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ENVIRONMENTALLY SOUND MANAGEMENT OF USED AND SCRAP PERSONAL COMPUTERS (PCs)

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NOTE: A major function of this draft document is to serve as a vehicle for focusing discussion at the Second OECD Workshop on the principal issues regarding development of ESM standards/guidelines. Given the major differences in the views expressed at the First ESM Workshop, it was decided that a "pilot" set of standards/guidelines should be developed. Thus, as a "pilot," it is hoped that this draft will inform and assist steps towards resolution of the numerous overarching issues that are present in the development of ESM guidelines generally, as well as those major issues that are somewhat more particular to the management of used PCs.

ISSUE: *One of the major issues that is attendant with development of ESM guidelines is the question of whether the guidelines should provide rather general information on various means to achieve ESM, or whether the guidelines should be of a more prescriptive nature. The more generic approach would allow a high degree of flexibility to countries and facilities to tailor their programs and operations to their individual needs (as well as to be mindful of evolving technology), while the alternative approach would provide greater clarity as to the specific processes that constitute ESM. As a starting point for the first draft of these ESM guidelines, they are written using primarily the first approach--that is, they are somewhat general in nature. There are numerous areas where the guidelines could be made much more prescriptive; these could include (1) specific facility permit conditions (e.g., emission limits) or (2) a specific list of the minimum regulatory elements of an adequate governmental infrastructure. However, the more generic approach has been used, for now, in recognition of the wide variety of national approaches and industry practices currently in place throughout the OECD.*

INTRODUCTION

Technological innovations in the field of computers continue to advance exponentially. Personal computers now available to citizens of OECD member countries at modest prices have more computing power than was available to their governments not very long ago. Connected to the Internet, these computers provide access to sources of information and means of communication almost beyond imagination. This power and usefulness has resulted in an equally exponential increase in the demand for and proliferation of personal computers, in households as well as offices. They are now ubiquitous in developed societies.

This proliferation of personal computers has raised environmental concerns with their ultimate fate in the environment. Hundreds of millions of computers are now in the hands of citizens and, with the astronomical pace of technological development, all of these personal computers are rapidly approaching obsolescence. Their owners need to dispose of them in order to make room for the next model … and the next ... and the next.

Governments in turn need to ensure that there is an infrastructure in place to manage this obsolete equipment in an environmentally sound manner. These guidelines describe such an infrastructure, including methods that can be used for environmentally sound reuse and recovery of used PCs, as well as their transboundary movements for these purposes.

These guidelines do not address other environmental issues, such as product design, choice of materials and energy efficiency while in use, which may arise in the life cycle of a personal computer, at any time from design and manufacture through to the end of its life as an operating electronic device.

ISSUE*: Development of ESM guidelines related to "design for the environment" was not included in this phase of the project. Such future work will be considered at the Second OECD Workshop on ESM in Vienna in September.*

DEFINITION AND CHARACTERIZATION OF “USED AND SCRAP PCS”

These guidelines encompass used personal computers, as well as portable computers (laptops and notebooks), that have been used in homes and offices:

a) Central processing unit (CPU): a case and all of its contents, such as the primary printed circuit board (the motherboard) and its components (chips, capacitors, connectors, etc.), additional printed circuit boards (daughter boards), one or more disc drives, a transformer (the power supply), interior wire, and a power cord. (This is the widely understood meaning of “CPU,” however, it is recognized that within the PC manufacturing industry, “CPU” may apply only to the chips.)

b) Monitor: a cathode ray tube (CRT), its case, interior wires and circuitry, cable to the CPU, and a power cord.

c) Printer: a case and its contents, such as an ink or laser cartridge, interior wire, cable to the CPU, and a power cord.

d) Miscellaneous peripheral devices: keyboard and mouse.

e) Portable (laptop and notebook) computers

ISSUE: *There are three options regarding the potential scope of these guidelines. These are: (1) the guidelines can be written to address only PCs that are hazardous waste; (2) they can address all PCs that are waste; or (3) they can address all used (or “end-of-life”) PCs, whether or not they meet the definition of waste (which varies among OECD members). In addition, the guidelines can be written to shift the applicability of each section of the guidelines among these three options, as deemed appropriate. There are a number of significant issues attendant with the selection of any of these options for the scope of the guidelines, not the least of which is the ease of understanding and implementing the guidelines.*

Given the discussions at the First ESM Workshop in Cancun (where it was felt that the ESM guidelines should be written in the context of sustainable development, including waste minimization and product policies), and for simplicity purposes, it was felt that this initial version of the draft guidelines should be written to demonstrate a potentially broad applicability. Thus, the draft guidelines are written according to the third option above. Use of this approach would give the guidelines more of a materials management focus rather than a more narrow focus on waste, or even a still narrower focus on hazardous waste.

These guidelines are written to address the management and disposition of used and scrap personal computers. Simply stated, “used PCs” are those PCs that have been used by an owner who no longer has a need for that PC. Used PCs are used materials; thus, they are not necessarily waste. Used PCs may still have considerable life remaining, and can be used by another owner either “as is” or after repair or upgrading. It is common for used PCs to be aggregated and shipped to a location where they can be evaluated for their potential for reuse or refurbishment. Transboundary movement of used PCs, regardless of whether the movement is for evaluative purposes, is addressed in section 3.0 of these guidelines.

ISSUE: *This draft uses the term "used" PCs rather than "end-of-life" PCs. Either term could be used. However, it is felt that if the guidelines are to address reuse or shipments of PCs for evaluation of reuse potential, then perhaps "used" is the more appropriate term. If, on the other hand, the scope of the guidelines will be limited to wastes, then perhaps "end-of-life" is the better term. Neither the term "used" nor "end-of-life" adequately addresses off-specification or surplus PC equipment that has never been used. Thus, the term "scrap"is used is these guidelines as an attempt to be inclusive of these materials.*

The term "used PCs" is not intended to include PCs shipped by an owner for repair/refurbishment and return to that same owner, whether under warranty or not. The term also does not include PCs that are shipped ready for direct reuse, i.e., those that have already been evaluated or refurbished and are ready for use. Of course, "used PCs" do not include unused PCs that are shipped ready for their original use. Thus, these guidelines do not address such PCs nor their shipment.

These guidelines are applicable to any PC components arising directly from production facilities, i.e., off-specification or surplus personal computers and components. These guidelines further address scrap, residues and waste arising from the disposition of used PCs, such as dust and slag generated in raw material recovery.

These guidelines do not encompass, for now, a variety of other and somewhat similar electronic equipment, such as mainframe computers, telecommunication devices, electronic organizers, or televisions. These guidelines can be expanded to encompass these devices at a later time, or separate guidelines can be created for them.

PRINCIPAL ENVIRONMENTAL CONCERNS

Substances of Concern

A personal computer contains several substances of environmental concern:

Lead: There is a substantial amount of lead in the CRT, perhaps two to three kg as a rough average, encapsulated in the form of leaded glass. There is also a much smaller quantity of lead in printed circuit boards in the CPU, in the form of solder. Printers and miscellaneous peripheral devices will also contain a small amount of lead in solder. Some portable (laptop) computers contain a sealed lead acid battery.

