons of various types[2] as well as other additives. Though values may vary for different grades and formulations of gasoline, NFPA–325[3] quotes general lower and upper flammability limits of 1.4% and 7.6% by volume in air at ambient conditions. To put these numbers in some perspective, OSHA has set the PEL (Permissible Exposure Limit) at 300 ppm (0.03%), and their STEL (Short-Term Exposure Limit) at 500 ppm (0.05%). OSHA[4] cites studies showing that exposure to concentrations between 500 and 900 ppm for one hour produces dizziness. While an odor threshold for gasoline is not absolute since its composition and people's sensitivity can vary, 3M[5] lists a value of 0.3 ppm (0.00003%). Thus the concentration of gasoline vapors in air at the LEL is several orders of magnitude greater than the point at which a person will smell gasoline, and also is far greater than the concentration ceilings that OSHA prescribes for workers.

Quenching Distance

A combustion reaction that is confined to a small opening or to the interior of a narrow space will lose heat or free radicals to the walls of the confining structure. This loss of heat or free radicals can prevent self-sustained combustion of otherwise flammable vapors. Flame extinction by this form of heat loss or radical loss is called "quenching." Quenching distance is a measure of the largest opening through which a flame will not propagate. The quenching distance of a specific mixture depends on the mixture composition, the characteristics and geometry of the surfaces surrounding the opening, and the atmospheric conditions (e.g. pressure and temperature). Quenching distance is an empirically determined parameter. For nearly stoichiometric mixtures (mixtures that are neither rich nor lean) of various hydrocarbons in air under atmospheric conditions, the quenching distance between electrodes is approximately 2

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1 ASTM E681 describes a standard test method for determining flammability limits.

2 Mobil Oil Corp., 15024-34 Automotive Gasoline, Unleaded, Material Safety Data Bulletin.

3 NFPA 325, "Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids," 1994.

4 OSHA Preambles, Air Contaminants (29 CFR 1910.1000) VI. Health Effects Discussion and Determination of Final PEL. www.osha_slc.gov/Preamble/AirCont_data/AIRCON6.html.

5 3M Occupational Health and Environmental Safety Division, 1990 Respirator Selection Guide, St. Paul MN, p. 20., 1990.

mm.[6] We therefore expect that a flame will not propagate through a flammable gasoline mixture through channels or openings that are significantly smaller than 2 mm (0.08 inches). In the context of electrical equipment, openings and gaps significantly smaller than 2 mm can prevent the propagation of a flame even if there is an interior ignition source.

Ignition Sources

A competent ignition source, assuming a combustible mixture is present, could be either a hot surface or a spark. For a hot surface to ignite a flammable mixture, its temperature must be above the auto-ignition temperature of the mixture. The auto-ignition temperature is determined experimentally by uniformly heating a specified volume of the mixture to different temperatures until full reaction is observed. NFPA-325 lists auto-ignition temperatures for gasoline that range from 536°F to 853°F. In practice, the hot surface temperature needed for ignition may be hundreds of degrees hotter than the auto-ignition temperature, since gases in contact with the surface will heat and convect away before reaching a temperature suitable for ignition propagation. The auto-ignition temperatures are well above the normal operating temperatures of any cell phone components; so hot surfaces would be an ignition concern only during a malfunction of the phone or battery, or if the battery's energy were used to heat some other object.

Electrical sparks are the result of a discharge of energy through a gap. The parameter of most significance for prediction of ignition is the spark energy. For any given vapor-air mixture, there is a "minimum spark ignition energy". Below this energy level, a spark will be incapable of igniting that specific vapor-air mixture. Minimum spark ignition energies are tabulated for specific fuel-air mixtures at specific atmospheric conditions, and are based on optimal electrode geometry and separation. The minimum spark energy required to ignite gasoline vapors is approximately 0.2 mJ at the optimum mixture ratio[7] (slightly rich of the stoichiometric mixture ratio) and optimum electrode spacing. The spark energy required for ignition increases as the mixture ratio departs from the optimum mixture ratio and the electrode spacing departs from the optimum spacing. As discussed above, the quenching distance for gasoline vapors is approximately 2 mm.

The energy available in a spark can be either calculated or experimentally measured. The sparking would occur, in the case of cell phones, if a current-carrying connection were opened. (Sparking is not a factor during the closing of a circuit because of the low voltages present in the cell phone.) To assess whether a generated spark can be considered competent to ignite a flammable mixture with a phone-battery combination, the spark energy should be computed or measured, and the distance between contact points during sparking determined, and these values compared to the minimum spark ignition energy and the quenching distance.

