CASE STUDIES

Aerosol Sector Conversion in Action

OzonAction Information Clearinghouse
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DISCLAIMER:

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ABBREVIATIONS:

CFC(s)	chlorofluorocarbon(s)
CTC	carbon tetrachloride
DME	dimethyl ether
GO_	Government of (first initial of a country)
GWP	global warming potential
HAP(s)	hydrocarbon aerosol propellant(s) - highly pure form of butanes and/or propane
HC(s)	hydrocarbon(s) - mixture of butanes and propane
HCFC(s)	hydroclorofluorocarbon(s)
HFC(s)	hydrofluorocarbon(s)
LPG	liquified petroleum gas - mixture of butanes and propane
LEL	lower explosive limit
MC	methyl chloroform (1,1,1 trichloroethane)
MeCl	methylene chloride
MF	Multilateral Fund
MP	Montreal Protocol
NFPA	National Fire Protection Association
OAFR	open air filling room
ODP	ozone depletion potential
ODS	ozone depleting substances
OORG	Ozone Operations Resource Group
ppm	parts per million
TAP	Technical Assistance Program
TOC	Technical Options Committee (unless otherwise stated, used here to refer to the UNEP TOC on Aerosols, Sterilants, Miscellaneous Uses and Carbon Tetrachloride.
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
VOC	Volatile Organic Compound
WB	The World Bank

List of Words and Terms:

activated carbon
alarm
anti-spark
can beads
Carbon Dioxide
coarse sprays
clog
corrosion
cosmetics
crimping
curl dimension
degreaser
deicer
density
deodorants
dilution
Dimethyl Ether
engine starter
explosion proof
extraction
feedstocks
filling area
fine sprays
flame
flame photometric
flammability
flammable
foams
formulate
formulation
gas detection equipment
gaseous phase
gaskets
gassing rom
hair sprays
handling
head space
hood
humidity
hydrogen
hydrogenation
insecticides
lacquer
lower explosive limit
lining
liquid phase
mercaptans
methylene chloride
methyl chloroform
molecular sieve adsorption
mousse
ozone
paints
perchlorethylene (PCE)
perfume
petrochemicals
piping
proprietary
pressure
pressure resistance
pump
pumping
purification
raw materials
refinery
resin
Roland Molina theory
saturated
seals
sensors
siren
sodium alumina silicate
solvency
solvent
spark
stability
storage
sulphur
swelling
tower
unsaturated
vacuum crimping
vapor tap (or phase) hole
ventilation
viscosity
warehouse
water base
water bath
wet sprays

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Forword:

The principal author of these "Aerosol Sector Case Studies" has visited over 20 countries in the last three years dealing with conversions in the aerosol sector, and the question that is always asked is "what was done in 'x' country." The "x" might refer to geographical nearness (Guatemala will compare with El Salvador); or size (China with India and vice versa), or natural competitors (Malaysia with Singapore or Thailand), but this is the only question that is invariably asked. Here are some of the answers!

In these Case Studies from around the world, from countries large and small, it can be seen how intelligent and effective work by men and women of many countries has solved a variety of problems and overcome numerous complex obstacles to achieving the common goal of reducing and eventually eliminating ODS usage in the aerosol sector.

The aerosol sector is unique in that it was the only sector for which the solution to the problem was known when ozone depletion became widely recognized in the 1970's. Conversion to propellants such as HAPs, the common choice, and substitution of pump sprays for true aerosols are known technologies that can not fail to solve the problem when correctly applied.

But, there is a saying that "God is in the details." Observe that in some cases HAPs are not available, or have odor or chemical composition problems that make their usage difficult or too expensive. Some conversion attempts have turned out badly, where technical information was not available when needed. It is explained how these problems have been met by governments, industry groups, businessmen and women and local and foreign experts, with implementing agencies often being able to provide financial help through the Multilateral Fund to finance well conceived projects.

Reading through these Case Studies will provide a great deal of the specific detail needed for other people approaching conversion, in order to recognize what kinds of problems they will face, and what support and technical advice they may expect. As on-going projects, by 1996 (or even late 1995) some of these projects may be changed significantly, but the lessons to be learned will not change. In aerosols we are dealing with technology 20 years old at least!

For further information, or to obtain copies of the UNEP *IE's Sourcebook: Technologies for Protecting the Ozone Layer: Aerosols, Sterilants, Miscellaneous Uses, and Carbon Tetrachloride,* or the *Aerosol Conversion Technology Manual,* or additional copies of these *Aerosol Sector Case Studies,* please contact:

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Introduction to the Aerosol Sector Case Studies

A Condensed History of Aerosols and the CFC Propellants:

The aerosol industry as we know it today began during World War II with the production of several million "sprays" known as "bug bombs" that were widely used by Allied soldiers in the Pacific Theater. These products used DDT as the active ingredient and were propelled by dichlorodifluoromethane, or CFC 12 (the "CFC" stands for "chlorofluorocarbon").

In the late 1940's, the development of the low pressure aerosol can, which was derived from beer cans, and the production of the aerosol valve that could be "crimped" into the container, made this innovative packaging form available to the consumer. Hair sprays and shaving foams, as well as insecticides, were the first successful "aerosol" products (the name is derived from the small size particles that insecticide and other "aerosol" sprays produce). They were packaged with a mixture of CFC 12 and CFC 11 (trichlorofluoromethane), usually with the gases in 50%/50% proportions.

Aerosols flourished in the 1950's, and their acceptance by the consuming public was in large part due to the noble qualities of the CFC propellants. It is likely that aerosols as we know them today would not have evolved without the CFCs. There were only three drawbacks to their use that were recognized in these early days:

- They were relatively expensive.
- They are heavier than water, causing problems with some aqueous products.
- They (especially CFC 11) had a tendency to hydrolyze, causing destructive corrosion.

These problems led to the search for an alternative. Isobutane (or a mixture of butanes and propane) was the proper pressure for use as a propellant, but was usually contaminated with mercaptans that had a very undesirable odor. Means were found to eliminate this odor (and the mercaptans), and the hydrocarbons began being used as propellants around 1955. During the following two decades, many products converted to the hydrocarbons, while many others remained with CFCs as propellant.

The popularity that aerosols enjoyed in the United States of America, Europe and Japan, was found to be universal, and most countries around the world began to take interest in aerosol manufacturing. Until the late 1970's, many countries had protective tariffs in place which made the importation of finished aerosols very costly, while it was found that producing aerosols was an industry that could be entered with relatively little capital investment. Aerosol manufacture became global in scope.

In June, 1974, Drs. F. Sherwood Rowland and Mario Molina of the University of California at Irvine published an article in the British Journal *Nature,* in which it was postulated that the chlorofluorocarbons were damaging the stratospheric ozone layer, which protects the earth against an excess of damaging ultraviolet radiation. Other scientists contended that this "ozone depletion" theory was absurd. The controversy raged on for almost a decade.

In September, 1987; 24 nations signed the Montreal Protocol on Substances that Deplete the Ozone Layer, promising initially to limit the production of CFCs and other ozone depleting substances (ODS), and later to desist in their use. By 1994, 128 nations have ratified this accord, representing 100% of all producers of CFCs, and about 96% of all consumption. Shortly after the Montreal

Protocol was prepared, new scientific evidence conclusively linked CFCs to ozone depletion, and indicated that ozone depletion had already occurred.

In the mid-1970's, aerosols represented up to 60% of all CFC usage. This figure began to decline at the very end of the 1970's, when the United States, Sweden, and Norway banned their use in aerosols This decline has accelerated since the Montreal Protocol was signed.

The Conversion Problem in Developing Countries:

Most of the major industrialized nations of the world, with their well developed chemical and petrochemical industries, high volume production, and ready availability of capital; have had little problem with converting to hydrocarbons, or other alternatives. They have been able to produce the special "hydrocarbon aerosol propellant" (or "HAPs") mixture of butane and propane that will result in over 80% of all conversions from CFCs to alternate propellants.

Thus the aerosol sector had acceptable alternatives available a decade ago, unlike other areas where CFCs are used, such as the refrigeration, air conditioning, or foams industries. This was to prove very important.

There remains the problem of the developing countries, which the Montreal Protocol defines in Article 5 as countries that have a per capita consumption of ozone depleting substances (ODS) of less than 300 grams per year. Some of these countries developed sources of HAPs and converted very early: Mexico, Brazil, Argentina, the Philippines, Peru, are just a few of the countries that have almost 20 years experience with hydrocarbon propellants. Other countries (Turkey, Morocco, and Egypt, to name a few) have converted since the signing of the Protocol.

There remains a large number of countries that still manufacture aerosols with CFC propellants, including China, India, Indonesia, Thailand, Malaysia, Tunisia, etc. There is also the special situation of the Russian Federation, not considered a developing country under Article 5 of the Protocol, whose very large and integrated aerosol manufacturing companies have also not converted.

Sources of true "aerosol grade" hydrocarbons are not available in most of these countries, and in some of them the aerosol fillers do not have the technology to safely fill them. (HAPs are highly flammable, and while they do not present a major safety problem for the consumer, they are very dangerous in the aerosol filling plant.) Nor do fillers in these countries have the capital available to make the major modifications that often must be made in their plants to fill HAPs safely.

Aerosol filling is a labor intensive industry, and the social cost of large scale shut downs of aerosol filling plants would be very high. It was necessary that something be done to both protect the aerosol filling companies against unacceptable accidents, while at the same time protecting the source of jobs that the local aerosol industry represents.

The Montreal Protocol Multilateral Fund:

A large majority of chemical plants that produce CFCs are in the developed, industrialized countries. It was these producers that have sold their technology and their products to the developing countries of the world. During the 1990 meeting of the Parties to the Montreal Protocol, the developed countries accepted the fact that it would be necessary to assist the developing countries in their efforts to convert to alternate technologies. They agreed to form a Multilateral Fund to assist Article 5 (developing) countries, and named three Implementing Agencies, the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP), and the World Bank. These original three implementing agencies have since been augmented by a fourth, the United Nations Industrial Development Organization (UNIDO).

It was agreed that this Multilateral Fund, which now consists of U. S. $550,000,000.00 for three years, would be used to fund *approved incremental costs* of Article 5 industries that were converting from ODS to alternate substances.

As mentioned earlier, aerosols already had an acceptable alternative, HAPs, before other sectors even knew what technology they would use to phase out CFCs. It is therefore not surprising that aerosol companies were among the first beneficiaries of the Multilateral Fund.

How Conversion Occurs in Developing Countries:

Converting aerosols from CFC propellants to hydrocarbons requires:

In almost all venues HAPs are less expensive than CFCs, so if the three factors above are present,

- The availability of HAPs, or at least an acceptable quality of hydrocarbon propellant for the type of products produced.
- The availability of technology. This covers both the required knowhow to convert the product formulations, and the specific safety technology required to use HAPs without accidents.
- The availability of sufficient capital to make the needed plant modifications.

the aerosol industry in a given country will largely convert to them. In countries where conversion took place early, many different scenarios occurred. In Mexico, a propellant company was formed in the early 1970's to produce HAPs. This company disseminated the necessary technology as part of their business strategy, and the aerosol fillers converted as capital was available to do so. This is Case Study #9. In other countries (Guatemala is a good example) an aerosol filler produced the first hydrocarbon propellant, and because of the cost differential, the competition was forced to do likewise or go out of business.

In 1995, all developing countries that have not converted are under strong pressure to do so. The following factors are forcing the conversion away from CFC propellants at this time:

Because of these factors, developing country governments around the world are insisting on action

- Governments are insisting on phaseout as part of their programs for compliance with the Montreal Protocol.

- Many developed country producers of CFC have stopped production, so supply is scarce and prices are rising. In less than a year all developed countries will stop CFC production, and the only sources remaining will be the developing countries (China, India, Mexico, Venezuela, Brazil, and Argentina are the known Article 5 producers of CFCs). Prices are sure to rise even more.

- CFC based aerosols cannot compete in most export markets because of cost.

- Many countries do not permit the importation of products that contain CFCs.

- Multinational companies are insisting that their aerosols be "ozone friendly," and are clearly stating on the product label that "this product does not damage the ozone layer," putting great pressure on local brands to do the same. Some major supermarkets and department stores will not purchase aero-sols that do not have this

now concerning aerosols, an area where the technology is well known, and progress can be rapid. The Implementing Agencies for the Montreal Protocol have responded by beginning programs in more than 15 countries concerning aerosols. This work has focused on resolving the three problems that impede conversion indicated above: the availability of HAPs, the necessary technology, and the needed capital.

The Dissemination of Aerosol Conversion Technology:

When field work began in aerosols in developing countries (1991), it became apparent that there was a serious lack of technical literature that could be of use to technical people in developing countries. In some areas no formal literature at all was available (the technology for purifying liquified petroleum gas or "LPG", for example), whereas in others the available literature was so technical and complicated as to be incomprehensible to technicians with limited experience and often limited applicable language skills. UNEP IE quickly acted to correct this lack, and has produced two valuable documents:

UNEP IE's Sourcebook: Technologies for Protecting the Ozone Layer: Aerosols, Sterilants, Miscellaneous Uses, and Carbon Tetrachloride *
*The Aerosol Conversion Technology Manua*l *

* Contact UNEP IE for more details concerning these documents

While these documents largely corrected the general lack of technical material written in a simplified manner, the increasing importance of the Multilateral Fund as a source of the needed capital for conversion has raised many *practical* questions in the field. Both governments and the aerosol industries are requesting "how to" knowledge of what has already taken place, so as to be able to foment their own internal policies, and plan the actions that will lead to successful phaseout of CFCs in aerosols.

The Aerosol Sector Case Study Series:

This series of case studies will largely correct the lack of available practical information on how conversions can take place. This series is not a technical manual - for that the two documents cited above will suffice. This document describes actual decisions that have been made, and deals with the following areas:

- **The Availability of HAPs:** Case studies dealing with conversions in China, Jordan, Mexico, Venezuela, Indonesia, and Ecuador directly deal with this subject.

- **The Use of Not-in Kind Substitutes:** A case study concerning a company in the Russian Federation deals with the conversion to mechanical pumps.

- **Conversions of Aerosol Fillers to HAPs:** Case studies dealing with conversions in China, Jordan, India, Mauritius, Indonesia, and Ecuador directly deal with this subject.

Many of the conversion projects described here are on-going, and changes may be made before they are finished. We are dealing with known technology, however, and once the proper planning has been carried out and a project is implemented, a successful conversion is a foregone conclusion. As on-going projects, however, there is always the possibility of cancellation, or of serious modification, but it is felt that even if this happens the lessons that can be learned would still be valid.

All of the projects described here require between 12 and 31 months to implement. The advantages of getting this information disseminated now far outweigh the disadvantage, which is that some changes may occur. The manner in which the problems were solved in these twelve case studies will be of use to both governments and individual aerosol industries that are struggling with how to convert from CFC propellants to alternatives as soon as is possible.

AEROSOL SECTOR CASE STUDY #1 A Central Filling Station for Tianjin, China

Introduction:

Major aerosol filling in China started somewhat late, but currently there is a boom in aerosol filling. Locally filled products enjoy a significant price advantage over imports. CFCs are practically the only propellants used in China, so the sharp rise in the sale of locally filled products has led to greatly increased CFC usage.

Projection of China's CFC Usage in the Aerosol Sector
(based on a UNDP study by Leo Laine, 1992)

Year	Production (million units)	CFC Consumption (metric tons)
1990	48	4,700
1991	96	9,277
1992	134	12,853
1993	192	18,058
1994	211	19.438
1995	232	21,373
1996	256	23,584

In addition, because China has such a large population and uses far fewer aerosols per capita than many other Article 5 countries, this usage is projected to rise sharply, with China's aerosol sector accounting for a growing share of the world's declining CFC usage.

The government of China (GOC) reacted vigorously to these projections, and even before they had signed the Montreal Protocol, they commissioned a study done by an experienced aerosol expert under the auspices of UNDP. This steadily increasing projected usage of CFC' was confirmed. It was obviously desirable to develop a strategy for phase out in the aerosol sector in China. This case study discusses one of the projects developed, the Tianjin First Daily Use Chemical Plant project, and explains the innovative "filling center" concept.

The Chinese Situation:

China is a very large country that developed its aerosol industry only relatively late, during a period of openness towards consumer products and expansion of the national economy. One of the characteristics of aerosol filling is that it requires relatively little capital investment. It is therefore not surprising that China has a large number of small aerosol fillers, at least 100-150 separate operations in all.

One major advantage in seeking to phase out CFCs in the aerosol sector is that the vast majority of the aerosol fillers in China are located in just three areas: in the northern coastal region in the Beijing-Tianjin area, the subject of this case study; in the central coastal area in and around Shanghai; and in the southern coastal region of Guangzhou. Each of these areas accounts for approximately 30% of China's aerosol filling, and the CFC usage in the aerosol sector. The

remainder of the country consumes the final 10%, although there are now (early 1995) indications that aerosol filling is spreading inward from the coastal regions.
China also has an economy with a great deal of state control. All CFCs currently used in the aerosol sector are produced locally, and some of the suppliers such as the important Tianjin Chemical Material Supply Station are government operated. The majority of Chinese aerosol manufacturing is controlled under the National Council of Light Industry (NCLI), while the overall ozone depleting substance (ODS) phaseout program in China is managed by the National Environmental Protection Agency (NEPA).

Tianjin area aerosol fillers consist of 17 plants in the city and suburbs, and 25 additional plants scattered within 200 km. of the central hub. While some "plants" produce 40,000 units per year, the large First Daily Use Chemical Factory produces in excess of 6 million units per year.

Finally, LPG (liquefied petroleum gas) is readily available in the Tianjin area, although not of aerosol grade. To derive HAPs (hydrocarbon aerosol propellants) from this feedstock, it must be purified to reduce odor problems.

