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Strategies for Sustainable Hydrocarbon Processing

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1. Introduction

Petroleum refining and associated downstream hydrocarbon processing operations are challenged on the one hand by the tightening product specifications and shifting crude quality on the other forcing an increased proportion of heavy and sour crudes. Regulatory specifications for products as well as process effluents are getting stringent over the years necessitating utmost optimization at every stage in refining operations while still retaining the industry commitment to economically provide hydrocarbon based fuel and feedstock and meet the increasing needs of the growing global population. All around awareness of environmental degradation caused by industrial activities in the hydrocarbon processing sector, on account of greenhouse gas emissions, stratospheric ozone depletion, acid rain and acidification, eutrophication, soil contamination, technological hazards, chemical mists and fog, all with potential damage to human beings, is indeed a topic of much discussions at both national as well as international forums.

Environmental considerations, therefore assume significant importance in hydrocarbon processing operations which generate large quantum of effluents and emissions capable of degrading environment. Besides meeting physical targets of production adhering to quality and safety stipulations , industry operators are also responsible for effective tackling of environmental issues consequent to the production process and avoid damages to the community. An effective environmental management perspective addresses the numerous issues relating to pollution control, ensure safety and thus maintain sustainability in the industry. Clean development initiatives in hydrocarbon industries is a major development in this direction.

The growth of hydrocarbon processing hitherto has been guided mostly by the necessity of increasing production at lower costs which led to serious environmental degradation of water resources, soil and air around the processing plants. Worldwide the focus of pollution control in the industry has shifted from end of pipe treatment to source reduction, avoiding pollution, clean technology and sustainable development. Hence, it has become imperative that environmental considerations shall play a substantive role in the future development of the industry especially at a time when more and more such industrial activities are being undertaken in the developing countries.

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In the recent years, several studies in different parts of the world focused this issue with the objective of identifying key issues in environmental protection in the different industrial processes, assessing as to what extent the national and international norms or guidelines regarding pollution control and environmental management are implemented in the industries, understanding the problems encountered in environmental management and exploring the reasons for the non-compliance. Suggestions were also made on the basis of the above studies to develop guidelines of an environmental policy and adopt cleaner technologies that will foster development with least degradation to the environment.

2. Status of Environmental Management

Environmental pressures have become a major driving force in the development of advanced process technologies, catalysts, retrofits and revamps of old installations. Today, most hydrocarbon processing units, be it in the developed or developing countries have specific environmental policies and their emissions, effluents and waste disposal are guided by the stipulations of the regulatory authorities. New plants that are being built have modern technologies where considerable integration has taken place at the inception stage itself to see that pollution prevention is a part of the process design itself. Other units, which came to existence earlier are now operated with additionally built state of art pollution control facilities. The pollution and environment control departments attached to the plants usually exhibit meticulous care to see that the above objective is achieved. Thus, now-a-days effective control facilities exist in most of the processing units and they are operated with due diligence. The stipulations of the pollution control and environmental protection agencies are also within the achievable limits of the available technology. Still excursions, at times, occur in the parameters on account of start up, shut down of plants or may be due to accidental situations.

Several national as well as international standards covering a wide range of parameters have been developed to specify the emissions and effluents from hydrocarbon industries. These include volatile organic chemicals (VOC), suspended solids, oils mist and chemical and biological oxygen demands in the effluent streams, particulate matter, nitrogen oxides, sulphur oxides and carbon monoxide in exhaust streams. Level of toxic compounds such as benzene , heavy metals, other reactive organic compounds, biological pollutants etc are also monitored in specific cases.

A typical refining installation may emit around a 0.1 to 3 kg of particulate matter; 0.2 to 6 kg of sulphur oxides, SOx (0.1 kg with Claus sulfur recovery unit), 0.06 to 0.5 kg of NOx; and 75 to 6 gram of BTX (benzene, toluene, xylene) for every ton of crude processed.

Of this, about 0.14g of benzene, 0.55 g of toluene, and 1.8 g of xylene may be released per ton of crude processed. VOC emissions depend upon the technology used for production, emission control mechanisms available, equipment maintenance, and climate conditions and may be in the range of 0.5 to 6 kg per tonne of of crude processed.