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6 Glassman, I., Combustion, 2nd Edition, pp. 312-313, 1987.
7 Glassman, I., Combustion, 2nd Edition, pp. 486-489, 1987.

Vapor Propagation

Gasoline vapors propagate in the atmosphere through a variety of physical processes. The slowest process is by diffusion. Other processes include forced convection (e.g., air currents or turbulent mixing), and buoyancy induced convection (e.g. heavier than air vapors descending). For vapors to enter an enclosure through an opening in a quiescent environment, diffusion would be the limiting process. Gasoline is a mixture of compounds, and a single value for the diffusivity of gasoline vapor in air is not definable. However based upon the diffusivities of pure hydrocarbons, we can roughly estimate the diffusivity, D, of gasoline vapors to be about 0.1 cm^2/sec.[8] A characteristic time for gasoline vapors to diffuse a distance of approximately an inch would be on the order of a minute. When considering enclosed spaces, such as the air passages inside a cell phone or battery, the concentrations of vapors outside and inside the phone will equilibrate by diffusion (in a quiet environment) and the minimum time for this to occur can be estimated based on the shape and dimensions of the enclosed space. A non-quiescent environment is one where the vapor propagation rate is dominated by one of the other processes mentioned. Experimental approaches are most effective to accurately quantify the time required to develop a flammable mixture in the interior of a specific cell phone design for a given set of circumstances. However, for a cell phone in a quiescent flammable environment, it could require on the order of minutes for sufficient gasoline vapors to diffuse into the enclosed spaces of a cell phone, and to build up to a flammable mixture.

Buoyancy has a strong effect in propagating gasoline vapors. Gasoline vapors are three to four times denser than air,[9] causing them to sink when released. Even at the LEL (the lowest ignitable fuel concentration), the fuel / air mixture is roughly 3%-4% heavier than air and will descend if a plume is released. Ignition sources closer to the ground therefore present a greater hazard than those higher up. Air currents and turbulence caused by wind, passing cars, and people will also increase the mixing of released vapors, diluting them to concentrations below the LEL.

Gasoline Stations

The concentration of gasoline vapors in an automobile's fuel tank is above the UEL. The concentration of these vapors is determined by the vapor pressure of the fuel in the tank. The vapor pressure, in turn, depends on the formulation (which varies with supplier, region, and time of year), temperature, and other factors. A typical value for the vapor concentration might be 50%. As the tank is filled, the vapors are displaced by liquid fuel. A characteristic flow rate for liquids (and hence vapors) would be 10 gallons per minute. At some locations, vapor recovery systems capture the bulk of the displaced vapor (California Air Resources Board certification requires a fleet average vapor recovery of 95% or better). If there is no vapor recovery system, the gasoline vapors will exit the nozzle at about the same rate as the tank is filled (e.g. 10 GPM),

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8 Perry's Chemical Engineers' Handbook, 6th Edition, McGraw-Hill Book Company, San Francisco, Sec. 3, pp. 256 –257, 1984.

9 NFPA-325, "Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids," 1994.

and will tend to descend to the ground and disperse. In the atmosphere, dilution causes the concentration of these vapors to decrease below the LEL. Calculating the regions where the vapor-air mixture is flammable is a complex function involving many factors. However, as an example, assume that a 20-gallon tank is filled, and 20 gallons of 50% gasoline vapor are emitted into the air surrounding the filler neck. If we further assume that the gasoline vapors remain within 1.5 ft of the ground, are uniformly mixed, and disperse radially to a distance of 20 ft (dimensions corresponding to the region identified by NFPA 70, the National Electrical Code, as Class I, Division 2 - discussed below), then the resulting mixture will be approximately 0.07% gasoline vapor (below the LEL of 1.4%). Even if the gasoline vapors only disperse radially to a distance of 10 ft, the resulting mixture would be approximately 0.3% gasoline vapor. These values are given for illustrative purposes only, since the vapor concentrations will not be uniform but will vary with time, height, and distance from the source, and will be affected by other factors such as wind or turbulence from vehicles or people passing by.

If gasoline is leaked or is spilled during the filling operation, additional vapor will be produced. The vapor will also descend and stay low to the ground due to its greater density. If the spill or leak is significant, then ignition of the vapors will create a pool fire potentially capable of igniting other materials in the vicinity.