Cadmium: There is a small amount of cadmium in plated contacts and switches, and a very small amount of cadmium may have been used as a stabilizer in PVC wire insulation, which may have been used in a personal computer. Laptop computers often contain a rechargeable nickel cadmium (Ni-Cd) battery.

Beryllium: There is a small amount of beryllium, in the form of a copper-beryllium alloy (typically 98% copper, 2% beryllium) in the motherboard, in the slots used for connection to daughterboards.

Lithium: Lithium metal may be present in a small battery on a motherboard.

Chlorine and/or Bromine: Brominated fire retardants may be present in the plastic in printed circuit boards and cases. There is chlorine in any PVC insulation of wires and cables used in a personal computer.

Phosphors: A phosphor coating, typically zinc sulfide (which is non-hazardous), is used on the interior of a CRT screen to convert the kinetic energy of an electron beam to light. However, cadmium sulfide and rare earth metals have also been used in CRTs.

Liquid Crystal Displays (LCDs): A large number of liquid crystal substances are in use in laptop and notebook computers. Some of these are toxic and/or carcinogenic. A notebook display contains about a half a gram of liquid crystals. In addition, large LCDs may have an illumination unit containing mercury.

Although these substances can present risks in recycling or disposal of used personal computers, it is important to note that some of these substances are present in personal computers for the purpose of lowering risks to human health during product use. These include the use of lead shields in CRTs to protect users from harmful x-rays and the use of flame retardants in plastics to reduce the risk of overheating and potential fires.

Exposure to Substances of Concern

All of the substances of concern in a personal computer are in solid non-dispersible form, and there is no cause for concern for human exposure or release into the environment in ordinary use and handling of a personal computer. None of these substances will be released from a personal computer through normal contact, including manual disassembly.

Human health and environmental concerns related to the presence of these substances in a personal computer arise if this used equipment is land disposed or incinerated. In addition, concerns are present in certain reuse and recycling scenarios: for example, when its component parts are harvested using certain methods (such as melting of solder) or subjected to processing for metal or plastic reclamation using methods such as shredding, grinding, burning and melting.

Lead: Lead in a CRT or printed circuit board may leach out of the leaded glass under certain land disposal conditions. Incineration can result in release of lead to the air as well as deposition of lead in the ash, which is then land disposed. The lead in a printed circuit board may also be released in the form of lead fume if the board is heated to facilitate harvesting of components, or in the form of fine particulate if the board is burned or shredded prior to metal reclamation. The lead in a CRT or a printed circuit board may be released as lead oxide dust or lead fume during high temperature metal processing, such as smelting.

Cadmium: The small amount of cadmium in plastic may be released in the form of cadmium oxide dust if the plastic is burned prior to or in the course of metal reclamation. Cadmium in plated metal contacts and switches may be released as cadmium oxide dust or fume during high temperature metal processing. Incineration may also result in releases of cadmium to the environment.

Beryllium: Beryllium in a copper-beryllium alloy may be released as beryllium oxide dust or fume during high temperature metal processing.

Lithium: Lithium in a battery will be released if the battery is shredded with the circuit board to which it is attached. When released, it may react with oxygen and moisture, generating heat and potentially causing fire.

Chlorine and Bromine: Bromine in plastics as brominated fire retardants, or chlorine in PVC insulation, may recombine with carbon and hydrogen in various disposal or recovery processes that involve heat, such as combustion or plastics extrusion, to form other halogenated organic compounds, particularly the highly toxic chlorinated or brominated dibenzo dioxins and furans.

Phosphors: Cadmium in the phosphor coating of some CRT screens could present an inhalation hazard to workers in CRT glass breaking operations. Cadmium can also be leached in a landfill environment. Air emissions of cadmium are a concern if computer monitors are incinerated.

LCDs: Toxic and carcinogenic liquid crystal compounds may leach into the landfill environment if land disposed without pre-treatment. Combustion without adequate emission controls may result in hazardous air emissions.

All of these exposures can be mitigated through appropriate work practices, combustion control, and air emission pollution control systems. However, the presence of these substances of concern in personal computers poses significant challenges in assuring the protection of human health and the environment in the course of material recovery or disposal.

OVERVIEW OF REUSE/RECYCLING PRACTICES

Overview of Reuse

With the rapid advances in computer technology, it is clear that a personal computer becomes obsolescent long before it has lost any capability of performing all of its essential functions. Continued use as a computer is, therefore, an obvious and desirable disposition, and includes a number of options:

- Direct Reuse: A used personal computer can be used by another person, without change. This is the most common first disposition of a personal computer. It will be reassigned to another user in the same organization or family, or will be given or sold directly to the next user.

- Refurbishment and Reuse: A personal computer can be refurbished or upgraded, and used by another person. All personal computers are modular to some extent, i.e., at least some parts can be replaced, either with the same parts or with upgraded parts. The useful life of a personal computer can, therefore, be extended, and it can continue to be used.

- Component Reuse: A personal computer can be disassembled for recovery of working electronic components. A used personal computer for which complete refurbishment and repair are not economically efficient may still contain one or more components which can be reused, such as a disc drive or memory device. Many components can be removed from a personal computer with simple hand tools, such as a screwdriver, and inserted into other personal computers and electronic devices. Others require desoldering.

These activities are principally conducted by a new industry that has sprung up as personal computers have become more prevalent--the used computer industry. This industry has for at least the last decade collected, refurbished, upgraded and resold used computers and computer components. This industry has somewhat informal origins--people with expertise would swap components or build computers from scratch with used components--and has expanded to consist of a relatively large number of individuals, small businesses and, increasingly, charitable organizations.

Electronics dismantlers, who tend to process larger volumes of used equipment more quickly than repair and refurbishment companies, also perform some reuse activities. They may resell some equipment, with or without repair, such as whole PC systems, monitors, etc. However, their main activity in the area of reuse is the harvesting and resale of the most valuable components of used PCs, such as integrated circuits ("chips"), disk drives, etc. However, the bulk of the materials processed by a dismantler go to raw material recycling, rather than reuse.

Environmental Considerations of Reuse

Reuse of a personal computer, or any of its component parts, raises several environmental concerns. First, an older computer may be less energy efficient than a new computer. A personal computer is not, however, such an energy intensive device that this concern should outweigh the societal advantages of continued use. Furthermore, it is not likely that a person who would acquire and use an older computer does so in place of a newer computer. The societal benefits of continued use of personal computers are substantially greater than the relatively small amount of increased energy use.

Environmental concerns with repair and refurbishment of a personal computer include those with immediate reuse, i.e., energy use. A personal computer can, for the most part, be disassembled and reassembled using hand tools, i.e., a screwdriver, and there are no special environmental concerns with such repair and refurbishment. However, this disposition will inevitably give rise to some personal computers and components which can not be repaired, or for which refurbishment and repair are not economically efficient. Such personal computers and components will require further disposition, with associated environmental concerns for protection of workers and release of substances into the environment.