The Filling Center Concept:

Many different GOC organisms participated in the initial study with UNDP that defined the filling center concept. Simply explained, this concept is based on two precepts. First, it is not possible for so many small enterprises to purify hydrocarbons for aerosol usage, and to fill aerosols safely. The required safety could not be achieved, and to attempt to do so would be costly and inefficient. It was decided that three large filling centers could purify all of the propellant required and do the gassing for all of the smaller aerosol companies.

Second, it was clearly indicated that it is not possible to oblige the small fillers to surrender part of their income without compensation. The filling centers would have to provide the HAPs at preferential rates to serve as an incentive to the smaller fillers to use this service.

A Country Defined Project for Tianjin:

Based on these circumstances and the desire to phase out CFC usage, NEPA and NCLI asked for a project to establish an LPG purification plant and central filling station to be operated by the First Daily Use Chemical Factory in Tianjin. The Chinese government has allocated funding for various parts of this project, upon approval of the Multilateral Fund for incremental costs associated with the purchase of imported machinery to equip the plant. This centralized filling station will serve not only this large enterprise, but all of the small aerosol fillers in the Tianjin area as well. It will also serve as a demonstration project for further phase out activities in the aerosol sector in other areas of China.

Cost savings through the use of HAPs, which are projected to cost half as much as CFCs in this area, will allow the smaller fillers to cover the cost of transportation to and from the central filling station. This will allow them to discontinue gassing in their own plants, which could not be individually upgraded to meet the strict safety requirements for filling with HAPs in a cost-effective manner. A few of the largest aerosol producers will be converted to safely fill HAPs. These fillers will purchase the aerosol grade HAP needed from the First Daily Use Chemical Plant.

Funding from the Multilateral Fund of the Montreal Protocol was thus requested for the purchase of the filling lines, the purchase of purification equipment for the HAPs propellant, for the tank farm to store the HAPs propellant, and for several other matters which are necessary for the filling center to function properly.

The project includes four additional activities to ensure success and safety:

- There will be a local quality assurance laboratory, following national standards supervised by the Shanghai Daily Chemical Institute.

- There will be a safety monitoring program for the filling and purification plants.

- There will be overseas and local training programs in formulation, safety and the use of alternate propellants.

- Before start-up, there will be a series of laboratory tests and trial runs.

Scope of the Project:

The list of equipment required for the Tianjin First Daily Use Chemical Company project included everything needed to receive and store LPG, the purification system to convert LPG into HAPs, and all of the filling equipment for filling service center (custom packaging). As some HAPs will be sold also, a cylinder filling line was included to fill 50 kg. cylinders for other clients.

The Tianjin company made major investments in the purchase of the land and construction of the required buildings. The following list includes those items that were deemed to be "incremental" so that financing could be requested from the Multilateral Fund (MF). This list does not necessarily apply to all situations, because circumstances vary, this is a very large installation, and the filling center concept requires some equipment that an individual filler would not need. Nonetheless an indicative list is given in the box opposite. Under the initial project proposal, the amount of $ 3.36 million US was requested from the MF for the incremental costs associated with the purchase of this equipment. $2.770 million was approved, and various foreign suppliers have now been asked to quote on supplying equipment. Contracts for this equipment should be let in the 2nd semester of 1994, and the entire project should be completed by the end of 1995.

Equipment Required for the Tianjin LPG Purification Plant/Centralized Filling Station:

LPG Purification Equipment:

- Propane/butane purification towers a capacity of 3,000 tons per year
- Propane/butane pumps
- Safety monitoring equipment
- Storage tanks for LPG (dirty)
- Storage tanks for HAPs (clean)

Filling Equipment:

- 2 automatic filling lines, capacity 50 cans per minute (cpm)
- 4 single manual filling machines, capacity 10 cpm

Other:

- Laboratory Equipment
  - Gas chromatograph
  - Copper plate corrosion tester

- Fire fighting equipment

In the meantime, activities inside China continue, and the Tianjin First Daily Use Chemical Company is preparing their plant for the switch from CFCs to HAPs; while the smaller fillers are preparing for the change from doing their own filling to using the central filling station.

Results:

The Tianjin First Daily Use Chemical Plant project to develop a HAP purification plant and centralized filling station to serve the entire Tianjin region is a model for the effective use of MF funding to encourage CFC phase out in the aerosol sector. This single project will result in a reduction in ODS usage, in this case CFC-12, by over 7,000 tons/year at current usage rates. Given the increasing consumption of aerosol products in China, this impact will be greater over time.

The Tianjin First Daily Use Chemical Plant Project - Keys to Success:

This project will be one of the most effective projects done anywhere, phasing out over 7,000 metric tons ODS at a very low cost. Three factors directly contributed to this success:

- The company and/or the Chinese government was willing and able to supply the residual amounts necessary to complete the investment cost. Here the Multilateral Fund financed less than 40% of the total required.
- Cooperation between the GOC and the lead implementing agency, the World Bank, has been excellent. World Bank technical missions (6 in two years) has assisted the Chinese enterprises at every level of the project.
- NCLI and NEPA have a large influence on local industries. Where the government cannot intervene directly to convince small fillers to send their aerosols to a "filling center" to be filled

In China, everyone works together, and this plan should work perfectly. Close cooperation exists between NCLI, NEPA, and the Tianjin First Daily Use Chemical Company, and this cooperation will extend to the small fillers. It was possible to obtain the residual financing necessary because of the involvement of more than 40 companies.

The presence of acceptable hydrocarbon feedstocks for conversion to HAPs is also a positive factor. This project is in keeping with the wishes of the Chinese government to reduce CFC usage, as well as modernizing their industrial sector, and because it will provide cost reduction to local fillers through the conversion to less expensive HAP propellants, the local economy and employment situations will be if anything improved by these conversion efforts.

Contact: For more information about Tianjin's experience, or any other questions raised in this case study, please contact:

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AEROSOL SECTOR CASE STUDY #2
A Regional Solution for the Middle East - A HAPs Plant for Jordan

Introduction:

Jordan is strategically located in the center of the Middle East, an area where several Arab countries and Israel share a small geographical region. Jordan, Lebanon, Syria, Iraq, Saudi Arabia, and other states all share borders in this compact area. While Jordan is a small country, it has a diverse population that is hard-working and unusually well-educated, with a large number of technical experts in a variety of fields. These include many well-qualified scientists and engineers. These men and women, as well as the Jordanian government, welcomed the chance to participate in work that would modernize the aerosol sector of their economy, while helping to bring Jordan into compliance with the Montreal Protocol by eliminating ozone depleting substances (ODS) in the aerosol industry.

The Aerosol Situation in Jordan:

Study work in Jordan in the early 1990's indicated that total usage of ODS in the aerosol sector was 225 tons, all imported CFC 12 and CFC 11/12 mixtures used as propellant. This usage accounted for 36% of the entire Jordanian consumption of ODS in 1991 (Jordan Country Study). Finding a method to quickly phase-out this usage would thus have a significant impact on total national conversion to non-ODS .

Since conversion to hydrocarbon aerosol propellants (HAPS) is the strategy being applied in the vast majority of conversions worldwide, early investigations sought to determine the availability of HAPS or appropriate feedstock to produce HAPS locally. It was determined that Jordan has one petroleum refinery capable of producing mixtures of propane/butane, the government owed Jordan Petroleum Refinery (JPR). With their cooperation, it was determined that JPR produces a cut of liquified hydrocarbon (80% butane, 20% propane) that is of the correct pressure for use in the majority of aerosols. Jordan has seven known aerosol fillers: one larger, four of mid-size and two quite small (volumes indicated at right).

Aerosol Fillers in Jordan:

Enterprise Name	Cans Filled Yearly
M. Haddad & Sons	1,000,000
Jordan Industrial Petrochemical	900,000
Dajani International	500,000
Households and Toiletries	300,000
Arab Center for Pharmaceuticals	300,000
Jordan Antiseptics and Detergents	60,000

The Problem:

Of these companies, the Households and Toiletries division of the important Suktian Group decided to become one the pioneers, .as they have the license to produce the "Taft" brand of hair spray, and were under considerable pressure to stop using ODS in this product. They purchased modern explosion-proof filling equipment in 1992, a Terco automatic filling machine. This was installed with a modular outside safe gassing room complete with ventilation system, gas detection, and the necessary alarms.

Using this equipment, which also included a molecular sieve purification system to remove sulphur from the propane/butane mixture, they began filling in 1993. Results were not good. Several batch lots of product were rejected because they appeared to have improper odor several weeks after they were filled, although the propellant appeared to be properly "odorless" at the time of filling.

It was quickly determined that the feedstock in Jordan was contaminated with undesirable olefins. Study revealed that one other filler, Dajani International, had previously installed to fill propane/butane. However, they fill principally insecticides, and because these are products that usually have a disagreeable odor anyway, they did not experience serious problems; odor was undoubtedly present, but not a concern. The problem would be limited to those producing cosmetics and medical products. For these fillers, olefins are a difficult and complex problem to overcome. Olefins are much more reactive than the saturated hydrocarbons (such as propane and the two butanes) because of their double bond, and this reactivity can cause serious odor problems in aerosols such as cosmetics and medical products, where the consumer is highly affected by the odor of the product and won't use a product that has a bad odor. This high reactivity can make olefins taint or destroy components of the perfumes used in aerosol products.

Unlike many contaminants that occur in aerosol feedstock, olefins can not easily be removed with molecular sieves, the simple, safe and inexpensive process that is most frequently used to deodorize aerosol propellants. The preferred method to remove olefins requires the use of hydrogenation, a process that is both highly technical and costly. It is not very suitable for individual enterprises to undertake. Ideally, a single technically advanced source of purified HAPS was needed.

In addition, it would be necessary to convince fillers other than Households and Toiletries to prepare to convert to HAPs, so they could obtain the facilities and equipment needed to quickly convert once a ready supply of HAPs was available. And, all Jordanian fillers would need not only foreign sourced filling equipment, but also the safety training necessary so that they could fill HAPs for years to come without undue risk of accidents.

The Solution - Government / Industry Cooperation:

The Government of Jordan (GOJ) was one of the earliest active participants in Montreal Protocol activities. A section of the Department of Environment was formed to supervise these activities, which is now funded by the Multilateral Fund and functions as the Project Implementation Unit (PIU) of the Department of Environment. They have participated in all stages of the discussions that have led to the resolution of the problems involved. Jordan Petroleum Refinery Company is the only refinery in Jordan, and produces all of the liquified petroleum gas (LPG) used in the country.

They were a willing participant from the start in finding a solution to the propellant supply problems. Their highly- trained technical staff has the required experience to easily undertake the hydrogenation of the propane/butane mixture to produce HAPs.

At first, cost was a concern. Just to produce the appropriate "cut" or mixture of propane and butane was already proving costly, as they had to readjust the process controls, working closely with quality control until the LPG being produced was acceptable. Hydrogenation would increase the process control problems and increase the cost. At the low volume required for aerosols in Jordan, the downtime required would far outweigh the profit from the sale of HAPs at a price which local fillers could afford.

To minimize this recurring cost, it was agreed that a solution must allow them to hydrogenate propellent in large batches, so they would have to disrupt normal production only three or four times a year. It was also agreed that installing this equipment in Jordan would prepare JPR for future marketing opportunities that might open up throughout the region, as countries like Iraq, Syria and Lebanon took steps to convert their aerosol industries. On the basis of the current MF assistance available, and with the prospect of these regional opportunities, JPR agreed to do this work if the capital equipment cost could be obtained.

The Multilateral Fund of the Montreal Protocol agreed to supply the required grant. The initial technical study was done by personal from JPR. Technical consultants from the implementing agency, in this case the World Bank, were also involved from the beginning, and helped identify the equipment and support work needed, and suppliers that could produce the required equipment.

The hydrotreating unit proved to be a problem. The required volume of production was extremely small, even if it was only produced 4 times a year on a batch basis. The Gunderson Engineering Company of Shreveport, Louisiana, USA was willing to supply a custom unit at the required volume. During the initial studies it was determined that the following would be needed to facilitate the process of hydrogenation, which could be implemented over a two year period:

Basic Project Concept - Jordan Petroleum Refinery - Aerosol Propellants

Four basic areas were addressed in preparing the project (and the project proposal):

- A storage area for the special LPG cut to be used as aerosol grade. This "dirty storage" will allow JPR to build up feedstock for hydrogenation without having the entire refinery interrupted each time aerosol propellant was needed.
- A hydrogenation unit to be attached to a "heavies" separator. This will eliminate any C_5 and C_6 product not removed in distillation.
- A storage area for the processed, clean HAPs. Each storage area would include tanks and piping as well as various construction activates to provide a safe site. A "dedicated" delivery truck is provided, to be used only for HAPs.
- A distribution area to dispatch clean HAPs to the fillers as ordered. This was originally purposed to be done only in cylinders, but it has been upgraded to also offer safer and more efficient bulk delivery.

The Aerosol Fillers:

At the same time that this project was being developed, a sub-project was addressing the conversion of M. Haddad & Sons, Jordan's largest aerosol filler, from CFC-12 to filling with HAPs. This project involves the installation of a new filling lines, using pneumatic and explosion proof equipment, with the gassing head separated from the crimping and product filling stations (see Aerosol Sector Case Study #10 in this series).

In addition, Haddad requested and received funding to construct a well-ventilated explosion-proof filling room, with modern gas detecting equipment, as well as a storage system to handle the safe storage of HAPs. And, they requested funding for extensive process and safety training by a experienced foreign expert. This equipment and training is to cost approximately US$250,000.00. A storage tank project was also done for Households and Toiletries.

All three proposals were submitted for funding to the Multilateral Fund. One important point which made the chances of approval greater was that Jordan Petroleum Refinery agreed to accept a formula for calculating costs that in effect requested assistance only in recovering the direct cost difference between the cost of purifying regular LPG and it's sale price and the cost of purifying HAPS and their sale price. This involved JPR agreeing to disregard indirect conversion costs such as increased downtime. By foregoing claims of such vague and hard-to-calculate indirect costs, they greatly increased the likelihood that their project proposal would be agreed to, as it was.

While approvals were being secured, Jordan Petroleum Refinery proceeded with further feasibility and cost studies, which resulted in one significant change: they were able to agree to delivery of HAPs to aerosol fillers via bulk trailer trucks, in addition to using only 50 kg. portable cylinders as originally considered.

Bulk delivery is always the preferred delivery method. A large tank is much less subject to mishandling than small cylinders, which are frequently pushed around on hand trucks during transport. Large tanks are secured to cradles,

while cylinders may be stored improperly and fall. And, large tanks are permanently connected to pipes, while small tanks are frequently connected and disconnected, another possible source of leakage.

Thus, using bulk tanks is a major safety benefit in both transport and storage. The original M. Haddad proposal was accordingly adjusted to provide to storage of HAPs in bulk tanks at their plant. As mentioned earlier, Households and Toiletries has also presented a project proposal for bulk

JPR Equipment List (taken from their project proposal):

The specific items needed and their approximate costs were as follows. Note that while these were the items needed here, it is an example only. JPR is providing additional resources needed to complete this project, and other applications may require slightly different equipment.

1	5-gallon/minute hydro-treating plant complete with heavies separator	US $	395,000
3	each 60,000 and 2 each 45,000 liter storage tanks		200,000
2	pumps with piping		16,000
	lot laboratory equipment		9,000
1	automatic fire protection system		5,000
1	automatic gas leakage detection system		10,000
1	transport trailer		60,000
	lot - civil and electrical works		50,000
	lot - engineering/inspection/commissioning/training/start up costs		60,000
	TOTAL	US $	805,000

storage which had not yet been acted upon. The details of the equipment ordered for the Jordan

Petroleum Refinery Company is given in the adjoining table.

The Results:

As of today (February 1995) work is proceeding in the implementation of these proposals. JPR, Households and Toiletries, and Haddad have begun procurement. Additional fillers in Jordan have begun working to preparing project proposals to obtain assistance in their conversion.

Jordan is a good example of the application of innovative thinking in developing a series of inter-related solutions that result in the speedy conversion of the aerosol sector of a country to the use of non-ODS. Highly educated and environmentally aware businessman readily accepted that they would benefit from conversion; officials of the Jordanian government and the JPR also showed their willingness to cooperate in developing a project that would help Jordan comply with the Montreal Protocol, and end the use of ODS in their aerosol sector quickly, while providing maximum benefit to their economy. The current timetable calls for Jordan to complete conversion of their aerosol sector by 1995. It appears certain that this timetable will be met, making Jordan a real success story and a model for the complete conversion of the aerosol sectors in other countries.

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AEROSOL SECTOR CASE STUDY #3
ODS Phase Out By Other Means in the Russian Federation Mechanical Pump Substitution

Introduction:

By far the most common way to achieve ozone depleting substances (ODS) phase out in the aerosol sector is through the conversion of local fillers from filling aerosols using CFCs as propellant to filling with some form of hydrocarbon propellant.

Many of the accompanying case studies deal with one or more aspects of just that problem; how to secure hydrocarbon aerosol propellants (HAPs), how to purify an existing feedstock that is not suitable for all products, or how to help local fillers convert their plants from filling with ozone depleting CFCs, that are otherwise safe and easy to handle, to the use of hydrocarbon propellants that have few environmental drawbacks, but are highly flammable and explosive.

Indeed, the case study that follows concerns a Russian company, and involves just such a conversion, although a huge and complex one. But in this case study we will be concerned with a totally different approach - the phase out of CFCs by substitution of mechanical pump sprays for traditional aerosol cans.

The Situation in the Russian Federation:

Following the dissolution of the USSR in 1991, the Russian Federation remained the largest country on earth (in terms of land area), with a population exceeding 150,000,000. The Russian Federation is probably by far the largest user of ODS in the aerosol sector on earth, using 33,000 metric tons of ODS in 1992. Achieving rapid phase out in the aerosol sector in the Russian Federation is of enormous importance in reducing the world's usage of ODS.

The former USSR had produced approximately 680,000,000 units of aerosol products of all sorts in 1988, apparently the peak year for aerosol production. Under the old Soviet system, 16 large vertically-integrated plants, several among the largest aerosol plants in the world (in terms of physical plant size), produced everything needed on-site, from packing cartons through the cans and valves and to the filled, finished product (for more information on this integrated approach and central planning, see case study #4 in this series).