Clean fuel initiative in the industry is a major step towards attaining environmental sustainability. Mandated by the US EPA in 1972, a gradual phase out of leaded gasoline was achieved in most countries of the world on account of public health concerns. Again sulphur removal from diesel fuel by the DHDS process, initially to lower levels and thereafter to ultra low sulphur level (ULSD) and use of alternative and renewable fuels such as ethanol, methanol and biodiesel are serious efforts in this direction. The underlining factor in these developments to improve its environment friendliness lies in the success of the industry to innovate and develop feasible technologies.

3. Clean Technologies

Major processes involved in the refining industry are distillation , catalytic reforming, hydrotreating, isomerisation, catalytic cracking, hydrocracking, alkylation and thermal operations. Except distillation and thermal operations all other processes employ catalysts. Current developments in environmental chemistry and hydrocarbon engineering have helped industry operators to reduce effluent generation at source and thus eliminate treatment and disposal itself. Very often treatment of pollutants emanating from industrial operations is linked to the processing technologies adopted in the plants. Over the years the specific

consumption of raw material and energy for manufactured products has registered a continuous trend of improvement with the adoption of efficient technologies and best operating practices at the plant level. This invariably contributes to achieving better environmental standards through reduction in emissions, effluents and solid waste per tonne of product manufactured.

Further improvements towards better environmental quality may require major design changes involving additional investment or going for a newly proven and commercialized process. This is a costly option and hence efforts in this line are limited unless it brings about economic incentive by way of increased productivity, lowering of energy consumption etc.

In the case of products having high water intensity, there is an economic benefit in reusing treated effluents so that water conservation is achieved.

The start up and shut down of plants are situations that may lead to an increased level of pollution of the environment compared to its normal operation. Hence most plants are equipped with specific provisions to take care of such situations.

Most of the pollution prevention methods implemented in the industries follow prescriptive approaches which follow standardized procedure built around questionnaires and check lists. The new approach is to adopt a more descriptive approach in which process operators are challenged to attack pollution problems and devise new and innovative ways for solving them.

Managements undertake substantial efforts to develop green belts and maintaining greenery around these plants to reduce the impact of green house gases. This is an important step in the direction of sustainable environmental control.

Establishment of ISO 14000 Environment Management Systems and a corporate environmental set up for regular monitoring and control is another major step in environmental protection. These systems are intended for continuous improvement of existing operations from the environmental angle. Certain industries have adopted zero effluent approach incorporating total recycle and reuse of effluents back to process, though it still remains more a concept than its effective implementation to a reasonable degree of reliability.

Most process plant operators use industry have codified Best Available Techniques (BAT) in their plants for environmental control to meet both effluent specific standards and product specific standards.

In India and many other developing countries systems are employed to the extent of controlling and reducing pollution from plants with in the limits set by the statutory authorities, i.e.; the Pollution Control Boards (PCB). Operating units do not put in further efforts for reducing the pollution effects beyond the limits prescribed by the pollution control boards (PCB). This is primarily due to lack of incentives to encourage additional investment towards improved technology to go for better environmental quality.

Most hydrocarbon processing operations emit large quantities of carbon dioxide (CO2), which is a major green house gas to the atmosphere. There are no emission standards for carbon dioxide as prescribed by the statutory bodies. Attempt to reduce green house gas emissions all over the globe to tackle climate change may bring in specific limits for carbon dioxide emissions or call for effective measures for sequestration in future.

Every processing unit imposes certain environmental burden to the local environment and its impact categories are acidity, global warming, human health effects, ozone depletion, photochemical smog, aquatic oxygen demand and eco-toxicity to aquatic life etc. Aparametric assessment of the contribution of each of these components can be used to compare yearly performances of plants.