Environmental concerns with reuse of a working component include those with immediate reuse or repair and refurbishment, i.e., energy use and subsequent disposition of non-working computers and components. In addition, some component removal raises additional concerns. For example, some components have been soldered into printed circuit boards. Removal of such components requires the application of heat to loosen the solder and, thus, there are worker health and environmental concerns with the possible release of lead from the solder. This type of component removal requires application of controlled heat, appropriate ventilation, consideration of emissions, and careful attention to worker health and safety. Furthermore, in all cases, this disposition of selective recovered components of a personal computer leaves the remainder to further disposition, with associated environmental concerns for protection of workers and release of substances into the environment.

Finally, but not least, it must be taken into account that computers may be shipped to a developing country for potential reuse, where there may be immediate worker health and environmental concerns if the computers are not ready for immediate reuse, and there will, in any case, be delayed concerns. Reuse of a personal computer in any country does not solve any environmental concerns regarding its ultimate fate. It defers, but does not substitute for, its disposition by other means, such as metal recovery, in which environmental concerns will arise. If reuse of a personal computer is directed to a developing country that does not have an appropriate infrastructure for ultimate disposition, such reuse raises concerns for subsequent and potentially adverse environmental, health and safety consequences. Notwithstanding, the societal benefits of such increased use of personal computers may well be overriding.

Overview of Raw Material Recovery

If a personal computer, or any of its component parts, can not be reused, it can be disassembled and processed for recovery of much of its contained raw materials – i.e., metals, glass and plastics. A personal computer contains a variety of metals, ranging from steel to precious metals, for which there are large existing markets. There is a sizable and growing market for the direct reuse of leaded CRT glass in the manufacture of new CRTs. Only a small market exists for the recycling of plastics; however, a large market exists for the burning of plastics for energy recovery.

Used PCs and any components that cannot be reused are normally dismantled and their parts segregated according to basic raw material type. Plastics, ferrous metals, non-ferrous metals, glass and circuit boards are all separated. In addition, any components that are considered hazardous and required to be removed by the competent environmental authority are also separated for special handling. The dismantling industry generally involves a high degree of manual labor for the disassembly of used computer components, however, some of the higher volume dismantlers are becoming more automated.

Many dismantlers specialize in the dismantling of personal and other computers, while some also process a wider array of electronic products. Specialization in the dismantling of computer and other electronics is a relatively new industry, with many new companies coming into existence. Many firms are very small businesses, however, some larger firms are also getting well established in the industry. This industry is directed at the collection, recovery and recycling of electronic equipment from commercial and household sources.

In contrast to the electronics dismantlers, the scrap metal industry has for many years reclaimed a wide variety of ferrous and non-ferrous metals, including steel, aluminum, and copper from computer cases and frames, wires and cables. However, this industry accepts used and scrap materials from many sources, and does not specialize in the electronics sector. It consists of companies, large and small, with capabilities including collection, dismantling, sorting and processing metal-bearing materials. This industry provides sorted feedstocks to steel mills and non-ferrous smelters and refiners.

To date, many dismantlers and scrap metal dealers have principally focused on large sources of electronic scrap and used equipment that can be obtained from manufacturing, government and commercial sources. This is mainly because the cost of collection and transport of used PCs from these sources is significantly less than for the recovery of similar equipment from the residential sector. In addition, the volume of used computers that is available from the residential sector still remains to be quite low, as many homeowners continue to hold onto their old computers even though they may have replaced them with newer models.

Ferrous and non-ferrous materials resulting from the dismantling of personal computers are sold to smelters for the production of raw metals. Smelters purchase secondary materials from many sources, not just scrap electronics. The non-ferrous metal industry has for decades reclaimed precious metals and copper from printed circuit boards, wires and cables, and other components such as chips, connectors, CRT copper yokes, removed from computers. There are a relatively small number of nonferrous metal smelters in Europe, Japan and North America that process such material, which is collected from throughout the world.

Leaded glass from CRTs generated by dismantlers can be processed and sold to CRT manufacturers for use in new CRTs. This is a relatively new and growing market. Because most CRTs are manufactured in Asia, shipment of processed glass cullet (or even, perhaps, whole CRTs) outside the OECD is necessary. Leaded CRT glass can also be sent to lead smelters for lead recovery, with the added benefit of the use of the glass as a fluxing agent to aid in the smelting process.

GUIDELINES FOR DOMESTIC PROGRAMS

Note: Guidelines in this section are not intended to be considered for transboundary shipments; rather, they are approaches for consideration by member countries for potential applicability to their own domestic programs. Discussed below are approaches to **maximizing waste reuse and recycling** which are currently in use (or being considered) by a variety of OECD countries.

Encouraging Reuse/Recycling; Discouraging Disposal

The waste management hierarchy signifies a clear preference for reuse and recycling over final disposal, specifically landfilling and incineration. Thus, it is incumbent upon OECD countries to be implementing programs to continually "push up" the waste management hierarchy by providing incentives for increased reuse and recycling and decreased use of final disposal. In fact, probably all OECD countries have programs in place that give emphasis to reuse and recycling of used PCs as the preferred means of materials management. Further, no OECD member countries focus on used PCs separate and apart from other types of used or waste electric and electronic equipment (WEEE); that is, the current domestic programs of OECD members tend to be broader programs, positively impacting the management of a wider array of used materials. The approaches discussed in this section, therefore, are not specific to the management of used PCs.

OECD member countries vary greatly in the extent to which mandatory or voluntary programs are used regarding WEEE. Certainly, as the volume of electronic equipment has so rapidly grown in recent years, many OECD countries have moved to put laws and regulations in place to mandate increased reuse and recycling and less reliance on final disposal. In spite of the differences regarding the degree of reliance upon mandatory approaches, the programs of all OECD countries involve, to some extent, the full complement of participants in the waste generation and management life cycle–manufacturer, distributor, consumer, repairer, waste management firms, and government. However, the roles of these participants in the domestic collection, reuse and recycling infrastructure differ throughout the OECD, as does the bearer of financial responsibility for proper management of WEEE.

Collection

The programs of all OECD countries are moving towards separate collection of many forms of WEEE. Collection of WEEE separate from municipal solid waste facilitates potential reuse and component recovery, as well as raw material recovery. In addition, used PCs and other forms of WEEE often contain substances of concern for which separate management is appropriate.

A large number of OECD countries are moving to require "take-back" of WEEE. The draft "WEEE Directive" of the EU also requires it. Take-back programs allow (or require) consumers to take their WEEE to retailers and other distributors, manufacturers, public collection points or specialized waste management firms, who accept this material for proper handling. Retailers and other distributors are generally required to accept any brands of the type of electronic equipment that they sell.

The draft WEEE Directive provides a target for EU countries to achieve regarding the collection of WEEE from households. The target is stated in terms of an annual amount of WEEE to be collected per capita.

