PLANT LOCATION

1. Introduction

Selecting a plant site is critical to the financial success of a plant. Several factors must be considered in selecting a general plant site location. The procedure for choosing a specific plant location can be presented in a series of required steps. After the site is selected, factors that go into getting the facility built, including permitting and the other necessary legal steps, need to be considered.

2. Siting Factors

The primary siting factors that influence the selection of a plant location are as follows: environmental and safety considerations, labor availability and productivity, raw material availability, proximity to market, property cost, accessibility to transportation, tax incentives, electric power availability and cost, and living conditions.

Table 1 shows a rating of the heavily industrial state business climate as defined by several criteria. The highest rated state is located to the left. Table 2 shows a similar rating of the least heavily industrial states. Note that the lowest number in the rating scale has the highest rating. These tables can be somewhat misleading in that states like Texas, Louisiana, and California, which have large petrochemical bases, are shown with low ratings.

In the selection of a plant site, it is a good idea to get broad-based input, including information from sales, production, plant engineering, and from the general manager. The first objective is to narrow the range of possible choices. This involves focusing on the most important criteria, which differ widely for each type of facility. Table 3 presents some of the factors to consider for plant siting. An objective rating system needs to be used; a listing of the important criteria and a point system that affords the evaluation committee a means of scoring the pluses and the minuses has been found to be useful. The scoring may need to be weighted so that the factors which most heavily affect the bottom-line profit are more heavily counted. At the end of this phase, the less desirable sites should be discarded so that a more in-depth evaluation of the final candidates can be made.

One of the key decisions that can influence site selection is whether to use conventional or modular construction (2). Such a decision will have an enormous economic impact on the project, since vastly different technical considerations and types of investments will be required for each approach. Conventional or "stick built" construction strategies are time honored: the engineering, procurement, and construction are done in a logical, consecutive fashion, with some parts done in parallel with the goal being to execute the project as expediently as possible. Equipment and materials are procured from worldwide suppliers and are delivered to the site. At the site, roads are paved, equipment is set, piping is erected and electrical wiring is completed, all according to the drawings, specifications and standards developed during the detailed engineering phase of the project.

However, at a particular site, the conventional construction approach may not be the most cost effective method for project execution. Factors that directly or indirectly affect construction project execution—and may favor one design and construction approach or site selection over another—may include construction labor availability at the site, weather conditions, the logistics of transporting equipment and materials to the site, schedule considerations and permitting issues.

Modular design and offsite construction of the plant may help to overcome many obstacles, such as weather and scheduling conflicts. In general, modularization involves the assembly of a plant at a convenient offsite location, using either local or imported labor. Each module represents a completed section of a plant including equipment, piping, electrical, instrumentation, insulation and painting. There has to be a methodology for transporting the modules to the site. Modularization may render a site economical and practical whereas it may not otherwise be with conventional construction.

3. Environmental and Safety Considerations

No matter how advantageous a site location may be, if a permit to build cannot be obtained or the uncertainties in getting the necessary permits jeopardize the timing of a project, then it may be necessary to choose another site. Thus, environmental considerations may be, overall, the most important siting factor. California has a reputation for environmentally strict regulations. For example, one chemical company had to pull out of a planned facility because timely permitting on a proposed northern California project was not forthcoming. An oil company has been in an ongoing battle with Santa Barbara, California, and federal regulators on the development of offshore oil fields. After spending hundreds of millions of dollars in court and legal fees, the company is scaling back its planned development.

For 2 years, Long Beach, California has debated a proposed $450 million energy terminal, weighing environmental and safety concerns against the demand for new jobs and much-needed natural gas (3). Long Beach has not been a city that avoids the downside realities of energy production. Oil pumps are scattered in the Los Cerritos marshes and those palm dotted islands offshore are really poorly disguised oil derricks. Despite the port city's reputation as proindustry, the proposed LNG terminal has set off a furious debate over safety. Long Beach now joins many other towns from rural Maine to Oregon, where fierce community opposition has ignited as >40 terminals have been proposed along the nation's coasts. With domestic supplies of the gas that fuels stoves, heaters and power plants on the decline, the industry is increasingly looking to import it. At the center of the debate in Long Beach and nationwide are concerns that an accident or terrorist attack at an urban LNG facility could puncture a massive tanker or storage tank and create a conflagration.