The necessity of maintaining a safe work environment for employees and the neighboring community is well recognized. For this purpose extensive hazard and risk analysis using techniques such as Hazard Operability (HAZOP) Studies and Quantitative Risk Assessment (QRA) are conducted based on which safe systems, work practices and risk reduction measure are adopted. The environment management plans of the production units are capable of mitigating the risk from most expected crisis situations barring those from nightmare incidents such as earthquakes, sabotage etc.

Information to the public regarding the environmental consequences of these plants is very important. The communities associated with these units have a right to know the environmental risk they are subjected to.

In most countries it is now mandatory that an Environment Impact Assessment (EIA) be done prior to implementation of a project having large scale environmental consequences. A proper Environment Management Plan (EMP) is also to be in place before the unit start operating.

4. Environmental Challenges

Climate change across the world, depletion of ozone layer in the outer atmosphere, loss of biodiversity elements such as migratory species and important genetic resources, widespread degradation of land, urban air, forests and natural waters and marine ecosystems, accumulation of persistent organic pollutants in nature are major global environmental concerns. These issues have an impact that transcendent national boundaries and hence require global solutions. We have over 200 international legislation governing environmental issues and together with currently available technology and adopting best practices mitigation of further degradation is possible. The far reaching measures to combat the effect of green house gases agreed up on in the Kyoto Protocol is getting thwarted by many developed nations such as the US and Australia. In India we have framed a comprehensive auto fuel policy that consider among other things, availability and security of supplies, vehicle technology, cost effective emission reduction, fiscal measures and institutional means to bring about progressive improvements by reducing vehicular emissions on ambient air. The fuel cell as a power source is becoming a viable alternative to the internal combustion engines with least environmental impacts. Thus concerted efforts are required both at the national and international level to stop further degradation and undo the damages already done. National environment policies shall foster efforts for sustaining environmental health of the people and shall call for a discrete assessment of pollutants entering the natural environment from human interventions in terms of their toxicity, persistence, mobility, bio- accumulation and methods available for source reduction and control mechanisms.

5. Consider Alternatives

More and more industries are switching over to environment friendly raw material and energy resources in order to improve own sustainability. Several examples are available.

The use of natural gas (predominantly methane CH_4) as a relatively benign raw material and energy source than other petroleum feedstock as naphtha and fuel oil and coal to produce ammonia which is the basic building block of the nitrogenous fertilizer industry indicate a shift to reduce pollution problem. This route has reduced CO_2 emissions, low waste generation and low energy intensity for the product.

The use of water in place of organic solvents to replace volatile organic chemicals (VOCs) as reaction medium in organic synthesis is another important innovation. Use of ethylene dichloride (EDC) for extraction of food items have been replaced by n-Hexane.

Manufacture of sulphuric acid from pyrite roasting has a lesser impact than using elemental sulphur. Recycling of metals, recovery of metals from spent catalysts, sludge from metallurgical operations etc are intended for reducing the impact of large scale mining of metals and minerals.

Begasse from sugar industry is used as a raw material for paper industry in place of wood pulp; Treated softwood is extensively used in place of hardwood for furniture. Several oxidation reactions involving air are being replaced with gaseous oxygen to ward off formation of toxic nitrogen oxides. Use of new generation polymers and plastics in place of metal in highly corrosive applications etc are intended to reduce the environmental burden arising out of products manufactured and lead to sustainability.

The construction industry is being increasingly encouraged to use locally available materials to replace steel, glass, wood, and cement.

Use of hydrogen in place of fossil fuels in engines is in advanced research stage and once it becomes technically and economically feasible, offer an environment friendly option for transportation. Natural zeolites find extensive applications in place of alkyl benzene sulfonates (ABS) as detergents. Power generation using vacuum residue from crude refining operations is a sustainable option to dispose of the unmarketable end product. These bottoms after improved crude utilization process such as hydro cracking etc are highly viscous, heavy, difficult to handle and as such are not marketable. The quantity of residue from refineries varies from 20 to 40 % of the throughput depending on the crude characteristics and secondary process employed. Refiners are looking for alternative residue utilization strategies for producing lighter, high-value products to help them remain competitive in a market where the demand for light oil products is steadily increasing.

