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Risk Assessment in Compressed Natural Gas (CNG) Pumping Stations

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Abstract: ***The study considers the application of Quantitative Risk Assessment (QRA) on the siting & storage of Compressed Natural Gas (CNG) stations and determining nearby land use limitations. In such cases the most important consideration is to be assured that the proposed site would not be incompatible with existing land uses in the vicinity. An analysis of the consequences and likelihood of credible accident scenarios coupled with acceptable risk criteria is then undertaken. According to the results in many cases, not only required distances have not been provided but also CNG stations are commonly located in vicinity of populated areas to facilitate refuelling operations. This is chiefly because of inadequate risk assessment studies and ambiguities to define acceptable risk criteria. Prepared work instructions, worker education, fix and maintenance and regularly equipment calibration can be useful in prevention of accidents in CNG stations.***

Keywords : Compressed Natural Gas (CNG), Individual Risk (IR), Quantitative Risk Assessment (QRA), Hazard & Operability studies (HAZOP), Health, Safety & Environment (HSE), Light Commercial Vehicle (LCV), American National Safety Institute (ANSI), Program Logic Control (PLC), Emergency Shutdown Systems (ESD).

I. INTRODUCTION

Compressed Natural Gas (CNG) has been distinguished as one of the substitute fills to fluid petroleum energizes, which has included natural advantages. This fuel is being utilized globally with the demonstrated accomplishment as a car fuel. CNG is a blend of hydrocarbon gasses and vapours comprising of mainly methane in vaporous structure which are packed to a weight of 200 to 250 bars for use as a vehicular fuel.

Natural Gas is a new age fuel. With standout carbon and four hydrogen atoms for each particle, Natural Gas has the least carbon to hydrogen proportion, thus it blazes totally, making it the cleanest of fossil energizes. Regular Gas fulfils the greater part of the prerequisites for fuel in a cutting edge modern culture, being effective, non-dirtying and moderately efficient. The intermittent vulnerabilities and unpredictability in both the cost and supply of oil have likewise helped Natural Gas develop as a noteworthy fuel in the vitality wicker container crosswise over nations.

Natural Gas comes in 4 basic forms:

A. Liquefied Natural Gas (LNG)

Natural Gas which has been melted at – (Minus) 160 degree centigrade. Normal Gas is melted to encourage transportation in substantial volumes in cryogenic tankers crosswise over ocean.

B. Re-gasified Liquefied Natural Gas (RLNG)

LNG Re-gasified before transporting it to purchasers through Pipelines.

C. Compressed Natural Gas (CNG)

Natural Gas compressed to a weight of 200-250 kg/cm2 utilized as fuel for transportation. CNG vehicular contamination on the goodness of being cleaner fuel than fluid energizes.

D. Piped Natural Gas (PNG)

Natural Gas circulated through a pipeline system that has wellbeing valves to keep up the weight, guaranteeing protected, continuous supply to the household part to cook and heating applications.

II. COMPOSITION & PROPERTIES OF NATURAL GAS

A. Typical Composition of Natural Gas

1) *Methane (CH_4):* 85-90%
2) *Ethane (C_2H_6):* 5-7%
3) *Propane (C_3H_8):* 2%
4) *Carbon di-oxide:*3-5%
5) *Others:* 1%

B. Physical Properties of Natural Gas:

1) Colourless
2) Non-toxic
3) Lighter than air
4) Non-corrosive

C. Other Properties of Natural Gas:

1) Boiling point – (-) 161.5º
2) Freezing point – (-) 182.6 º
3) *Vapour density* – 0.65 (air-1)
4) *Solubility in water* – soluble in water at 30 º
5) Chemical stability - stable
6) Hazardous reaction product- forms flammable mixture

III. BENEFITS OF NATURAL GAS

A. A Clean & Green Fuel

Ordinarily the green fuel in light of its lead and sulphur free character, CNG lessens unsafe outflows. Because of the nonappearance of any lead or benzene content in CNG, the lead fouling of sparkle attachments and lead or benzene contamination are wiped out.

B. Increased Life of Oils

Another practical advantage observed is the increased life of lubricating oils, as CNG does not contaminate and dilute the crankcase oil.

C. Mixes evenly in Air

Being a gaseous fuel CNG mixes in the air easily and evenly enabling complete combustion.

D. Low Operational Cost

The other fuels like petrol, diesel and LPG vehicles are running more than the operational cost of CNG vehicles is significantly high. Good average in comparison to other fuel.

