CNG FUELLING STATIONS DESIGN PHILOSPHY

Presented By:
Eng. Hisham Radwan
Natural Gas Vehicles Company

I. OVERVIEW

(a) Compressed Natural Gas - CNG:-

Natural Gas, as an alternative fuel for vehicles, is supplied from the *Natural Gas Distribution Network* to the CNG fuelling stations to be compressed to 250 bars. It is then dispensed, to be stored on board of the vehicle at about 200 bars in a cylinder installed in the rear, under carriage, or on top of the vehicle.

When the Natural Gas is required by the engine, it leaves the cylinder traveling through a high pressure pipe to a high pressure regulator, where the pressure is reduced close to atmospheric pressure, through a specially designed mixer, where it is properly mixed with air. The mixture then flows into the engine's combustion chamber, and is ignited to create the power required to drive the vehicle.

(b) CNG Fuelling Stations General Description:-

- **Gas Supply and Metering**

  The incoming gas supply and metering installation primarily depend on the pressure and flow demands of the gas compressor.

- **Natural Gas Compressor**

  In general, gas compressors for natural gas filling stations have relatively low flow rates, but they produce high pressure lifts ***"typical***

to 250 bars". The compressor is usually a multi-stage reciprocating machine, which may be driven by an electric motor, or an internal combustion engine.

- **Gas Storage**

  A large volume of gas may be stored to facilitate continuous filling of vehicles. Storage is provided in banks of multiple cylinders to speed filling, reduce the size of the compressor, and limit the number of start/stop cycles.

  Usually cylinders are manifold together to facilitate a ***"cascade dispensing sequence"*** at the vehicle filling point.

- **Vehicle Filling Dispenser**

  In general, a vehicle filling dispenser comprises the following:

  1- A dispensing, sequencing, and metering unit.

  2- Filling hose and nozzle.

  A gas dispensing procedure requires a degree of manual operation, similar to liquid fuel facilities.

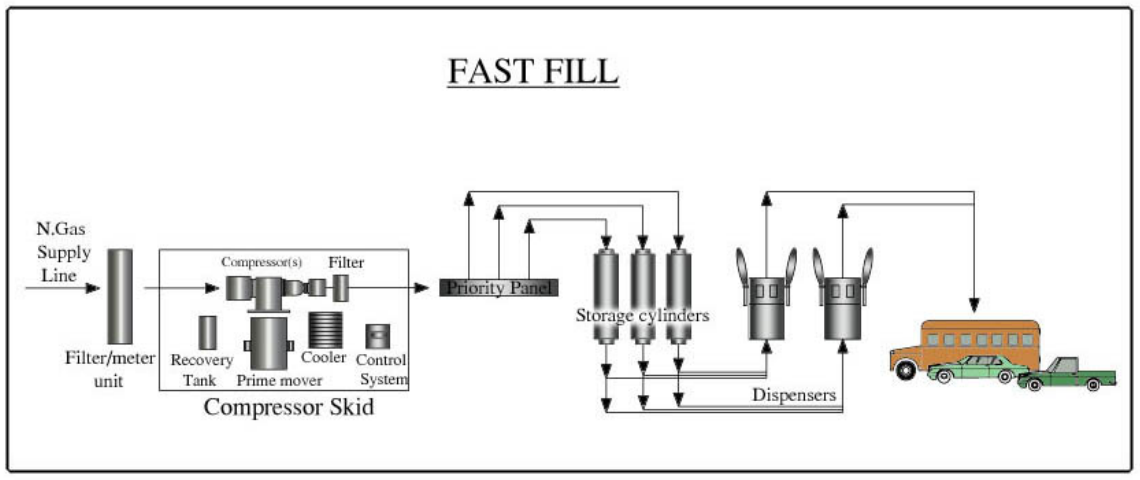
- **Filling Method and Operation**

  The vehicular filling can be undertaken in two ways:

  A) Fast Fill

  A filling operation which is comparable in duration to that of liquid fuel. The dispenser is used to connect the vehicle to the cascade storage system, and control the maximum fill pressure of the vehicle cylinders.