Currently, the Russian Federation contains 8 very large plants producing 244,000,000 million units in 1992. Three of these plants not only use CFCs, but actually produce their own in sections of their plant. While aerosol production and ODS usage were somewhat less in 1993 due to the current economic troubles, Russia remains a large producer of aerosols and is still using about 20,000 metric tons of ODS a year in the aerosol sector. Less than 20% of aerosol production is currently converted to HAPs. All of the old state-owned enterprises are now some form of joint-stock company, typically partly owned by individual investors, often including employees, and partly by some government entity.

Despite the slight progress in conversion, all these large Russian producers are sophisticated technical facilities, with highly-educated and well-trained staffs. These fillers have been aware of the need to convert their CFC usage for some time, and have in all cases run tests of filling with HAPs or at least a mixture of HAPs and CFCs. When enterprises in the Russian Federation learned that funding might be available through the Global Environmental Facility (GEF), to supply badly needed capital to purchase the modern foreign equipment needed for conversion, all were eager for assistance. In several cases, project proposals have been or are under development which will allow them to complete the "normal" conversion to filling with HAPs.

The Situation at Altaichimprom:

The Altaichimprom plant, with a historic annual production of about 20,000,000 units (though a current production of considerably less, due to a lack of capital and the current economic difficulties in Russia) turned out to be totally unsuited for conversion to HAPs. Their entire production operation uses 20 year old machinery that cannot be converted to safely filling with highly flammable HAPs. With CFC filling, defects are wasteful, but not dangerous. Product and propellant leak in the plant, and in transit, and in the warehouses and shops, but this is generally merely a nuisance, and quite common in many countries. HAPs present a very different set of concerns. The key to safely filling HAPs is to minimize all risks in the first place, and only secondarily to use gas detection, automatic shut down and modern fire-fighting equipment to avoid disasters. If 1%, 2% or 3% of cans leak in filling, the plant is likely to suffer a fatal explosion. No line can safely run with anything like that amount of hydrocarbons being leaked into the building, not to mention the risks of leakage in storage or transport. Neither the valves nor the aluminum cans they manufacture at Altaichimprom allow for the nearly defect-free manufacturing that HAPs require. The machinery installed almost 20 years ago for producing valves, cans, and for filling the cans has been carefully maintained, but it has fulfilled its useful lifetime. It cannot be repaired to safely fill HAPs.

Totally new machinery would be required, as well as significant re-engineering of the filling process. New HAPs storage facilities would need to be built, along with significant warehousing modifications, and very extensive safety training by foreign experts. For these reasons the enterprise decided to consider the substitution of mechanical spray pumps for almost all products manufactured currently. Under their proposal, only insecticides, not suitable for mechanical pumps, will be filled as aerosols with HAPs at the nearby Novosybirsk Domestic Chemical Company. The list of required materials is lengthy, but may give other prospective users an idea of what is required for just a part of the entire substitution process:

Altaichimprom Plant Proposal **Concept:**			**Cost in US$ '000**
2	plastic blow molding machines for bottles, 100 kg/hour	**US$**	1,281
1	bottle transport system		190
1	electrical control system		166
1	cooling system		102
1	compressed air supply system		64
3	sets multicavity molds (12 molds) for above	400	
1	silk screen decoration line		322
	modification of valve making equipment to make pumps		33
	molds for pump components		252
2	assembly machines for actuators		240
2	pump assembly machines w/ball placers and tube placers		760
1	120 bottle/min. filling line, complete		420
	shrink wrap packaging units for finished bottles		270
	pneumatic pump testers		200
	spare parts		235
	import agent fees		141
	import taxes		235
	transport of new equipment to central Russia		235
	estimated start-up downtime (direct labor + scrap)		102
	cost of foreign assistance for start-up and training		55
	TOTAL	**US$**	**5,703**

Note that this is not a complete list, because this plant is able to make springs, gaskets and several plastic pump

Problems with Not In Kind Substitutions:

Substitution of mechanical pumps for aerosols is fully supported as an appropriate way to achieve phaseout by the *1991 UNEP Technical Options Report on Aerosols, Sterilants, and Miscellaneous Uses and Carbon Tetrachloride.* Yet such substitutions are rather uncommon, because of a variety of reasons. All of these have been considered in the case of Altaichimprom. The most common reason for rejecting mechanical pumps is that they won't sell. In other markets, mechanical pump sprays now dominate some categories of products (example - window cleaners) and are popular. But, where there is variety of choices, most consumers continue to favor aerosol presentations. Part of the reason aerosols are preferred may be because, in many countries, pump sprays were around before aerosols, and aerosols were seen as "newer equals better." As there are no pump sprays available in the Russian Federation at all, this factor may actually be reversed. It appears certain that enough market can be captured in this case.

Further, many companies worldwide have produced pump sprays as an additional product rather than as a substitute product. Other companies have avoided "pumps" completely, feeling that the introduction of a pump spray would achieve low volumes, and compete almost exclusively with the aerosol product. No marketing company wishes to have two slow-selling products instead of one moderate-selling one. Since no pumps exist in Russia, these marketing problems do not appear to apply - loyal consumers to "brand X" aerosol will probably buy "brand X" pump sprays without worrying about the change in presentation.

Another factor is cost. Mechanical pumps are 2-4 times as expensive as aerosol valves, and often more product concentrate must be used (to replace the propellant). This can be mitigated in some cases, such as this one, by providing for a change to plastic bottles, which are less expensive to produce than aerosol cans. But mechanical pump sprays can easily be more expensive to produce than aerosols.

Some products cannot use pumps. Insecticides for flying insects require a spray with small particle size to be effective. The aerosol can readily produce very small particles, but mechanical pumps cannot. And, a partly filled aerosol is not likely to spill in storage, as a pump may - an important consideration with a potentially toxic product.

For these and other reasons, pumps are often rejected because they fail to meet the test of being the "best available technology." Also, in most countries, converting a "filler" involves only the replacement of a filling line, purchase of a modular "safe room" for gassing the hydrocarbon, and some additional construction, often involving storage tanks and warehousing modifications. The determination of "best available technology" is normally still viable where these steps need to be taken. Costs may be considerable, but they are the "usual" ones, and many enterprises successfully convert despite these costs. In short, in countries with more direct access to all potential solutions, it is usually cheaper to convert to HAPs which are available, import HAPs from another region or even, in rare cases, from abroad, or try to secure a source of HAPs locally, where none exists, then convert products to mechanical pump sprays. The unique integration of enterprises and geography defeat these possibilities in Russia.

Altaichimprom is hundreds of kilometers away from any possible source of HAPs, and is such a large plant that important quantities would need to transported. This would raise costs, and would create great potential for accidents of every kind. Even in the best of developed country situations, it is not common to ship HAPs or LPG further than absolutely necessary by road, for example. But more important, are the previously mentioned direct cost factors, i.e. that the entire aerosol production and warehousing facility of this very large enterprise, including can and valve making operations, would have to be replaced, as well as a sizable tank farm constructed. Costs would be millions of dollars more than changing over to pump manufacture. In this case, mechanical pumps can indeed be considered the "best available technology," providing for timely phase out at the lowest possible cost to the enterprise.

The Results:

Funding for the Altaichimprom proposal is being requested at the current time. Possible sources are the Global Environment Facility (GEF), the Russian Federation government, the Stavropol state government, and private banks or investors. This project stands nearly alone as a Case Study where a "not in kind" alternative technology is likely to be the "best available technology" for conversion because of the specific circumstances in this case. It is clearly better to use pump substitution here, rather than try to reconstruct this entire large entity to meet some pre-conceived notion (that converting to HAPs is best).

In this case, substitution is far preferable to conversion, from the point of view of the entity, which

Mechanical Pump Selection Criteria

Common mechanical pumps come in two varieties, "finger pumps" and "trigger pumps" (where a lever similar to the trigger on a gun is pulled). Trigger pumps are used to dispense large quantities (1-4 grams per actuation), usually of cleaners, and are not appropriate for many products. Finger pumps usually operate at levels of 0.05-0.10 grams per pump, adequate for many products.

Finger pumps, where an actuator is pushed downward with the finger, can be mounted on the container by having a screw top, by having an aluminum ferrule that is crimped onto the container, or by snapping into place (as on a normal aerosol can). But, finger pumps dispense ***much less*** product than aerosols. If the same size container is used, it can result in a long use period for the consumer. This is excellent for the consumer, but not good for the producer, who will not sell that user another product until the previous one is empty.

Suitability is the first criteria. Most pumps work well only with aqueous or alcoholic solutions. Then, if pumps are suitable, the pump is always more expensive than an aerosol valve, so in popular products where cost is important, a plastic container must usually be used (and provided for). Where cost is less important, glass or aluminum may be used.

Where the product can be seen (in glass or plastic bottles), the product must be full (about 95% - there must still be some "head space"). Where the product concentrate is expensive, this can lead to very expensive products. Sometimes a product with very expensive concentrate might best be packaged in an expensive aluminum can, so that only 60% volume fill need be provided.

wants to stay in production, and from the point of view of obtaining the required financing, which should be the least amount possible. This project will eliminate usage of 2,000 metric tons of ODS when completed. However, in deciding on what equipment to purchase, consideration was taken of the fact that the ten-year record of this plant, that is to say their production in more normal times, suggests that they will soon be producing many more units than the 1993 figure. Historic production has used about 5,000 metric tons of ODS, and the production capacity requested should be viewed as offsetting that volume.

Once funding is obtained, this project can be completed in 24 months time, and it is expected that this will result in phase-out by the end of 1997. The Russian Federation is passing a period of political volatility, and this is one of the projects in this case study series with the greatest possibility of being modified. The lessons to be learned are so unique, however, that the authors decided to include one "not-in-kind" substitution project, and Altaichimprom was by far the best example.

Contact: For more information about not-in-kind substitution or Altaichimprom's experience, or any other questions raised in this case study, please contact:

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AEROSOL SECTOR CASE STUDY #4
A Complicated Substitution of HAPs for a Large Plant at Novosybirsk

Introduction:

In the previous Case Study we dealt with a uniquely Russian application of pump substitution as a method of replacing ozone depleting substances (ODS) in the aerosol sector. In this case study, we will deal with the more usual method of eliminating this ODS usage: the conversion from the use of CFCs in aerosols to hydrocarbon aerosol propellants (HAPs).

The Situation in the Russian Federation:

Following the dissolution of the USSR in 1991, the Russian Federation remained the largest country on earth (in terms of land area), with a population exceeding 150,000,000. The Russian Federation is by far the largest user of ODS in the aerosol sector on earth, using 33,000 metric tons of ODS in 1992. Achieving rapid phase out in the aerosol sector in the Russian Federation is of enormous importance in reducing the world's overall usage of ODS.

The previous USSR had produced approximately 680,000,000 units of aerosol products of all sorts in 1988, apparently the peak year for aerosol production. Under the old Soviet system, 16 large vertically integrated plants, several among the largest aerosol plants in the world (physical plant size), produced everything needed on-site, from packing cartons through the cans and valves and onto the filled, finished product.

The Soviet production control system, centered on a State Planning Office in Moscow that dictated what was produced, how much, where and when, meant that enterprises had little concern for marketing their products; they produced what they were ordered to and shipped it as directed. Who or where the ultimate customers were was not their concern. What they used to produce it was a concern, but theoretically that arrived as needed according to the dictates of the Plan. And the Plan was a national one, often securing materials from one end of the old USSR for use at the other. Developing local sources of supply was of at best secondary concern.

Currently, the Russian Federation contains 8 very large plants producing 244,000,000 million units in 1992. Three of these plants not only use CFCs, but actually produce their own in sections of their plant. While aerosol production and ODS usage were somewhat less in 1993 due to the current economic troubles, Russia remains a large producer of aerosols and is still using about 20,000 metric tons of ODS a year in the aerosol sector, with less than 20% of aerosol production converted to HAPs. All of the old state-owned enterprises are now some form of joint-stock company, typically partly owned by individual investors, often including employees, and partly by some government entity.

Despite the slight progress in conversion, all these large Russian producers are sophisticated technical facilities, with highly educated and well trained staffs. These fillers have been aware of the need to convert their CFC usage for some time, and have in all cases run tests of filling with HAPs or at least a mixture of HAPs and CFCs. An adequate supply of useable LPG for HAPs is available within reasonable distance (i.e., 1,000 km.) of Novosybirsk.

The Novosybirsk Domestic Chemistry Plant (NDCP):

NDCP is a very large integrated company in the Siberian city of Novosybirsk. It is 51% owned by employees, 15% by the Russian Federation, and the rest by investors. The aerosol division of NDCP includes facilities for the manufacture of aerosol valves and three piece tinplate aerosol cans, and equipment for aerosol filling. The plant has been in operation since 1975, and is still using the original Italian, English and U.S. made equipment, which was very good when it was new.

NDCP has produced upwards of 30,000,000 units a year, but, as everywhere in Russia, production has fallen in recent years due to the national economic difficulties. These difficulties, particularly a shortage of capital, prevented the plant from converting on its own. Technical studies have been done, and the detailed engineering has been completed for much of the conversion, which has not advanced because of a lack of funds.

Any solution to conversion at NDCP had to take into account the historic volumes, both because the economy seems to have bottomed out and to be on the rebound, and because in Russia, as everywhere else, both the government and management want conversion to provide the same or even increased employment. To convert at the current reduced volume, reflecting a short-term economic decline, would certainly lock in reduced employment, and might well seal the fate of the company.

It would likely be impossible for this very large plant to operate profitably producing only a fraction of their historic output. NDCP is anxious to end their 4,482 metric tons of annual ODS usage, but anxious to survive as a manufacturing entity, as well!

The NDCP Conversion Project:

Hydrocarbons are the obvious choice for conversion here. The company's most popular products are personal deodorants, hair sprays, room fresheners, and insecticides; which all can be packaged very well with hydrocarbons. All other alternate propellants are eliminated because of cost (dimethyl ether, the HCFCs and the HFCs), or because they don't work well (CO_2 N_2O or N_2). It was determined that the plant had the space to convert to HAPs, including room for the sizable tank farm that would be required for such a large filler. But major changes would be needed, including one change that put a particularly Russian twist on the project.

The plant, like all aerosol plants in Russia, but unlike the situation in most other countries, produces its own packaging components, including aerosol cans. The can making equipment has been well maintained, but it has fulfilled its useful lifetime. The current leakage rate is approaches 3%, which do not reach the consumer because of careful quality control. With CFC filling, such a failure rate is messy and inefficient; with HAPs it is unacceptably dangerous. It is unlikely that millions of aerosol cans can be filled at this rate of leakage without a serious accident. Even if the filling can be done, leaking aerosol cans would be a major hazard in storage, in transit, and even in stores and people's homes.

With this being the case, "conversion" here would have to include a new can line as well as new filling equipment, a tank farm and piping. Also, the plant would need a safe, explosion-proof filling room, plus extensive changes to the finished-goods warehouse that are also needed for safety reasons. Each phase would require significant purchases of foreign-made equipment, as the proper quality of equipment is not made in the Russian Federation. Most auxiliary equipment can be purchased locally, and certainly all of the civil works can be done locally.

With additional equipment required to outfit the new explosion-proof gassing rooms, the tank farm capable of safely storing 550,000 liters of HAPs, new testing and laboratory equipment required to properly quality control product, modernization of aerosol valve production equipment already in place, plus the necessary construction, shipping and training costs, the total amount required for the conversion was calculated at US $13,752,108..

Additional work and costs, such as planning and site preparation costs, would be covered by the enterprise. In preparing the project proposal, it was necessary to consider what additional costs conversion would be, and what savings would result. On balance, here the savings clearly would exceed the costs. This is not always the case, especially where products with expensive concentrates are filled.

It was possible to calculate how much both increased costs and savings would be, in order to offset some of the total costs to reflect the savings NDCP would realize from conversion. Not only is this fair and logical, but it is an important step necessary for the proper completion any conversion project.

CONVERSION OF NDCP: MAJOR EQUIPMENT NEEDED:

FOR CAN MAKING:

250 CPM AEROSOL CAN PRODUCTION LINE FOR 52.4 X 167 MM AND 65.3 X 170 MM CAN SIZES, CAPABLE OF OPERATING AT 80% EFFICIENCY, WITH TOP AND BOTTOMING STAMPING AND GUMMING, "SOUDRONIC" SIDE-SEAM WELDING AND ASSEMBLY OF FINISHED CANS, INCLUDING SPARE PARTS.

US $ 4,650,000.00

FOR AEROSOL FILLING

2 EA. AUTOMATIC AEROSOL FILLING LINES RUNNING AT 120 CPM, INCLUDING UNSCRAMBLING TABLE, ROTARY PRODUCT FILLER, VALVE PLACER, ROTARY VACUUM CRIMPER, 6 CONVEYORS (APPROXIMATELY 3-5 METERS), ROTARY GASSER, BUTTON PLACER, WATER BATH, CODER, CAPPER, SPARE PARTS. TWO MODULAR EXPLOSION PROOF SAFE GASSING ROOMS ARE INCLUDED.

US $ 2,600,000.00

PROPELLANT HANDLING:

TANK FARM INCLUDING 14 STORAGE TANKS, 19 PUMPS, 6 COMPRESSORS, PIPES, ELECTRICAL INSTALLATION, INCLUDING SPRINKLERS AND EMERGENCY POWER STATION.

US $ 2,570,900.00.

Should funding for this project be obtained from the Global Environment Facility, it will be necessary to calculate *net incremental costs,* which requires that an analysis of additional costs and savings. Should another financial institution provide the funds, they will nevertheless require a cash flow analysis, where increases of costs and savings should be taken into account. In the table above is a summary of the most of the major items needed for conversion at NDCP.

As mentioned earlier, there are a number of factors that increase to cost of operations when filling HAPs, even when entirely new equipment is used. Factors that would **increase** costs are indicated in the box below.