However, in Mexico one-half a dozen of such projects are moving forward along Mexico's Pacific and Gulf Coasts (4). The first strategic objective of the

Mexican government's energy sector is assuring a sufficient supply of energy with international standards of quality and competitive prices. The Mexican government believes that coastal natural gas terminals are a key to the country's efforts to guarantee future supply without pressuring the North American market which is already at a deficit.

Some states have become very active in promoting the construction of new plants in order to bolster their local economies. States such as Mississippi, Alabama, Tennessee, and Georgia have started courting the chemical processing industry (CPI) sector. Other states, such as Louisiana and Texas, had been known for their ease in issuing environmental permits in order to get plants built which would create jobs. However, these states have been tightening up their policies as a result of citizen outcry and the adverse publicity generated by environmental issues that have been brought to public attention.

Many companies are opting to increase the efficiency of existing facilities and add more capacity to selected plants rather than to try to site new facilities, because of the difficulties of the environmental permitting process.

4. Labor Availability and Productivity

Plants need to be run by people and the availability of employees can constitute the overriding consideration in certain businesses, in relation to siting. Labor-intensive businesses have to either move to a location where labor is available or move their employees to the new plant site, which can be costly both from the standpoint of the physical move and with regard to the additional expense of relocating a family from one place to wholly new surroundings. Older and less flexible work forces often choose to accept early retirement, quit, or not to relocate.

Training a new work force can also be costly. Bringing a new employee to the required level of proficiency requires time, and does not always succeed. It is therefore preferred to have access to a work force with developed skills that can be readily converted to suit the special requirements of a new business. The new plant site needs to be accessible to a sufficiently large work force that the incremental new requirements do not cause a shortage to develop that could raise the wage rates above prevailing rates. Usually the factors that make a site desirable also include incentives that have already attracted a skilled work force that can be hired away from other, similar employers. It is advisable to have a labor survey conducted well in advance of site selection in order to avoid surprises. This can be done by hiring local recruiters, by running blind advertisements in local newspapers for key positions that are to be filled first, or by using consultants.

4.1. Living Conditions. An investigation of the following community quality-of-life considerations, which are considered important in attracting personnel to relocate, is necessary: living conditions, ie, house availability, costs, and safety; schools, ie, quality, class size, and distance; healthcare, ie, availability of a major hospital and local doctors; recreational facilities, ie, types and proximity; cultural, ie, musical, plays, and movie theaters; and sports, ie, Major or Minor League teams.

5. Raw Material Availability

For many industries, such as the petroleum (qv) and petrochemical industries, the accessibility of raw materials is the overwhelming factor in selecting a plant site. In the United States, the majority of the refineries are located in three geographic areas either where raw materials are located or where foreign oil can be easily brought in by large tankers. Texas has three significant refining areas that include the Houston Ship Canal, Corpus Christi, and Port Arthur-Beaumont. In Louisiana, the 160-km stretch of the Mississippi river located between New Orleans and Baton Rouge is home to several hundred refining and petrochemical facilities. In California, the refineries are either located near the Long Beach and Los Angeles harbors, in the San Francisco Bay area, or in the San Joaquin Valley. All these areas have either a source of crude oil, access to ports in which foreign oil can be brought by large tankers, or a combination of the two. The East Coast is highly dependent on the importation of foreign crude. The two principal refinery areas are near Philadelphia and in New Jersey, where tankers can bring in much of the crude oil.

The other refining centers in the United States are all located near one of the major pipelines that are supplied either from the Gulf Coast oil fields or from Oklahoma, Texas, or Louisiana fields. The Pacific Northwest refineries were originally supplied mostly by Canadian production. Currently ($\sim$1995), these refineries are predominantly supplied by Alaskan North Slope crude, which is brought in from Valdez to the refinery ports in tankers.