Codes and Standards

The National Fire Protection Agency (NFPA)[10] and the Uniform Fire Code (UFC)[11] have standards for service stations reflecting the hazards present from expected operating conditions. The NFPA 30A Code, Section 9-9 requires that warning signs be conspicuously posted in the dispensing area incorporating the following wording: “WARNING – It is unlawful and dangerous to dispense gasoline into unapproved containers. No Smoking. Stop Motor.” These warnings are designed to prevent large spills of gasoline, and to prevent ignition of low-lying vapors from sources such as discarded matches or operating automobiles.

Both the NFPA and UFC codes classify various regions around gasoline service stations and dispensing devices for the purposes of installation and utilization of electrical equipment under the classes and divisions defined in Chapter 5, Article 500 of the NFPA 70, National Electrical Code[12]. The figures from NFPA-30A are attached (Table 1, and Figure 1). They show that the area within the dispenser enclosure is rated as an NEC Class I, Group D, Division 1 area. The area within 18 inches surrounding a dispenser, and 18 inches above the ground level to a distance of 20 feet surrounding the dispenser is rated an NEC Class I, Group D, Division 2 area.[13]

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[10] NFPA 30A, “Automotive and Marine Service Station Code,” 1996.
[11] UFC, Article 52, “Motor Vehicle Fuel-Dispensing Stations,” 1997.
[12] NEC, Article 500, 1999.
[13] Articles 501 and 504 of the NEC define requirements for intrinsically safe electronic devices in Class I, Division 1 and Class I, Division 2 areas.

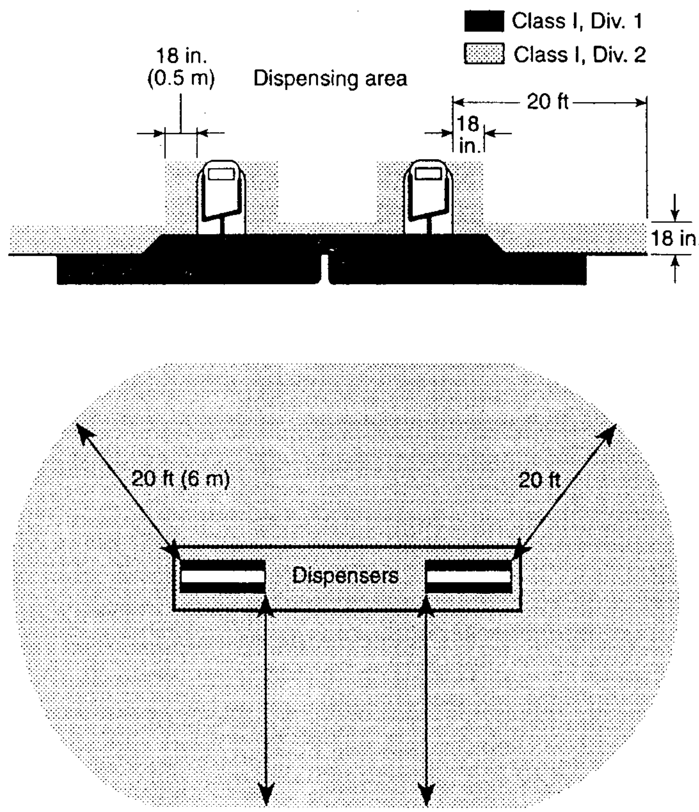

Figure 1. Classified areas adjacent to dispensers as detailed in Table 1 [Table 7, NFPA 30A–1996 "Automotive and Marine Service Station Code"].

The NEC rating system defines Class I locations as "those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures." Group D includes those locations in which gasoline vapors are or may be present. Division 1 locations are those in which:

1. "ignitable concentrations of flammable gases or vapors can exist under normal operating conditions; or

2. ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or

3. breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment..."

Division 2 locations are those in which:

1. "volatile flammable liquids or flammable gases are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or
2. ignitable concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operation of the ventilating equipment; or
3. that is adjacent to a Class I, Division 1 location, and to which ignitable concentrations of gases or vapors might occasionally be communicated unless such communication is prevented…"

In Article 500, the NEC specifies a variety of "acceptable protection techniques" for electrical equipment in classified locations. These techniques include a product being designated explosion-proof, intrinsically safe, or nonincendive. Each of these "protection techniques" references a series of standardized tests that a product must withstand.[14] The nonincendive designation is the least strict of the acceptable techniques: it is acceptable in Division 2 locations, but not in Division 1 locations. A nonincendive designation requires that circuits and components under intended operating conditions be incapable of causing ignition of a specified flammable gas- or vapor-air mixture. In addition, in Article 501, the NEC specifies minimum standards for electrical equipment construction and installation for use in Class I, Division 1 and Division 2 areas.