Several biofuels are being used in the automotive industry. Ethanol and bio-diesel that have emerged as reasonable alternatives to the conventional petroleum fuels. These are of agricultural origin and can be easily blended with hydrocarbon fuels unto 50% blends and can be used in existing vehicles without any modifications. Biofuels are renewable resources, non-toxic, and biodegradable and have reduced inflammability and their performance is also superior. Ethanol blended gasoline have become a commonplace fuel in many countries. Ethanol largely available as a byproduct of the sugar industry is non-toxic and is thus environment friendly causing no harm to soil, water bodies and public health. Being an oxygenated fuel ethanol enhances the combustion of gasoline and effectively lowers emission rates from engines.

The use of natural fibers like coir, jute etc put least burden on the environment vis-à-vis other products for similar applications such as nylon, polyester, poly ethylene etc. Coir geo-textiles find extensive application in preventing landslides.

The use of biotechnology products reduce the intensity of normal cropping in terms of inputs like fertilizer, water and have better resistance to adversities like pest infection, crop losses and increased productivity. Several BT products help to reduce environmental footprints.

Recycling of paper and use of natural polymers in place of plastics are greener options. Currently, 150 million tons of plastics are produced a year from fossil fuels all around the world. Plastic products have gained universal use not only in food, clothing and shelter, but also in the transportation, construction, medical, entertainment etc. There is a growing demand for biodegradable plastics as a solution to global environmental and waste management problems.

Research on biodegradable plastics and polymers has been carried out worldwide with the aim of achieving a balance between human activities and the natural environments Ideal biodegradable plastics are defined as materials, which are completely degraded to carbon dioxide and water by the action of microorganisms. The resources of biodegradable plastics and polymers are mainly classified into bio-synthetic polymers such as poly-hydroxyalkanoic acid, plant poly-saccharides such as cellulose, starch and xanthan, and synthetic polymers such as polylactic acid, poly ε-caprolactone and poly aspartic acid. Biodegradable plastics are expected to replace plastics derived from petroleum products in natural environment such as agricultural and fisheries, civil engineering and construction materials and toys where recovery and reuse are difficult and where composting of organic waste is effective such as food packaging, hygienic products on account of its specific features, such as slow release, water retention, medical use, low oxygen permeability and low melting temperature.

6. Green Manufacturing

Green Manufacturing (GM) aims to prevent pollution and save material and energy through innovation and development of new knowledge that reduces or eliminates environmental damages right from the design, manufacture, and application of products or processes. Apart from use of benign materials, changing technologies for processing also add on to the environment friendliness of manufacturing industries. Existing processes also undergo sea changes to become environment friendly. Thus GM requires rethinking of manufacturing systems by pursuing environmentally related goals and objectives, non-traditional manufacturing processes, new marketing strategies, and product design based on a life cycle approach.

Improved catalysts increase conversion and yields, reduce recirculation and increase outputs. The best illustration is the innovation is the development of ruthenium catalyst in place of conventional iron catalyst for the ammonia reaction which helped to improve conversion threefold, reduce size of plant equipment and rendered higher plant capacities viable.

In sito generation and consumption of hazardous and toxic intermediates and thus avoiding storage and transport is another option. An example is the manufacture of methyl isocyanate and its immediate conversion to pesticides without going for storages, a lesson we have learned from Bhopal.

Other sustainable improvements in reaction engineering include Carbonylation using dimethyl carbonate instead of using phosgene or carbon mono oxide, use of solid catalysts to minimize waste, attempt to manufacture petro chemicals from renewable sources, produce alpha olefins from fatty acids rather than petroleum products, avoiding use of toxic acids, catalysts, solvents in all applications and going for photo catalyzed reactions using natural dyes as catalysts instead of heavy metals etc.

Use of low analysis fertilizers with nutrient content sufficient only to meet the demand of the plants, so that leaching to the environment is minimal

The development of membrane cell process for caustic soda in place of mercury cells is an example. This has helped the industry to ward off mercury contamination and the byproduct hydrogen could be used for food grade applications. Membrane separation processes and pressure swing adsorption have come of age for physical separation of gases in place of chemical absorption and regeneration.