Many OECD countries are moving to implement programs of extended producer responsibility (EPR) for WEEE. These include countries of the EU, Norway, Switzerland and Japan. In EPR, producers take responsibility for certain phases of the waste management of their products. This financial or physical responsibility is seen by these countries as creating an economic incentive for producers to adapt the design of their products to meet the needs of sound waste management; e.g., contain less toxics and have greater reusability and/or recyclability. Under these programs, producers are responsible for financing the treatment, recovery and disposal of WEEE. In the U.S., in lieu of implementation of a program of EPR for WEEE, a program of “shared responsibility” is favored that does not emphasize the producer’s unique responsibilities as under EPR. Instead, it is the shared responsibility of government, consumers and all industry actors in the product chain for all the environmental impacts during the product’s life cycle.

There are a number of approaches being used within the OECD as to whether consumers should be assessed a “user fee” that would make clear their financial responsibility in the collection and recovery of WEEE. Most of the countries implementing programs of EPR for WEEE provide that household generators can return WEEE free of charge to distributors and manufacturers. In Japan, end-users can be charged a fee per item returned to cover industry’s costs for collection and recovery, however, the fees must be set at a rate appropriate to prevent illegal dumping. In Denmark, end-users are charged through collection fees or local taxes. Visible, advance disposal fees on new electronic appliances can be assessed by product distributors in the Netherlands. In the U.S., visible, advance disposal fees are also being considered in some States for certain types of WEEE.

Information Dissemination

The draft WEEE Directive of the EU requires that information be provided to consumers to inform them as to the importance of their role in contributing to reuse and recycling, as well as the return and collection systems that are available to them. Producers are required to mark their products with a symbol that makes it clear that the item should not be discarded with other municipal solid wastes. Producers are also required to provide treatment facilities (e.g., dismantlers) with information on the content of WEEE to facilitate recycling and prevent adverse impacts on the health of workers or the environment due to the presence of hazardous substances.

Bans on Landfill and Incineration

In order to maximize the potential for reuse and recycling, a number of OECD countries have enacted bans on the landfilling and incineration of WEEE. These countries include Sweden, the Netherlands, and Switzerland. Such a ban is also part of the WEEE Directive of the EU. Some States in the U.S. have enacted or are considering final disposal bans for some types of WEEE.

Reuse and Recycling Goals

ISSUE*: As a means of encouraging the achievement of a high rate of reuse and recycling of used PCs, the OECD may want to consider whether it is appropriate to establish numerical goals that member countries would strive to achieve by a specific date(s). Ideally, any such goal(s) would be clearly defined; otherwise* *there will be vastly different interpretations as to what the goals mean and how they can be met. If it is decided that one or more such goals are appropriate, then consideration should be given to setting levels that are achievable; to assist in gaining achievability, a progressive approach may be appropriate. Measurability is also a major issue that accompanies any numeric goals that may be set--efficient and cost-effective means of measuring the goals should be available. A means of reporting progress to the OECD on achievement of these goals would probably also be needed. The following options can be considered:*

1. No OECD goals. Of course, one option is that the OECD will decide not to set any organization-wide, numeric goals related to increasing the reuse and recycling of used PCs.

2. Comprehensive reuse/recycling goal. The OECD could decide that a numeric goal would be helpful in encouraging both reuse and recycling of used PCs. That is, all reuse and recycling would be captured, such that the amount of used PCs refurbished for resale and dismantled for material or component recovery would be counted toward the achievement of this goal. By having a goal that includes refurbishment, this particular activity is emphasized, in addition to the alternatives of dismantling and raw material recovery.

3. Material and component reuse and recycling goals. The OECD could decide to focus on development of targets for maximizing the rate of recovery of raw materials, as well as salvable components of used PCs. This approach would focus on the activities of dismantlers and not those of refurbishers. In particular, it could be used to encourage dismantlers to minimize the amount of components that go to landfill or incineration, as opposed to recycling or reuse. This approach is included in the draft EU Directive on WEEE.

GUIDELINES FOR TRANSBOUNDARY MOVEMENTS

ISSUE: *Consistent with the discussion of scope of these draft guidelines in section 1.1, this section on transboundary movements is written to encompass all used PCs, not just those that are hazardous wastes. In addition, this draft section does not categorize various components and sub-components of used PCs as "hazardous waste," "non-hazardous waste" or even "non-waste," and identify appropriate ESM guidelines for such categories. This non-categorical approach has been used for purposes of this draft to keep the focus away from hazard classification at this time, as there are, for example, very different interpretations among OECD members as to the applicability of the green and amber listings to used PCs. It is of note that, with the development of ESM guidelines, and especially a companion scheme for assuring conformance, the importance of differing interpretations of hazard classification may be substantially reduced. For example, for materials such as whole PC components (e.g., CPUs and CRTs), which as products are universally and safely used throughout society, the risks of their mismanagement within the OECD once they become used materials are very small, if ESM can be assured. In order to maximize opportunities for reuse and recycling, including "takeback," it may be necessary to examine the classification issue in relation to potential implementation of ESM guidelines in the OECD. (Note: In the U.S., in order to maximize recycling, "universal wastes" are not required to be handled as hazardous wastes, provided environmentally sound recycling can be assured.)*

The existing infrastructure for materials recovery of used PCs and scrap involves a very significant international trade, both among and beyond the OECD member countries. Both whole PC components, such as CRTs, and specific metal-bearing scrap, such as shredded and/or burned printed circuit boards, are transported long distances for smelting, refining and manufacturing of new products. While raw material recovery (e.g., smelting and refining) itself raises issues of environmental concern (see the guidelines on page 21 regarding proper controls to assure environmentally sound operations), the transportation of these materials, in most instances, poses few environmental concerns (see page 29 for discussion). Certainly, these used and scrap materials pose little, if any, additional risk in transportation beyond that posed by many other virtually identical materials (such as new CRTs or scrap metals from other sources) that are a common part of international commerce. Transboundary movements to appropriate facilities are an essential part of any program for environmentally sound management of used PCs and scrap.

OECD member countries have considered or used a wide variety of approaches to making determinations of environmentally sound management of waste exports. These range from (1) an outright presumption that every OECD country has waste management facilities and regulatory regimes to assure ESM to (2) approaches that involve consideration or assessment of the importing country's regulatory infrastructure, without a facility-level review to (3) both an assessment of the importing country's regulatory infrastructure and a detailed review, on a facility-level basis, of all potential handling and management of the waste and its residues in the importing country. The second and third of these approaches often involve the comparison of the importing country infrastructure and/or facilities to those aspects of the exporting country's domestic requirements. Some member countries that have used approaches that consider "equivalency" of the importing country infrastructure and/or facilities to those of their own domestic program have noted the highly resource-intensive and time-consuming nature of these reviews.

The purpose of this portion of this guideline document is to provide a common set of benchmarks/approaches, as well as implementation schemes, that can be used by OECD countries in meeting the obligation to determine the environmental soundness of export for recovery. These guidelines are intended to identify benchmarks/approaches and implementation schemes which are generally recognized by OECD member countries as representing environmentally sound practices for the purpose of export.