Most of the petrochemical facilities that depend on a cheap and abundant supply of natural gas are also located in the Gulf Coast, where a surplus of offshore gas is available. These facilities use cracking of natural gas to produce ethylene as the starting point for the refining of their products. This process not only uses natural gas as feedback, but also uses natural gas to fire the ethylene cracking furnaces. About one-fourth of the world's chemical production is located in Texas.

Other industries that are traditionally located close to the source of raw materials include the steel (qv) industry, located close to iron ore; the flour industry, close to wheat fields; the meat-packing industry, close to grazing land for cattle; pulp and paper, close to forests; and the mining industry, close to mines. The inorganic industry, including salts, ash, borax, and gypsum, has always been located near the source of the needed raw material.

6. Accessibility to Transportation

For relatively low priced products, the cost of transportation can be a significant deciding factor in plant site selection. The plant needs to be located close to the market. The cost of shipping by tanker is lowest, pipeline is next lowest, and truck and railcar shipment is the highest. These last two means are sometimes the only options for some products, etc. Most refineries have the product distribution terminal located outside the plant. Pipelines are used to send blended products to intermediate storage tanks located at the distribution terminal, which could be located hundreds of miles away from the refinery. This minimizes the land haul cost. It also gets the traffic of the truck loading away from the refinery gate.

7. Property Cost

Land cost in certain highly desirable petrochemical manufacturing areas can be as high as $\$25/m^2$ (eg, Houston ship canal), whereas in most normal industries land costs are in the $\$4-12/m^2$ range. Where a lot of land is needed for feed and product storage, the cost of land can be significant. Many of the lots located on the deep-water ship canals are so orientated as to minimize the amount of costly land facing the waterway to only that needed for shipping products and receiving feed with the rest of the plant located farther back, away from the expensive real estate. Plants also tend to locate away from areas where encroaching residential homes drive up the property cost.

8. Tax

Several states that have a large number of CPI plants offer various types of tax incentives. Louisiana, eg, offers a 10-year tax exemption from property taxes on buildings, equipment, and improvements to land (5). Texas, which has a large petrochemical industry, offers a 7-year tax abatement program. Neither of these states have a state income tax. Both states offer a tax credit for each job created and provide free worker training.

When considering taxes, all types need to be considered: initial fees, capital value, corporate rate, personal income tax, sales tax, property tax, unemployment insurance, workmen's compensation, and nuisance tax. During the construction phase, several types of taxes may be levied. These include building permits, special fees, assessments, and sewer connection fees.

9. Electric Power Availability and Cost

Several industries are highly dependent on inexpensive electric power. These include the aluminum industry; the Portland cement industry; electrochemical industries, eg, plating and chlorine production; the glass industry; and the pulp and paper industry. Other industries, eg, as the petrochemical industry, which is highly competitive, depend on low priced power. About two-thirds of the cost of producing ammonia is electrical cost.

These industries try to locate near a source of hydropower (Niagara Falls or Hoover Dam) or near a source of excess nuclear power. They generally work out arrangements to get power at a reduced cost based on being the first one cut off when electric load shedding is required.

Many CPI industries have installed cogeneration facilities so that they are carried on a separate balance sheet and are often owned by a third party. The cogeneration unit is usually located next to the CPI facilities so that the latter can take the steam and return condensate while the electric power can either be used or exported to the electric utility grid. This eliminates the disadvantage of the inherently inefficient use of energy by a power producer that generally has to throwaway two-thirds of the energy to condense the exhaust steam from the turbines that generate power, rather than consuming the heat for useful purposes.

10. European Siting Considerations

European siting considerations are somewhat different than those in the United States. Germany, The Netherlands, France, and Italy were traditionally the favored locations for European CPI industry plants because of their proximity to the markets, cheap energy, and presence of a skilled labor force. However, labor costs, when considering all of the fringe benefits including liberal vacations and retirement policies, make doing business in Europe expensive.