IV. RELATED WORKS

A. Naser Badri et al., (2010) "Quantitative Risk Assessment to Site CNG Refuelling Stations"

This study considers the utilization of quantitative Risk Assessment (QRA) on the siting of packed characteristic gas (CNG) stations and deciding adjacent area use impediments. In such cases the most critical thought is to be guaranteed that the proposed site would not be contradictory with existing area utilizes as a part of the region. It is conceivable by the classification of the assessed levels of individual Risk (IR) which the proposed site would force upon them. An investigation of the outcomes and probability of valid mischance situations combined with adequate danger criteria is then embraced. This empowers the IR parts of the proposed site to be considered at an early stage to permit brief reactions or in the later stages to watch confinements. As per the outcomes much of the time, required separations have not been given as well as CNG stations are generally situated in region of populated ranges to encourage refuelling operations. This is essentially in view of lacking danger evaluation studies and ambiguities to characterize satisfactory danger criteria.

B. Mahmood Farzaneh-Gord et al., (2011) "Studying effects of storage types on performance of CNG filling stations"

At CNG filling station, packed common gas must be put away framework with a specific end goal to make the use of the station more proficient. There are two frameworks for putting away regular gas in particular cushion and course stockpiling frameworks. In cradle stockpiling, CNG is put away at single high-weight supplies. The course stockpiling framework is typically isolated into three stores, by and large termed low, medium and high-weight repositories. In current study, taking into account first and second laws of thermodynamics, discussion of mass and genuine gas suppositions, a hypothetical investigation has been created to study impacts of reservation sort on execution of CNG filling stations and filling process. Considering the same last regular gas vehicle barrel

(NGV) on-board in-chamber pressure for both stockpiling frameworks, the outcomes demonstrate that every capacity sort has points of interest over the other. The best design ought to be chosen by adjusting these favourable circumstances.

C. EuiSoo Kim et al., (2013) "Risk analysis of CNG composite pressure vessel via computer-aided method and fractography"

As ecological issues undermine the across the board utilization of fossil fills, Compressed Natural Gas (CNG) vehicles are investigated as another option to the traditional gas fuelled vehicles. CNG vehicles must be furnished with sheltered and solid stockpiling tanks, for example, composite pressure vessels, since the disappointment of the CNG stockpiling tank can prompt traveller fatalities and wounds. The most likely explanations of disappointment of the CNG vehicles are flame and vessel break. In this exploration, the reason for vessel disappointment is examined through formal assessment and building test strategies. In particular, the disappointment component will be distinguished by fractography, and the material properties of a reference part will be researched through the instrumented space method. Also, the composite weight vessel configuration will be accepted utilizing the limited component technique.

D. Muhammad Imran Khan et al., (2015) "Technical overview of compressed natural gas (CNG) as a transportation fuel"

Expanding urbanization and industrialization have prompted an exceptional development in transportation request around the world, combined with a grouping of vehicles in metropolitan urban areas. Concerning progressively stringent emanation enactment normal gas is picking up enthusiasm as a transportation fuel with worldwide more than 19 million characteristic gas vehicles in operation. This paper shows the overall foundation, prospects and difficulties of characteristic gas fuel and common gas energized vehicles alongside ecological and financial parts of compacted regular gas as a change fuel. Specialized parts of compacted characteristic gas properties, stockpiling, wellbeing issues and its impact on motor execution, effectiveness, discharges and hindrances to normal gas vehicles adjustment are talked about in point of interest. The principle pointers chose for the relative evaluation of regular gas as vehicular fuel seem to be: monetary, emanation execution and wellbeing viewpoint. The outcomes demonstrated that CNG has a few focal points over both diesel and gas fuel, including impressive emanation and cost decreases.

V. COMPRESSED NATURAL GAS

A. Compressed Natural Gas

When the natural gas is compressed to higher pressure, it is called Compressed Natural Gas. The CNG is dispensed through the CNG stations to CNG customers. Natural gas is compressed to a pressure of 200-250 Kg/cm² (g) (due to its low density) to enhance the vehicle onboard storage capacity. Thus, the compressed form of natural gas is used as a fuel for transportation purposes.

B. Types of CNG Stations

Mother station, Online station, Daughter Booster station, Daughter station.