Certainly, it is the right of any OECD member country to utilize more rigorous benchmarks and/or implementation schemes related to exports than are contained in these guidelines. However, the larger the differences between the export procedures of OECD members, the less efficient recovery may be, which may in turn affect the attractiveness and amount of recovery. Both efficient and environmentally sound recovery have long been recognized as OECD goals related to transboundary movements. As stated in C(83)180:

> "... efficient and environmentally sound management of ... waste may justify some transfrontier movements of such waste in order to make use of appropriate disposal facilities in other countries."

It is expected that the use of these guidelines will assure both efficient and environmentally sound transboundary movement and subsequent management of used and scrap personal computers.

National Program Infrastructure

Environmentally sound management of used PCs in any country relies, in part, upon the presence of a comprehensive set of national, regional and local programs that provide a context of standards and guidelines, oversight and assistance. There are three essential elements to fulfilling the governmental role in the environmentally sound management of wastes:

(1) adequate environmental laws, regulations, policies and assistance programs;

(2) appropriate compliance, inspection and enforcement programs; and,

(3) adequate resources for improving and implementing regulations and policies, as well as assistance and oversight programs.

Most OECD members have in place "cradle-to-grave" programs that govern management activities for hazardous and other wastes from the point of generation through storage, transportation, treatment, recovery and disposal.

Effective national programs for the environmentally sound management of used PCs promote, through a variety of either mandatory or voluntary methods, movement up the waste management hierarchy. For example, many OECD members have programs that focus upstream of waste generation, in the areas of waste minimization, pollution prevention and "design-for-the-environment," as well as programs to enlarge markets for recycled materials and "green products." The waste management hierarchy is as follows:

a) Waste prevention

b) Reuse

c) Waste recovery, including recycling

d) Waste disposal, including landfilling and incineration

ISSUE: *There are two major issues pertaining to the development of guidelines regarding the national program infrastructure of the importing country. One issue is whether the ESM guidelines will only be generally stated (such as those above) or whether specific elements (i.e., appropriate laws, regulations, policies, enforcement capabilities, etc.) need to be elaborated. The other major issue is how conformance with the general or specific guidelines will be assessed.*

If specific guidelines relating to importing country infrastructure are written, another issue that will arise is the relevance of some of the specific guidelines to the importation of a particular waste to a particular facility. That is, could a waste be imported to a facility if the facility conforms with the ESM guidelines, even though the country does not fully meet one or more of the infrastructure guidelines? What about in the case where the country's non-conformance regards guidelines that are not applicable or only marginally applicable to the particular case of import?

There are several options for assessing whether an OECD-member-country's infrastructure (at the national, regional and local levels) will assure that management of imported, used PCs will take place in a sound regulatory context. These include:

1. Importing country self-certification. This option would involve the importing country making a self-determination as to whether its domestic program is in conformance with the OECD guidelines.

2. Third-party determination. One such approach would be to perform such an assessment as part of the OECD program for country performance reviews. Another approach would be to utilize non-governmental, environmental auditing/certifying organizations. The OECD guidelines regarding national program infrastructure would be used as the benchmark.

3. Exporting country determination. In this case, the exporting country would make the determination as to whether the potential importing country has a satisfactory domestic program to allow the export of used PCs and components to that country. The OECD guidelines and/or the characteristics of the regulatory program (laws, regulations, policies, inspection capabilities, etc.) in the exporting country would serve as benchmarks in the assessment. If the exporting country uses its own domestic program as the benchmark for comparison, this may bring into question, to some degree, the utility of the OECD guidelines in defining ESM. This concern would be particularly exacerbated if a number of OECD countries used their own programs as benchmarks, rather than the OECD guidelines.

Questionnaires or checklists would be a valuable tool for implementing any of the above options. In-country audits/assessments would likely be necessary if the option for a third-party determination is used. In-country assessments are currently part of the OECD country performance reviews.

Facility Guidelines

A facility that receives imported used PCs and scrap must be operated to maximize the opportunities for either (1) reuse of the used equipment (through repair or refurbishment) or (2) material recovery from the incoming materials. Import/export of used and scrap PCs is principally for the purpose of reuse or materials recovery. Import by facilities that do not maximize reuse or material recovery is not environmentally sound and should be precluded. However, it is common that material recovery at the initial importing destination may only be partial; that is, some materials may need to be sent to subsequent facilities for further processing and extraction of recyclable materials. These subsequent markets for partially processed materials should be known, at least in general, prior to export so that there is reasonable assurance that the export will occur principally for the purpose of environmentally sound reuse or material recovery.

The potential for adverse impacts on worker health and the environment at an importing facility is very much dependent upon the nature of the refurbishment, dismantling or materials recycling activities that are utilized. Similarly, the appropriate degree of governmental control and oversight by the importing country is dependent upon which of these activities are engaged in, as well as the magnitude of the operations. National, regional and local government programs, therefore, need to be tailored to the nature and size of these operations.

Also driving the need to tailor governmental control and oversight, is the fact that the facilities engaged in the PC reuse and recycling industries are not neatly divided into those that conduct certain operations as opposed to those that conduct others. For example, even some very small shops that conduct repair and refurbishment may also conduct dismantling of components that are not reusable. On the other hand, some large dismantlers may conduct some degree of refurbishment as well. Both refurbishers and dismantlers may salvage usable components for resale. However, in general, firms tend to specialize and make their principal business activity either refurbishment or dismantling in preparation for raw material recovery. Most raw material recovery facilities (such as smelters) are focused on processing materials (such as glass and ferrous and non-ferrous metals) that have already been prepared for recovery, and do not conduct refurbishment or dismantling operations. However, there is some vertical integration by firms engaged in raw material recovery and, in some cases, subsidiary firms conduct dismantling prior to raw material recovery. At least one facility (in Canada) smelts some used and scrap electronics without prior dismantling.

The following general guidelines are provided.

Refurbishment

Facilities that are principally engaged in the refurbishment of used PCs derive their principal source of revenue from the resale of used PCs for reuse. Any revenues from the sale of unusable components to dismantlers or raw material recovery firms are only a secondary, and generally minor, source of income. Workers at a refurbishment facility have been trained specifically for PC repair–some hold technical licenses and professional diplomas in their field, while others have received on-the-job training.

The risks posed to workers and the environment at refurbishment facilities are generally quite small. This is because used PCs are manually repaired or upgraded with great care, i.e., destructive means are not used which would make used PC components unusable and could result in the release of hazardous constituents to the workplace or surrounding environment. The principal environmental issues posed by refurbishment facilities relate to the adequacy of storage of PC components on site and the adequacy of off-site destinations for unusable components.

Refurbishment facilities, especially those engaging in the import of used PCs, should be properly authorized by the local, regional or federal governments. Such authorization may take the form ranging from a local business license (in the case of rather small facilities) to a license or permit that provides worker health and safety guidelines or very basic provisions for environmental protection (for larger facilities). The authorization for larger facilities should specifically address the management of processed and unprocessed components, with limits on the amount that may be accumulated on site. Processed components should be regularly sent off-site to authorized recycling or disposal facilities.

Large refurbishment facilities should be inspected on a regular basis by the competent authority for compliance with the conditions of the facility authorization.