Readers from developed countries may be surprised to find items #1 and #2 in this list. Manufacturers in most developed countries have long accustomed to having the necessary quality control inspectors on a production line. Also, it is known that quality is not produced by quality control, but rather by good manufacturing practices, and one of these is that the production line be stopped for maintenance whenever necessary, i.e. whenever defects produced exceed a predetermined norm. The Russian Federation is by no means a developing country, but crisis conditions exist in manufacturing at this time and many expediencies are being resorted to that are not conducive to long term progress. Hand selecting tinplate for high quality uses (such as making aerosol cans) is also common in developing countries, and may have to be employed here.

Three factors that would increase production costs after conversion:

1. More quality control supervisors and inspectors will be needed, to maintain a defect rate of less than 0.1%, required for safe use of HAPs. .

2. Increased maintenance is necessary keep quality high, especially after first two years, as the machinery ages. Both direct labor for maintenance and spare parts utilization will be higher than with CFCs in many companies. .

3. Tinplate costs will rise, because many more sheets of tinplate will be rejected for being out of specification. Tinplate that is completely out of specification may possibly be returned to the supplier, but marginally out of specification tinplate must be sold for its scrap value.

The offset this, there will be **savings** from conversion. Three factors that would result in savings due to HAPs conversion:

1. Less scrap made by new equipment. By using new can making equipment and new aerosol filling equipment, it is obvious that defective can scrap will be drastically reduced. The increase in quality control will also reduce scrap.

2. Less scrap because of increased maintenance. While shutting down the production line at the first sign of defective cans is a cost factor (because of lost line time), this does reduce the amount of defective cans produced, and the cost of scrap.

3. Material savings through use of a less expensive propellant. Changing from CFCs to HAPs usually produces savings, sometimes quite great savings. This should be calculated on a case by case basis, as sometimes materials costs increase. With aerosol deodorants and hair sprays, for example, it may be found prudent to increase the amount of perfume used when the conversion is made.

In considering the need to offset some of conversion costs with the savings, two more points needed to be considered. First, some of the "savings" would in fact be increased profits to the company, currently taxed at 35% by the Russian Federation and state authorities. This obviously effects any cash flow calculations.

And, these savings would come after the fact, while all of the direct conversion costs would come before production with HAPs occurred, also a factor in cash flow calculations. Given the lack of capital available in Russia, these are both obviously important factors that must be taken into account in financial planning.

The analysis between costs and savings that exists at NDCP calculated over 4 years using net present value calculations (as required by the GEF) shows US $661,000. in operating cost increases, as compared to US $3,931,000 in operating savings. Thus the enterprise will have to obtain additional financing from another source for slightly over US $3 million, or put up this amount out of operating profits.

Results:

As this is written, the enterprise is investigating the possibility of obtaining financial assistance from the Global Environment Facility, other international sources of financing, the state and federal governments, and local banks and investors.

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AEROSOL SECTOR CASE STUDY #5
A Difficult Double Conversion in Mauritius

Introduction:

The tropical island nation of Mauritius is far from the snows of Russia where the previous two case studies are set. Russia is a country with huge, technically prepared aerosol fillers, requiring huge but cost-effective investment to obtain conversion from ozone depleting substances (ODS) to hydrocarbon aerosol propellants (HAPs). Mauritius has the same basic need, capital to convert to HAPs, but in a setting that is vastly different from the Russian one in every way.

The Situation in Mauritius:

Aerosols are the second largest cause of ODS usage in Mauritius, a small island country off the east coast of mainland Africa. The country has three rather small (by international standards) aerosol fillers. All know that they need to stop using ODS, and one at least has already tried to do so while maintaining market share, satisfied customers and the current level of employment, which is very important for the national economy.

Unfortunately, this initial attempt at conversion was not satisfactory. Conversion was done to carbon dioxide (CO_2) propellant. Laboratory testing was conscientious, and it appeared that the personal deodorants produced were adequate. There were problems with consumer acceptance that are described below.

Compagnie Manufacturiere de Produits Cosmetiques Itee ("COMANU") is the largest aerosol filler in the nation. They are a contract filler, filling well over 50% of the total number of aerosol cans packaged in Mauritius, and historically using about 80% of the ODS consumed in the aerosol sector there.

Unlike many other countries, Mauritius imports all propellants, so all aerosol fillers share the same sources of supply, which do not cause any problems in conversion. Imported HAPs are available to COMANU at an affordable price. And, unlike the situation in Russia at NDCP, described in Case Study #4 in this series, filling equipment is not a concern. COMANU already has a modern explosion-proof Pamasol pneumatic filling machine.

Nearly all aerosols used in Mauritius are cosmetics and deodorants. As the filler of many of the most popular brands for large international companies, COMANU was sensitive to the need to switch their filling line over to a propellant that did not contribute to ozone depletion. With this concern in mind, and with the approval of their clients, they unilaterally converted their line to fill with CO_2 beginning in late 1992.

They had considered switching to HAPs, which they knew was the common conversion, but could not afford the extensive modifications to their plant which would be required to safely fill with HAPs, including the construction of an explosion-proof filling room. Switching to CO_2, which is not flammable, could be done at little cost.

The Limitations of CO_2 (and other compressed gases):

The results of this attempt at filling perfumes and deodorants with CO_2 propellants were unsatisfactory. CO_2 is a compressed gas, not a liquified gas like the CFCs or HAPs. With CO_2 there is no reservoir of liquefied propellant in the container. Only the amount that can be dissolved in the concentrate within the pressure limitations of the container can be used.[1]

CO_2 has several other limitations and disadvantages as a propellant. First, compressed gases like CO_2 produce only wet sprays, making them unsuitable for dispensing the kind of fine, "dry" sprays often required. CO_2 does not work at all for foams or gels, such as shower gels and mousses, other popular cosmetics products.

In fact, CO_2 only works well with concentrates that are naturally good solvents for CO_2 and, even then, is still susceptible to a problem that filling techniques can not overcome. This is the natural "misuse" of CO_2 products by consumers doing what they quite normally do with other aerosols. Because CO_2 products have very little propellant, and no reserve of liquid propellant in the can, a single instance of turning the can over and spraying it may discharge much of the propellant at once, leaving a nearly full and unusable can. Such usage is entirely common with perfumes, deodorants, and hairsprays, and not a concern with traditional propellants like HAPs or CFCs, which have many times as much propellant in the can.

Converting CO_2 to HAPS to Avoid Using CFCs:

When a technical consultant working on behalf of UNEP and UNDP visited Mauritius, COMANU was attempting to cope with the difficulties of the conversion to CO_2. One major brand, "Fa," was switched to a pump spray, but several other popular products were unsuitable for this substitution. COMANU faced the prospect of converting back to CFCs, despite their desire and that of the Mauritius Ministry of Environment and the Quality of Life to comply with the Montreal Protocol and amendments. Such a conversion of their entire production would result in the renewed usage of 25 tons of ODS per year. Upon discussion, it was clear that they would welcome assistance to switch to HAPs instead.

Before a conversion project could be developed, careful consideration had to be given to what method of filling would be meet the safety requirement of filling with HAPs and suit the nature of the enterprise, the design of their current plant, the location of their plant site, and even the climate of their location in tropical Africa.

In working with the UNDP technical expert involved, they had to consider two possibilities: should they construct a filling room indoors, as is common in colder climates, or could they use the concept of open-air filling, which allows natural ventilation to provide most of the safety factors in avoiding disastrous explosions.

Plants throughout the world are currently filling HAPs safely using both types of filling. This has been the case for many years. Safely filling HAPs depends on a variety of specific and technical requirements being met, but the philosophy behind safely filling HAPs may be stated as follows:

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[1]Complete information on alternative propellants and their various advantages and disadvantages can be found in Chapter 5 of **The Aerosol Conversion Technology Manual**, which may be requested from the UNEP IE, whose address is listed at the back of this series of case studies.

In the case of COMANU, open air filling would seem to best meet some major concerns of safety. Given Mauritius' mild climate, it is certainly possible to fill outdoors, and open-air filling, which takes all necessary steps to provide for HAPs filling without leakage, but lets the wind dissipate any gas that is leaked before a dangerous concentration can occur, is often a first choice because it is cheaper to fill in the open air than to construct a safe, explosion-proof indoor facility.

The Fundamental Philosophy of Safely Filling Aerosols with HAPs:

- ♦ Safety is an attitude. *Management must be committed to safety first!*
- ♦ Everything possible should be done to eliminate HAP leakage. A small amount will always escape when each can is gassed, but no other leakage is permissible. Plant design should allow for no place where HAPs can concentrate to be ignited.
- ♦ Anywhere there is a is a *possibility* of leaked HAPs, all sources of ignition must be eliminated.

Moreover, open-air filling has a long-term benefit, as well. Since nature is providing the ventilation, there is no maintenance required for long-term upkeep of the fans, gas-detectors and other devices needed to safely fill HAPs indoors. This is not only less expensive for the concern, but fool-proof. With the type of sophisticated equipment needed for indoor filling, staff must be trained and held accountable for maintaining these safely devices in prefect operating condition over a long period of time.

Criteria for the Employment of the Open Air Filling Method:

- An open-air filling room may have one solid wall (parallel to the outer wall of the plant), or it also may have just a roof over the machines, out in a field. If the filling room adjoins one wall of the plant, there should be at least 1 or 2 meters between the plant wall and the filling room wall. Holes for conveyors (in main plant wall) must be small.
- Any additional walls can be wire mesh, and the roof plastic or fiberglass panels. There must be **nothing** to stop the movement of air.
- It must not adjoin anything, such as an area with a pump, compressor, electrical panel, or boiler, which may cause sparks and/or flame. This also applies to parking lots, driveways, etc.
- Only pneumatic equipment should be used. If explosion-proof electrical equipment is used, it must be well maintained and constantly inspected.
- Natural light should be used where possible, with explosion-proof lighting the next choice. Normal electrical lighting n electric lighting is not acceptable.
- Wherever located, the "room" should be raised above ground level, if possible, with no drains or low areas nearby where gas can collect.

Still, further investigation was needed. The enterprise was unsure that its large international clients would accept filling "open air" - often they want to see sophisticated equipment. And, since open-air filling has no other source of ventilation but the wind, there must be a free-flowing and dependable air movement to remove any leaked HAPs from the area before a dangerous concentration develops. This flow of air must not be blocked by anything, or such a concentration can quickly develop in low-lying areas. There is an acceptable area at the COMANU plant for siting an open air filling room, but it is too near an electrical transformer, which must be moved if this option were to be selected. A project for an open air filling area was developed. The requirements of this system are as follows:[2]

A project was also developed with assistance from the UNDP technical expert that provided for the purchase of a modular explosion-proof "safe" filling room for COMANU. Here the choice of design was dictated by cost. It is possible to build such a room in a totally enclosed interior part of an existing structure, but this design requires the reconstruction of walls and ceilings to either make them withstand high pressures (490 kilograms per square meter), and the installation of a blowout panel in the roof or exterior wall that will collapse at very low pressure(49 kg/sq. mt.). (see **The Aerosol Conversion Technology Handbook** for complete details). Cost made this option unattractive to COMANU.

It was determined that they had an area that was being used as a driveway that adjoined the side of their building. This would allow the purchase and installation of a modular outside enclosed filling room, where it is required that only the wall facing the existing plant is capable of withstanding high pressure. The existing plant wall, of solid construction, could be used.

Conveyors will be used to move in-process product from the main building to the filling room, and the finished product back for storage. Proper dual-speed automatic ventilating equipment, and gas detectors, along with equipment to shut down the HAPs supply if gas is detected, will be purchased abroad. Staff will also receive extensive safety training from an experienced aerosol expert. Appropriate fire-fighting equipment and training in it's use will be obtained.

The overall project cost for this option is about US $125,000.00, including a 10% contingency, and the project should take no more than 12 months once initiated. The option of using open air filling can also be completed in less than a year, and would cost about half as much.

The Results:

The case of COMANU is a good example of help from an Implementing Agency, in this case first UNEP and then UNDP, being vital to help a small country bring their aerosol sector into compliance with the Montreal Protocol and amendments. Once COMANU is converted, the remaining two fillers in Mauritius will be under increasing price pressure to convert their operations, since HAPs are much less expensive than CFCs.

COMANU has obtained a grant from the Multilateral Fund of the Montreal Protocol for about $60,000.00. They are currently determining whether to use this for open air filling of HAPs, or whether to select the second option, which will require an investment on the part of the enterprise to complete the required amount. It appears at this writing that they will move to a new locale and use the open air filling method.

While current CFC usage is only 5 tons a year (with COMANU still using some CO_2), the alternatives are clear. Without outside assistance, ODS usage would return to about 25 tons a year. With such assistance, ODS usage at this enterprise in Mauritius will be zero. The scale is not a great as that faced in Russia, but Mauritius is prime proof that a worldwide view is really being taken in phasing out aerosol ODS usage rapidly.

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[2] For a discussion of the advantages and design of open-air filling rooms, see the Aerosol Conversion Technology Manual, which is available from the UNEP IE address listed at the back of this document.

Mauritius thus serves as an example to other very small countries that are signatories to the Montreal Protocol and amendments. Help is available to all, large and small countries and large and small entities, as well. Sources that may help are listed at the conclusion of this document.

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AEROSOL SECTOR CASE STUDY #6
A Plant Relocation to Achieve HAPS Filling In India

Introduction:

In the previous case study we looked at the problems associated with converting a small filler in a small nation, and discussed the potential for the use of open-air filling versus enclosed filling in that case. This same analysis of techniques leads to the best possible solution to achieving conversion at Aero Pharma Pvt., Ltd. in India.

The Situation in India:

India is a very large country with the second-largest population on earth. Current ozone depleting substance (ODS) usage in the aerosol sector is estimated at 1,400 metric tons annually, mostly in the form of CFC-11 and CFC 12. India collectively is a rich country, but the individual households, as one would expect with such a large population, are generally not wealthy. Aerosol packaging is often used for convenience items, is rather more expensive than some other usable packaging for some items (such as cleaners and polishes, which often can be wiped on), and is relatively costly in general to people with very limited incomes.

Per capita usage of aerosols in India is growing, but is still very low. This is good, given that non-ODS hydrocarbon aerosol propellants (HAPs) are not yet in general use in India. But, it also offers the potential for vastly increased ODS usage should nothing change and demand grow to more normal levels of usage. Even were the consumption to equal that of other developing countries, this might be five-ten times the current usage in India. Thus if no action is taken, there may be a major increase in ODS usage here.

As is, despite India's huge population, the aerosol industry is quite modest. There are aerosol plants in Russia filling as many units in a single location as all of India produces per year (estimates vary, but current data indicates India produces approximately 45,000,000 aerosols annually).

Yet, the small volume of units consumed (for the population and size of the country) is offset by the complexity of how business is done in India. First, India is a state with a highly visible government role in business. Sizable businesses face strict and varied controls at local, state and national levels. Rules are enforced, taxes imposed, and requirements set and changed routinely.

It is little wonder that there are no single large aerosol plants here at all. Such diverse countries as Mexico and Brazil, Thailand and Jordan all have fillers that represent 20% or more of the national production of aerosols. There are no Indian fillers that represent 20% or more of national fillings. A few dozen small- to medium-sized facilities exist (100,000 to 2,000,000 annually), but the vast majority of fillers, totalling perhaps 150 or more, are very small. Many fall into what could be considered the un-regulated or unofficial category.

"Plants" are often rooms in someone's house, a shed outside, or a partition in the back of another enterprise. Since a sizable majority of these companies apparently produce small perfumes and cosmetic products, which are the largest segment of the Indian market, they play an unmeasurable, but important, part.

Thus the aerosol sector in India is hard to quantify, and enterprises are hard to locate. Even the possibility of obtaining technical or financial aid may not matter enough to motivate some companies to come forward and be counted. Many small companies are reluctant to change their way of doing business to meet government regulations. Of course such change would increase productivity, allow them to advertise for new markets, and improve safety and efficiency, all major benefits in the long term. But, this segment is still hard to reach. Efforts are being made to reach these "informal" companies by both the implementing agencies and the Ministry of Environment and Forests of the Government of India (GOI).

Repeated World Bank missions, working with Indian consultants, have sought to increase the available information about the aerosol sector, and have formulated an approach to expedite conversion in this important country. This effort has had positive results, as follows. Two major needs were identified. One was the need to provide India with dependable sources of hydrocarbon aerosol propellant (HAPs). The other was the need to convince the medium-sized fillers to convert to HAPs as soon as possible.

Because HAPs conversion would allow them (and competition would force them) to pass on the sizable savings realized by using HAPs in the form of lower prices, such conversion would start a "domino-effect," causing the smaller companies to reduce prices to an unprofitable level, convert (if that is possible) in their usually small and congested locations, or stop producing aerosols altogether. The desire is to bring these companies out into the open and help them as the first choice. Showing them the cost savings that can be achieved with HAPs is an important step. Aero Pharma, a formal medium sized enterprise, was the first company in India to present a project proposal for HAPs conversion and get it approved.

The Project Proposal:

Aero Pharma Pvt., Ltd., is a part of the larger Aero Pharma group that consists of a variety of companies handling products in the pharmaceutical, cosmetic and personal product fields. A considerable part of their business activity consists in the packaging of Johnson's Baby Oil for the large multinational Johnson and Johnson, Inc. Aero Pharma currently fills about 1,000,000 cans of aerosols a year, and uses about 30 metric tons of CFC to do so. After discussions with experienced consultants about the requirements for

Conversion Requirements for the Aero Pharma Aerosol Filling Plant:

1. Space and design limitations at their current site made safe conversion at that location impossible.

   For example, the only space on their lot where they could install an outside enclosed filling room adjoins a neighboring company that does welding just over the wall between the properties, producing sparks creating a clear explosion danger.
2. Construction of an interior enclosed filling room would be prohibitively costly. Walls and ceilings could not be made to resist the required pressures for explosion containment. There is also no room for safe storage of HAPs.
3. Reconstructing on the existing site would not solve these problems, and would in any case mean closing down during the construction, not possible for an enterprise employing 160 workers, without seriously damaging the company economically.

safe HAP conversion, Aero Pharma realized that their most cost-effective choice was to relocate to a new site, and to set up to fill HAPs at that location. As far as relocation, this was determined after they realized that no other alternative that was practical was possible. In doing this, their needs were determined in the table above.

