# INDUSTRIAL WASTE (IW) MANAGEMENT

GPCA GUIDANCE NOTES ON MANAGING INDUSTRIAL WASTE IN THE CHEMICAL INDUSTRY

Initiative by GPCA Industrial Waste Task Force

18 June 2018

# Contents

# 1. Executive summary

There is increasing recognition by both society in general and industry in specifically that waste generators need to take full responsibility for the effective and safe management of their wastes. It is also recognized that good waste management can be challenging in developing regions, such as the GCC, where regulatory frameworks and supporting infrastructure may not be well established. The Gulf Petrochemicals and Chemicals Association (GPCA), as part of its mission and commitment to Responsible Care®, has identified industrial waste management in the chemical manufacturing sector as an improvement opportunity across the GCC. In line with this, the GPCA Responsible Care Committee appointed an Industrial Waste Task Force (IWTF) to work with GPCA member manufacturing companies to establish an understanding of waste generation and management practices. IWTF is comprised by at least one member from each GCC country to ensure broad and representative input on any subsequent debate.

The taskforce has conducted several surveys with GPCA member companies to determine types of waste, amounts and frequency generated, and the strategies used for managing them. The objective was to share practices and ideas among member companies and assist in the identification of improvement opportunities. Understanding regulatory requirements for industrial waste management across the GCC is equally important and manufacturers are encouraged to fully understand the regulations that apply to them.

While a target of zero industrial waste is desirable, realistically it is unlikely to be realized. It is important to note that not all member companies are at the same point in the development and implementation of their waste management plans. Newer facilities may have used current design strategies to reduce their waste inventory while older facilities could be faced with the challenge of retrofitting plant features to meet prevailing environmental regulations which may not be technically or economically feasible, making disposal the only viable option.

The objective of this guidance document is to provide a mechanism for member companies to evaluate their position in the waste management planning process and to provide a resource to help them improve.

## 2. Introduction

The objective of this document is to provide guidance to GPCA member companies on how to strategically approach the management of their industrial waste streams. This management process applies a simple sequential logic through the lifecycle of a manufacturing facility and aims to eliminate, reduce, recover and reuse waste before moving to the last resort of treatment and disposal. This approach is typically referred to as the waste management hierarchy in environmental literature.

While a target of zero industrial waste is desirable, realistically it is unlikely to be realized due to site specific differences such as technologies, products, age of facility etc. It is also important to note that not all member companies are at the same point in the development and implementation of their waste management plans. Newer facilities may have used current design strategies to reduce their waste inventory while older facilities could be faced with the challenge of retrofitting which may not be technically or economically feasible and that disposal may be the only viable option.

## 3. Scope

The scope of this guidance document is applicable to the management of all hazardous or non-hazardous industrial waste streams arising from chemical manufacturing operations. Wastewater streams that are permitted to be discharged to approve receiving systems are not included in the scope of this document as they are normally regulated separately.
The primary focus of this guidance document is on the oil, gas and petrochemical sectors, although the basic principles can also be applied to other manufacturing industries.

## 4. Definitions

Some definitions may vary regionally e.g. the classification of waste as hazardous or non-hazardous depends on the regulatory criteria used by the local or national body under which waste is managed.

The following definitions are often used in the GCC:

**Industrial waste**: Any unwanted material arising from industrial facilities, such as surplus raw material, out-of-specification end products or by-products, production wastes that cannot be recovered and re-used, material from industrial waste treatment facilities.

**Non-hazardous waste:** A common definition for non-hazardous industrial waste from the chemical industry is any waste material that has not been in contact with the chemical manufacturing process or processes; e.g. construction waste, wood, metal, etc. In some cases, these wastes can be disposed directly to a municipal landfill.

**Hazardous waste**: Commonly defined as industrial waste from the chemical industry that has been in contact with or has been potentially contaminated by the chemical process or processes whether de-contaminated or not.

## 5. Facility design considerations

Waste generation is an important consideration during the design of a new and major expansion or minor modification of manufacturing facilities. It is essential to take the opportunity to identify waste streams early in the project development as this enables methods of elimination, reduction or modification to be identified and built into the initial design. From a design perspective, there is clearly more to gain with a new greenfield facility than an existing facility that may require retrofitting; however, both cases will be discussed in the following text.

The design phase should determine as much as possible the expected "design" composition, characteristics and quantity of all expected waste streams as that information will be useful in evaluating how best to handle them from a waste management standpoint.