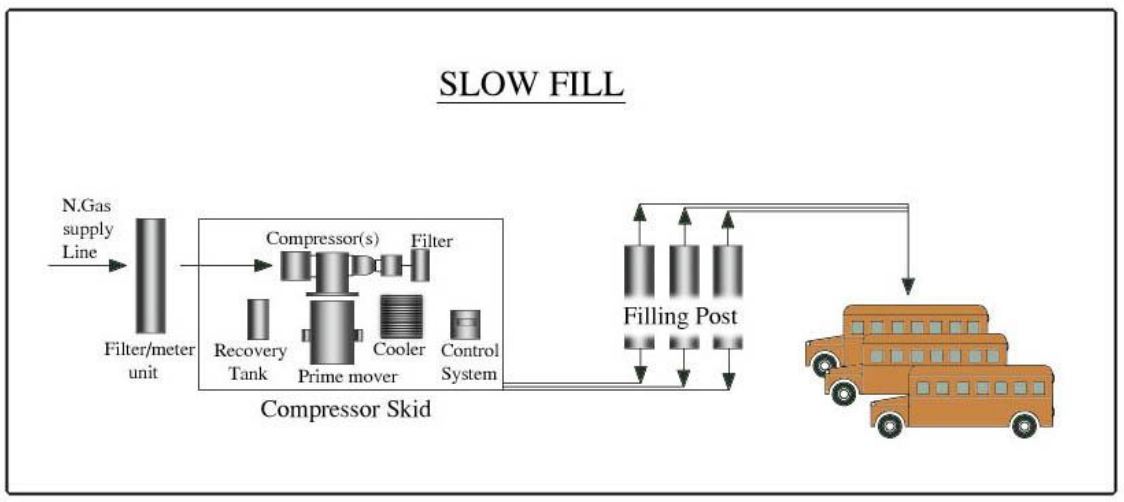
  This filling operation normally takes 2 – 4 minutes.



B) Slow Fill

A filling operation which takes typically several hours (5 – 8 hours) - for example over night.

The fill post connects the vehicle directly to the compressor discharge line. In this case, the vehicle fill pressure is equal to the compressor discharge pressure.



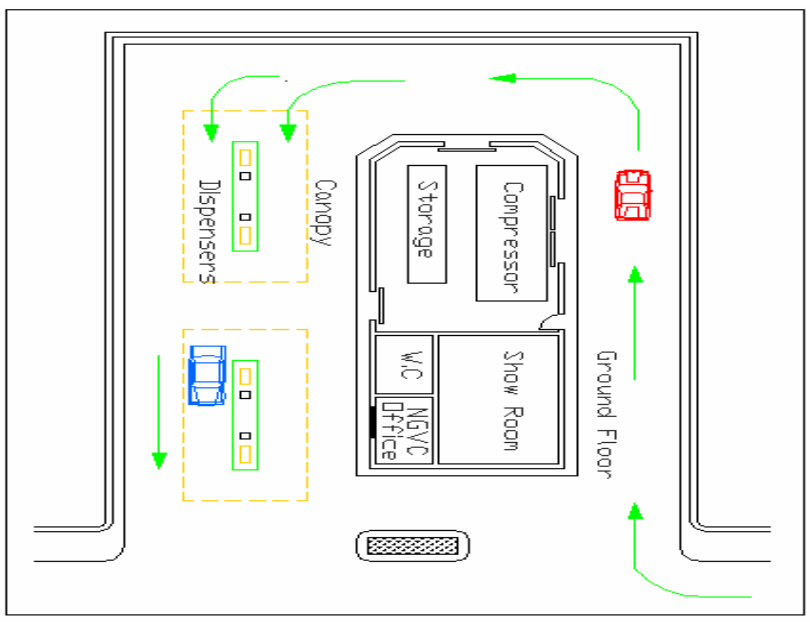
II. OPERATIONS

(a) Layout Considerations:-

To choose a location for a public access filling station, some queries must be defined properly, including:

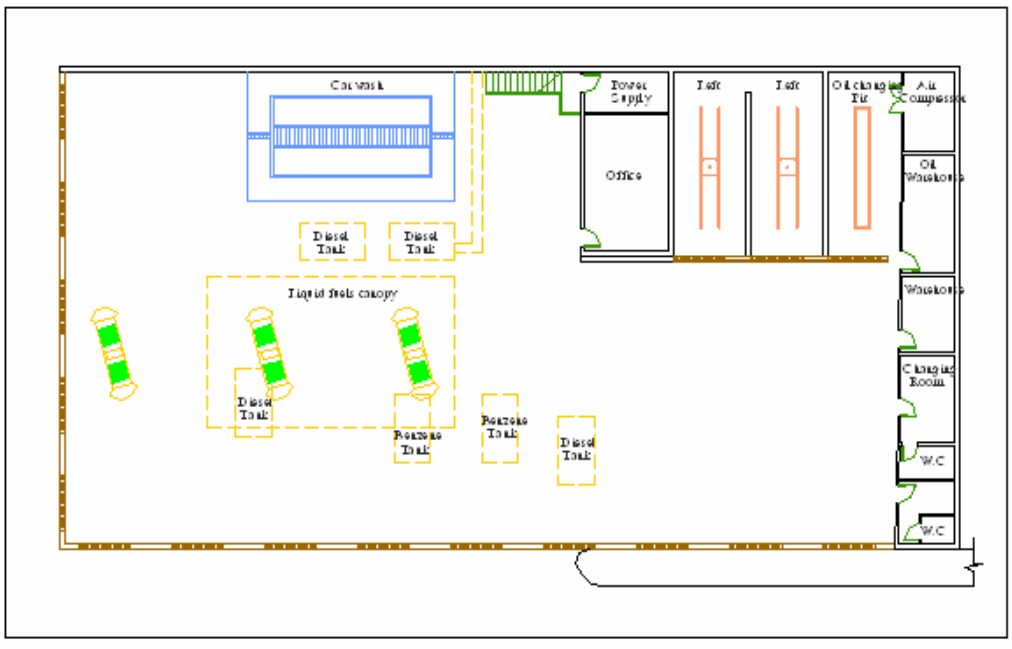
- Given site square area.
- Physical dimensions, streets locations, and traffic flow directions.
- ***"Safety Separation Distances"*** required by the ***Civil Defense Authority – CDA***, and the Egyptian Standard **ES: 4101/2003**
- Present potential CNG sales and demand.
- Future expansion "if applicable"
- Additional service to be offered if required

The Nasr City station layout here under shows that waiting area and lanes help avoid vehicle traffic violations, allow extra service required by the land owner, and maintain easy vehicle circulations and exits.