FaAA has not evaluated whether any cell phones or batteries produced by Motorola or by any other manufacturer meet the requirements for Class I, Group D, Division 1 or 2 locations. However, in order to encounter an NEC classified location (Division 2), a cell phone would have to be held close to the fuel dispenser, or be lying on or within 1½ feet of the ground and within 20 feet of the dispenser. Both of these are possible scenarios, but do not represent typical cell phone usage conditions. It is very unlikely that a gasoline station customer would be able to introduce a cell phone into a Division 1 area.

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[14] ANSI/UL 1203 "Explosionproof and Dust-Ignitionproof Electrical Equipment for Use in Hazardous (Classified) Locations," ANSI/UL 913 "Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous Locations," UL 1604 "Electrical Equipment for Use In Class I and II, Division 2, and Class III Hazardous (Classified) Locations."

Literature on Alleged Incidents at Fueling Stations

The literature we reviewed was filled with articles expressing concerns and opinions on the potential hazards of cell phone use at gasoline stations.[15 - 23] However, our search uncovered no instances of fires or explosions that were confirmed to have been caused by the operation of a cellular phone in a gasoline station. While there have been reports of cellular phones allegedly starting fires in gasoline stations, further investigation showed these reports to be unsubstantiated.[24, 25]

Cell Phones as an Ignition Source

FaAA has not undertaken an analysis of every model and style of cell phone or related communication device produced either by Motorola or any other manufacturer. However, we can provide some general guidelines for evaluating ignition hazards. For the cell phone to be considered a competent ignition source, it would need to either:

a) discharge enough energy via a spark in a geometry where the gaps are larger than the minimum quenching distance, or

b) it must have a component or area heated to a temperature high enough for hot surface ignition to occur.

As discussed earlier, the minimum spark energy required for ignition is 0.2 mJ (0.0002 Joules), and the minimum quenching distance is about 2 mm. The minimum temperature for hot surface ignition is geometry dependent, but will be hotter than the auto-ignition temperature of gasoline, which is about 536 ºF. Both of these types of ignition sources are discussed below.

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15 Associated Press, "Cell phones to be banned at gas stations in Finland as safety debate continues," January 14, 1999.

16 Kathy Chen, "Latest Urban Legend? Cell Phones Igniting Fumes at Gasoline Stations," *The Wall Street Journal*, July 9, 1999.

17 Paul Zucker, The Gale Group, "Don't Use Cellular Phones at Service Stations," April 22, 1993.

18 Associated Press Information Services, "BP Amoco Curbs Cellular Phone Use," October 8, 1999.

19 Associated Press Information Services, "Report: BP Amoco to Ban Cell Phones," October 7, 1999.

20 The Gale Group, "Shell bans mobile phones on forecourts," July 9, 1993.

21 *Kyodo News International, Inc*., "Cellular Phones May Cause Fire at Gas Stands," June 7, 1999.

22 WTN 1204-99.

23 *Bridge News*, *Sao Paulo*, "KRF Brazil newspaper summary: new law restricts cellular phone use," September 11, 1996.

24 *The Hong Kong Standard*, "Mobile phone ruled out as cause of petrol station blast," March 4, 1999.

25 *Newsbytes*, "Hong Kong advises against mobile phone use in gas stations," June 13, 1999.

Spark Discharge

The possibilities for a cell phone to create a spark are limited, and include:

a) Pressing buttons

b) Disconnecting the battery

c) Vibrator mode

d) Accidental shorting of the battery terminals

e) Electrostatic discharge

In each of these circumstances, energy is stored either in the electromagnetic fields associated with the current, or in electrostatic fields (e.g. capacitors). This energy might result in the release of a spark that jumps between the terminals when a circuit is opened (for example by the release of a pressed key).

If the battery is disconnected during operation, the energy dissipated in any spark will be related to the current drain on the battery, and the circuitry connected to the battery. This energy will be dependent on the phone type and mode of operation. The sparking, if any, will occur between the battery contacts and the cell phone contacts, an area enclosed in most phones and therefore unlikely to have a combustible mixture present at the moment of sparking.

The vibrator in some phones is a tiny motor with an eccentric weight. Depending on the type of motor, for example one with brushes, sparks may be generated with operation. The motor is enclosed within the phone housing, and is therefore unlikely to be in contact with a combustible mixture of gases if the phone is placed briefly in a combustible atmosphere.