### 5.1 New and modifying facilities

Early identification of all waste streams from a new or modified manufacturing process at the design stage is a key advantage as it allows important questions to be asked, such as:

**5.1.1** What is the source of waste stream and can it be eliminated by using an alternative process design or using alternative chemicals with the potential of less environmental impact or the possibility for reuse or recycling?

**5.1.2** Is the local infrastructure available to receive and handle the stream properly?

**5.1.3** Will there be a need to store wastes on site for a period prior to offsite disposal?

**5.1.4** Can the stream be eliminated by reusing it elsewhere in the process, e.g. fuel?

**5.1.5** What is the composition of the waste stream, how much will be generated and can the constituents be recycled?

**5.1.6** Can the environmental impact of the stream be reduced through design i.e., by using alternate materials or in-situ clean-up of a material prior to removal from the process for disposal e.g. absorbent, adsorbent or catalyst?

**5.1.7** Can the waste material be regenerated and reused in the process?

**5.1.8** Does the waste stream have legitimate potential to be a raw material or feedstock for another company?

Answering these questions will enable changes in process design or materials to be incorporated prior to construction, while also having a profound impact on the design waste inventory and its environmental footprint. An important design aspect that is often missed is the provision of an adequately designed on-site storage facility in situations where it is required. On-site storage facilities are typically tightly regulated to minimize the potential for environmental damage; therefore, careful consideration should be given during design.

The primary objective should be to reduce the waste inventory to both the lowest amount and least environmental impact as is practically and economically possible. Many projects do not take this opportunity either due to naivety or to avoid additional costs. However, it will cost potentially significantly more if a smart design approach is not taken at this stage.

Exploring all process design options can achieve many gains in terms of reducing the volume and/or the environmental impact of a waste stream. The most common methods used in this phase would be:

- **Exchange or replace:** This approach involves the identification of alternative manufacturing processes that create lesser impact waste. This may involve the use of different technology or different materials with reduced environmental impact (e.g. catalysts, absorbents, etc.). Some examples of high environmental impact substances that should be avoided, if possible, are listed in Appendix 1. Inevitably, economics will be a factor in the decision to change materials but the long-term cost of disposal should also be included in the evaluation.

- **Recycle or reuse:** There are certain design considerations to identify opportunities to recycle or reuse some materials and plan accordingly.

- **Fuel blending:** Identification of liquid and gaseous streams that are suitable for use as a fuel supplement can be incorporated into the design and reduce plant operating costs. This is economically better if incorporated into the original facility concept design to ensure proper combustion capabilities are in place to manage compliance with air emission regulations. Retrofitting existing and ageing facilities can be prohibitively expensive.

- **Thermal destruction (incineration or similar techniques):** Identification of streams that are not compatible with fuel systems, but are problematic to dispose in a safe and compliant manner by alternative techniques or technologies may require total thermal destruction.

- **In-situ decontamination:** Identification of catalysts and other process materials (e.g. absorbents) that have been in process contact that can be cleaned up on-line prior to replacement and disposal. This may reduce the level of contamination of the waste stream and, also the risks and costs associated with disposal. Neutralization of acidic or basic streams may also fall into this category.

## 5.2 Retrofitting existing facilities

The development of a waste management strategy for an existing facility is more challenging because it is already operational and many design options for reducing, eliminating or reusing a waste stream are no longer economically viable or even technically possible. However, the waste streams should still be evaluated to assess the potential for implementing cost effective modifications wherever possible.

The starting point for retrofitting existing facilities is that all waste streams need to be identified, quantified and analyzed to determine the quantities, composition and characteristics. We can then ask similar questions as in the case of a new facility:

- What is the source of the stream and can it be eliminated by modifying the design?

- Can the stream be eliminated by reusing it elsewhere in the process (e.g. fuel)?
- Can the environmental impact of the stream be reduced through modified design or changing the materials used in the production process?
- Can the waste stream be regenerated and reused in the process?

If the answer to any of the above questions is "yes", then a project should be considered to assess the economic feasibility and benefit of implementing a design change. The driver for the project should be continued environmental compliance but it would nevertheless be influenced by the economics, i.e. is it more cost effective to make the change or accept the cost and potential risk associated with safe disposal? Due regard must be given to the potential for negative publicity in the event of non-compliance with prevailing environmental regulations.

