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Corrigendum

FURTHER DEFINITION OF INCREMENTAL COSTS

This corrigendum is being issued to replace pages 31, 32, and 33.

Project: **Manufacturer using CFC-113 or MCF for metal/Electronics/Precision cleaning, wishing to switch to alternative solvents**

Note: Cost listed under four options:

Option A : elimination of need for cleaning or "no-clean" (inert gas or low solid flux soldering)
Option B : gas plasma cleaning
Option C : aqueous and semi-aqueous cleaning
Option D : alternative solvents (terpenes, organic, alcohol based solvents and HCFC solvent blends).

	Year 1	2	3	4
Conversion of existing equipment and product manufacturing facilities				
1. Patent, design and royalties				
All options	0	0	0	0
2. Capital costs:				
Option A (Electronics cleaning)				
- New soldering equipment, to eliminate need for cleaning altogether	X	0	0	0
Option B (Precision cleaning)				
- New gas plasma cleaning equipment	X	0	0	0
Option C (Electronics, Metal and Precision cleaning)				
- New equipment for aqueous and semi-aqueous cleaning systems	X	0	0	0
- Water treatment equipment	X	0	0	0
- Redesigning of line layout and manufacturing processes	X	0	0	0

	Year 1	2	3	4
- Adapting aqueous system to mechanical handling (e.g., rinsing, brushing, steam jet, ultrasound)	X	0	0	0
- Surface changes e.g., blind holes, welts, cracks, capillary boring	X	0	0	0
Option D (Electronics, Metal Cleaning)				
- New equipment for alternative solvents cleaning systems (PCB cleaning)	X	0	0	0
- Redesigning of line layout and manufacturing processes	X	0	0	0
- New fire safety equipment due to combustibility and explosive nature of non-halogenated organic solvents	X	0	0	0
• Retraining				
All Options	X	0	0	0
• Research and Development				
All Options	X	0	0	0
3. Operational costs				
Option A				
(i) inert gas soldering:				
. costs of nitrogen consumption	X	0	0	0
. costs of eliminating solvents (savings)	Y	0	0	0
(ii) low solid flux soldering:				
. increase in flux costs	X	0	0	0
. eliminated solvent costs (savings)	Y	0	0	0

	Year 1	2	3	4
<u>Option B</u>				
Pre-cleaning costs	X	0	0	0
Process gas costs	X	0	0	0
Eliminated solvent costs (savings)	Y	0	0	0
<u>Option C</u>				
(i) Labour costs in water treatment	X	0	0	0
(ii) Excess energy costs	X	0	0	0
(iii) Savings in material costs	Y	0	0	0
<u>Option D</u>				
Savings in material costs	Y	0	0	0

NOTES

There is no single substitute for all uses of CFC 113 and MCF. Every solvent application has at least one or more available alternatives. The incremental costs of solvent substitution would therefore depend on the particular use of the solvent and its specific applications. For each of the four principal options for CFC solvent substitution listed in the template, listed below are their main uses, a number of specific applications and their indicative incremental costs.

Option A (No-clean)

No-clean options eliminate the need for cleaning and solvents, mainly in electronics assemblies, through modifications in the soldering technology and materials used.

No-clean options include the use of low-solids fluxes in printed circuit board manufacture. Numerous new fluxes have been developed containing 2-10 per cent solids as opposed to the traditional 15-35 per cent solids. Further testing is required to determine the relevance of this technology to different applications. There are nevertheless likely to be incremental costs for new soldering equipment and increased flux costs. These would be balanced against savings from not using solvents.

Controlled atmosphere (inert-gas) soldering is another cost-efficient, no-clean option. An inert gas (such as nitrogen) or a reactive gas is used to reduce the oxide layer formation normally associated with soldering. This option would involve changes in soldering equipment and would necessitate additional costs for nitrogen to achieve the required atmospheric changes, which would be balanced against savings from not using solvents.