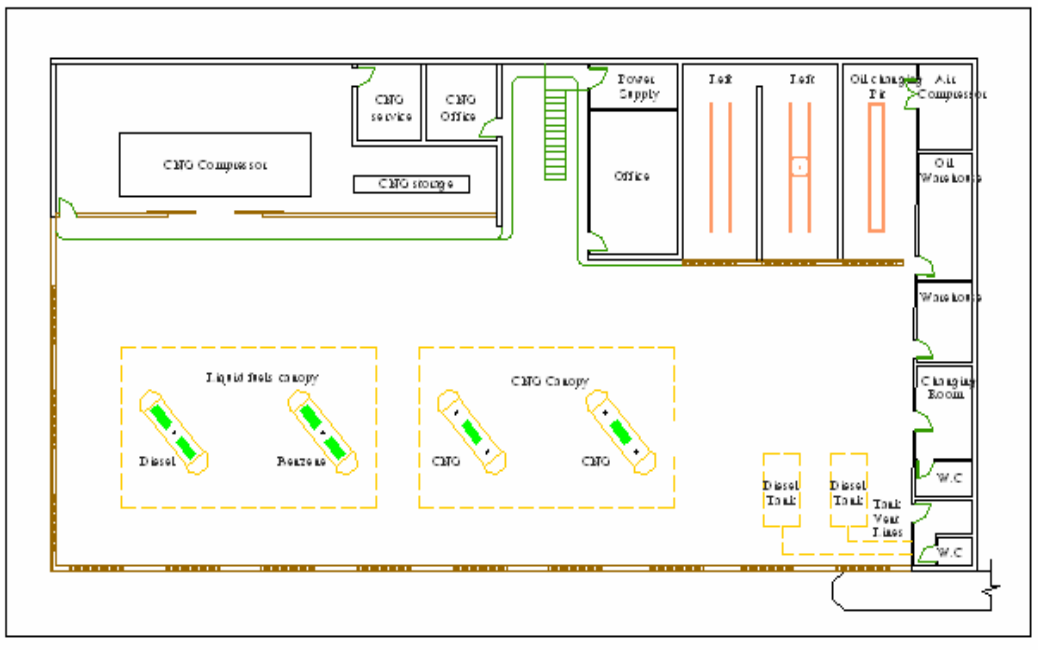


Bi – Fuel Station Equipment Re-allocation

Before:



After:



(b) Equipment Sizing:-

The concept of the ***Fast Fill Method*** is mainly based, but not limited to, the pressure difference between the compressor and the vehicle. Maintaining the pressures of the storage banks at a higher level than the allowed stored pressure makes the filling faster.

- **CNG Compressors**

  The choice of the capacity of the compressor discharge is based on the number of dispensers. One compressor is mainly chosen to feed a maximum of 4 – 5 dispensers.

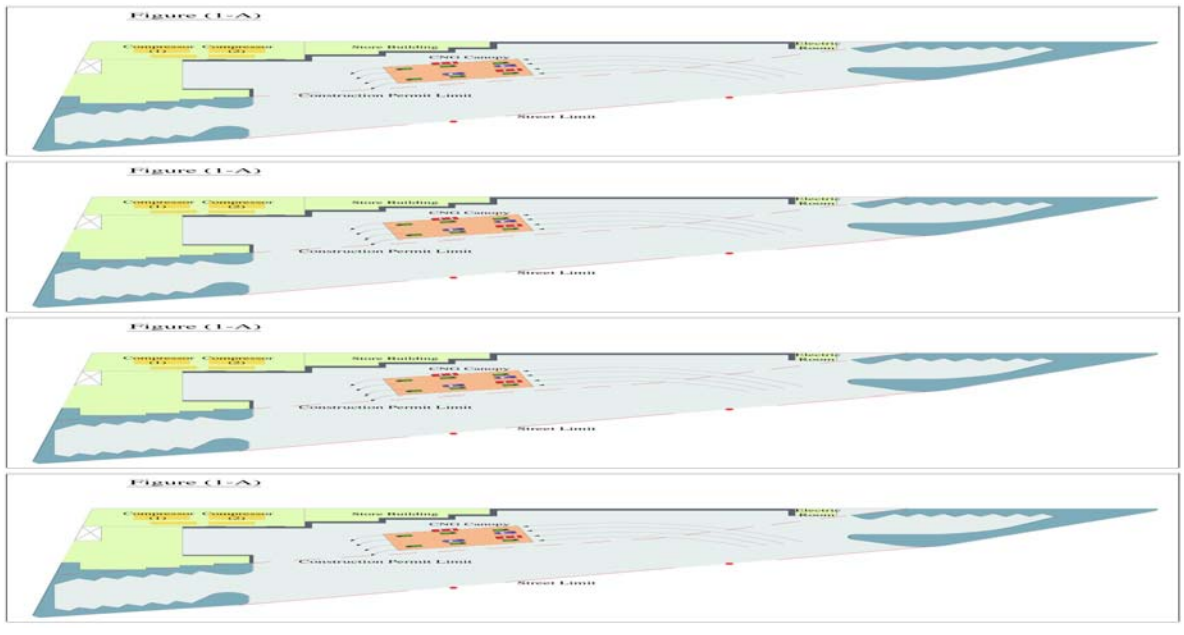
  In case of ***multi-compressor mega stations***, each compressor acts as a substitute stand-by in case of any failure that might result due to preventive or corrective maintenance.