Refurbishment facilities that handle a significant volume of used PCs should be required to maintain a financial instrument that will assure that, in the case of (1) gross mismanagement of used PCs or components or (2) closure of the facility, the facility will be properly cleaned up.

Business transactions that involve the transboundary movement of used PCs and components must be based on contracts (or equivalent commercial arrangements) made in advance that detail the quantity and nature of the materials to be shipped. Through the keeping of records, a refurbishment facility should be able to characterize, on at least an annual basis, the percent (by volume or weight) of used PCs and components that are refurbished, sent for recycling and sent for disposal.

Refurbishment operations, including storage of inventory and unusable components, should be conducted indoors, with impervious floors. Storage areas must be adequate to hold all inventory and waste materials.

Material Recovery

- *Dismantling - General Facility Guidelines*

  Facilities that are principally engaged in the dismantling of used PCs for recovery of usable parts and/or materials for raw material recovery range from very small operations to those that are quite large. They also range from those that extensively utilize manual labor for disassembly to those that are highly automated. The degree of hazard posed to workers and the environment also varies greatly and is dependent upon the specifics of individual facility operation. For example, some manual disassembly operations pose few worker or environmental issues, while others that involve, for example, the melting of lead solder, the breaking of CRTs or the use of shredders present a wider array of potentially more serious concerns.

  Dismantling facilities should be properly authorized by the local, regional or federal competent authorities. If the dismantling is manual and only involves hand tools (not involving heat or shredding, for example), the degree of worker and environmental risks may be on a level similar to a refurbishment operation and, thus, it may be appropriate to authorize such a dismantling facility on a par with refurbishment facilities, as described above.

  However, many dismantling facilities also use some practices or equipment that will result in hazards to workers or the environment if the proper safeguards are not taken. This is because dismantling operations generally involve destructive means of disassembly which can result in the release of hazardous constituents from various PC components. Destructive disassembly also permits a higher rate of used PC processing than can be achieved in refurbishment; therefore, larger volumes of potentially hazardous materials are generally on site at dismantling facilities. Thus, dismantling facilities, in general, require closer governmental oversight than is described above for refurbishment facilities.

  In general, a dismantling facility needs to have the appropriate equipment for proper processing of the incoming materials as well as controlling environmental releases. A system needs to be in place for identifying and properly managing hazardous components (e.g., batteries) that are removed from used PCs during disassembly. The facility needs to assure that personnel are properly trained with regard to material and equipment handling, worker exposure, controlling releases and safety and emergency procedures.

The facility should have procedures for monitoring, reporting and responding to pollutant releases and other emergencies, such as fires. A financial instrument should be maintained that will assure that, in the case of (1) major pollutant releases or gross mismanagement of used PCs and scrap or (2) closure of the facility, the facility will be properly cleaned up.

The facility authorization (license or permit) should describe the capacity of the operation, particularly the amount of unprocessed as well as processed materials that are allowed to be kept on site. This will assure that the capacity of storage areas is not exceeded and hazards to human health and the environment during operation or, in the case of unexpected facility closure, are minimized.

Dismantling operations should be inspected on a periodic basis by the competent authority for compliance with the facility license, as well as other safety, health and environmental requirements. The facility itself should conduct regular audits and/or inspections of its environmental compliance.

Facilities should manage all materials to minimize adverse exposures to workers and releases to the environment. Dismantling operations, as well as storage of any components that contain hazardous substances, should be conducted indoors, with impervious floors. Storage areas must be adequate to hold all processed and unprocessed inventory. As discussed above, dismantling facilities that use heat to soften solder or that shred various PC components need to design their operations to control hazardous air emissions.

For business purposes, many facilities engaged in dismantling keep close track, on a shipment-specific basis, of the fate of used PCs and components that are received. Not only is this good business practice for purposes of understanding and maximizing the efficiency of the flow of inputs and outputs, but many dismantlers will offset the fees charged for receipt of the used PCs by giving a credit for the value of reusable or recyclable components. Using this data, it should be relatively easy for dismantlers to have information, on at least an annual basis, indicating the percent of used PCs and components that are sent for reuse, recycling and disposal.

Transactions that involve the transboundary shipment of used PCs and components must be conducted based on contracts (or equivalent commercial arrangements) made in advance that detail the quantity and nature of the materials to be shipped.

- *Raw Material Recovery - General Facility Guidelines*

Facilities that engage in raw material recovery, i.e., activities beyond refurbishment, disassembly and sorting, will require a higher degree of governmental environmental oversight, commensurate with the environmental concerns that arise from their activities. Raw material recovery, e.g., via smelting, often involves the generation of emissions or residues that require careful control in order to avoid adverse impacts on worker health, as well as human health generally, and the environment.

The level of regulatory oversight and permitting of raw material recovery facilities need not, however, rise to the level of the full domestic hazardous waste infrastructure. With regard to metal recovery facilities, the metals contained in a personal computer, some of which raise environmental concerns, do not raise unusual or special environmental concerns, i.e., concerns which are different from those encountered in other metal processing activities. Printed circuit boards, of course, contain a variety of metals. But copper ores will commonly contain the same metals, including nickel, lead, arsenic, cadmium, mercury, antimony, selenium, iron, sulfur, bismuth, zinc, silver and gold. Gold ores contain copper, silver, platinum, mercury, tellurium, antimony, arsenic, lead, bismuth, silicon, magnesium, iron, zinc, chlorine and sulfur. Therefore, smelters, and their competent environmental authorities, should already be very familiar with the environmental issues that arise from metals smelting, and adequate safeguards for environmentally sound smelting should already be in place.

In general, a raw material recovery facility should meet the following criteria:

◊ The facility should have a full complement of permits and licenses, addressing facility operation, worker health and safety, control of emissions to air, land and water and waste management.

◊ Have the appropriate equipment for proper processing of incoming materials and controlling environmental releases.

◊ Have a system in place for properly identifying and handling any hazardous components in the incoming materials.

◊ Personnel are properly trained with regard to material and equipment handling, worker exposure, controlling releases and safety and emergency procedures.

◊ Procedures are in place for monitoring, reporting and responding to pollutant releases and other emergencies, such as fires.

◊ A financial instrument should be maintained that will assure that, in the case of (1) major pollutant releases or gross mismanagement of used PCs, components and scrap or (2) closure of the facility, the facility will be properly cleaned up.

◊ The permit should describe the capacity of the facility, particularly the amount of unprocessed materials that may be kept on site.

◊ The facility should conduct frequent and detailed inspections and/or audits of its environmental compliance. The competent authority should also conduct regular inspections for compliance with all permits.

◊ The facility should manage all materials to minimize adverse exposures to workers and releases to the environment.

◊ Transactions involving transboundary movement of used PCs, components and scrap shall utilize contracts (or equivalent commercial arrangements) made in advance that detail the quantity, nature and quality of the materials to be shipped.