Many firms are finding areas, eg, Ireland, Scotland, Spain, and southern Italy, where unemployment rates are relatively high and governments offer property tax exemptions, grants toward capital investment, low interest loans, and other incentives, attractive from those standpoints. Some of these areas have developed a good infrastructure based on businesses already attracted to the area.

There is also, however, an increasing resistance by local communities to siting new plants in many of these European areas. Moreover, the environmental regulations have become increasingly stringent in Germany, The Netherlands, and France. It is estimated that the environment and other safety-related costs in Germany have risen to the point where 30% of the total capital investment needed is for environmental and safety measures.

11. Site Purchase

Once the site is selected, the land purchase must be made. Usually a third party, eg, a real estate agent, is employed to do this work. It is advisable first to secure an option to buy the land so that all of the potential problems can be evaluated or solved before the purchase is made. Other negotiations besides the purchase or lease of the site also need to be negotiated. Zoning, easement, building costs, access roads, taxes, and the like need to be settled before the land is purchased. It is best to keep the identity of the purchaser secret while all this is being handled. Contact between the plant owner and utilities, railroads, pipelines, and the local community need to be finalized in writing before a final purchase.

11.1. Environmental Permitting. An environmental baseline is usually required to establish how the plant would affect the surroundings. Air quality issues can be the deciding factor in siting, as air permits often take the most time to obtain. Water pollution also needs to be addressed. Federal, state, and regional regulations are often in conflict with each other. Hiring a consultant to steer a way through these complex myriad regulations can be useful. What the environmental discharges are and how best to mitigate their effects by providing a plant that is designed to minimize the impact are key issues.

An environmental impact statement (EIS) nominally has to be prepared and a public hearing held in order for the community to air its views. This can take up to 2 years. Getting a public relations effort under way helps in getting these requirements completed in a timely fashion. Efforts should be made to foster good relations with local authorities and neighbors. The opposition to a new plant can often be well organized and articulate. An early assessment of the political climate needs to be made in order to determine if public opinion is in such strong opposition to a new development that no matter what is done, it will be fought.

11.2. Local Site Condition Evaluation. In addition to visiting the site, drawing up a contour map and geology reports, acquiring soil bearing information, and a knowledge of boundaries, setbacks, local requirements, utility tie-in locations, sewer connections, access to roadways, pipelines, railroads, etc, may be needed to make a full assessment.

A buffer zone may be required around the plant, and even if it is not required, it is less costly to provide a buffer at the start rather than to buy more property at a later date when the price has gone up.

12. Specific Plant Site Considerations

Once a general plant location has been established, a specific plant site location needs to be determined. This requires developing a list of requirements for the plant. One approach is to use the "cornfield" method of plant site assessment, the essence of which is to develop an ideal list of specifications that define what would be required to put the plant in any cornfield. This approach should be carried out by devising a preliminary plant layout (qv). All the requirements for the plant and the supporting infrastructure are put down on a to-scale drawing. This drawing has to be modified to adapt to the features and terrain of the ultimate site. Some of the considerations that should be listed as requirements are as follows: number of employees; size of process units; utility requirements, ie, for cooling water, power, water, fuel, and steam; shipping requirements, ie, road access, and access to railway lines, waterways, and pipelines; disposal requirements for solids waste, chemical sewer loads, and sanitary sewer loads; and permitting factors such as air emission, water emission, and those that are applicable to the particular type of product.

An example of a checklist is provided in Table 4 as a typical item-by-item check for use after a final site has been selected. This example is based on an evaluation for hazards (6).