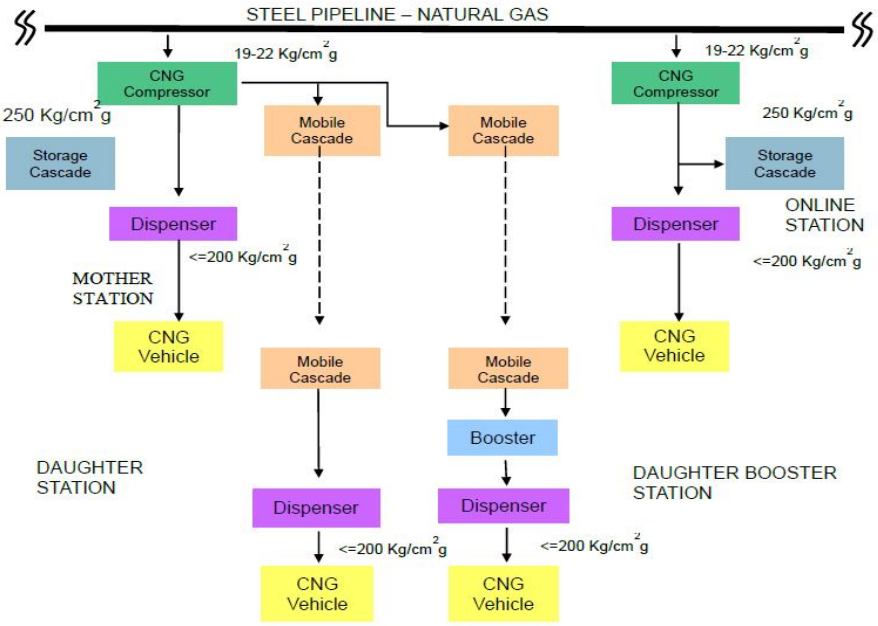


Fig 5.1: Process of Compressed Natural Gas

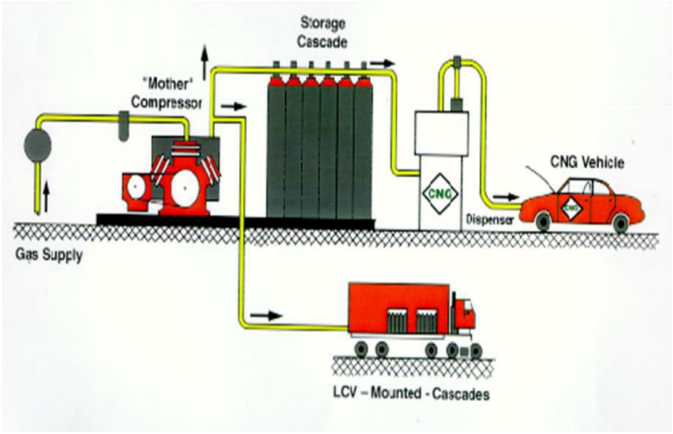


Fig 5.2: Mother CNG Station

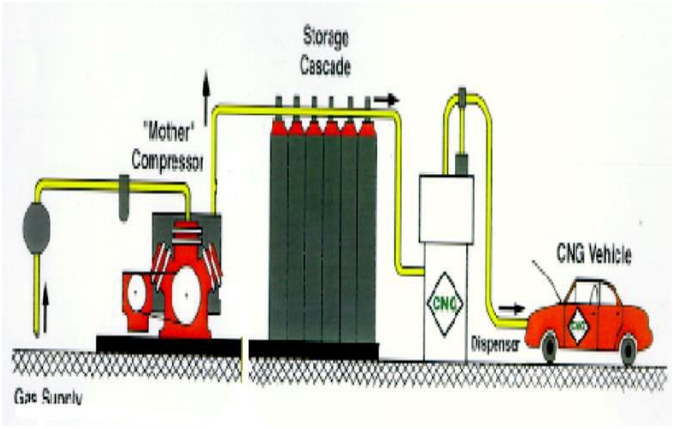


Fig 5.3: Online CNG Station

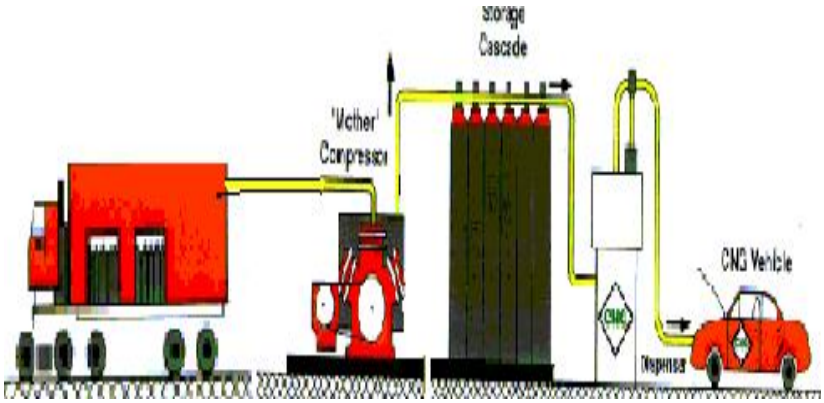


Fig 5.4: Daughter Booster Station

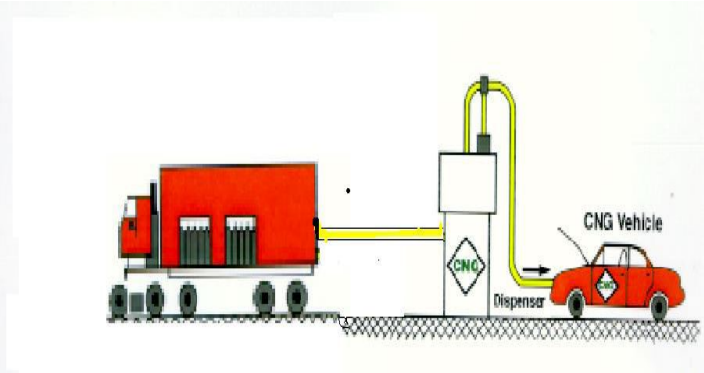


Fig 5.5: Daughter Station

C. Elements of CNG Pumping Station

A CNG pumping station has a number of components to be dealt with in order to have a steady flow of CNG through the cascades up to the point of discharge into the vehicle.

The following are the different elements that can be seen normally in a CNG pumping station:

1) Gas Compressor
2) Cascade
3) Dispenser
4) Air compressor
5) Generator
6) SS tubing (Stainless Steel)
7) Metering skids
8) Light Commercial Vehicle (LCV)

It is very much evident to look upon each element of the CNG station in order to infer the different type of risks associated with each element as well as to quantify the risk in order to have a safe fuel filling premises.

VI. RISK ASSESSMENT IN CNG PUMPING STATIONS

A. Quantitative Risk Assessment (QRA):