The harshness of chemical reactions as depicted by elevated temperature, increased concentration, high pressures, large reactor volumes, corrosion tendencies, flammability characteristics etc are being considerably brought down through technological innovation. Now-a-days several reaction are being carried out under lower temperature, pressure and concentration with improved catalytic efficiencies. The best example is again from the fertilizer industry where ammonia was used to be synthesized 350 atmospheres pressure two decades ago, has been lowered down to operate at as low as 80 atmospheres. The potential for recycling and reuse within are being exploited considerably and modern plants are built with such integrated facilities.

7. Promote Integrated Chemical Complexes

Refinery, fertilizer, power and petrochemicals are themselves major investment and high technology decisions and very often these units are put up by different agencies and function as independent companies. Technology brings in lot of scope for exploiting the synergy with in these units, which could play a major role in improving the bottom line of current operations of these units. Integration of refineries, fertilizer and petrochemical plants, and power generation units at the planning phase it self to develop integrated complexes will help to drastically reduce emission and other pollutants and ensure optimized operation.

8. Review Existing Control Limits for Pollutants

The present standards for discharge of effluents from industrial units are technological limits attainable through application of available technologies for abatement and control available at the time of specifying these norms and are not based on their long-term health effects. Revised standards based on the health impacts of each of the pollutants may be developed incorporating the advancement in this area. While doing so care must be taken to see that the prescribed limits are achievable within the means and reach of the industry.

9. Beyond Compliance of Statutory Stipulations

In process plants systems are employed to the extent of controlling and reducing pollution from plants within the limits set by the statutory authorities. The units do not put in further efforts for reducing the pollution effects beyond the limits prescribed by the pollution control boards (PCB) in the interest of public health. This is primarily due to lack of incentives to encourage additional investment towards improved technology. Hence industrial units shall be encouraged to go beyond compliance and become more environment friendly.

10. Potential of Environmental Biotechnology

Environmental biotechnology employ living organisms–flora and fauna-engineered to exhibit specific traits in order to identify, control or prevent pollution. This technology has been applied to clean up hazardous waste sites more efficiently than conventional methods, thereby reducing the need for incineration or extraction-based methodologies. Bio-remediation has been applied to the cleanup of numerous varieties of pollutants, including oil spills, heavy metals, persistent organic pollutants, explosives, sewage and industrial waste. Because of the prevalence of tropical climate, biological processes for pollution control have an edge over chemical processes and are more efficient. Modern developments such as recombinant and genetically engineered organisms find extensive application in biological processes for pollution control and bioremediation

11. Reduce of Emission of GHGs

Encouragement through adequate financial incentives shall be made available to those intending for voluntary reduction of greenhouse gases and those resulting in climate change etc. The extension of natural gas pipelines, harnessing clean coal technologies, integrated gasification of coal and biomass with combined cycle for power generation shall be encouraged.

12. Reduce Water Intensity

Hydrocarbon processing is a highly water intensive industry. It takes approximately 1-2 barrels of fresh water to refine each barrel of crude. Availability of good quality water for the community and industry is going tor be a major problem in the coming years. In order to address the issue of availability of adequate water for industries recycling and reuse to the extent possible may be resorted to. It has become a boon that membrane technologies have come of age and cost effective these days. Most units rely on ion exchange and reverse osmosis to purify water. Recycling of municipal waste water after adequate level of treatment offers a large scope for industry demand for water and help to improve environmental sanitation around the area.

13. Develop Pollution Inventory Database

The policy shall strive to develop a national level pollution inventory database and ensure that pollutants get reduced over a period of time during the development process.

14. Changing Role of the Regulator

Environmental regulatory authorities in developing countries may be encouraged to become solution providers to the industry rather than being mere policing agents.