Accidental shorting and opening of the battery terminals by some external agent is a remote possibility when in use. Motorola batteries traditionally have over-current protection (and some have diode protection) that limit or prevent discharging current through the exposed external terminals in the event of a direct short. Furthermore, the terminals are guarded, so a short across the terminals is very unlikely. Thus, sparking due to external shorting of the battery terminals is difficult to achieve in practice.

Electrostatic discharge might arise from triboelectric processes, such as rubbing a plastic object against fabric. Materials vary in their ability to collect a static charge. Materials that are more conductive have a lesser ability to build up a localized static charge. FaAA has not performed any investigations into the capacity for static charge buildup by cell phones or batteries made by Motorola or any other manufacturer.

In some of the articles listed above, the energy during transmission was identified as a potential ignition source. FaAA has seen no credible evidence of this being an ignition source.

Hot Surface Ignition

As discussed earlier, the surface temperature needed to ignite a combustible mixture of gasoline vapor and air will be higher than the auto-ignition temperature. A very conservative estimate for the hot surface temperature needed for ignition would be the auto-ignition temperature for gasoline vapor-air mixtures, which is at or above 536 F. Under normal operation, no surfaces on or in the phone or battery reach temperatures close to this value. Therefore, hot surface ignition for a normally operating phone is not a consideration.

Under fault conditions, a component or components can reach temperatures above the auto-ignition temperature. One fault condition would be a short circuit between cells internal to the battery, or a short circuit inside a cell, such as a Li ion cell. In these cases, components might reach temperatures high enough to serve as ignition sources. The battery is generally well enclosed, and therefore getting a combustible mixture inside the battery housing would be difficult. Furthermore, the combustible mixture would have to be present during the brief period of time that the cells short. The probability of this happening is very remote.

Another fault condition might be overheating and thermal runaway of a component or components inside the cell phone. Generally, this would be a transient event, and would occur within the enclosure of the cell phone. It is very unlikely that a combustible mixture of gasoline vapor and air would enter the phone enclosure, and furthermore that it would occur at the moment that a component overheated. There may be rare circumstances where the heat generated by the component overheating breaches the enclosure. These circumstances are exceedingly rare and do not pose a significant concern, especially when the overheating must coincide with the phone being positioned in a combustible mixture at the moment of component failure.

Motor Vehicles as Ignition Sources

The engine in a motor vehicle can act as an ignition source if operated in a combustible environment. Some potential ignition sources are: alternator brushes, starter motor assembly, electric fans on the radiator, grounded spark plug wires, and even hot surfaces on an exhaust system of an abnormally performing engine. Most of these sources would be closer to the ground than a cell phone in operation, and thus closer to any combustible mixtures of gasoline vapor and air resulting from filling operations or a spill. Another possible ignition source is static discharge between the driver and the car that might occur in dry weather. Such discharges, which would occur when the driver first touches the body of the car, might happen in the vicinity of the filler opening. The spark energy associated with electrostatic discharge

(ESD) by a person depends upon many factors. For comparison purposes, electrostatic discharge (ESD) simulator requirements can reach 10 mJ or higher.[26]

Conclusions

Based on our analyses, the ignition of flammable vapors at a gasoline station by a cell phone is a highly unlikely event. While the cell phone cannot be ruled out as a potential ignition source under all physically possible scenarios, numerous other more likely ignition sources are present during the normal process of refueling a vehicle. This conclusion is supported by the following observations:

1. No confirmed incidents of fires at gasoline stations started by cell phones have been found.

2. Combustible vapors produced during fueling will not generally collect in regions of probable cell phone operation.

3. The small openings present in a typical cell phone's casing will limit the concentration of any combustible vapors present within the cell phone. In addition, narrow gaps may quench any flames if they are ignited internally, preventing their propagation outside the enclosure.

4. A combination of events would have to occur in order to create an accident, including:

   a. the placement of the cell phone in a flammable mixture for a sufficient length of time to allow a flammable mixture to form inside the cell phone,

   b. a fault, malfunction, or spark generation in the cell phone that would produce a competent ignition source that could propagate outside of the battery or phone enclosure.

   (A spill or dispersion of liquid gasoline on or near the phone would increase the hazard by increasing the likelihood of having combustible vapors present at the ignition source.)

5. Automobiles and the process of refueling provide potential ignition scenarios that are more likely to result in flammable vapor ignition.