It is a method for making an efficient investigation of the dangers from risky exercises, and shaping a level headed assessment of their essentialness, keeping in mind the end goal to give contribution to a basic leadership process. QRA is now and then called 'probabilistic danger appraisal' or 'probabilistic security examination'; terms initially utilized as a part of the atomic business. The term 'quantitative danger investigation's is generally utilized, yet entirely this alludes to the absolutely numerical examination of dangers with no assessment of their centrality. The study depends on the premises of a conventional Quantitative Risk Assessment.

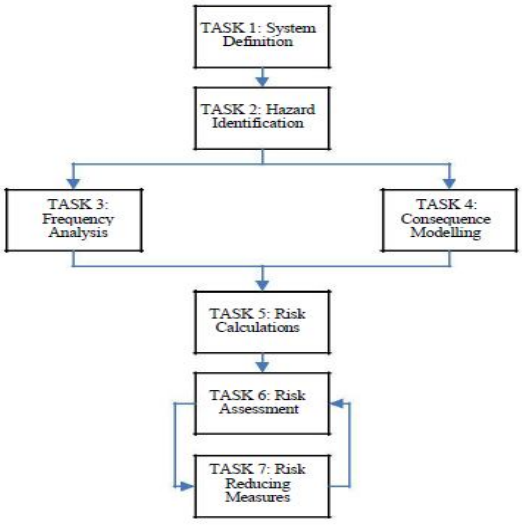


Fig 6.1: QRA Methodology

The Hazard distinguishing proof comprises of a subjective survey of conceivable mischances that may happen, taking into account past mishap experience or judgment where essential. There are a few formal systems for this, which are valuable in their own entitlement to give a subjective valuation for the reach and greatness of dangers and show suitable relief measures. This subjective assessment is depicted as "Hazard assessment".