15. Hazardous Waste Disposal

Management of hazardous waste materials generated in the industries has become a major concern of plant operators from the environmental angle. Hazardous waste may be a solid, semi-solid or non-aqueous liquid which because of its quantity, concentration or characteristics in terms of physical, hydrocarbon, infectious quality capable of significantly contributing to an increase in mortality or an irreversible damage. Left uncared or improperly treated, stored, transported and disposed, they are capable of posing a potential hazard to human health and neighboring environment. A waste material is classified as hazardous if it exhibits whether alone or in contact with other wastes or substances, any of the characteristics such as corrosively, reactivity, ignitability, toxicity, acute toxicity or infectious property. These substances either created as by-products of the industry or as residues of the process adopted are highly toxic and are capable of causing irreversible damages to the environment. Most industries have identified such materials coming under the purview of hazardous wastes from their operations and are subsequently classified.

A lot of hazardous waste is generated in countries as a result of several industrial operations and there are imports too for recovery of valuables etc. Disposal of such waste is yet to gain the desired importance despite legislation in this regard for over 10 years. Still many industrial districts are yet to identify disposal sites. Determined efforts from the part of local Governments to put up facilities for treatment with in a definite time frame have become necessary.

16. Emergency Planning for Disaster Mitigation

Local level emergency planning for disaster preparedness in case of natural calamities and manmade disasters is important. Effective mechanisms for mitigation of hazards shall be developed under the district administration. The programme may be coordinated on the lines of the Awareness and Preparedness for Emergencies at Local Level (APELL) project of the United Nations Environment Programme (UNEP).

17. Key Issues

Thus, the key issues in environmental management in the processing industries are pollution from solid waste resulting in contamination of land space, liquid effluents endangering water streams and ground water resources and gaseous emissions degrading the quality of atmospheric air, risk to life from operational incidents to people and property in the industry and those in the neighborhood of these units due to storage, handling, transport and use of large quantities of inflammable and hazardous chemicals and hydrocarbons, large scale depletion of natural resources, raw materials, energy resources and water, contribution to global warming due to emission of greenhouse gases and post utility impacts.

Studies also reveal that the units have been successful in controlling pollution from their operations to the level prescribed by the statutory authorities and as required by the law. The best available technology for pollution control and environmental management are being used and it compares well with such practices being adopted internationally.

Generally there is a good deal of compliance by all units to the standards prescribed for discharges of effluents. Often units are committed to attain the norms for various parameters as stipulated by the Pollution Control Boards. Units even go to levels pollution control beyond compliance if there are sufficient economic incentives for making the required additional investments. In other situations no attempt is made by units to achieve better control of pollution beyond the statutory limits.

18. Addressing Challenges: National Environment Policy

The important problems encountered in environmental management in the HPI are lack of

- Incentive for continuous improvement in the direction of pollution reduction beyond the compliance limits of the Pollution Control Boards,
- Integration of environmental concerns in to the core of the business strategy and
- Sufficient transparency with regard to environmental information.

To effectively address the above problems and foster development an apex level environmental policy incorporating clean development strategies with the following elements will be required. Systems are practices are to be in place to identify and assess potential environmental impacts at the conception and planning stage itself , take adequate steps to mitigate impacts during execution of the project and later throughout the operations and still continue to monitor and mitigate impacts even after its decommissioning and site remediation.

18.1 Role of Top Management

The first and foremost guiding principle of an environmental policy facilitating growth of the industry is to ensure the unstinting commitment, involvement and action oriented approach of the top management of the organization in achieving the set environmental goals.

18.2 Environmental Policy Statement

Top management shall codify their environmental commitment, values and perceptions in a documented policy. The policy shall be relevant to its activities, products, and services and taking into account of its implications on the different stakeholders. Attempts for improving energy efficiency, resource productivity and use of renewable source of energy and raw material need special mention in the policy.

18.3 Environment, Health, Safety (EHS) Vision Statement

Every unit shall have an environment, health and safety a vision statement depending upon the nature and scale of its operation and specifying its current thinking and aspirations of the future. They shall adopt a national pollution prevention policy that encourages source reduction and environmentally sound recycling as a first option, but that also recognizes safe treatment, storage and disposal practices as important components of an overa ll environment protection strategy.