Exploring all process design options should achieve many gains in terms of reducing the waste inventory.

# 6. Industrial waste management planning

As stated previously, not all member companies are at the same point in the development and implementation of their waste management plans. More recent facilities may have used current design thinking to reduce their waste inventory, while others could be faced with the challenge of an older facility where retrofitting may not be economic and disposal is the only option. Disposal must be considered as "last resort" and not the "first choice" The following text outlines the thought processes to be applied to the development of a waste management plan for both new facility designs as well as the modification of existing facilities. The main elements of a waste management plan are listed in Appendix 2.

## 6.1 Policy development

Establishing a waste management policy, approved by management, is an important first step as it aligns the organization on a clear objective and purpose.

## 6.2 Regulatory requirements

Regulations governing the management of industrial wastes are not consistent across the GCC so a good understanding of applicable local and national environmental requirements should be a pre-requisite at the conceptual design of a new project. In the absence of local regulations, plant design should reflect the environmental control standards employed elsewhere e.g. US EPA (40 CFR), EU Directives etc. A key aspect is to fully determine any permitting requirements and submit design basis documents (EIR, EIA) for approval by the regulating authority. This would normally precede commencement of commercial operations but requirements may differ across the six GCC states.

In addition, it is important to gain a detailed knowledge of the existing local waste management and treatment infrastructure and what, if any, future facilities or developments are planned. These factors may have a significant influence on the design basis of a new facility and accordingly will play a major role in minimizing the waste inventory from the outset.

## 6.3 Understanding infrastructure capabilities

Gaining an understanding of local waste management infrastructure capabilities is essential to determining what approved and acceptable disposal options are available. It is sensible to not only look at current infrastructure capabilities but also to determine what enhancements may be planned for the future so they can be considered during the planning process.

This will enable the individual wastes on the company waste inventory to be matched up with infrastructure capabilities to determine gaps and areas of concern. For the purposes of exercising Responsible Care® waste generators should satisfy themselves that waste management or waste recycling companies are licensed to operate and have the necessary and appropriate facilities and technologies to undertake the waste disposal or recycling process in a safe and compliant manner. Generators should not rely solely on a certificate issued by the environmental regulator and must manage their own liabilities.

## 6.4 Establishing the waste inventory

Identification of waste streams occurs typically during the facility design phase which is covered in detail in section 6. It should be recognized that generation rates and composition are only estimated at this stage, although lower and upper limits of waste generation quantities should be quantifiable. Actual operating data should be used to update and refine the inventory to reflect the actual profile of each waste stream.

Establishing and maintaining the waste inventory will provide a baseline for trending the benefits of waste reduction efforts and is an essential component of the waste management plan. The waste inventory should be subject to annual review and updated to reflect modifications made to manufacturing facilities (engineering, production rates, etc.) as they can also result in changes to both waste generation rates and composition.

## 6.5 Waste characterization and profile

The design phase should determine as much as possible the expected "design" quantity, composition and characteristics of all expected waste streams as that information will be useful in enabling a preliminary evaluation of how best to handle them from a waste management perspective. In many cases, it will be necessary to conduct tests on the waste to gain a full understanding of its composition and determine the most effective method of handling. Tests may include simple analytical testing for pH, dry solids contents, spot testing for VOC's etc. or may involve more sophisticated analysis such as gas chromatography (GC) with or without mass spectrometry (MS) or other techniques such as toxicity characteristic leachate procedure (TCLP), which simulates the chemical profile of a leachate following surface containment.

## 6.6 Waste reduction considerations

Waste reduction can be achieved by actively assessing the capability for reusing or recycling each waste material. The objective is to either eliminate the waste altogether, minimize the volume of waste generated through in-process means or reduce the environmental impact by using some form of in-process treatment (e.g. steam stripping of a catalyst prior to removal from the process, API oil separators, ammonia stripping towers, etc.). All of these approaches would potentially reduce disposal costs and liability to the generator. The ideal time to look at reduction opportunities is the original design phase. However, it is recommended that this be an ongoing effort to explore the benefits of new technologies.

## 6.7 Selecting waste treatment or disposal method

The most important aspect of this phase is to understand the composition of the waste stream and the environmental risks it presents so the options for disposal can be identified for evaluation.
Understanding applicable regulations is essential in this evaluation as disposal options may be dictated by the environmental regulator which may promote or prohibit specific technologies or waste destination routes.