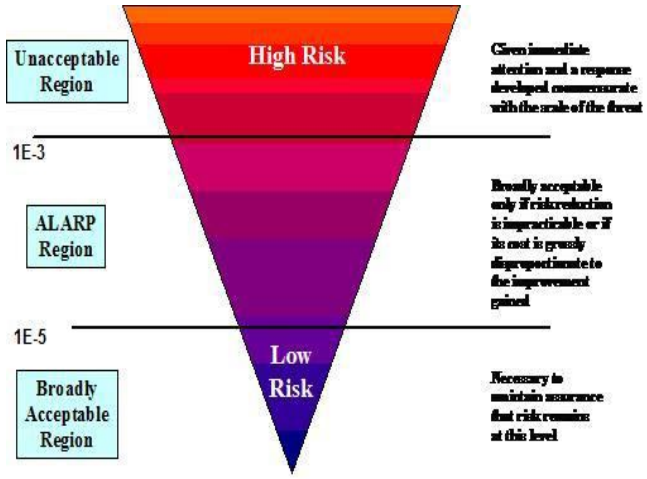


Fig 6.2: Risk Assessment pyramid

VII. SAFETY MEASURES IN CNG PUMPING STATIONS

A. General Safety Rules & Guidelines

1) Smoking is strictly prohibited in the areas where flammable materials are handled
2) Employees should not leave their jobs until the persons to relieve them are properly advised of all operating conditions
3) Personal protective equipment must be worn by employees while handling hazardous substances
4) Only authorized personnel should operate or stop the equipment and can change the status of valves etc. Other personnel are strictly prohibited from operating any of the equipment except during emergency that too under the instruction authorized personnel
5) All employees including contractor employees shall wear safety belt while working at heights of more than 1.2m and where adequate protection or working platform or proper railing as a safeguard against falling is not available
6) In addition to the requirement of wearing a safety belt while working at height, the employees shall also wear safety belt with life line anchored when they go inside any tank/vessel or sewers or enclosed spaces
7) Before starting any repair or maintenance work on the equipment/system, make sure that you have obtained the necessary safety work permit
8) Use of flash type camera or any other non-flame proof instruments, mobile phones or machines are not permitted in hazardous area
9) Carrying of any arms and ammunitions inside the operating area is strictly prohibited
10) When any dangerous/unsafe condition is observed, it should be immediately reported to your supervisor and/or safety department
11) All stairways, platforms and walkways must be kept clean at all times
12) Do not attempt to operate or set in motion any machine or equipment to which you are not assigned
13) Horseplay is strictly forbidden. Apply your thoughts to safety and through workmanship
14) Do not use defective equipment of any kind
15) Keep the fire fighting equipment free from all obstructions as these are required to be used in emergencies
16) Any injury, no matter how minor it is must be reported to your supervisor and safety department.
17) In case of oil/chemical spill on your body, wash thoroughly with water & change your clothes and report immediately to hospital for further treatment/advice
18) If any gas leak occurs, inform your supervisor area in charge and the fire & safety dept., stop all hot jobs, and keep spark producing equipment away from the leakage area

19) All traffic sign and regulations must be observed at all times
20) When ascending or descending monkey ladder, it is important that worker faces the ladder and obtains a firm grip with both hands
21) Portable ladders when placed must either be fixed at the top or a man must be stationed to hold the foot of the ladder
22) Ladders must be carefully lowered and not be dropped on to the floor or any other object/structure
23) Never place the ladder on slippery floor
24) Rest the top of the ladder on a solid base and secure it by tying
25) Ensure that the ladder is placed at a safe angle
26) Always face the ladder and hold with both the hands while climbing and descending
27) Follow the three point contact rule strictly
    a. Do not climb the ladder with muddy/slippery shoes
    b. Place ladders on a firm base and secure at top of ask person to hold the ladder
    c. Ladders should rise at least 1 meter above landing place
28) Beware of overhead lines while using ladders
29) When climbing on ladders or structures, carry tools or material in shoulder bag / waist bag so as to provide free use of your hands
30) Do not leave tools or materials in such a manner or at such places where they may accidentally fall on persons below
31) Do not wear polyester (Terene/ Terylene) or nylon or any other synthetic fibre clothing while on duty. There are chances of generation of static charge in these clothing which may become a source of ignition