But determining that plant relocation would be required was only a beginning for a great deal of work to come. Given the inexpensive cost of labor in India, and the fact that most of what is required can be purchased locally, the major part of the required investment is the purchase of the land, the purchase of the modular safe room, and the construction of two small buildings. It was then immediately necessary to make certain design decisions to provide for safe, efficient and legal construction of the new plant site:

Design considerations for the new Aero Pharma Filling Plant:

1. The new site must be in a remote area. This will provide a measure of safety in itself, and will allow the purchase of the sizable amount of ground (800 square meters) needed at a cost far less than what such a parcel would cost in an established built up zone.

2. Current filling machinery was adequate, being of a modern, explosion-proof design. The best choice for filling was determined to be a modular explosion-proof "safe" room, complete with automatic shut off valves, explosion-proof electric lighting, and dual speed ventilation. Modern automatic gas detectors would be included, and connected to the shut off system and an alarm system.

3. Other safety equipment (face masks, goggles, fire extinguishers, etc.) would need to be purchased locally, as India has sources for such equipment that many smaller developing countries lack. Training in HAPs filling and formulation, and in the use of safety devices would be required, and would be done by a experienced expert.

4. Buildings will be constructed on-site for concentrate preparation and finished goods storage. Provisions for safe storage of HAPs would be needed. For safety reasons, and to comply with local codes, the site would be completely walled.

The company has chosen to cover the cost of the land and buildings from their own capital resources, and request assistance from the Multilateral Fund only for the purchase of the modular safe filling room, the storage tank, and auxiliary equipment.

To arrive at the "incremental cost" of their conversion, as required by the Multilateral Fund, it was necessary to analyze both the increase in operating costs and the operating savings involved in this project. The company is certain that their maintenance costs will increase with HAPs, as they must shut down and repair even with minor leakage. This cost increase will affect the filling of both their own captive brands and of products that they fill under contract for other companies.

Concerning the products that are filled under contract, there would be no savings, as the difference in propellant costs accrues to the marketer, the owner of the brand. The savings Aero Pharma would achieve by bringing their captive brands into the marketplace with HAPs before competitors converted are real and must be taken into account. It was calculated that there would be very little difference between the long-term but small increase in costs, versus the large savings that would last only a short time, until the competition converted and lowered their prices.

While the enterprise felt that long term the result will probably be a slight increase in costs, it is impossible to be sure what the actual difference would be. Aero Pharma wisely determined that attempting to prove this small difference would delay the entire process, and presented their proposal with a statement saying they consider the increased costs and increased savings to be equal.

HAPs Supply:

The first draft of these case studies contained a project for a private enterprise to purify and supply HAPs. Plans discussed at the time of the Country Programme mandated at least two suppliers. Late in 1994, the GOI announced that government refineries would supply HAPs. They requested and got the following specifications for HAPs (see box opposite).

HAPs Were Needed - TheGenerally Accepted Specifications for HAPs:

- < 99 % propane, isobutane, or n butane
- > 0.5% ethane, pentane (and other heavies)
- > 5 ppm sulphur (1 ppm is considered the norm for good suppliers)
- > 5 ppm H_2O (1 ppm is considered the norm for good suppliers)
- > 100 ppm unsaturated compounds
- Odor - pass test

The Current Situation:

Some revision to this project proposal may prove to be necessary. For one thing, a very small amount was calculated in addressing the needs for safe storage and handling of HAPS. As the enterprise has already requested financial assistance and presented a project proposal, any changes that require additional investment would have to be covered by the company.

The Aero Pharma HAPs conversion project will result in eliminating the usage of 30 metric tons of CFCs annually. It will also work as a demonstration project for other established, "official" fillers in India. Further, it represents a needed first step on one of the several fronts being pursued to help reach, identify and safely convert the many dozens of other aerosol fillers in India.

This project alone can not completely expedite conversion of the aerosol sector in India. Because India is so large and both the aerosol industry and market so fragmented, it is by no means certain that having a leading filler using HAPs in one place will result in cost pressures that force everyone else to convert. Fillers in Bombay may not generally compete with those in Delhi, for example, although provision of HAPs to some fillers in either area will impact their local competitors.

And, cost pressures alone will not overcome the resistance of many smaller, "informal" aerosol fillers to convert, especially since most will not be able to continue in business at their current locations while safely filling HAPs. Indeed, in this case study we have seen that even a fairly large and well established formal aerosol filling company will have to re-locate in order to fill safely with HAPs

India is a country with great promise, a growing aerosol industry, very well-educated technicians, and astute businessmen. But, despite effort by the government of India, local and foreign consultants, and forward-thinking enterprises, it remains a country needing much more work to achieve success in eliminating ODS usage in aerosols.

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AEROSOL SECTOR CASE STUDY #7
Another Conversion Possibility - DME for Southern China

Introduction:

The purpose of the Multilateral Fund is to enable large and small developing countries that are parties to the Montreal Protocol to rapidly phase-out their usage of ozone depleting substances (ODS). China, the most populous nation on earth, obviously deserves a great deal of attention and help in doing so. The government of China has been vigorous in their efforts to eliminate ODS usage, and has insisted upon the cooperation and support of the implementing agencies to achieve phase out in the aerosol sector.

Multiple missions to China, starting in 1991, determined a national program to achieve phase out. At the heart of this plan was the knowledge that the vast majority of aerosols filled in China were done in three places: In the north, in the area around Tianjin (the subject of a previous Case Study in this series); in the coastal area around Shanghai; and in the south, in the Guangdong area. Each area accounts for around 30% of the aerosol ODS usage in China, and each fills somewhere around 30-35,000,000 units annually.

The rest of China is believed to fill less than 10% of the aerosols, although this is being studied intensely at this time. The National Program that was developed in 1991-1992 is based upon the concept that filling 90% of the aerosols in China with less expensive propellants than the CFC's now being used will force most of the scattered fillers to convert also, because they will otherwise be priced out of the market.

Both the Tianjin and Shanghai conversion efforts followed the most common path for conversion in the aerosol sector: they are converting to produce and fill hydrocarbon aerosol propellants (HAPs). This conversion strategy was quickly found to be impossible in Guangdong.

The Situation in Guangdong:

Guangdong province, in the southern region of China, was determined to be the center of aerosol production for the southern third of the country in the China Country Programme, the official document of reference for phase out activities in China. Under the agreed program, Zhongshan Fine Chemical Industrial Ltd., (ZFCIL) 100% owned by the Chinese government and the largest filler of aerosols in China, would be converted to the regional filling center for south China.

Not only would ZFCIL change over to non-CFC filling, but it would serve as a filling center for numerous small entities that could not be cost-effective converted. And, it would supply propellent to other, mid-sized fillers where on-site filling could continue following their conversion.

While all of this is not unusual and was readily agreed to by all parties concerned, soon complications arose in developing a viable, affordable project. These reflect the unique situation in Guangdong, but they also provide lessons in the application of creative thinking to the resolution of conversion problems anywhere.

Over 80% of all aerosol sector conversion efforts worldwide result in the conversion from CFCs to

HAPs, purified forms of propane and butane, or mixtures of these. These propellants are non-ODS, but they are explosive and highly flammable, which means they can not be transported and stored in the same casual ways CFC is handled, nor are they supplied generally by the same suppliers (CFC comes from chemical companies, HAPs from refineries). They also may not just be filled in place of non-flammable CFCs, but instead require explosion-proof equipment and an absolute control over leakage during the filling process.

Factors Making HAPs Unusable in Guangdong:

- The local shortage of LPG, with supplies needed for cooking and other fuel uses.
- Safety risks involved with transporting low odor LPG long distances. This is not advisable where roads and infrastructure are not of first quality. The best supplies of LPG for purification into HAPs have very little odor, which increases the problems of transporting them safely; even significant gas leakage may not be noticed until it is too late.
- LPG is in very short supply throughout China. Distances to outside (foreign) sources of supply are great and HAPs are expensive to transport. Dedicated pressure containers, requiring special storage, handling and return, are always needed. They are heavy, further raising shipping costs, and the empty cylinders must be returned, further increasing handling difficulties and costs.

All of these questions would need to be dealt with in Guangdong. But conversion in Guangdong presented very different problems, as well. The hydrocarbon feedstock used to produce HAPs are not readily available there. It required a good deal of time and effort to be certain this alternative was not viable before it was possible to find a solution to successful conversion in the Guangdong area.

In Guangdong, indeed in all of southern China (and many other places around the world), the liquified petroleum gas (LPG) that forms the basis for HAPs is the principle source of fuel for cooking, heating and other vital domestic and commercial uses. While aerosols are popular and valuable consumer items, they are not the necessities of life. It so happens that LPG is not produced in large amounts in Guangdong, and is in extremely short supply due to this, plus the great demand. Transport problems make any cost-effective attempts at importing LPG impossible. Under these circumstances, the Chinese government is unable to allocate domestic LPG that is needed for cooking and fuel to filling aerosols.

Under ordinary circumstances, this would lead to securing a supply from another region or country, at a higher but often still reasonable cost. Various missions in 1992 and 1993, working with ZFCIL, determined that there was simply no safe way possible to transport large qualities of low odor LPG feedstock to ZFCIL.

Domestic sources were largely unavailable, with costs of safe transport prohibitive. What little HAPs was imported into the region was unacceptably expensive for filling aerosols, largely due to the cost of importing LPG tanks that had to come via Singapore and Hong Kong from starting points in Europe and the Middle East, and then be returned empty to avoid paying for the containers, as well.

In the final analysis, it became clear that HAPs could not be obtained safely at a price that would allow products filled with them to be sold in the competitive marketplace that is evolving in China.

This process led ZFCIL to consider Dimethyl Ether or DME as a possible propellent. DME is supported as an aerosol propellant choice by the 1991 UNEP Technical Options Report on Aerosols, Sterilants and Miscellaneous Uses and Carbon Tetrachloride. However, since it is more expensive than HAPs in most cases, it is usually not considered the best available technology. Further, a quantity of DME was already being imported to Guangdong, and it was possible to determine that the cost of locally made DME an economically possible alternative.

The Characteristics, Advantages and Disadvantages of DME as an Alternative Propellent:

Before deciding on the specifics of a proposal to use DME as a substitute for CFCs, it was necessary to determine if this was truly practical. This involved two questions: the technical aspects (is DME suitable) and the business aspects (was the required investment such that the enterprise could obtain the necessary financing, either from local sources or from the Multilateral Fund, or from a combination of the two).

The technical characteristics of DME are well known, since about 1/2 the world's production of DME (170,000 tons annually) is used for aerosol propellants. DME offers the following benefits to the filler:

Advantages of DME as a non-Ozone Depleting Propellant:

- DME is an approved substitute, with well established characteristics.
- The only liquified propellant that is substantially soluble in water. Formulating "water-based" is easy with DME, lowering cost of total contents (often there is no chemical solvent needed), and lowering or eliminating the flammability of the mixture.
- DME was readily available in Guangdong province at a price that allows for profitable filling.
- DME's natural slight sweet odor is relatively benign in cosmetic and air freshener applications, which account for 70% of ZFCIL's operations. The odor is insignificant in most of the other applications, such as paints and industrial products.

To offset these advantages, it was necessary for ZFCIL to consider two major disadvantages: that DME is still a highly flammable chemical, meaning transportation, storage and handling costs would still need to be considered closely; and that DME, unlike HAPs or CFCs, is also highly reactive. It attacks filling equipment, damaging hoses and seals, as well as attacking aerosol valves, can seals, and the linings of cans themselves.

Yet, DME is a relatively popular propellant choice in Europe and the USA. Cost is the principle reason it is not used more often.

In seeking to meet these challenges, ZFCIL purposed establishing a plant to produce DME locally in Guangdong. However, a heavy investment would be required to do this, and ZFCIL would be totally dependent on this plant being successful in producing usable DME, which is not assured. And, while such project might have been fundable under the initial criteria used for evaluation by the Executive Committee, current criteria do not allow for funding of "producer" (direct manufacturing of substitute chemicals) projects. The Executive Committee of the Multilateral Fund has taken the position that producer projects are eligible for funding only when an equivalent amount of CFC production is eliminated.

ZFCIL also developed a project proposal to simply purify DME locally, but again received advice that this was too risky a possibility to be readily approved. Purifying DME requires complex steps and precise quality control that is difficult even in developed countries.

The Final Project Proposal:

Having worked at developing a DME proposal that was not acceptable for funding by the Multilateral Fund, and a second that would possibly not be funded either, ZFCIL developed a third proposal that has been approved.

As stated earlier, DME is currently being imported to Guangdong, at a cost that is acceptable for aerosol filling, and indeed less than HAPs could be obtained for in Zhongshan, according to ZFCIL's cost study. In the case of HAPs, good sources are thousands of kilometers from Guangdong, in the Middle East or Europe. ZFCIL would have to purchase and maintain pressure containers for HAPs, and have sufficient storage to keep several months supply on hand, in case anything happened to this long supply line.

DME is available from nearby Taiwan. The Chinese vendors there have solid relationships with their mainland counterparts through Hong Kong. A double reduction in cost is available here. It was possible to determine that a sufficient supply could be obtained, with the supplier providing the reusable containers. Further, this short and dependable supply line meant that relatively few cylinders would be needed and that ZFCIL would need only a modest storage capacity on-site.

The total project proposal for conversion using DME included the costs of modifying existing pneumatic filling equipment to use DME safely, the purchase of additional filling equipment to replace non-explosion proof lines currently operating that cannot be upgraded.

In addition, there is provision for safe storage of DME and finished goods, renewal of hoses and seals in all handling and storage areas to resist DME. There is also the provision of safety and firefighting equipment, as well as training by in safety procedures by an experienced expert. The total amount requested and approved is approximately US $1.7 million. The project will require 24 months from approval for implementation.

Results:

ZFCIL have calculated that their DME project will be very profitable, even though the total investment - mostly in new plant and buildings for the safe filling of the dangerous DME - will be in excess of US $ 8 million dollars. Because of the profitability of the venture, they are eligible for only US $ 1.7 million dollars in funding from the Multilateral Fund for their conversion. The Chinese government will supply the balance, as ZFCIL is a 100% government owned facility.

The conversion of ZFCIL will allow the approved China Country Programme to be implemented by establishing a central filling station in Guangdong province. It will allow for the elimination of over 2,500 tons of CFC usage by ZFCIL, and by over 4,000 tons once the other local fillers are converted.

DME aerosol products can be easily formulated and can be profitably sold in the marketplace. There is some concern about the ability of ZFCIL to deal with corrosion problems associated with DME. Should excessive corrosion problems occur, they can be resolved with assistance from experienced experts at a reasonable cost.

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AEROSOL SECTOR CASE STUDY #8
Filler Conversion in a Small Market Setting - HAPs Substitution in Ecuador

Introduction:

Ecuador is a relatively small nation on the west side of South America. The national economy is at a point where significant changes are taking place, and it is moving from a closed, protected environment to an open and competitive one. Ecuador is a land of low labor costs, yet a place where some artifacts of the modern consumer world are still being imported as finished products.

However, aerosols are produced locally, albeit with largely imported parts, even including cans in some cases. The local aerosol industry developed because this type of small consumer product was previously protected by high import tariffs. By 1992, aerosols were being produced by about 15 companies in Ecuador, and national production was about 6,000,000 cans per year. Over 80% of all aerosols produced were of the personal deodorant or deo-cologne type.

And, some conversion away from CFCs had taken place as early as 1992, with certain large multinational companies pressuring their affiliates to stop using ozone depleting substances (ODS). One company was using a local hydrocarbon for insecticides, apparently for cost reasons, and had been doing so for several years, but the remainder of early conversions involved the use of carbon dioxide.

CO_2 is not a general replacement for CFCs (see Case Study #5, which explains the reasons fully). This limited conversion efforts to a handful of products. This case study addresses the need to secure hydrocarbon aerosol propellants (HAPs) to ensure the total conversion of the aerosol sector in Ecuador, and the conversion plans at the company that is the largest filler of aerosols in the country.

The Situation at Laboratorios Windsor:

Laboratorios Windsor (Windsor) is the largest aerosol filler in Ecuador, using approximately 60 metric tons of ODS, mostly CFC 11 and CFC 12, to fill about 2,000,000 units a year. This production is 90% personal care products, like deodorants, hair spray and shaving cream, with most of the rest being insecticides and air fresheners. They are a market leader in many product categories.

Windsor serves three primary markets. About 70% of their filling is house brands, while 20% are brands filled under license, and 10% are products filled under contract for other companies. Prior to 1992, Windsor filled exclusively with CFCs, but converted appropriate products to CO_2 at that time. [3]

Management at Windsor recognized their need to eliminate CFC usage, and understood the conversion to HAPs would need to be undertaken. But Ecuador in 1992 did not produce or import HAPs, and did not encourage badly needed foreign exchange resources to be used for recurring

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[3] It should be remembered from the Case Study regarding Mauritius that many common products can not be effectively converted to CO_2. (See Case Study #5 for details.)

purchases abroad, unless absolutely necessary. Aerosols are valuable and desirable products, but seldom considered to be absolutely necessary. There appeared to be no way practical for them to obtain the propellent that Windsor knew was the common conversion solution for companies in their situation around the world.

Laboratorios Windsor's Three Steps to Eliminating CFC Usage:

1. Convert products needing wet, coarse sprays to CO_2 propellant. This could be accomplished by simply changing propellant in the filling line, but is unsuitable for many products.
2. Substitute mechanical pumps for use in those products that would be unacceptably light and likely to dissatisfy consumers (they would seem "empty") if filled with CO_2. Suitable for deodorants and hairsprays.
3. Convert all other products to filling with HAPs, once they were available. By preparing for this, Windsor would be encouraging implementing agencies and the government of Ecuador to resolve various roadblocks to the importation of HAPs.