- *Treatment of Specific Components*

CIRCUIT BOARDS AND BOARD COMPONENTS	Printed circuit boards are particularly valuable components of a used PC, as they may contain marketable chips that can be removed and sold for reuse, and because they contain valuable metals that can be recovered in a smelter. Dismantling facilities that recover marketable chips utilize heat to soften the solder holding the chips to the printed circuit boards. In this heating process, lead contained in the solder is emitted as a fume and must be captured to protect both workers and the environment. Equipment for the capture of the lead fumes includes the use of vacuum hoods and filters for removal of lead from the exhaust. The facility license should specifically address these required safeguards at facilities where the heating of lead solder is utilized. Printed circuit boards contain a substantial quantity of copper and valuable concentrations of gold, silver and palladium. These metals are usually recovered through copper smelting followed by metal-specific refining. In almost all respects printed circuit boards serve as a substitute for primary copper concentrates from ore, because they contain not only a high concentration of copper, but also contain many other metals commonly found in copper ore, such as lead, cadmium, gold and silver. However, because of high economic value, a batch of circuit boards is often processed in advance of smelting, by shredding and burning of some or all of the batch, in order to obtain a representative sample and metal assay. The shredded boards and components and ash are then smelted. Shredding of circuit boards gives rise to dust, of which some fraction will be the metals of concern. Burning of circuit boards, whether before or during smelting, gives rise to concern regarding the release of these metals in furnace exhaust emissions, as well as the release of other products of combustion. Facilities which shred and/or burn printed circuit boards and non-ferrous smelters require attention to these concerns. Workers require training in management of hazardous materials (e.g. handling of dusts and ashes), as well as personal protection from exposure. Furnaces require proper furnace combustion conditions (e.g., temperature, residence time, oxygen levels), and furnace emission control systems appropriate for their feedstocks (such as acid gas scrubbers and particulate controls, or both). The facility permit regarding air emission controls should specifically authorize the processing of electronic scrap. The presence of halogens – chlorine and bromine – in plastics which will be burned during metal recovery raises concerns which differ from those most commonly associated with copper ores. Attention must be given with such electronic scrap feedstocks to the possibility of creation of dibenzo-furans and -dioxins in burning processes. The first consideration is in the burning itself, which most OECD member countries require to be at a temperature of 850 deg.C. (1600 deg.F.) or higher, with a residence time of 2 seconds, with excess oxygen. Complete thermal destruction of hydrocarbons will substantially reduce the possibility of formation of dibenzo-furans and -dioxins in the furnace emission stream. Halogens will be converted to acids, and then to salts in an acid gas scrubber. A final consideration, deemed to be maximum achievable control technology in the United States, is control of the exhaust gas temperature at the inlet to a dry particulate control device (i.e., electrostatic precipitator or fabric filter) at or below 200 deg.C. (400 deg.F.).

BATTERIES	
Lithium metal	A personal computer motherboard contains a small battery to maintain electrical energy to computer settings such as the time and date. By far the most common type is a lithium cell, approximately the size of a small coin, and referred to as a coin cell. A coin cell contains less than a gram of lithium, encased in solid form as the anode. The coin cell should be removed from the motherboard prior to shredding. If a cell remains on a board, the shredding operation will open the cell, exposing the lithium anode. If some of the lithium is unreacted, it may then react with oxygen in the air or with moisture, generating heat and, potentially, hydrogen gas. A fire may be started immediately in the shredding operation, or the lithium may smolder and a fire may occur at a later time. Such a fire, in the midst of burnable circuit board fragments, may be difficult to control, and may cause hazardous air pollution. A facility which shreds printed circuit boards requires visual inspection of motherboards for the presence of a coin cell, and removal if a cell is present. A coin cell may be removed without tools if it has been inserted into a mechanical holder. If, as in more recent computers, the coin cell has been soldered onto the board, hand tools will be required for removal. Once separated, coin cells should not be accumulated in quantity without physical separation from each other, so that uncontrolled electrical discharge will not occur. Coin cells may be thermally processed with other components of a personal computer, as always with appropriate combustion and emission controls. A lithium coin cell does not present an additional problem in combustion or smelting. A coin cell can not be recharged, but its lithium can be recovered, after it has been fully discharged to eliminate potential reactivity, by shredding and gravity separation.
Portable (Notebook) Computer	Batteries used in portable (notebook/laptop) computers include rechargeable nickel cadmium (Ni-Cd), nickel metal hydride (NiMeH) and lithium ion batteries. Some lead acid batteries are also used. These batteries are all removable by hand, and should be removed in the dismantling process and then sorted by type. All battery cells should be managed to avoid inadvertent external short circuits and current flows. Large inventories of batteries should be avoided, and batteries that cannot be reused should be sent for metal reclamation. Ni-Cd and NiMeH batteries can be recycled for recovery of nickel, and by some companies for recovery of cadmium. Lithium ion batteries do not have the fire hazard problem associated with lithium metal batteries because the lithium is in the stable form of lithium hydroxide. Care should be taken by workers if lithium ion batteries are opened or broken, as lithium hydroxide is somewhat corrosive. The lithium contained in these batteries can be recycled.

CATHODE RAY TUBES	A CRT contains by far the greatest amount of all substances of concern in a personal computer – in its 2-3 kilograms of lead. This lead is encapsulated in glass, and cannot be released unless and until the glass is broken. However, the glass must be broken into relatively small pieces before significant levels of lead would be available for release into the environment. A CRT will also contain a small amount of copper in its yoke and internal wiring, but little if any other metal value. There are several options for environmentally sound management of the leaded glass in a CRT. The leaded glass in a CRT can be recovered for direct reuse in new CRT manufacture. This can be done by removal of all non-glass components of the CRT, including the plastic monitor case, CRT yoke and electronics. These steps require aeration (release of the vacuum) by drilling into the CRT. This is followed by the breaking of the bare CRT and careful separation of the glass parts, i.e., the faceplate, funnel and neck, according to their respective lead concentrations (which vary from CRT to CRT). Workers should be protected from inhalation of dust that may contain lead as a result of CRT breaking. The CRT glass is cleaned and the phosphor coatings are removed. The phosphor coatings can present an inhalation hazard if managed in a dry state. Wet processes are often used to remove the the phosphors. The phosphors ultimately require either thermal treatment for destruction or stabilization prior to land disposal in a secure landfill. Currently, there is very little recovery and reuse of phosphors practiced. Glass fines and filters generated during the cleaning process can be sent to a lead smelter. The cleaned, leaded glass fractions, with assayed lead concentrations, can then be used as a feedstock in the manufacture of new leaded glass components in the CRT manufacturing industry. Such direct reuse may require transboundary movement of glass cullet, because most CRTs are manufactured in Asia. The lead in a CRT can also be recovered as lead by a lead smelter. This requires preliminary disassembly, particularly removal of the plastic monitor case, because lead smelters do not usually have pollution control systems suitable for burning of plastic. The glass also serves as a silicate flux in the lead smelting process, and is a substitute for silicate which the smelter would otherwise acquire and use. The glass used for lead smelting may be mixed and dirty CRT glass which is generally not acceptable by CRT glass manufacturers. The leaded glass in a CRT can also be used as a silicate flux by a copper smelter, again as a substitute for silicate which the copper smelter would otherwise acquire and use. The copper smelter may also have a subsequent procedure in which the silicate slag from the copper smelting is treated for lead recovery. A copper smelter may also have a pollution control system which permits it to burn plastic and, therefore, may be able to treat the monitor from a personal computer without preliminary disassembly. If the lead in a CRT is not recovered as leaded glass, but instead is placed in a smelting process, some or all of the lead will remain in the slag produced in that process. Lead in silicate slag is immobilized and may be disposed in an industrial landfill. Such disposal will require specific licensing by the competent environmental authority with oversight responsibility for the smelter.