  Vehicles circulation and maneuvering under the canopy, as well as the entrances and exits of the station, also have their effect on the compressor discharge. In sizing and utilizing a given compressor discharge, the maximum usage is focused on the current maximum gas filling capacity by the Points of Sales – "POS". The better the maneuvering, the higher is the CNG filling volume.

- **Number of Dispensers "POS"**

  As mentioned before, the POS is installed according to the available discharge volume. Better vehicle circulation optimizes the usage of dispensers and decreases the number of unused dispensers.

NGVC Shoubra Station – Cairo



(Figure 1-A) shows bad vehicle circulation that created excess unused capacity.

(Figure 1-B) shows that by improving the vehicle circulation and creating more waiting lanes and areas for the vehicles, allows more benefits of the compressor size.

(Figure 1-C) Shows that adding more POS and an extra compressor allowed maximum benefit of the same available area.

- **Number and Size of Storage**

Keeping the pressure at the storage higher than the allowed pressure makes the fuelling process faster. Also the compressor being on the lower usage limit of the discharged volume lowers the storage capacity and increases the start/stop compressor cycles, which exposes the compressor to wear and tear effects. 40% of the wear of the moving parts is due to the starts cycles.

The more we increase the storage volume, the lower the compressor discharge volume can maintain the pressure by using cascade multi-pressure banks, that allow using the compressor capacity and maintaining sufficient pressure difference among the different pressure levels of the vehicle.

The ***Programmable Logic Control – PLC*** controls the storage filling priority panel, located at the compressor area, which is used to maximize the usage of the storage volume, in most cases by 35 – 40%, to be utilized by the POS.

- **Transit Bus Fuelling Stations:-**

Normally in the public access fuelling stations, the filling window is open 24 hours per day, with an average running time of 14 hours. This figure is relative to the availability of vehicles, total daily fuelling rush hours, preventive maintenance plans, and any down time resulting from corrective maintenance. On the other hand, the transit bus fuelling stations filling window is only over night for 5 hours at most.

In correspondence to the public access station for the same amount of CNG sales, the Transit Bus Station Equipment will be 3 times the capacity and cost, i.e. the payable period will significantly expand. The best possible way to achieve the economical balance is to open the Transit Bus Station for public access for the rest of the day (this could only be done when the Transit Bus Station is near the potential traffic area), or buses could be fueled from public access stations. This will improve the Internal Rate of Return – IRR.

- **Economical Operation**

As mentioned before, using a standard size of the compressor on a narrow range saving cost of engineers and trained technicians minimizes spare parts inventory investment, and builds trust and confidence in the company's filling equipment.

Also establishing highly trained crews, working 24 hours a day, helps overcome down time resulting from corrective maintenance, and precedes the preventive maintenance at the lowest demand time for CNG.