## 6.8 Managing waste inventory

Having maximized waste reduction through smart design most facilities will be left with a residual waste inventory to manage. Further reductions may be more challenging to achieve and reflect the "Law of diminishing returns". They should, however, remain the primary objective. Facilities that maximized waste reduction by design may "hit a plateau" in their ability to reduce inventory further and, in some instances, may even increase due to production expansion activities. It is recognized that some waste generation rates are directly related to production rate; therefore, if production increases so would waste generation.

## 6.9 Tracking waste management performance

Maintaining records of the generation and disposal of each individual waste stream is important to enable understanding of changes in generation rates as well as details of how and where waste was disposed together with any trend in actual disposal costs.

Setting annual reduction targets can also be a useful approach for driving further reductions although this needs to be done with care. Targets need to be demanding yet realistic and achievable and reflect the different situations at each company and between "identical" plants operating in other geographic locations. Those with design reductions in place will not necessarily be able to take on and achieve significant target annual reductions over time as their gains are made in the facility design phase. Given this, reduction targets should be site specific and not mandated across the manufacturing sector.

# 7. Transportation of wastes

Transfer of waste from the manufacturers' facility to the approved disposal site is normally done by third party contractors who are approved by the governing regulator and in accordance with all regulatory requirements. All waste movements should be carried out under a manifest system which ensures that all information relates to the waste, i.e. the waste generator, the transporter, the waste recipient, the quantity and the necessary health and safety precautions to be observed. The transport vehicle should also be suitably placarded in accordance with environmental regulations and transport standards.

The manifest document is signed by all involved parties at each point as evidence of the chain of custody with the final manifest document returned to the generating manufacturer with the invoice from the waste recipient.

## 8. Selecting disposal facilities

In most cases, manufacturers will dispose their waste streams to third parties but will still retain title over the waste and the inherent responsibility and liability for ensuring that proper treatment and ultimate disposal is undertaken in accordance with current environmental regulations. In some GCC countries contract disposal facilities are licensed and approved by the regulating authority and industry is required to use them. In these cases, the burden on the manufacturers for evaluating, assessing capabilities and ongoing performance monitoring is minimal. It is still recommended, however, that manufacturers conduct initial and periodic site audits of disposal facilities that they have contracts with and to report any non-compliance to the regulatory agency.

In situations with no regulatory oversight of disposal facilities, it is important that manufacturers take full responsibility for evaluating, selecting and monitoring ongoing performance. This would include establishing an auditable process that tracks the waste stream from generation through to final disposal i.e. from “cradle to the grave.” Appendix 3 lists some typical questions that could be included in audits of disposal facilities but it is important that local conditions be considered and appropriate questions be included.

## 9. Training

The importance of providing training to those involved in the management of industrial waste from manufacturers and transporters through to contact disposal sites, should not be underestimated. This training should be constantly reviewed to keep pace with changing regulations to ensure ongoing compliance with requirements.

## 10. Exceptions

Typically, the transfer of waste material from the generating country to another country for disposal is banned under the Basel Protocol which has been signed by most countries in the world including the GCC states. However, it is possible to transfer some wastes, from which some value can be recovered, e.g. precious metals to a third country for processing, but this needs to be done under a strict control procedure. The procedure is justifiably rigorous requiring justification, documentation and tracking be followed to ensure complete control and traceability between the generating and receiving countries.

## APPENDIX 1 – Chemical substances to be avoided

| Substance to be avoided | Possible alternative(s) |
|---|---|
| Leaded paints | • Unleaded paints. Also water-based or low-volatility solvent formulations |
| Lead naphthanate (lubricant) | • Lead-free lubricants |
| Leaded thread compound | • Lead-free thread compounds (for tubing and casing) |
| Mercury (in pressure-measuring<br>devices/ instrumentation) | • Differential pressure cells/transmitters, pneumatic or electric instrumentation |
| Asbestos | • Non-asbestos containing materials |
| Heavy metals (in reverse emulsion<br>breakers, barite and grit blast) | • Polymer (non-latex)-based formulation, low metals concentration barite and grit blast |
| Hexavalent Chromate corrosion inhibitors | • Sulphite or organic phosphate corrosion inhibitors, especially those with reduced toxicity<br>amine function |
| Chrome lignosulphonate (as fluid loss controlling agent) – acceptable in<br>small amounts for rheology control | • Carboxymethyl starches for fluid loss control. Improved mud control to reduce fluid loss. If used (for rheology), keep dose small and use formulations with trivalent form complexed in lignin structure. |
| Polychlorinated biphenyls (PCBs) | • Silicones, esters, cast resin |
| Pentachlorophenol (PCP) and formaldehyde (biocides) | • Glutaraldehyde, iso-thlazoline (or other low-toxicity biocides) |
| Chlorofluorocarbons (CFCs) | • Depends on use. CFC alternatives lists can be obtained through:<br>» US EPA – CFR reference, 40 CFR 82 subpart G appendices<br>» UNEP DTIE – Ozone action branch |
| Chlorinated solvents e.g., carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene | • Non-chlorinated hydrocarbon-based solvents, steam cleaning |