Option B (Gas Plasma Cleaning)

Plasma cleaning is a widespread method of cleaning gyroscopes. Electrically charged gases (such as oxygen, argon, helium and silicon tetrafluoride) are used to remove contaminants, resulting in volatile compounds which are swept out of the chamber by a gas. The process is non-toxic and has low operating costs, but the capital cost of new equipment can be high. Plasma cleaning is a viable option only for special circumstances since its use must always be preceded by solvent cleaning to achieve an ultra-clean, smooth surface. The incremental operating costs of gases and pre-cleaning, in addition to the high capital costs, must be weighed against the operational savings of not using CFC solvents.

Option C (Aqueous and Semi-aqueous Cleaning)

Aqueous and semi-aqueous cleaning processes are used in a variety of applications in Electronics, Precision and Metal Cleaning.

Electronics assemblies can be specifically designed with aqueous cleaning in mind. This process requires no distillation equipment, sometimes no water pre-treatment but water disposal. Aqueous cleaning equipment includes mechanised brush cleaning machines, dishwasher-type batch machines, high throughput batch machines, tank-immersion batch machines, and in-line conveyorised machines, each method being relevant to specific electronics applications. Substitute solvents can be used in combination with aqueous cleaning. Cost comparisons between aqueous and solvent cleaning favour aqueous methods by a small margin, particularly for large manufacturers. New closed-loop aqueous cleaners minimise the discharge of contaminated water by recycling the water; they reduce operating costs and are commercially available.

Aqueous and semi-aqueous cleaning is also used for "precision cleaning" applications. The term "precision cleaning" is used to describe the cleaning of delicate instruments and surfaces, which may be metal, plastic or glass. For example, computer disk drives, miniature bearings, optical components, medical equipment, telecommunication parts and aerospace instrumentation all require an extremely fine level of cleaning because their mechanical parts have very close fits. Precision cleaning is also needed in some specialised forms of manufacture, maintenance, testing and assembly. In precision cleaning, aqueous cleaning may involve the use of spray, ultrasonic, hot-air or vacuum drying processes. Semi-aqueous cleaning uses hydrocarbon/surfactant blends as emulsions in water solutions. The major considerations are ease of drying the materials and parts and the delicacy of the instruments in this sector.

Solvents are also extensively used in general metal part cleaning in a wide range of manufacturing and maintenance processes throughout industry. Solvent use is integral to many production processes. The wide range of substitutes and the variety of processes mean that process-specific alternatives must be found.

Semi-aqueous cleaning processes include the use of alkaline cleaners, which are the most widely applicable substitute solvents for metal degreasing. Hundreds of alkaline cleaners are already available, and more are being developed for specific applications.

Aqueous cleaning processes can also be used in all metal cleaning operations. These would involve using immersion with a mechanical agitation or spray processes. However, they are limited in dealing with complicated product geometries, and achieving spotless surfaces. Specially designed equipment may be needed, sometimes with solution heaters, dryers, part-handling automation equipment and solution filtration. In addition there may be incremental costs for redesigning the layout of the cleaning processes and adapting the aqueous system to existing mechanical handling equipment, e.g. for rinsing, brushing, steam jet and ultrasound. Finally, aqueous cleaning causes a water pollution problem which may be costly to deal with depending on the size of the operation and the legal requirements. Recycling and water treatment (especially for non-biodegradable by-products) equipment, with associated capital costs, may be needed.

Option D (Alternative Solvents)

Alternative solvents are used in electronics assemblies and metal cleaning, and include trichloroethylene, perchlorethylene and methylene chloride, which have been used as effective cleaners for many years, plus other organic solvents, such as hydrocarbons, ketones and alcohols.

Some of these require careful handling due to their combustibility, flammability, and toxicity, and there may be incremental costs for investment in fire and safety equipment. Also, some of the alternative solvents may require a change in the cleaning process possibly moving from a one stage to a two stage cleaning, to include precleaning. Most of the alternative solvents would require new equipment, such as extractor hoods, water filtration and possibly waste collection and reprocessing equipment. These costs would have to be balanced against possible operating savings arising from the cost and required volume difference between CFC and the alternative solvents.

General

R&D costs are likely to be incurred as substitute processes would need to be suitably tailored to the specific applications for which they are considered. In addition, there are incremental costs for retraining staff in the new operational, maintenance and, possibly, safety requirements, for the substitute processes.