B. *General Safety Rules for CNG Pumping Stations*

1) Switch off the mobile phones while entering the CNG station
2) Validity of the CNG cylinder should be ensured before refuelling
3) Keep watching the customers and passengers not to use their mobile phones inside CNG station area
4) Request passengers & visitors to stay away from the dispenser, high pressure & unauthorized entry area
5) Ensure no vehicle is started when there is any leakage in the CNG station
6) Ensure that there are no unauthorized persons inside the restricted entry area
7) Always use PPE while moving around the compressor & high pressure area
8) Keep yourself away from the hot surface while inspecting compressor & generator
9) Do not open the doors of running compressor & generator
10) In case of any leakage of gas inside the CNG station immediately stop refilling & stop the compressor. Do not allow the driver to start vehicles & move vehicles away from the leakage area by manual push method to safe area
11) Identify & know the location of the emergency shutdown buttons for compressor & dispensers in the CNG station. Also learn how to operate these ESD
12) Ensure that there is no leakage of gas from cascade or from any fittings. Leak test should be done with foam solution or with a portable gas detector
13) Ensure that cascade cylinders are hydraulically tested every three years
14) Always follow work permit system while doing any maintenance work in CNG station
15) Keep away from the live part of the electrical installation
16) Ensure placement of Fire Extinguishers at safe distance and easily accessible place for use in case of emergency
17) Know how to operate fire extinguishers in case of any fire in the CNG station
18) In case of emergency follow the emergency action plan
19) Do not refill the CNG while passengers are inside the vehicle
20) Use of match box, open flame & smoking is prohibited inside the CNG station
21) Identify & know the location of the isolation valves in the CNG station which will require to be closed during any emergency in CNG station
22) Be aware of the location & operation of the cylinder valve, master shut off valve and burst disc of the CNG vehicle cylinder. The valves are required to be closed during any gas leakage in the CNG vehicle

C. *Safety Instructions for Filling CNG Vehicle*

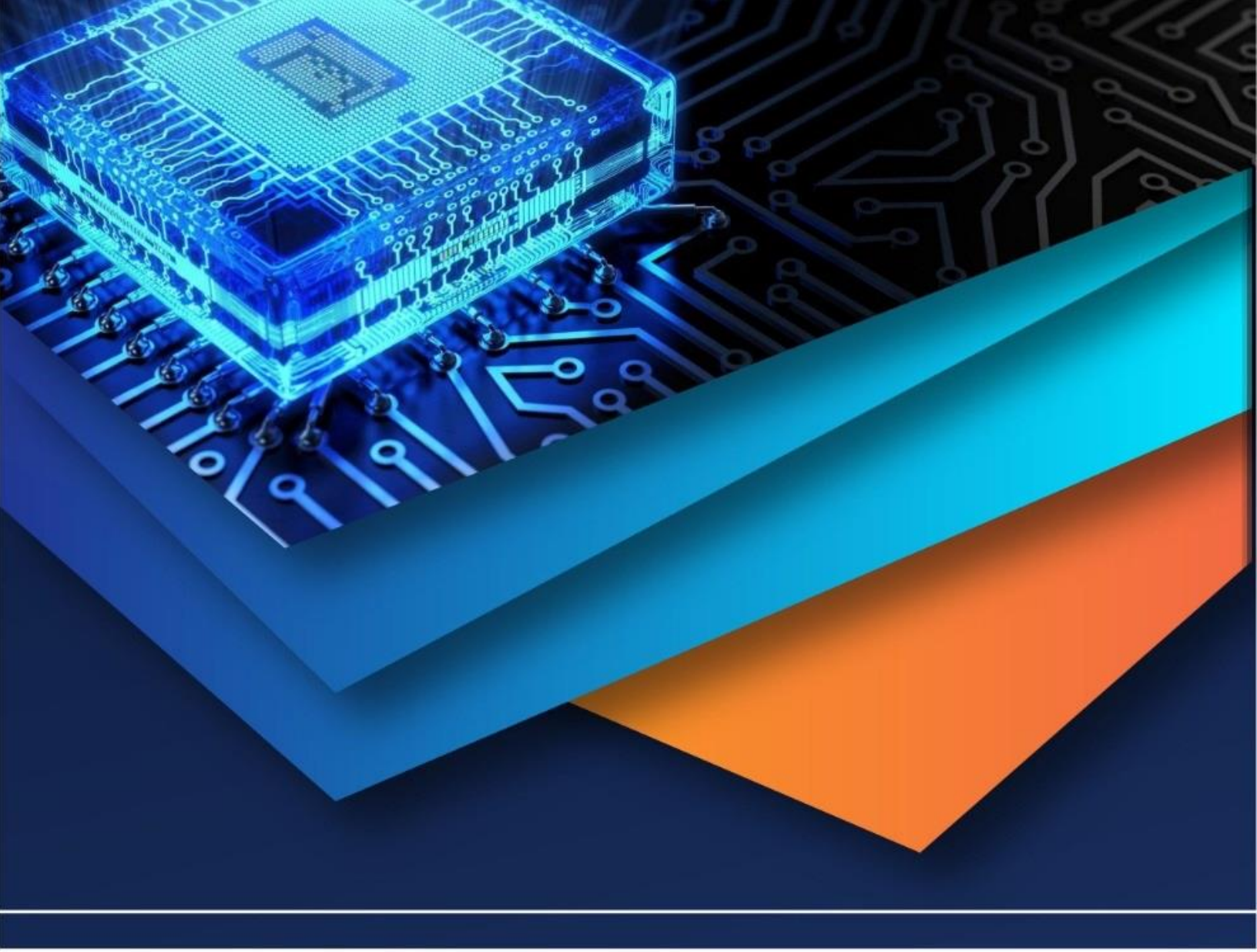
1) Ensure that the CNG vehicle is entering the station slowly and reaching the dispenser safely
2) Stop the CNG vehicle at designated place only
3) Stop the engine and remove the ignition key
4) Remove all the passengers from the vehicle and send them to assembly point
5) Check the hydro test due date of the CNG cylinder and ensure the validity of the test date. Also ensure that there is no physical damage on the CNG kit and refilling receptacle
6) If any defect is found then instruct the customer to rectify the defect at the earliest
7) Enter the defect in the log book maintained in the CNG station
8) Ensure that the defects are rectified before filling the CNG in the vehicle
9) Ensure that there are any open wires, any abnormal smell, high temperature & any other defect not existing in the vehicle before filling of CNG
10) Ensure that there is no flammable materials are present in the vehicle
11) Ensure that the station area is no smoking area
12) Ensure that mobile phones are not used in the CNG station area
13) Ensure that there is minimum three meter distance maintained between the vehicles during refilling
14) Ensure that the earthing is connected during filling.
15) Cover the battery with a rubber mat prior to start of refilling
16) Check the vent pipe
17) Remove the dust plug
18) Ensure that the nozzle is properly fitted in the filling point and then open the valve. Hold it securely while refilling
19) Ensure that the cylinder pressure will not go beyond 200.2 / kg cm
20) Remove the nozzle carefully after filling the CNG in the vehicle, Put the dust plug
21) Remove the rubber mat from the battery
22) Ensure that there is no leakage of natural gas prior to start of the vehicle
23) Start the engine and move the vehicle out of the station slowly