In summary, the enclosures protecting the battery and cell phones, the low voltages and current drains of these components, the geometry of their interconnections, and the physics of electrical discharge and vapor diffusion strongly direct against the cell phone and battery acting as an ignition source while at a service station.

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[26] DOD-HDBK-263, IEC 801-2.

Table 1: From NFPA 30A – 1996 "Automotive and Marine Service Station Code"

Location	NEC Class I, Group D Division	Extent of Classified Area[1]
Underground Tank Fill Opening	1	Any pit, box, or space below grade level, any part of which is within the Division 1 or 2 classified.
	2	Up to 18 in. above grade level within a horizontal radius of 10 ft from a loose fill connection and within a horizontal radius of 5 ft from a tight fill connection.
Vent — Discharging Upward	1	Within 3 ft of open end of vent, extending in all directions.
	2	Area between 3 ft and 5 ft of open end of vent, extending in all directions.
Dispensing Device[2,3] (except overhead type)[4]		
Pits	1	Any pit, box, or space below grade level, any part of which is within the Division 1 or 2 classified area.
Dispenser	2	Within 18 in. horizontally in all directions extending to grade from (1) the dispenser enclosure or (2) that portion of the dispenser enclosure containing liquid handling components.[3]
Outdoor	2	Up to 18 in. above grade level within 20 ft horizontally of any edge of enclosure.
Indoor with Mechanical Ventilation	2	Up to 18 in. above grade or floor level within 20 ft horizontally of any edge of enclosure.
with Gravity Ventilation	2	Up to 18 in. above grade or floor level within 25 ft horizontally of any edge of enclosure.
Dispensing Device — Overhead Type[3, 4]	1	The area within the dispenser enclosure, and all electrical equipment integral with the dispensing hose or nozzle.
	2	An area extending 18 in. horizontally in all directions beyond the enclosure and extending to grade.
	2	Up to 18 in. above grade level within 20 ft horizontally measured from a point vertically below the edge of any dispenser enclosure.
Remote Pump — Outdoor	1	Any pit, box, or space below grade level if any part is within a horizontal distance of 10 ft from any edge of pump.
	2	Within 3 ft of any edge of pump, extending in all directions. Also up to 18 in. above grade level within 10 ft horizontally from any edge of pump.
Remote Pump — Indoor	1	Entire area within any pit.
	2	Within 5 ft of any edge of pump, extending in all directions. Also up to 3 ft above floor or grade level within 25 ft horizontally from any edge of pump.
Lubrication or Service Room — with Dispensing	1	Any pit within any unventilated area.
	2	Any pit with ventilation.
	2	Area up to 18 in. above floor or grade level and 3 ft horizontally from a lubrication pit.
Dispenser for Class I Liquids[3]	2	Within 3 ft of any fill or dispensing point, extending in all directions.
Lubrication or Service Room — without Dispensing	2	Entire area within any pit used for lubrication or similar services where class I liquids may be released.
	2	Area up to 18 in. above any such pit and extending a distance of 3 ft horizontally from any edge of the pit.
	2	Entire unventilated area within any pit, below-grade area, or subfloor area.
	2	Area up to 18 in. above any such unventilated pit, below-grade work area, or sub-floor work area and extending a distance of 3 ft horizontally from the edge of any such pit, below-grade work area, or sub-floor work area.
	Nonclassified	Any pit, below-grade work area, or sub-floor work area that is ventilated in accordance with 5-1.3.
Special Enclosure Inside Building Per 2-2	1	Entire enclosure.
Sales, Storage, and Rest Rooms	Nonclassified	If there is any opening to these rooms within the extent of a Division 1 area, the entire room shall be classified as Division 1.
Vapor Processing Systems Pits	1	Any pit, box, or space below grade level, any part of which is within Division 1 or 2 classified area or that houses any equipment used to transport or process vapors.
Vapor Processing Equipment Located within Protective Enclosures (*see 4-5.7*)	2	Within any protective enclosure housing vapor processing equipment.
Vapor Processing Equipment Not within Protective Enclosures (excluding piping and combustion devices)	2	The space within 18 in. in all directions of equipment containing flammable vapors or liquid extending to grade level. Up to 18 in. above grade level within 10 ft horizontally of the vapor processing equipment.
Equipment Enclosures	1	Any area within the enclosure where vapor or liquid is present under normal operating conditions.
	2	The entire area within the enclosure other than Division 1.
Vacuum-Assist Blowers	2	The space within 18 in. in all directions extending to grade level. Up to 18 in. above grade level within 10 ft horizontally.