Under these circumstances, limited conversion to CO_2 was all that was possible. However, Laboratorios Windsor did not limit their creative thinking to what could be achieved in only the existing circumstances. They looked beyond these limitations and recognized that a three step approach would ideally serve their entire market structure while resulting in total elimination of CFCs. Their plan is outlined in the table on the right.

An additional project was developed for the national importation of HAPs, and the government of Ecuador (GOE) agreed to facilitate this importation. Thus Windsor converted to CO_2 where applicable, and developed project proposals to solicit financial assistance for pump substitution and conversion to HAPs filling. The Implementing Agency (the World Bank) and the ozone unit of the Ministry of Industries determined that it would not be prudent to request financial assistance to convert to two different technologies. Only the plan to obtain financial assistance for the HAPs filling for Laboratorios Windsor was presented and approved.

At this time it was believed that the HAPs would have to be imported, either from the United States or Columbia. Plans were initiated to have central storage facilities for HAPs, possibly at Guayaquil so as to be readily accessible for ocean freight. But time is an important and sometimes favorable factor. While everyone wants phase-out as quickly as possible, in this case the time necessary to proceed to this stage allowed events to turn out better than originally expected.

While the Windsor project was being prepared and presented other studies were moving along, it was determined that Petroecuador could supply a feedstock adequate for molecular sieve purification into aerosol grade propellant. Both the national strategy and the Windsor request for financial assistance was modified accordingly, with Windsor to install a three column molecular sieve system for purification.

The final conversion project will take advantage of Ecuador's mild climate to use the open air filling system that is very popular throughout Latin America and the Far East in countries of temperate climates. This system requires that the HAPs propellant be filled completely in the open, using only a roofed-in area to protect from the rain. Wind and natural air movement are used to dissipate the small amount of hydrocarbon that always leaks when a can is filled, as otherwise this routine leakage could accumulate to dangerous concentrations.

The salient points of this conversion are the close cooperation between the government of Ecuador, the implementing agencies, and the enterprise, and the facility with which the project has been modified to achieve the desired result.

Final HAPs Conversion Project at Laboratorios Windsor:

- Spare parts are being imported from Switzerland to repair Windsor's PAMASOL filling equipment.
  Conveyors and auxiliary equipment are being made locally.
- The purification technology and the three column molecular sieve system is being imported from Germany.
- LPG storage vessels are being built locally under the supervision of experienced German technicians.
- All civil works are being done locally.

At this time project start-up is scheduled for mid-1995.

Without this type of cooperation this project would not have been completed, and certainly would not have been modified as it progressed to present the best possible conversion. The GOE arranged early for interest on the part of the aerosol industries, and provided, through the implementing agencies, several experienced experts that provided valuable guidance. Because of this it was possible to know that HAPs could be produced locally, a factor that will be of assistance to all aerosol fillers. The Laboratorios Windsor project is now being implemented as described in table.

The original plan as developed by Laboratorios Windsor was innovative, and would have provided an excellent basis for industrial development in the aerosol industry. The modified plan will successfully satisfy all of the criteria to eliminate CFC usage at Laboratorios Windsor, and provide the benchmark for the conversion of the remaining fillers. Another innovative part of the project was the use of open air filling for the conversion to HAPs:

Criteria for the Use of the Open Air Filling Method: [4]

- An open-air filling room may have one solid wall (parallel to the outer wall of the plant), or it also may have just a roof over the machines, out in a field. If the filling room adjoins one wall of the plant, there should be at least 1 or 2 meters between the plant wall and the filling room wall. Holes for conveyors (in main plant wall) must be small.

- Any additional walls can be wire mesh, and the roof plastic or fiberglass panels. There must be **nothing** to stop the movement of air.

- It must not adjoin anything, such as an area with a pump, compressor, electrical panel, or boiler, which may cause sparks and/or flame. This also applies to parking lots, driveways, etc.

- Only pneumatic equipment should be used. If explosion-proof electrical equipment is used, it must be well maintained and constantly inspected.

- Natural light should be used where possible, with explosion-proof lighting the next choice. Normal electrical lighting n electric lighting is not acceptable.

- Wherever located, the "room" should be raised above ground level, if possible, with no drains or low areas nearby where gas can collect.

While Windsor continues to study the possibility of doing enclosed filling, principally as a means of impressing their large trans-national clients, the current project proposal involves the open air method, easily the least expensive and possibly the safest means of filling the highly flammable HAPs.

The open air system was apparently developed in several countries independently. Fillers in Indonesia, Mexico, India, Brazil and other countries have been using this method successfully for more than twenty years. The important aspects of open air filling are: Laboratorios Windsor does indeed choose this useful and inexpensive method of filling HAPs is of little concern here. It is important that it be considered as a viable option in all conversions that take place in temperate climates.

As part of the overall plan, Windsor will have capability to process more propellant than their own needs, and will be in condition to sell the other aerosol fillers in Ecuador the amount of propellant that they require, once they have converted their facilities to be able to use HAPs safely.

Results:

Much of Laboratorios Windsor's previous consumption of 60 metric tons of CFC propellants has already been converted to CO_2. The remainder will be eliminated in early 1995 as the HAPs purification equipment comes on stream. This conversion project demonstrates innovative problem solving during a prolonged period during which important and positive modifications were made to the initial conversion project.

[4] For a discussion of the advantages and design of open-air filling rooms, see the Aerosol Conversion Technology Manual, which is available from the UNEP (address listed at the back of this document).

The cooperation of the GOE with the Implementing Agencies and Windsor, the use of Multilateral Fund financial assistance, and the creative use of open air filling all make this an important demonstration project that will assist the remainder of Ecuador's aerosol fillers to convert.

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AEROSOL SECTOR CASE STUDY #9
A HAPs Plant Leads to Phaseout in Mexico

Introduction:

In the late 1960's and early 1970's Mexico was a developing country with slightly over 50 million people, and an integrated aerosol industry almost 15 years old. Per capita sales of aerosols were less than 0.5 cans per year, mostly hair spray. Over 80% of all cans were filled with CFC propellants.

In three years all of that changed. In July of 1974 Aeropres, S. A. began delivering hydrocarbon aerosol propellants (HAPs) to five clients, and in two years, by the end of 1976 they had taken over 70% of the entire propellant market! This is their story.

The Mexican Aerosol Market, Then and Now:

Promoted by very heavy protective tariffs, and with labor costs of less than 10% of those of their big neighbor to the North, many local industries flourished in the 1950's and 1960's even though they were too small to be viable industries without protection. Such was the case with aerosols. In the early 1950's, an engineer who had refrigeration experience established Virmex, S. A. to fill CFC-propelled aerosols using the cold filling method. In the late 1950's two young chemical engineers from the Autonomous University of Mexico started the competition, Aerobal, S. A. This company filled by pressure filling, "through the valve."

While everything was initially imported, soon two suppliers existed for aerosol valves (under license to Newman Green and Precision), two suppliers for tinplate cans (Continental and a local supplier, Envases Mexicanos), two suppliers for aluminum cans (both local, Tubos de Estano and Industrias Santa Clara), and two suppliers of CFCs (Du Pont and an affiliate of Allied Chemical). Until the latter part of the 1960's there was no supplier of hydrocarbons at all.

Hydrocarbons were being used by one company, S. C. Johnson, in their "Raid" insecticides and "Glade" room fresheners. The technology had come down from the home company in Racine, Wisconsin, USA and the remaining fillers really had no idea of how to fill hydrocarbons, or the safety requirements for doing so.

But price pressure was intense and U. S. aerosols were much cheaper, both due to the large volumes produced in the United States, and due to the fact that U. S. companies were in the process of converting to hydrocarbons. There was a very real fear that contraband would flood the country through a porous 3,000 kilometer border, something that never really happened, although there was some serious contraband problems in the early 1990's.

The aerosol fillers were able to convince the two propellant suppliers that they needed blends with hydrocarbons for cost reasons. At first it was possible to fill 90/10 (90% CFC 12 and 10% HAPs) and 45/45/10 (45% CFC 12, 45% CFC 11, and 10% hydrocarbon). These two mixtures can be filled in basically the same equipment as pure CFCs -they are essentially non-flammable. Later, the suppliers were forced by their clients to sell blends with 25% HAPs, then 50% HAPs, and finally 100% HAPs. They protected their CFC markets by putting high prices on the HAPs.

The blends were highly flammable, and the CFC companies sold them reluctantly "as is." There was no attempt to support the HAPs with technical service, or safety training. Indeed, they repeatedly warned that anyone using HAPs was in constant peril. In 1968, this was supported, as the Polvrimex plant burned to the ground in a hydrocarbon related accident, and several people were seriously injured.

Meantime, the plant manager of S. C. Johnson had left the company, found financial backing, and started the Mexican Propellant Company to sell hydrocarbon propellants. This company had all of the S. C. Johnson technology - they knew which refinery could sell the best feedstock, and they had some notion as to purification procedures. But the corporate goal was limited to selling S. C. Johnson, and the equipment was small and did not produce a quality adequate for usage in aerosol cosmetics.

By 1973 the aerosol market was probably using about 30% hydrocarbon, S. C. Johnson and a few others using it at 100% and several other companies taking blends with CFC. This was the grand period of expansion of Aerobal and the other contract fillers - they converted their filling lines early, and at the beginning of the 1970's were converting many clients. A client could use their filling services with hydrocarbons, and in some cases still have a cheaper product than filling it in house with CFC. A key problem was that no technology was available, and many of the marketers were afraid of filling hydrocarbons.

Yet the conversions to hydrocarbons were happening very slowly. Several factors effected this:

Reasons Why Hydrocarbon Propellant Usage was Limited Prior to 1974:

* The "scare tactics" of the two CFC companies were working.

* The accident at Polvrimex scared everyone.

* Mexican Propellant Company gas was of very poor quality. It was mostly adequate for insecticides but nothing else.

* Some companies did not want to surrender control of their products to a contract filler, but did not have access to technology for safe filling with hydrocarbons.

* Cosmetic companies need good quality HAPs which was not available.

Enter Aeropres, S. A.:

A series of circumstances led to the resolution of the problems indicated above, and to a dominance of HAPs in the Mexican market within a very short period:

- A local consultant tried to convince Aeropres Corp. of Shreveport, Louisiana, USA that they should open a branch in Mexico. He was unsuccessful, but stimulated interest in expansion south of the border at Aeropres Corp., which was experiencing very high growth and excellent profits.

- This same consultant approached the owner of a major aerosol group - Grupo Sabesa - to try to interest him in a hydrocarbon plant. The owner of Grupo Sabesa had social dealings with the owner of one of the principal dealers in LPG gas in Mexico, Gas Uribe.

- Gas Uribe had excellent relations in PEMEX, the Mexican petroleum company, and had fine relations with TATSA, the affiliate of Trinity Tank Company that supplied most of the storage tanks for liquified petroleum gas (LPG). Gas Uribe also had an affiliate, Instalaciones Gas Uribe that was dedicated to doing permanent installations of stationary storage tanks.

The result was inevitable. After several months for study, the Mexican group went to Aeropres's plant in late 1963, and a deal was struck.

Service and Safety:

From the start, Aeropres, S. A. was dedicated to service and safety. Service because one of the tactics used previously was to restrict HAPs sales. Clients were continually told that "the tankcar did not arrive on time" or "there are no cylinders available" or something, and delivered their hydrocarbon days or weeks late. An aerosol plant fills cans every day, and must have propellant to fill. Aeropres S. A. was determined to avoid these problems by always having sufficient gas on hand, and by having sufficient delivery equipment to assure good service even when a truck broke down.

The initial response to safety issues was just as clear and just as determined. Aeropres, S. A. would deliver no HAPs at all in portable cylinders, would deliver only to stationary installations made or approved by their affiliate company, and would never deliver to any installation deemed to be unsafe.

The Business Plan:

The Aeropres S. A. business plan was based on three factors:

Aeropres's Business Plan was Based on the Characteristics of the Shareholders:

* Joint ownership - Aeropres Corp. of Shreveport, La. U. S. A. were 14% partners.

* Grupo Sabesa's knowledge of the aerosol industry.

* Gas Uribe's knowledge of the LPG business and hydrocarbon safety.

The business plan called for:

- Aeropres, S. A. to lease two 16 ton trailers and 2 local delivery trucks from Gas Uribe. Because of the nature of HAPs, these were either new or completely cleaned units. Only dedicated storage and transport equipment can be used with HAPs - otherwise contamination will occur.

- Aeropres, S. A. would use LPG import permits that Gas Uribe already had to import HAPs.

- Aeropres Corp. gave the Mexican company a preferential price to buy the HAPs and agreed to transport them to the Mexican border at cost.

- Gas Uribe leased Aeropres, S. A. sufficient space in Zumpango, State of Mexico (30 miles - 50 kilometers from Mexico City) for a storage facility initially and later to put up a purification plant. 11 hectares were immediately available.

- Aeropres propellant went on sale the first week of July, 1974; at 10% more expensive than the CFC companies were selling it. In reality, this was a discount - previous deliveries were in portable cylinders, and far more than 10% of the HAPs was remaining in the cylinders.

At first there was some resistance because the clients were going to be obligated to buy their storage tanks, but Aeropres, S. A. immediately answered with a simple agreement whereby a slight overcharge (about 8%) would be charged per liter of gas delivered against the price of the tanks until they were paid for. Five companies signed on the first week - Aerobal, Technosol and Aerospray (the three major contract fillers), Alberto VO5 (cosmetics) and Industrias H 24 (insecticides).

The first clients were merely substituting a safe delivery of HAPs in stationary storage tanks for HAPs in portable cylinders. During the first full year over 20 tanks were put out on this loan/repayment basis, and service and quality were so good that it became possible to sell the tanks outright. By this time Aeropres, S. A. was selling principally to CFC users, where less than 1 year payback was the rule.

Consolidation:

The danger area here was the importation. Mexico was developing the Campeche gas fields, and would soon become self sufficient in LPG. At that time, possibly the border would be closed, Also, the competition were using their strong political influence to damage this new "upstart" that was taking business away from them. Clearly importation was not a long term solution.

Plans were made to purify Mexican feedstock. A thorough study was made of feedstock sources, and it was found that acceptable propane would have to come from Reynosa (a border town were the gas was being imported - 600 miles [1000 Km.] from the plant); whereas the butane mix that would represent 70 % of the total required could come from Poza Rica (200 miles - 300 Km.) from Mexico City. Once it was ascertained that good feedstock was available, the following equipment was purchased (all equipment was purchased locally).

Molecular Sieve Purification System with Regeneration:

2 molecular sieve towers 2.80 meters by 12 meters

1 "hot gas" regeneration system including:

* pump
* heater (salt bath transfer or other, but not direct fire)
* heat exchanger
* condenser/separator for H_20
* insulation (insulation of pipes and columns previously quoted to allow the towers to be heated

These oversized towers were spectacularly successful, although any expert will quickly advise that the ratio of diameter to height is incorrect; and that a diameter of 1 meter would have been better for 12 meter high towers.

Conclusion:

Aeropres S. A. has been one of the greatest aerosol success stories worldwide. It has made its shareholders a lot of money, and consistently maintained more than a 70% share of all propellant sales in Mexico, for what is this year the twentieth straight year. Based on this supplier, the aerosol industry in Mexico has been able to grow continually. There has never been a hydrocarbon related accident in the handling and storage areas where Aeropres is directly responsible, and accidents in the filling room have been few and minor.

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AEROSOL SECTOR CASE STUDY #10
A Two-Stage Conversion to Hydrocarbons in Jordan

Introduction:

A previous Case Study (#2) in this series described how the environmentally concerned aerosol manufacturers of Jordan, in combination with the government owned petroleum supplier, the Jordan Petroleum Refinery (JPR), and the Project Implementation Unit (PIU) of the Department of Environment, joined forces to secure a national and regional source of hydrocarbon aerosol propellants (HAPs). This will be produced by the difficult process of hydrogenation, and provided by JPR. Concurrently, thinking turned to additional projects to ensure conversion occurred.

Thus Jordan also has several other projects in implementation, to prepare Jordanian fillers for HAPs filling. In this Case Study, we will look at the situation of one such filler, M. Haddad & Sons Company, and see how they developed a project for HAPs conversion at their new plant site. And, we will see that additional work beyond their first proposal ended up being needed.

The Aerosol Market in Jordan:

Jordan has been described earlier, in terms of its setting in the center of the Middle East. Recent political developments, and the rapid building of even better relations with its neighbors are likely to further increase the growth of the Jordanian economy, and the volume of aerosols that the country will produce.

Two aerosol producers are already filling hydrocarbons, (Households & Toiletries and Dajani International), albeit with problems because aerosol grade propellant is not yet available. The remaining fillers continue reluctantly to fill with CFC propellants, but are in preparation to convert as soon as aerosol grade hydrocarbon is available..

The Conversion at M. Haddad & Sons Company:

In the aerosol market of Jordan, M. Haddad & Sons Company (Haddad) has been successful, and is planning for future success. The company is the largest aerosol filler in Jordan, currently filling more than 1 million units of house brands, as well as being the contract filler for the large international J. B. Williams Company. They are currently using CFC 11 and CFC 12 propellants, and responsible for about 40% of the CFC usage in the aerosol sector in Jordan. Haddad has an annual usage of about 85 tons of ozone depleting substances (ODS).

Haddad's current plant in Zerka is six stories high, and could never be made safe for HAPs filling. They are building a plant extension adjacent to the current plant, but it is of the same height. This new facility could possibly be made suitable for HAPs filling, but it is not adequate for the installation of a large bulk storage tank.

As for equipment, they are currently using old Coster and Pamasol filling equipment, which are machines which have served them well for CFC filling, but which would pose a safety hazard if used with hydrocarbons. While in theory aerosol machinery can be completely rebuilt, in practice it is seldom worthwhile and may be dangerous.