III. HEALTH, SAFETY AND ENVIRONMENT

Natural Gas, like all fuel, needs special arrangements and treatments, however, being compressed to about 250 bars, and used in urban areas, it requires extra precautions through:

- Health wise, all kinds of gas leakage and vent must be minimized by recycling vented gas and properly maintaining the equipment according to precise strict plans.
- Compressor units or high speed machines (1500 -2000 r.p.m.), compressing natural gas, produce very high levels of sound (120 dp), that must be treated.
- Automatic and manual fire extinguishing systems must be used.
- Operational and engineering shut-down systems, as well as emergency shut-down buttons must be authorized and located in approachable areas.
- Storage water cooling system must be used to cool down the storage tank in case of fire, and maintain the pressure at the designed and allowed level.
- Risk assessment, as well as training all employees on fire fighting and emergency cases is a must.
- Labels, warning signs and notices must be provided at the areas of significant risk to health and safety.
- Descriptions and classifications of hazardous areas must be with respect to the selection of electrical apparatus.
- Continuous testing a recalibration of all safety devices.
- Periodically monitoring the performance of all equipment.
- Allowing only the trained personnel to deal with the CNG equipment.
- Strictly following the hot and cold work permits procedure

IV. ECONOMICAL COSIDERATIONS

The table here under shows the items that are covered in the feasibility study for any location suggested for the construction of a CNG fuelling station.

The study covers both the Fuelling Facilities Costs and the Station Operating Information as follows:

	FUELLING FACILITIES COSTS	**EGP**	
TECHNICAL AND ENGINEERING DEPARTMENT	*GAS PIPELINE*		
	COST		
	LICENSE		
	MODULE		
	MACHINERY		YEARS
	ENCLOSURE		
	DISPENSERS		
	STORAGE UNIT		
	WIRING/GAS PIPEWORKS		
	SPRINKLER SYSTEM		
PROJECTS DEPARTMENT	*CONSTRUCTIONS*		
	GENERAL CIVIL WORKS		
	BUILDING		
	CANOPY		
	CANOPY ACCESSORIES		
	STORAGE UNITS FENCE		
	GATEHOUSE AND FENCE		
	UTILITIES		
	ELECTRICITY		AVERAGE
	WATER		AVERAGE
	WASTE / SEWAGE		AVERAGE
	TELEPHONE/FAX		
AREAS DEPART	*TOOLS*		
	VEHICLES		
	COMPUTERS		
	OFFICE SUPPLIES		
HSE DEPART	HSE EQUIPMENT		

STATION OPERATING INFORMATION

COMMERCIAL DEPARTMENT	TARGET SALES		CUBIC METERS PER DAY	
	ANNUAL INCREASE		% PER YEAR	
	INITIAL SALES		CUBIC METERS PER DAY	
	TARGET REALIZATION		MONTHS	
	STATION CAPACITY		CUBIC METERS PER DAY	
	LAND LEASE PERIOD		YEARS	LEASE OPTION
	COMMISSION RATE		EGP PER M3 OF CNG	
	MNIMUM MONTHLY LEASE COST		EGP PER MONTH	
	ADVANCED PAYMENT		EGP	
	LEASE DURING CONSTRUCTION		EGP PER MONTH	
	REN PERIOD		YEARS	RENT OPTION
	MONTHLY RENT COST		EGP PER MONTH	
	ANNUAL RENT ESCALLATION		% PER YEAR	
	ADVANCE PAYMENT		EGP	
	RENT DURING CONSTRUCTION		EGP PER MONTH	
	LAND PURCHASE COST		EGP	
AREAS DEP	***STATION OPERATING EXPENSES***			
	MANPOWER		EGP PER MONTH	
	UTILITIES		EGP PER MONTH	
PROJECTS DEPART	***PREOPERATING EXPENSES***			
	MACHINERY RENT		EGP	
	SUPERVISION		EGP	
	CONSULTING		EGP	
	LICENSES		EGP	
	LEGAL EXPENSES		EGP	
	OTHER EXPENSES		EGP	
	CONSTRUCTION PERIOD		MONTHS	

PROJECT INDICATORS	**PAYBACK NOT LATER THAN**		YEARS
	PROJECT NET PRESENT VALUE		EGP
	PROJECT INTERNAL RATE OF RETURN		%
	PROJECT PROFITABILITY INDEX		%

TOTAL INVESTMENT COST

The analysis of all the above items allows a clear vision of the location's feasibility from the economical point of view.