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Table 1. **Which State Is Best (Heavily Industrial States)**[a,b]

	State														
Parameter	N.C.	Vt.	Wis.	Miss.	Ala.	Va.	Ga.	Ariz.	Tenn.	S.C.	Mo.	Ind.	N.J.	N.H.	R.I.
chemical output, $\$10^9$	12.9	0.28	5.11	2.03	5.28	6.23	7.96	1.85	7.41	9.25	9.04	13.9	45.4	0.5	0.83
number of chemical plants	113	8	71	34	57	53	97	31	86	72	117	108	413	14	12
employees, 10^3	40.9	1.1	18.6	6.9	19.2	26.3	21.7	6.8	30.9	29.8	31.1	46	155.5	1.8	3.2
energy costs, $\$/10^6$ kJ	6.93	9.03	6.26	5.50	4.66	4.76	6.03	5.75	6.03	6.20	6.12	4.43	7.66	10.8	7.79
environmental record	37	2	21	44	47	36	38	40	45	35	33	49	28	8	7
environmental policies	18	12	6	46	49	22	29	50	40	32	23	27	3	20	10
fiscal policies	25	4	30	26	14	31	15	16	12	42	28	22	27	1	8
state-related labor costs	1	24	20	4	12	7	17	31	11	8	21	2	3	27	38
labor costs	11	27	18	5	10	32	15	4	16	7	22	44	41	39	31
resource productivity	29	18	11	42	40	3	39	36	43	37	26	19	15	44	20

[a]Ref. 1. Ranks states with the best manufacturing climates in descending order, from left to right, on the basis of four weighted factors.
[b]Heavily industrial states are those accounting for >2% of U.S. industrial output, with at least 16% of the work force in manufacturing.

Table 2. **Which State Is Best (Light Industrial States)**[a]

	State									
Parameter	N. Dak.	Wyo.	S. Dak.	Nebr.	Iowa	Nev.	Utah	W. Va.	Oreg.	Kans.
chemical output, billion	0	0.16	0.44	0	1.75	0.41	1.22	6.51	0.48	3.0
number of chemical plants	0	3	2	0	38	13	15	29	18	40
employees, thousands	0	0.43	0.18	0	5.8	1.6	5.6	17.3	2	7.4
energy costs, $\$/10^6$ kJ	4.21	4.76	5.81	5.51	5.24	7.67	5.39	4.19	6.17	5.63
environmental record	16	25	12	24	29	9	22	41	3	43
environmental policies	37	44	48	30	16	43	41	45	2	28
fiscal policies	44	3	10	17	34	2	40	5	11	37
state-related labor costs	9	13	5	16	18	10	6	25	28	19
labor costs	3	28	2	6	8	19	17	34	20	30
resource productivity	1	3	17	6	4	50	28	23	38	16

[a]Ref. 1. Ranks states with the best manufacturing climates in descending order, from left to right, on the basis of four weighted factors.

Table 3. **Factors to Consider for Plant Siting**

Plant requirements	Labor	Transportation	Raw materials	Markets	Power
acreage[a] present/future expansion	supply proximity available	railroads rates, sidings,[b] shifting, transfers, belt line	haul quantity permanency	schedule/rates shipping	fuel supply electricity
building[a] drainage, foundation, subsoil, maintenance[b]	character wages h/day, overtime, bonus	waterways boat lines, canals	quality annual consumption	storage requirements (inventory)	water supply quantity/quality, boiler purposes, condenser water
natural features topography, climate, local supplies	disposition union, content, strikes	highways	storage requirements	competition shipping costs, custom charges	water power (hydroelectric)
public utilities[b] streets, phones, light, heat, gas, power, telegraph, newspaper, fire protection	housing health, sanitation, markets, shopping, schools, churches, recreation	motor traffic passenger buses, freight lines			
		street/railways present/future schedules, fares, freight, express			
water					
supply[a] quantity/quality					
waste disposal[b] sanitary/industrial advertising value					
government character, legal permits, police protection, taxes, insurance[b]					
legal phases laws, status, ordinances, board of health requirements					

[a]Represents an investment cost.
[b]Represents an operating cost.