18.4 Environmental Targets

The environmental targets i.e., the qualitative and quantitative changes that are to be brought about to bring in more environment friendliness in the industry and acceptance to the community around are to be clearly set. Steps that are envisaged for minimizing environmental impacts, reducing emissions of toxic gases and those causing global warming and improving the current levels of employee health, safety and pollution prevention are to be specified. The target must also address achieving zero accidents at work places, reducing incidents of work related diseases and overall reduction of the risk exposure to the employees as well as the community around. It focuses achieving sustainable development and eco- efficiency as a new business perspective for the industry through production and innovation integrated environmental protection, responsible product stewardship and aiming total quality improvements. It is desirable that the environmental friendliness of the industry shall improve year by year through implementation a guided approach and action plan. For this purpose existing environmental burden (EB) imposed by these units have to be quantified by considering suitable indices for every environmental aspect. A life cycle analysis (LCA) based approach from conception and production to full scale utilization and disposal of the product may be used to determine the overall environment burden.

18.5 Control Strategies

The policy shall provide for the use of legal, financial and social instruments, which influence the behavior of companies, citizens, public bodies and authorities for achieving the objectives of the policy. Existing and innovative control mechanisms such as statutory provisions, stipulations of the various regulatory bodies may be used. Industry may be asked to go for the currently best available technology for pollution abatement. During the interim phase strategy of monitoring comparison with set standards and penal action wherever required shall continue. Plants shall be operated to standards that will comply with the requirements of appropriate national and international legislation and codes of practice. The Govt shall formulate country specific Best Available Techniques (BATs) for the industry to facilitate continuous improvement in environmental management. Technically and economically feasible regulatory as well as non-regulatory measures are also suggested to improve environmental management in hydrocarbon processing operations. Fiscal incentives may be provided to encourage adoption of technologies that reduce pollution.

18.6 Risk Management

It is necessary that the management shall ensure that potential health, safety, and environmental risks associated with the activities are assessed early to minimize and manage adverse effects and to identify opportunities for improvement. A workable Disaster Preparedness and Emergency Management Plan (DPEMP) shall be kept ready to mitigate any such situations in the unlikely event of its occurrence.

18.7 Staff Training

Necessary and state of art training may be given to the concerned people responsible for environmental management. This should include keeping them abreast of the new developments, technologies and practical tools, accident investigation, environmental impact prediction, selecting appropriate protective equipment, implementing emergency response plans as and when necessary and so on. They may be trained to learn from previous incidents and similar experiences. They must be made conversant in the corporate environmental management systems and the proposed action plan for its implementation .In short necessary capabilities must be available in-house with all organizations to tackle probable emergency situations that are likely to arise.

18.8 Monitoring

The policy shall call for regular and meticulous environmental performance monitoring to keep track of the environmental burden imposed by the company and watch the direction of its progressing trends. Quantitative as well as qualitative approaches may be used for this purpose. Emissions, waste streams, hazardous waste, disturbance, resource depletion etc shall be addressed accordingly. Commitments towards targets for Responsible Care and Social responsibility may also have to be assessed.

The current operations shall be regularly and systematically assessed for the purpose both of identifying and correcting any element which may put human beings, real property or the natural environment at risk of nuisance or damage and of establishing a basis of safety- related improvements of processes and products. Any new process and product as well as any new information of existing processes and products should be thoroughly analyzed with regard of their health, safety and environmental implications.

The concerned authorities shall be kept well informed of the operations and of their health, safety and environmental implications. Any incident entailing a risk of environmental disturbances or of conflict with existing regulations should be promptly reported to the proper authority.

18.9 Public Information

Necessary provision may be made for sharing information on environment safety and health with the public is to be incorporated in the policy. The policy shall provide for involvement of the community and working with active environmental groups in the region in bettering the environmental situation and thereby enhancing public perception of the industry.

18.10 Annual Reports

The policy shall call for Annual Environmental Status Reports (AESR) along with the financial performance reports. Such reports are now available from many operators around the World. The feedback on these reports from the concerned stakeholders may be used for continued improvement of existing systems. The policy document shall be integrated with the national environmental plan of the country.

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