Of course, enterprises in developing countries often make parts where needed, and make do where entities in developed countries would simply order new parts or entirely equipment, but there must never be this kind of mentality when the life of the company and its workers are at stake. Rebuilding aerosol filling machines to fill with HAPs presents exactly this type of extreme risk.

The sum of the problems listed in the following box (top of next page) is that such dangers are very real, indeed unavoidable, when aerosol machines that have served out their time are mistakenly kept running. Further, years of working with CFCs has put their company in a mind-set that the management realizes is dangerous for workers. An important part of their need is for an experienced safety expert to provide detailed safety training, to overcome the altitudes that exist among their workers. For example, while a leak of CFCs is treated casually; such a leak of HAPs could easily lead to a disastrous explosion, including the possible loss of human life.

The Problems Encountered when Aerosol Filling Equipment is Re-built:

Aerosol equipment manufacturers make their profit on the sale of new equipment, and to a lessor extent, on the sale of spare parts. The machinery is designed such that a few parts will require frequent replacement, while many other parts will continue to work for the reasonable lifetime of the equipment. Once a piece of equipment has exceeded this period, the cost of purchasing all of the spare parts that have undergone wear and should be replaced can exceed the cost of the equipment itself, as spare parts are priced at a premium. This is not so very different than would be the case with an exotic automobile.

Further, aerosol equipment is sold without detailed manufacturing drawings, so it is not possible to completely ascertain which parts should be replaced, as the user does not have the original specifications and tolerances. For this reason, rebuilding an aerosol filling machine without resorting to the manufacturer is fraught with problems. It can be done cheaply, especially in developing countries that have low labor costs but skilled craftsmen, but it cannot be done well. The re-builder cannot know:

- What were the original dimensions.
- What were the manufacturing tolerances.
- What steels were used. How were they heat treated.
- What were the specifications of the other materials used - valves, hoses, seals, micro-switches, etc.
- What was the design pressure resistance of each component.

Old hoses, seals, and even gassing cylinders have been known to burst, producing an immediate worker safety problem, which increases dramatically if a flammable propellant is used.

The Project Proposal:

The initial project developed at Haddad envisioned their needs for HAPs filling installed at their new adjacent plant building. The specific request was as follows:

The Haddad Project Proposal:

- A complete aerosol filling line, including 1 product filler and 1 vacuum crimper mounted on a table, and one 300 cc. gasser, mounted on a separate table.
- 1-One by three meter "L" shaped return conveyor.
- 1 set of racks for 20 propellant cylinders (50 kg. each).
- A complete explosion-proof filling room, including ventilating system, blow-out wall, an explosion-proof electrical system, and necessary automatic gas detection equipment.
- Extensive safety training by an experienced expert.

This is the project proposal that was submitted for approval by the Multilateral Fund's Executive Committee and approved at the same time as the project for the Jordan Petroleum Refinery to produce the required HAPs propellant.

It apparently met the entire needs of Haddad to phase out their ODS usage in an approved, safe manner. All that was needed was for them to modify their plant under construction, and for JPR to complete their construction of a hydrogenation plant to remove olefins from the available liquified petroleum gas (LPG) feedstock, thus making HAPs available by the time the Haddad plant was ready.

However, this turned out to not entirely be the case. A major complication developed. Two internationally know safety consultants visited Jordan, and both indicated that managing large volumes of hydrocarbon propellants in small, portable cylinders was innately unsafe. While this does not appear to be of much difference, in reality this was a major problem, as it had already been ascertained that the adjacent building site was adequate for 50 kg containers, but that not enough space existed for the installation of a large stationary HAPs storage tank under Jordanian law.

Once they discussed their plans with JPR, following approval of the first proposal, JPR readily agreed that for Haddad's volume a stationary storage tank was the best solution. The issues involved were several and tended to have a multiplier factor; that is, it is easy to deliver one cylinder safely, but the slight risk multiples each time. How does one safely transport, store and handle thousands of pressure cylinders annually, and how safe is it to store 1000 kg of HAPs in storage racks? The experts said it was innately dangerous to try to do so.

In the end, JPR and Haddad agreed that they were in fact taking an additional great a risk by trying to use small cylinders for HAPs filling at their volume. Small cylinders have fewer safety valves each than fixed installations, yet many times more total valves (20 cylinders have 20 on and off valves) that might leak. They can easily fall and rupture, they are most subject to being dropped in transit, etc. While small cylinders are widely used for home cooking fuel, where they are the only answer for the general populace, the volumes are small. Even though leakage is readily detected by odor, which is not present with HAPs, accidents sadly do occur. But such a family tragedy is much different than the scale of disaster that would occur if twenty or more tanks exploded in a plant otherwise filled with solvents, flammable products, etc.

The best solution by far was to modify their original plan for aerosol filling operation to include a change of locale to a place where sufficient space exists to accommodate stationary tank storage of HAPs, and use of a safe piping system to supply their gassing room. Since their project proposal with the Multilateral Fund had already been approved and funded, they submitted an additional project proposal for the changes in plan, in the knowledge that if this is not approved they will have to support the additional costs themselves.

Modifications to Provide Fixed Storage Facilities at the New Haddad Plant:

●	Tanks for HAPs storage.	US $	78,000
●	Plant modifications, includes costs of driveways, tank bases, etc.		20,000
●	Shipping costs.		15,000
●	Additional Extinguishers, portable gas detectors, etc.		4,000
●	Additional piping.		6,000

The Project Modifications:

In developing the proposal for bulk storage of HAPs, Haddad was forced to ask for twice the storage capacity they cited earlier. This was because 20,000 kg is the capacity of a tanker truck such as would be used to fill their storage tank, and the refinery insisted that they buy full truck loads at one time. Haddad determined that they could provide sufficient space for such a storage tank, and they made the required modifications to their previous plan. Also, they would need additional safety equipment, such as portable leak detectors which are used to examine for leaks in piping and valves.

This proposal was only recently prepared and will be submitted for approval by the Executive Committee of the Multilateral Fund. It reflects the need for any enterprise converting to HAPs to always inquire thoroughly into safety related issues, and the need to do things the safest way possible at all times. In cases around the world where safety has remained the dominant characteristic at HAPs filling and storage sites, there have been remarkably few accidents in the 20 years that there has been extensive HAPs filling activity. In the few unfortunate cases where HAPs has been treated more like CFC and casually stored and handled, there have far too many cases where there have been fires, explosions and loss of property and of human life.

The safety expert from the United States of America indicated clearly that HAPs are only transported in cylinders for use in aerosol laboratories. The Mexican expert stated that Mexico has experience with about 600,000,000 liters of HAPs safely delivered over twenty years, but that the two suppliers of HAPs in Mexico will not deliver in portable cylinders at all because of safety concerns.

The Results:

The overall phaseout effort in Jordan has been proceeding very well, because of several related factors. The government and the implementing agency, the World Bank, have worked well together to achieve successful phaseout efforts, most notably in the degree of cooperation that the government has shown is the case of providing HAPs by implementing hydrogenation at the government-owned JPR, which has cooperated enthusiastically.

But the success and progress towards phaseout seen in Jordan has other causes, as well. Intelligent business leaders have recognized the need and desirability of converting away from ODS CFCs. The desirability is the focus of efforts under the Montreal Protocol, of course, but there is an unusual awareness in Jordan that the world is changing in other ways, as well.

Jordan has seized the opportunity provided by the Multilateral Fund of the Montreal Protocol and submitted these and other project requests faster than business people in many other nations. These business leaders want the most modern and cost-effective operations they can provide to stay competitive for years to come.

It is not surprising, then, that the projects approved or in the approval process in Jordan should remove the vast majority, at least 70% of the 225 metric tons of ODS usage in the aerosol sector in Jordan by 1996. About half of this volume will be at M. Haddad and Sons.

Contact: For more information about HAPs conversion in Jordan or any other questions raised in this case study, please contact:

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AEROSOL SECTOR CASE STUDY #11
Modifying a Plant to Achieve Safe HAPs Contract Filling in Indonesia

Introduction:

Various case studies have dealt with the challenges involved in the conversion of small and large fillers in small and large developing nations, from CFCs to hydrocarbon aerosol propellants (HAPs). Such elements as safety, engineering, HAP propellant availability and purification, training and costs are all important to the success of such programs. The following pertains to the conversion progressing at P.T. Candi Swadaya Sentosa -- the largest contract aerosol filler in Indonesia.

The Situation in Indonesia:

Indonesia consists of Java and other groups of equatorial islands lying northeast of Australia. Jakarta is the capital and major city -- population about 11,000,000 and growing rapidly. The average wage for relatively unskilled men is about US $ 2.00 per day. In the many less developed areas of Indonesia it is much less. This explains the high concentration of aerosol fillers in and around Jakarta, as well as the relatively small size of the aerosol industry, currently estimated at about 55,000,000 units per year, and less than 1.0 per capita. Despite the fact that this island country lies at the south end of the second largest oil-producing center of the world, land-based refining facilities on Indonesia and nearby Malaysia are so oriented toward fuel-grade end-products that these countries have no source of low-odor HAP products.

It is very difficult to obtain reliable information from Pertamina, the national petroleum company. Their liquified petroleum gas (LPG) assay sheets do not stand up to scientific scrutiny. For example, upon adding up the ingredients of HC blends, one obtains impossible totals, such as 113%. Listed pressures for nearly pure iso-butane are over twice the actual pressure for this chemical. Olefinics are rarely listed, and then only stated as "nil". Also, despite sulfur contents corresponding to about 11.4 to 230 ppm of ethyl mercaptan (CH_3-CH_2-SH), the company adds still more, prior to shipping.

Like China, India and Malaysia, Indonesia is a country with a highly pervasive government role in business. This has led to the larger businesses being highly regulated and taxed, and to a rather large number of much smaller businesses that function covertly to escape these burdens. The number of "moonlight" or "cottage industry" aerosol fillers far outnumbers the larger ones in Indonesia -- as they do in the other countries mentioned.

The number of aerosol fillers in Indonesia is estimated at about 70 to 100 firms. For statistical purposes only the 18 largest have been recognized for formalized assistance, a technical assistance program financed under the Multilateral Fund in coordination with the Indonesian Ministry of the Environment (LH). This program will provide technical and safety training in the proper handling of LPGs, fire control, ventilation aspects and so forth. Fillers will be encouraged to buy a package containing suitable fire extinguishers, crimp diameter and depth gauges, portable flammable gas detectors and an information pack. Several plant visits would be made by recognized aerosol safety experts.

The Indonesian aerosol industry can be assessed in relation to firm size and propellant consumption

Indonesian Aerosol Fillers and Propellant Consumption

Size of Filler	Number of Fillers in Group	CFC Used 1991	CFC Used 1993	HAP Used 1991	HAP Usage 1993
Large to Medium	18	1,300 mt.	250 mt.	3,000 mt.	3,700 mt.
Medium to Small	22	150 mt.	100 mt.	220 mt.	290 mt.
Small to Very Small	30 - 60	50 mt.	50 mt.	0 mt.	10 mt.

as follows:Aerosols are growing at a steady rate of about 10% per year, which places some degree of urgency on the implementation of the CFC reduction program. Some conversions have occurred, placing pressure on the rest of the filler community to also reduce their consumption of CFCs.

Currently, the low price of domestic LPG is an incentive for using it in aerosols. The price is a stable US $0.34/kg when plants are served by typical 8 ton trucks. In contrast, the bulk price of imported HAPs is about US $ 1.85/kg., and that for imported dimethyl ether (DME) is about US $ 2.35/kg. CFCs now cost from US $ 3.50 to $ 4.50/kg.

In August, 1993 the Indonesian government under President Sukarno banned the further use of CFCs in aerosols (except for certain medical and essential-use products). However, CFCs remained freely available, and since the small "cottage fillers" feel they need CFCs because of their low odor and non-flammability attributes, they continue to buy CFC 12 and some CFC-114, and this means that the law has driven them further underground. The "cottage industry" people typically fill aerosols in homes, garages, partitioned off rooms in the back of a business establishment, and so forth. The owners of these buildings strongly object to any use of flammable propellants, since a mishap could burn down the premises, and the subsequent investigation would disclose that they were party to an illegal business operation. To minimize the economic problem of using more costly CFCs, the "cottage industry" operators prefer to fill products that either require very little propellant per can, such as mousses, or high-end products where the retail price is high enough to justify using a more costly propellant. Aerosol perfumes and colognes fit into this second category, and of course, the low odor of CFCs (compared with that of the domestic LPG) is very important to marketing success.

The LPG available domestically has a bad odor. The odor arises from sulfur compounds that naturally occur in all the local products, plus the contribution from additional sulfur compounds (ethyl or t.butyl mercaptans) that are deliberately added for stenching purposes. Unsaturated hydrocarbons and carbonyl sulfide are also present, and while they are less odorous than the sulfur compounds, they are able to react with aerosol ingredients to produce bad odors.
The larger Indonesian fillers have had to install molecular sieve and related equipment in an effort to reduce the LPG odor levels. They sometimes use a column of potassium hydroxide to remove hydrogen sulfide and some methyl mercaptan, plus water. This is always followed by multiple columns of Mol-Sieve Type 4A, which adsorbs carbonyl sulfide, methyl mercaptan, most ethyl

mercaptan and propylene gases. It is unfortunate that no one in Indonesia appears to use Mol-Sieve 13X, which is a zeolite structure with a large pore size (10 Angstroms), and capable of adsorbing t. butyl mercaptan and the C4 and C5 unsaturated hydrocarbons, like isobutylene.

The initial cost, size and maintenance of the adsorption equipment is significant. It is out of the reach for the "cottage industry" people, for example. The poor and variable quality LPG offered by Pertamina has such relatively high levels of odorous or reactive contaminants that molecular sieves quickly become saturated, and must be discarded. The ultimate solution would be hydrogenation, followed by molecular sieving to remove hydrogen sulfide, water, CO_2 and other contaminants. However, this involves an operation costing an estimated US $ 3,000,000 (US) and is not practical at this time. The nearest hydrogenation equipment is in Australia, and (soon) in Shanghai.

A background worry related to conversion to HAPs is the possibility of a serious fire. This could intervene the program, causing a surge in "safe" CFC use. This is a justification for the training and safety assessment program now proposed.

Four key things should be considered to reduce the present 300 to 400 tons/year of CFC consumption for aerosols in Indonesia:

1. Work with Pertamina to assure a single source of LPG supply - preferably from their Pengolahan Until IV -Cilicap (Terendah) facility. This would require a dedicated bulk storage tank at the Pertamina storage area in Jakarta. If deliberate stenching could be avoided for this LPG, that would be a plus.

2. Work with a filler to provide for partial purification of the LPG into HAP, using KOH/Mol-sieve type 4A/13X technology. The firm of Candi Swadaya Sentosa, P.T. has indicated a willingness to provide this service. By this means one large cleaning operation would take the place of 20 to 50 smaller ones of less assured merit.

3. Provide the safety training, plant audit, information-transfer, and follow-up visit program promised.

4. Try to uncover the small and very small fillers, now heavily dependant on CFCs, to provide information and possible assistance in changing over to partially purified HAPs.

The two largest fillers in Indonesia are Bayer Indonesia P.T. (using about 1600 tons of HAPs in 1994), and the contract filler Candi Swadaya Sentosa P.T., using about 800 tons of HAPs in 1994. The latter firm has largest molecular sieve station in the country - on the order of 6 to 8 times the capacity of that used by Bayer. With engineering refinements and modest additions it could probably handle the present needs of Indonesia's aerosol industry. The present location of Candi Swadaya Sentosa P.T. is not conducive to large scale intake of LPGs and output of HAPs, since it lies near residential districts and small businesses. Relocation of the purification unit seems inevitable, especially since the aerosol industry is growing by about 10% per year compounded, and on that basis could reach about 100,000,000 units by the year 2000.

Certain decisions would have to be made concerning safety, efficiency and legal construction of a HAP gas supply site. For minimum economics, it would consist of a bulk tank for LPG, the purification apparatus, and a bulk tank for one HAP blend. HAPs produced from the Terendah product is summarized as (on the right): Currently it is adulterated with 10 ml. per 1000 U. S. Gallons of tert. Butyl Mercaptan. The Terendah refinery is located perhaps 10 hours outside Jakarta by tanktruck.

Indonesia - Typical LPG Specifications	
Ethane	0.1 v.%
Propane	10.0 v.%
Butanes	88.8 v.%
Pentanes and heavier	0.4 v.%
Olefins	Trace
Water	None
Density	0.565 at 60◦ / 60◦ F
Pressure	61.0 psig at 100◦ F.

In the purification operation, Pertamina would be expected to maintain required levels of raw Terendah LPG in the supply bulk tank, while a dedicated truck for carrying HAPs would be leased or purchased to carry LPG to fillers using small bulk installations. The standard 50 kg cylinders could be refilled on the site, or traded for pre-filled cylinders, if a cylinder inventory was considered feasible against the cost of a storage area. One engineer and one semi-skilled worker could provide coverage for 10 to 12 hours per work-day. Those few aerosol fillers who require higher-pressure HAP blends, such as in some paint products, could make purchases from Pertamina as they do now. Other fillers may wish to continue using LPGs or poorly cleaned HAPs for those products that of themselves possess substantial odors, such as paints and insecticides. However, it is estimated that about 75% of the current 4800 tons (1995) of hydrocarbon usage per year could be centrally processed. This would be about 3600 tons in 1995 and a projected 5800 tons in the year 2000.

The concept of centralized purification is widely used in North America, Western Europe, the Middle East (Emirates Gas Bottling Co., Ltd.), Japan, Australia and other countries. Users pay a fee for purification, which eliminates their involvement with this activity, and makes their facilities statistically safer by reducing hydrocarbon handling and processing requirements. The financial involvement of the Multilateral Fund in a central purification facility could be one of conveying a business loan or grant to Candi Swadaya Sentosa, P.T. or some alternative enterprise.