Table 4. **Facility-Siting Checklist**[a]

Spacing between process components

have adequate provisions been made for relieving explosions in process components?
are operating units and equipment within units spaced to minimize potential damage from fires or explosions in adjacent areas?
are there safe exit routes from each unit?
has equipment been adequately spaced and located to safely permit anticipated maintenance (eg, pulling heat-exchanger bundles, dumping catalyst, lifting with cranes) and hot work?
are vessels containing highly hazardous chemicals located sufficiently far apart? if not, what hazards are introduced?
is there adequate access for emergency vehicles, eg, fire trucks?
can adjacent equipment or facilities withstand the overpressure generated by potential explosions?
can adjacent equipment and facilities, eg, support structures, withstand flame impingement?

Location of large inventories

are large inventories of highly hazardous chemicals located away from the process area?
is temporary storage provided for raw materials and finished products at appropriate locations?
are the inventories for highly hazardous chemicals held to a minimum?
where applicable, are reflux tanks, surge drums, and rundown tanks located in a way that avoids large-volume concentration of highly hazardous chemicals in any one area?
where applicable, has special consideration been given to storage and transportation of explosives?
have the following been considered in the location of material handling areas: fire hazards
location relative to important buildings safety devices, eg, sprinklers slope of area (is it level?)

Location of motor control center

is the motor control center located so that it is easily accessible to operators?
are circuit breakers easy to identify?
can operators safely open circuit breakers? have they been trained?
is the motor control center designed such that it could not be an ignition source? are the doors always closed? is a "No Smoking" policy strictly enforced?
is the motor control center designed and meant to be a safe haven?

Location and construction of control room(s)

is the control room built to satisfy current corporate overpressure and safe-haven standards?
does the construction basis for the control room satisfy acceptable criteria
are workers protected in the control room (or their escape routes) from all of the following: toxic, corrosive, or flammable sprays, fames, mists, or vapors
thermal radiation from fires (including flares)
overpressure and projectiles from explosions
contamination from spills or runoff noise
contamination of utilities, eg, breathing air
transport of hazardous materials from other sites
possibility of long-term exposure of employees to low concentrations of process material
odors
impacts, eg, from a forklift
flooding, eg, ruptured storage tank
are vessels containing highly hazardous chemicals located sufficiently far from control rooms?
were the following characteristics considered when the control room location was determined: types of room construction
types and quantities of materials direction and velocity of prevailing winds
types of reactions and processes

Table 4. (*Continued*)

operating pressures and temperatures
ignition sources
fire protection facilities drainage facilities
if windows are installed, are they of rigid construction with sturdy panes, eg, woven wire-reinforced glass?
is at least one exit located in a direction away from the process area? do exit doors open outward? are emergency exits provided for multistoried control buildings?
are ends of horizontal vessels facing away from control rooms?
are critical pieces of equipment in the control room well protected? is adequate barricading provided for the control room?
are open pits, trenches, or other pockets where inert, toxic, or flammable vapors could collect located away from control buildings or equipment handling flammable fluids?
where piping, wiring, and conduit enter the building, is the building sealed at the point of entry? have other potential leakage points into the building been adequately sealed?
is the control room located a sufficient distance from excessive vibration sources?
is positive pressure maintained in control rooms located in hazardous areas?
could any structures fail on the control room in an accident?
is the control room roof free from heavy equipment and machinery?

Location of machine shops, welding shops, electrical substations, and other likely ignition sources

are likely ignition sources, eg, maintenance shops, roads, and rail spurs, located away from release points for volatile substances (both liquid and vapor)?
are process sewers located away from likely ignition sources?
are all vessels containing highly hazardous chemicals or components containing material above its flash point located away from likely ignition sources?
are the flare and fired-heater systems located so as to minimize hazards to personnel and equipment, with consideration given to normal wind direction and wind velocity and heat potential?