D. *Safety instructions for CNG Customers*

1) Fit & Repair the CNG kit from accredited workshop only
2) Get the CNG kit checked every year from a recognized workshop and hydro test the cylinder every three years. Get the compliance plate from the work shop & fit it near the filing point. Always carry the certificates along with the vehicle
3) Stop the engine and remove the key from the vehicle & give it to the filler boy. All the passengers including the driver must get down from the vehicle prior to filling of CNG
4) Keep the wiring of the vehicle in a good condition and do not use open wires. Battery terminal must be covered prior to filling of CNG. Do not keep the terminals loose and cover it with insulation tape
5) Do not start the vehicle during any leakage of gas and take the vehicle to a safe location by pushing the vehicle. Then close the cylinder valve to stop the gas leakage
6) It is prohibited to use open flames like match box etc. in the CNG station area
7) It is prohibited to smoke in the CNG station area
8) It is prohibited to use mobile phones in the CNG station area, Please keep the mobile phones off in the CNG station area
9) Do not spread rumours during any emergency and follow the instructions of the CNG station staff
10) Keep patience during emergency & keep yourself away from the emergency area, Always follow the safety & security rules

REFERENCES

[1] Naser Badri “Quantitative Risk Assessment to Site CNG Refuelling Stations”, 2010
[2] Eui Soo Kim “Risk analysis of CNG composite pressure vessel via computer-aided method and fractography”, 2013
[3] Muhammad Imran Khan “Technical overview of compressed natural gas (CNG) as a transportation fuel”, 2015
[4] Mehdi Parvini “Consequence modeling of explosion at Azad-Shahr CNG refuelling station”, 2014
[5] Javad Khadem “Mathematical modeling of fast filling process at CNG refueling stations considering connecting pipes”, 2015
[6] Mahmood Farzaneh-Gord “Studying effects of storage types on performance of CNG filling stations”, 2011



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