**NOTE:** This is a list of common environmentally damaging substances and is not all inclusive. All substances should be verified before a disposal option is selected.

| Source | Action(s) |
|---|---|
| Obtain management approval and commitment | • Review planning basis with management.<br>• Resolve resource/scheduling issues.<br>• Obtain management approval and commitment to develop plan. |
| Define objective and purpose | • Outline organizational and geographical boundaries covered by plan. |
| Identify and categorize wastes | • Determine that all wastes generated within the area are covered by the plan.<br>• Identify physical and chemical characteristics that may warrant special handling.<br>• Determine volumes, frequencies and differing types and quantities of waste generation through life-cycle of project.<br>• Determine types of waste that will be generated with contingencies i.e. plan for the unexpected.<br>• Categorize waste as appropriate. |
| Identify applicable regulations, restrictions and requirements | • Identify applicable host country and local laws and regulations.<br>• Evaluate agreements (Intergovernmental agreements, lender commitments to internationally recognized standards e.g. World Bank requirements) and any potential trade restrictions.<br>• Account for project partner(s) publicly stated company policies and operating standards. |
| Identify infrastructure requirements | • Evaluate local waste management facilities and collection/storage/transportation/disposal or reuse systems.<br>• Consider regulatory restrictions, engineering limitations, operating feasibility (locally available spare parts and trained personnel to operate specialized equipment), practicability and the availability of approved waste management sites. |
| List and evaluate waste management options | • List potential waste management practices.<br>• Determine each option's HSE risk. |
| Perform source reduction analysis following the waste hierarchy (eliminate, reduce, reuse recycle, dispose with energy recovery, dispose) | • Evaluate opportunities for source reduction, followed by volume and toxicity reduction.<br>• Re-use/recycle, if possible.<br>• Evaluate contractual conditions for vendors to supply goods with reusable/returnable packaging or return unused product to vendor whenever practicable. |
| Select waste management methods | • Choose environmentally sound, practicable and legal method for the area of operation and location.<br>• Select alternative management method if appropriate. |

## APPENDIX 2 – Elements of a waste management plan

| Source | Action(s) |
| --- | --- |
| Develop and implement plan | • Procure/build/staff any additional plant or facilities.<br>• Develop/ revise procedures for waste handling and facility operations.<br>• Develop and execute deployment plan.<br>• Provide communications and training/competence to affected parties.<br>• Review and resolve any new resource commitments with management.<br>• Test waste producer line of sight to the final treatment and/or disposal point of all wastes generated (Duty of Care).<br>• Obtain management approval & commitment to implement plan. |
| Review and update plan | • Verify and track environmental performance - Environmental Performance Indicators (EPIs).<br>• Periodically review plan.<br>• Evaluate new or modified waste management practices.<br>• Revise plan as necessary. |