Location of engineering, lab, administration, or other buildings

are administration buildings located away from inventories of highly hazardous chemicals?
are administration buildings located away from release points for highly hazardous chemicals?
are workers in administration buildings protected from all of the following:
toxic, corrosive, or flammable sprays, fumes, mists, or vapors thermal radiation from fires (including flares)
overpressure and projectiles from explosions
contamination of utilities, eg, water contamination of spills or runoff noise
transport of hazardous materials from other sites
flooding, eg, ruptured storage tank odors

Unit layout and location of facility relative to neighbors

are large inventories or release points for highly hazardous chemicals located away from public access roads? from vehicular traffic within the plant?
is the unit, or can the unit, be located to minimize the need for offsite or intrasite transportation of hazardous materials?
are workers in adjacent units protected and workers in this unit protected from the effects of all of the following from adjacent units or facilities:
releases of highly hazardous chemicals
toxic, corrosive, or flammable sprays, fumes, mists, or vapors
overpressure from explosions
contamination from spills or runoff
odors
noise

Table 4. (*Continued*)

contamination of utilities, eg, sewers
transport of hazardous materials from other sites
impacts, eg, airplane crashes, derailments
flooding, eg, ruptured storage tank
could specific siting hazards be posed to the site from credible external forces such as high winds, earth movement, utility failure from outside sources, flooding, natural fires, and fog?
is there adequate access for emergency vehicles, eg, fire trucks? are access roads free of the possibility of being blocked by trains, highway congestion, spotting of rail cars, etc?
are access roads well engineered to avoid sharp curves? are traffic signs provided?
is vehicular traffic appropriately restricted from areas where pedestrians could be injured or equipment damaged?
are cooling towers located in such a way that fog generated by them will not be a hazard?
are the ends of horizontal vessels facing away from personnel areas?
is hydrocarbon-handling equipment located outdoors?
are pipe bridges located such that they are not over equipment, including control rooms and administration buildings?
is piping design adequate to withstand potential liquid loads?

Location of firewater mains and backup, eg, diesel pumps

are firewater mains easily accessible?
are firewater mains and pumps protected from overpressure and blast debris impact?
is an adequate water supply available for firefighting?
are the firehouse doors pointed away from the process area so that doors will not be damaged by an explosion overpressure?

Location and adequacy of drains, spills, basins, dikes, and sewers

are spill containments sloped away from process inventories and potential fire sources?
have precautions been taken to avoid open ditches, pits, sumps, or pockets where inert, toxic, or flammable vapors could collect?
are process sewers that transport hydrocarbons closed systems?
are concrete bulkheads, barricades, or beams installed to protect personnel and adjacent equipment from explosion or fire hazards?
are vehicle barriers installed to prevent impact to critical equipment adjacent to high traffic areas?
do drains empty to areas where material cannot pool?
can dikes hold the largest tank's capacity?
is there access in and out of dikes, pits, etc?

Location of emergency stations (showers, respirators, personnel protective equipment, etc)

are emergency stations easily accessible?
are first-aid stations prudently located and adequately equipped?
are safety showers heated, freeze-protected, and wind-protected?
is there a control room alarm for water flow from a safety shower and eyewash station (is there a need for such an alarm)?

Planning

what expansion or modification plans are there for the facility?
can the unit be built and maintained without lifting heavy items over operating equipment and piping?
are calculations, charts, and other documents available that verify facility siting has been considered in the unit layout? do these documents show that consideration has been given to:
normal direction and velocity of wind
atmospheric dispersion of gases and vapors
estimated radiant heat density that might exist during a fire

Table 4. (*Continued*)

estimated overpressure
are appropriate security safeguards in place, eg, fences, guard stations?
are gates located away from the public roadway, so that the largest trucks can move completely off the roadway while waiting for the gates to be opened?
where applicable, are safeguards in place to protect high structures against low flying aircraft?
are adequate safeguards in place to protect employees against exposure to excessive noise, considering the cumulative effect of equipment items located close together?
is adequate emergency lighting provided? is there adequate redundant backup power for this lighting?
are procedures in place to restrict nonessential or untrained personnel from entering hazardous areas?
are indoor safety-control systems such as sprinklers and fire walls provided in buildings where personnel will frequently be located, such as control rooms and administrative buildings?
are evacuation plans (from builidings, units, etc) adequate and accessible to personnel?
are evacuation drills conducted routinely?

[a]Ref. 6.