THE PROJECT PROPOSAL:

Candi Swadaya Sentosa P.T. is an enterprise constituted for contract filling aerosols, employing about 80 people. They have a single aerosol line with an output averaging about 35 units per minute, or about 36,000 per two shift day. They are reported to produce about 10,000,000 units per year, or about 20% of Indonesia's aerosol production. The owner, speaks several languages, which greatly eases the tasks of visiting experts. The property is roughly 200 X 200 ft^2 (61X61 m^2, or 0.96 acre or 0.389 hectare) in area, consisting of buildings, bulk-tanks, purification equipment and so forth. It is not considered to be of a suitable size (or neighborhood) to support a larger LPG purification station. The purification equipment consists of about 30 columns, vertical about 300 to 400 mm in diameter and 3 to 4 m tall; along with suitable pumps, controls, piping, filters and other associated equipment. It occupies an area of about 3 x 12 m (or 36 m^2) in a large concreted open yard. This installation is so large that it could form the nucleus for a purification center for the entire country's

HAP requirements.

Moderate size bulk tanks would be needed for a national supply center, and 20,000 U.S. Gallon (76 m3) "propane"-rated horizontal or vertical tanks would be sufficient in size, as a minimum. At the minimum density of 0.500 g/mL, each tank could safely hold 84,000 lbs. (38,000 kg. or 38 tons) of propellant. This would be about 1.00% of the maximum throughput of LPG and HAP for the year 1995, as projected. The property should be large enough that space is allowed for another two tanks in about 5 years time, and to keep these tanks at least 100 ft (30.5 m) from any other properties, structures, walkways, parking lots and so forth. Consequently, a land area of about 270x270 ft^2 (82x82 m^2) will be required for installation and safety purposes. Other engineering aspects such as birm construction, explosion-proof electricals, and so forth are beyond the scope of this case study. Ideally, the site should be outside Jakarta, in an essentially unpopulated area, but served with all-weather roads.

The present program for safety training, plant visits, safety kits and so forth is aimed at further reducing the use of CFCs by the largest 18 aerosol fillers. In 1993 these fillers processed about 250 tons of CFCs that figure should be somewhat less for 1995. The fund also aims at reducing fire-related accidents that could have a set-back effect upon the general program of converting CFC uses to HAP uses. The smaller filler, estimated at consuming about 150 tons of CFCs in 1993, and possibly 200 tons in 1995, would not be affected by the above program - exception a very peripheral fashion. However, if they were to be afforded access to reasonably purified HAP, some might be able to convert, while still providing cosmetic aerosols of acceptable odor to their customers.

The national ban August, 1993 on CFCs for aerosols, the fact that DuPont (SUVA) will cease making CFCs worldwide on 1 January, 1996, plus other factors, make these small fillers more amenable to changing to HAPs.

The Current Situation:

The proposed Multilateral Fund financing plan for the Indonesian aerosol technical assistance program was approved in 1994; and implementation should start in early 1995. The proposal to establish a national LPG purification facility, uniquely for aerosol uses, has been discussed in Indonesia in 1993 and 1994 by Dr. Montfort A. Johnsen, who contributed these notes on how such a program would work. During the World Bank mission that Dr. Johnsen made, cost data was not been developed, but is estimated at about US $250,000 minimum, on a loan or grant basis.

To arrive at the "incremental cost" of this conversion -- from a multiplicity of small purifier units to one, serving all aerosol fillers - one could suggest a CFC reduction of about 150 tons per year.
If the odorous and uniformityqualities are better than what is now obtainable, even larger conversions might be motivated. The cost of the facility would then be ratiocinated to US $ 1,667 per ton of CFC eliminated from aerosol emissions, per year.

Indonesia is a growing country, showing great promise in many areas. Getting them on the right track toward early elimination of CFCs in aerosols, by education, safety engineering, plant visits, conveyance of safety materials -- and lastly by the development of a national facility for the purification of raw LPG into good quality, relatively low odor HAP -- is an element of worldwide environmental support that deserves serious considerations.

Case Study #12
Venezuela - A Slow Conversion for Cost Reasons

Introduction:

Ninety nine percent of all aerosols produced in Venezuela are filled without CFCs. The one percent remaining is made up of industrial aerosols, automotive aerosols, and pharmaceuticals. Less than 30 tons of CFC are sold annually for aerosol purposes.

The process of conversion was a long one, began many years ago when one company obtained permission from the government of Venezuela to transport liquified petroleum gas (LPG) without odor. Paint and insecticide aerosol fillers converted immediately, while cosmetic aerosol fillers, many of whom have high profit margins and can support high costs, slowly converted over a decade. This is the story of Venezuela's conversion.

The Aerosol Market in Venezuela:

The aerosol market in Venezuela is about 42,000,000 units (1993); of which the following very rough breakdown exists:

Insecticides	16,450,000
Room Deodorants, other households	9,150,000
Personal products	5,850,000
Paints	5,300,000
Industrials	5,000,000
Others	100,000
Totals	41,750,000

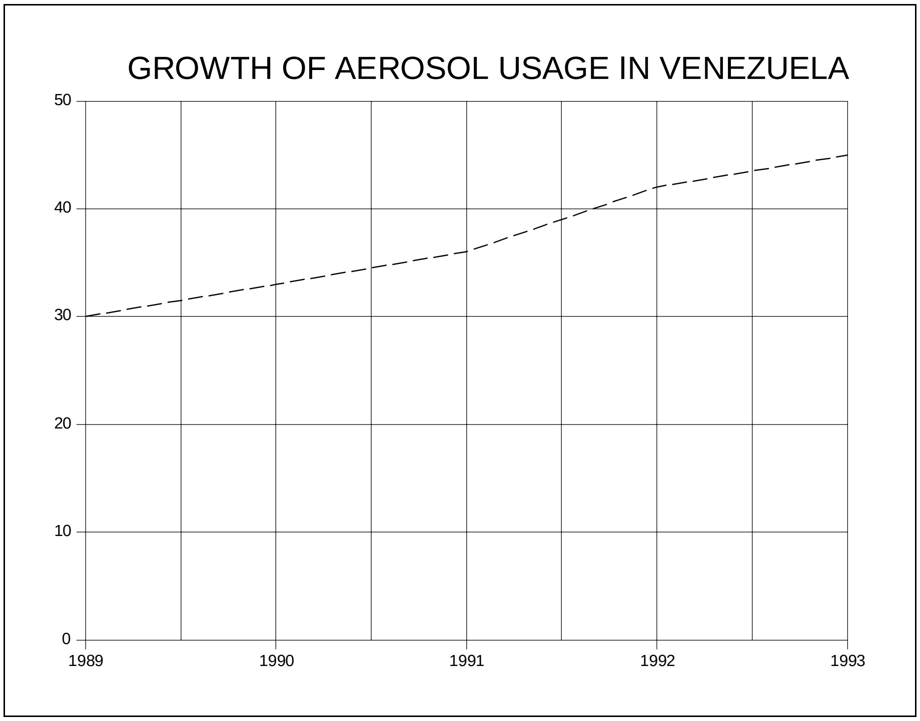
The total industry sales figures are much more reliable (see graph below - in millions of units). The major fillers are: Spray Quimica, Bayer, and S. C. Johnson

The Supply of Hydro-carbon Propellant:

The company UNIGAS was formed in the 1970's, and began by obtaining permission from the government of Venezuela to transport LPG without odor. They were able to arrange to be supplied two streams of gas LPG at the principal refinery; one pure propane and the other a mixture of butanes, normally about 80% N Butane and 20%

Isobutane. Gas at this refinery is so pure that mercaptans must be added to the normal streams when the gas is to be sold as fuel. Few places have this quality feedstock.

For aerosol use, an arrangement exists such that when the truck from UNIGAS arrives to pick up feedstock, the refinery shuts off the dosifier that adds the mercaptans. One or two truckloads of fuel are loaded (which obviously have less than the normal amount of mercaptan, but still enough to be safe - the mercaptan odor is very pervasive, and is difficult to remove completely) and then the UNIGAS truck is loaded, after which the dosifier is turned on again to begin adding mercaptan.



This unusual and seemingly dysfunctional system has existed for many years and continues to function. The system worked right from the start because it did not try to convert people. Rather UNIGAS allowed people to know that they had basically "odorless" gas, and those that wanted to converted at their own speed. Paint and insecticide aerosol fillers converted immediately, while cosmetic aerosol fillers, many of whom have high profit margins and could support high costs, slowly converted over a decade.

Paint and insecticide fillers had few quality problems. The solvents used in spray paint and the kerosine used in aerosol insecticide have heavy, undesirable odors. A slight residual "odor of gas" in the propellant was in most cases completely unnoticed.

Further, in the case of insecticides, there are both cost and safety reasons for formulating "water-based" products, and the hydrocarbon propellants are very superior for this type of product. HAPs are just not reactive and cause no corrosion problems.

Three Problems with CFCs and Water-Based Aerosols:

- Cost. CFC 11 and 12 are more expensive than HAPs to start with, and when it becomes necessary to use the much more expensive CFC 114 as a pressure depressant, cost is a major factor.
- Corrosion is always a concern with water and CFCs. By 1995 billions of shave cream cans have been produced with CFCs, and this is proof that these problems have solutions that a good formulations chemist can find, but there is always concern.
- The can emptying problems that occur with CFCs because they are more dense than the water-based concentrate. Mostly they can be resolved by cutting the dip tube properly.

It was possible to formulate water-based products with CFCs, but very difficult and very expensive. CFC

12 alone cannot be used - the pressure is too high. CFC 11 is the most common pressure depressant, but cannot be used in most water based products because of hydrolysis and other serious corrosion

The CFC Manufacturer's "Scare Tactics" Defended Their Markets for a While:

Common Statements of CFC manufacturers circa 1978 (not necessarily pertaining to Venezuela):

- "Don't convert to hydrocarbons, your plant will blow up."
- "Don't convert to hydrocarbons, your product will smell like gas LPG."
- "Don't convert to hydrocarbons, you will be selling bombs to your customers."

mechanisms. CFC 114 can be used to lower the pressure of the CFC 12 - it is very stable, which also has led to its being the propellant of choice for fine perfume and fragrance aerosols - but it is very expensive.

There is another problem with CFCs and water-based products. The CFC is not soluble in the water based concentrate, but rather separates. Since CFC is denser than water it separates at the bottom of the can. The user should shake the can, but often does not do so, and if the dip tube of the aerosol valve goes all the way to the bottom of the can, the propellant can be selectively dispersed at first, and there will be none to empty the can.

The problem then becomes how to cut the dip tube of the valve. By cutting the dip tube of the valve such that it suctions a little bit above the bottom of the can, the possibility of cans not emptying if they are not shaken can be reduced. This is done, however, at the cost of always leaving some product in the can, 2-5% that lies below the valve dip tube and often cannot be emptied. Many consumers can feel this residue and feel that they are being cheated.

HAPs (or any hydrocarbons) float above the concentrate because of their low density, completely eliminating all of the emptying problems.

Changing themes, cosmetic aerosol fillers had much more serious problems. They never really wanted to change, because the hydrocarbon is never completely pure, and a product always smells better when packaged with CFCs, As mentioned in the introduction to these case studies, CFCs are as close as possible to the ideal propellants and have many nobel qualities.

Further, the reality is that the CFC companies in the late 1970's worldwide were defending their markets with what could properly be called " scare tactics:"
We now know these scare tactics to be basically that, scare tactics, but many aerosol fillers in the 1970's resisted the conversion because of them. As a matter of fact, at one time it appeared that the cosmetics fillers in Venezuela would not convert at all. But the price differential between CFCs and

HAPs is just too much. Usually such a conversion produces few additional profits, but there are secondary factors that are extremely important.

The first company to convert has a short term very large advantage in increased profit margin, but usually this lasts only a very short time. In Mexico three of the largest insecticide fillers began producing aerosols with HAPs in the same week, and withing one month the heavy promotion that they were doing indicated that they were using the savings in a competitive manner, by passing them on to the end consumer. It would not be far from the truth to state that there never any real savings in this case.

But there is a strong negative incentive. A CFC filler cannot long compete with competition that fills with HAPs. The latter can lower his prices or keep them the same and do more advertizing and promotion. Either way his sales will increase at the cost of his competitor. This is even more marked in the case of contract packagers. They must have low costs and prices to survive.

In Venezuela, of the two major contract packagers, Spray Quimica modified their installations to fill hydrocarbons, while Aerosoles Unidas, the then largest contract filler did not. By 1979-1980 Aerosoles Unidas was in bankruptcy, and it was apparent that it would be necessary to be able to fill hydrocarbons to survive. This lesson has been repeated all over the world.

The Purification of LPG:

UNIGAS supplies a very good grade of feedstock, but for cosmetics it is not satisfactory for use

Common Purification Systems - Pros and Cons:

- Silica or Alumina gel - good mostly for drying, and thus extending the life of molecular sieves. Since humidity is not a major problem in most cases, they are seldom very effective. When used in a three tower system (1 - silica gel; 1- activated carbon; and 1- molecular sieve); they are actually damaging, in that there is no security for breakthrough on the molecular sieve tower.

- Activated carbon - normally recommended because it can adsorb very heavy hydrocarbons, also seldom present, or unsaturates, where it is not the best technology. Also can be damaging (see comments on three tower system above).

- Molecular Sieve 4A - widely and incorrectly used. It is an excellent drying agent that does remove some sulphur compounds, but not as many as the compound below that is the recommended one, used at most propellant supplier's plants around the world.

- Molecular Sieve 13X - Sodium Aluminum Silicate it is normally used in 1/8" or 1/16" pellets. This compound is very good for both humidity and most sulphur compounds, and does adsorb some unsaturates and heavies. A three tower system should be three towers of 13X, and the quality control manager should be monitoring the towers (ideally with a gas chromatograph, but usually by smell) to stop the system when there is bad odor passing tower #2. At this moment tower #3 is still protecting the quality of the finished aerosol.

without purification. Most of the fillers have installed filters to do this final purification stage. The common filters used are molecular sieves alone and mixtures of molecular sieves with either silica gel or alumina gel or activated carbon.

Other factors, Results:

UNIGAS sells installations of tanks and sells spare parts and services existing installations. This is very important, as safety has been assured because of this. Some safety training has also been done by UNIGAS. The importance of these elements was stressed in Case Study #9 on Mexico and it is not necessary to repeat it here.

Contact:

For more information about HAPs conversion in Venezuela or any other questions raised in this case study, please contact:

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Conclusion - Conversions Around the World

The number of companies that have converted from CFCs to hydrocarbons is now very large. Some companies did this conversion over 20 years ago for cost reasons - mostly they are companies in the insecticide or paint fields that do not need excellent propellant, or they are from the few developing countries where HAPs has been available for many years.

In this final section we are enclosing what is very much a partial list of aerosol conversions. Those listed below may be less than 1% of all converted companies. The experiences of these companies in general we have judged to be less pertinent than those of the first 12 case studies. Still, it is important to know that the 12 case studies represent the tip of the iceberg, that these conversions have and are taking place all over the world. Here is our very partial list:

FLUID PACKAGING CO. INC.
800 Airport Road
Lakewood, NJ 08701
Tel. (1) 908 367 1000
Fax. (1) 908 367 2114

ACCRA PAC
2730 Middlebury Street
PO Box. 878. Elkhart, IN 46515
Tel. (1) 219 295 0000
Fax. (1) 219 522 1468

CHASE PRODUCTS CO.
19th & Gardner Road
Broadview, IL 60153
Tel. (1) 865 1000
Fax. (1) 865 7041

CCL CUSTOM MANUFACTURING INC.
1 West Hegeler Lane
Danville, IL 61832-8398
Tel. (1) 217 442 1400
Fax. (1) 217 442 1400

ENSIGN LABORATORIES
470-490 Wellington Road
Mulgrave, Victoria, 3170 Australia
Tel. (60) 3 560 5566
Fax. (60) 3 562 0341

PHILIPPINE AEROSOL CONTAINER CORP.
Reliance Cor. Brixton Street
Pasang Metro Manila, Philippines 1501
Tel. (63) 2 631 1775 to 1779
Fax. (63) 2 631 4028

D & L INDUSTRIES INC.
65 Calle Industria
Bagumbayen, Quezon City
1110 Metro Manila Philippines
Tel. (63) 2 635 0680 to 0695
Fax. (63) 2 635 0703/0696

AEROVAL IND. E COM. S.A.
Rua Dr. Rubens Gomes Bueno 533
04730 Sta. Amaro Sao Paulo CP 22501 Brazil
Tel. (55) 11 247 7693 or 11 247 0522
Fax. (55) 11 523 1576

INDUSTRIAS NOLEYRA
3a. Ave. 8 y 9 Calle
Comayaguela, Honduras
Tel. (50) 4 37 37 56 or 37 46 68
Fax. (50) 4 379 715

COSTER AEROSOL VALF SANAYI A.S.
Sanayyi caddesi No. 24
81430 Kartal Istanbul
Tel. (90) 306 67 10 (3 hat)
Fax. (90) 353 22 64

ODUL ILAC SANAYII KOLL. STI.
Sultan Orban Mah Yagcipinar
Nevkii No. 18 41400
Gebzi/Kocaeli - Turkiye
Tel. (90) 262 641 1113
Fax. (90) 262 646 2429

PHARMA - CHEMICAL INDUSTRIE LTD.
Seyhli Vadi Sok No. 481520
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INCHCAPE CONTRACT MFG. SDN.
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There is no good reason to make this list longer. The twelve case studies cited in the body of this document should be indicative of the vast majority of the conversion problems that exist. Should it not be possible to find the answers to specific questions here, we would once again recommend that the reader recur to our two basic references:

The Database on CFC Free Technologies: Aerosols
The Aerosol Conversion Technology Manual

Both of these documents are available from the UNEP IE office in Paris. That is our final recommendation - if more information is necessary, the reader should call, fax, or write:

For further information, or to obtain copies of the "Technologies for Protecting the Ozone Layer: Aerosols," The Database on CFC Free Technologies: Aerosols or the Aerosol Conversion Technology Manual, or additional copies of these *Aerosol Sector Case Studies*, please contact:

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