## APPENDIX 3 – Checklist for evaluating contractor waste management facilities

| To consider in the Evaluation | Checklist / list of required evidence |
|---|---|
| What types of waste are accepted at the site for treatment and disposal, and what methods are used? | • Applicable site license in place.<br>• Site procedures. |
| Are the treatment and disposal methods appropriate, for the types of wastes accepted? | • Local legislation.<br>• Company policy.<br>• Good practice. |
| Are all required regulatory permits in place? | • Copies of relevant permits/licenses for site and equipment (if required). |
| Is the facility in compliance with regulations and permits? | • Reports submitted to regulator.<br>• Regulator site inspection reports.<br>• Records of breaches/fines. |
| Are the facilities located, designed and constructed to provide environmental protection? | • Was an Environmental Impact Assessment performed?<br>• Appropriateness of design in relation to e.g. local geology, land use, topography, presence of usable groundwater, soil permeability.<br>• Evidence of e.g. landfill lining, emission controls (for incinerators etc.), integrity testing for disposal wells. |
| Does the site have effective management and monitoring controls? | • Site procedures.<br>• Environmental monitoring program.<br>• Evidence of monitoring and tracking emissions against maximum permissible limits.<br>• Organized and effective waste manifest system.<br>• Use of competent, accredited laboratories for analysis.<br>• Vehicle maintenance and service records. |
| Have steps been taken to mitigate the risk of HSE incidents? | • HSE Management Plan.<br>• Condition of containers holding waste materials.<br>• Provision of secondary containment and/or impervious barriers to prevent migration of materials and spills.<br>• Level of housekeeping.<br>• Any apparent spills and stains.<br>• Training and awareness of staff. |
| Does the facility respond quickly and effectively to any incidents? | • Spill response plan.<br>• Spill observation and reporting system.<br>• Spill response training records.<br>• Provision of spill kits on-site. |
| Does the facility have a good safety culture with adequately trained and resourced employees (including appropriate protective equipment)? | • Appropriate risk assessments.<br>• Training plan and training records.<br>• PPE availability on site.<br>• Appropriate PPE, SDS, and Signage etc.<br>• Performance track record. |
| Does the site have soil or groundwater impacts from previous or current operations? | • Site EIA (Environmental Impact Assessment)/license.<br>• Records of previous use. |
| Does the facility have a good safety culture with adequately | • Appropriate risk assessments.<br>• Training plan and training records.<br>• PPE availability on site. |

| | |
|---|---|
| trained and resourced employees (including appropriate protective equipment) | • Appropriate PPE, SDS, and Signage etc.<br>• Performance track record. |
| Are impacts from nearby sources potentially affecting the site, for instance from groundwater migration? | • Groundwater monitoring program results. |
| How close is the facility to nearby residents, cultural properties, or sensitive environmental areas? | • EIA (Environmental Impact Assessment).<br>• Site location plan. |
| Is security at the site adequate to prevent unauthorized access? | • Adequate fencing/patrolling.<br>• History of security breaches.<br>• Sightings of unauthorized personnel on site. |
| Are any sub-contracted services selected and managed responsibly? | • Evidence of effective sub-contractor audits. |
| What is the financial security of the facility, in terms of its longevity of operation and its ability to pay for potential incidents? | • Company funding/share owners, date of company founding, market share. |
| What are the relations with the surrounding community and regulators; is the facility a 'good neighbor'? | • Records of complaints, fines, local perceptions. |
| Does the facility have an end-of-life reinstatement plan and provision for its implementation, e.g. financial assurance? | • Decommissioning plan. |

## Acknowledgements

The Gulf Petrochemicals and Chemicals Association (GPCA), Responsible Care Committee (RCC) and the Industrial Waste TaskForce (IWTF) would like to recognize every member and associated company that has supported IWTF in finalizing this report by either providing their waste management information and / or sharing their waste management practices. IWTF would also like to extend its gratitude to waste management regulatory authorities in the GCC for their usual outstanding support and transparency. Finally, our appreciation goes to the professionals at waste management contracting companies who were ready, on short notice, to share information about their capabilities, capacities and the challenges they face in helping industry to manage their wastes in an environmentally sound manner.

## Disclaimer

While every care has been taken to ensure the accuracy of the information contained in this publication, neither GPCA nor any of its past, present or future IWTF members guarantees its accuracy or will, regardless of its / their negligence, assume liability for any foreseeable or unforeseeable use made thereof.

The aim of this document is to provide useful reference information related to the requirements of GCC waste management practices, generation analyses with data provided by participating Waste Generators, the related applicable waste management legislations in the GCC, and best practices examined in limited number of countries outside the GCC. The content, however, is not intended to replace, amend, supersede or otherwise depart from regulatory requirements in GCC countries. In the event of conflict between the provisions of this document and local legislation, the applicable laws shall take precedence.

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## About GPCA

The Gulf Petrochemicals and Chemicals Association (GPCA) represents the downstream hydrocarbon industry in the Arabian Gulf. Established in 2006, the association voices the common interests of more than 250 member companies from the chemical and allied industries, accounting for over 95% of chemical output by volume in the Gulf region. The industry makes up the second largest manufacturing sector in the region, producing over USD 108 billions worth of products a year.

For more information, please visit www.gpca.org.ae.