INSULATED WIRE	Insulated electrical wire accompanying a personal computer, such as its power cords, may be covered with polyvinylchloride (PVC), or with a plastic elastomer, or with some other plastic. The substance of concern is PVC, because of its chlorine content. In the past, the insulation was removed by burning, sometimes in uncontrolled combustion. This should not be considered environmentally sound, because the burning may be incomplete, emitting a variety of particles of incomplete combustion, and chlorinated dibenzo-furans and dibenzo-dioxins may form in the exhaust emissions. Insulated electrical wire should be separated from a personal computer if the wire is accessible during dismantling, such as with computer power cords. The separated wire should then be shredded or chopped (or both) to a relatively small size (typically between one to ten centimeters in length). It can then be burned under controlled combustion with an air emission control system designed to prevent formation of chlorinated dibenzo-furans and dibenzo-dioxins. Shredded or chopped wire can also be granulated to separate the insulation from the copper. The resulting mixed material can be separated by a variety of physical means, using water or air. The entire process, when properly executed, will produce clean copper and a plastic fraction which is suitable for land disposal or reuse in plastic. It is not practical to attempt to remove all insulated wire from the inside of a personal computer, and burning of relatively small amounts of such insulated wire, in controlled combustion with an appropriate pollution control system, permitted by its competent environmental authority, is not unsound.
FERROUS AND NON-FERROUS METALS	In addition to the recovery of metals from circuit boards, as discussed above, both ferrous and non-ferrous metals from other components of used PCs should be recovered. For example, PCs contain substantial quantities of steel and aluminum that can be relatively easily separated from other PC components, using manual or mechanical means. These metals can be sold to smelters who should be equipped with state-of-the-art flue gas cleaning systems.
PLASTICS	Plastics (such as equipment casings and bases) are the one major category of material components for which recycling opportunities are quite limited. This is because (1) numerous resin types are used in PC equipment, (2) plastic parts are not labeled according to their type and (3) the presence of chlorine and bromine compounds in some of the plastics requires measures for the protection of human health and the environment in operations where these plastics are shredded or heated. A wide variety of brominated flame retardants have been used as additives to some of the plastic components in PCs. Thus, opportunities for recycling need to regard not only the particular resin types of the various parts, but also the types of flame retardants that are present in the plastics, as the safety of the recycling may be affected. When hard plastic components containing brominated flame retardants are shredded, workers can be exposed to dust containing these chemicals. Thus, workers in shredding areas should be protected through adaptations in shredder design, air flow controls, personal protective devices or a combination of these measures.

	After preliminary processing, the recycling of plastics involves extrusion to make new products. The use of heat in the extrusion of plastics containing brominated flame retardants can cause the formation of highly toxic brominated furans and dioxins. Thus, operations that involve the recycling of plastics from used PCs need to be carefully reviewed by the competent environmental authority during the facility authorization process.
LIQUID CRYSTAL DISPLAYS (LCDS)	The "liquid crystal" in an LCD is generally a polycyclic aromatic hydrocarbon or a halogenated aromatic hydrocarbon. These substances are not actually liquids and will not flow freely if the display is broken. At this time, recycling of LCDs or their components is not commercially available. LCDs should be thermally treated, either in a smelter along with other PC components for metal recovery or in an incinerator. Temperatures in excess of 800 deg.C. are necessary to assure complete combustion and avoid reforming hydrocarbon compounds in the exhaust gases. Large LCDs in notebook computers may contain an illumination unit containing mercury. These units should go to a specialized mercury recovery facility or to a hazardous waste incinerator with emission controls such as charcoal filters.

Energy Recovery and Disposal

It is likely that some components of used PCs cannot be recycled. These components, likely to principally be plastics, will need to be safely burned or landfilled. Preferably, combustible fractions should be burned for energy recovery, as this method is a form of recovery and is higher in the waste management heirarchy than is burning without energy recovery or landfilling. The incinerator or other combustion unit (with or without energy recovery) should be operated to minimize the formation of toxic furans and dioxins, as well as be equipped with state-of-the-art flue gas cleaning systems. Combustion ash, as well as materials from the processing of used PCs that cannot be recycled, can be disposed in a secure landfill.

Facility-Level Assurance of ESM

ISSUE: *There are a number of possible approaches regarding how determinations of environmentally sound management at the facility level, in the case transboundary movements of used materials, wastes or hazardous wastes, can be made. These approaches are quite varied in a number of respects, such as the extent to which they rely on facility self-certification versus a determination made by an independent third-party certifying organization or governmental competent authority.*

The following discusses four basic approaches. (Options similar to these, and other options, are discussed in some detail in a paper that was circulated at the first OECD workshop on ESM, held in Cancun, Mexico in October 1999. The paper is by Rick Picardi of the USEPA and is entitled, "Options Analysis of Possible Government Approaches to Assessing Environmentally Sound Management.")

The OECD has several options related to the issue of whether and how environmentally sound management at the facility level, for the purposes of transboundary movements, should be assured within the OECD. The OECD could (1) select one of the following four approaches, (2) construct a strategy that *uses two or more of the approaches in some manner or (3) determine that the OECD guidelines will not include an implementation scheme for assurance of environmentally sound management at the facility level.*

1. Self-certification. In this case, the importing facility itself provides data and information about the facility and its management that is meant to demonstrate that the facility meets domestic requirements and OECD guidelines. This information can be supplied in response to a questionnaire, however, the response would not be reviewed/approved by the competent authority in the country of import. Because of the reliance of this approach solely on the credibility of the facility in question, it may well be that the utility of this approach, on its own, is rather limited. However, this approach might be appropriate for shipments (1) of used materials or wastes that are not high in hazard or (2) to facility types, such as refurbishers, who are considered, because of the nature of their activities, to potentially pose less hazard to workers or human health and the environment generally. Under this approach, a public database of self-certified facilities could be maintained.

2. Third-party certification. This approach would involve certification by a non-governmental organization that the facility and its management have programs in place that are consistent with (1) international environmental management standards (EMS) such as ISO14000 or the Eco-Management and Audit Scheme (EMAS) of the European Union, and/or (2) the OECD ESM guidelines. Companies that conduct ISO and EMAS certifications are specifically licensed for those purposes. OECD would have to decide whether environmental auditing firms would have to be specifically authorized to provide certifications regarding a facility's consistency with the OECD ESM guidelines.

   Due to the cost involved in obtaining such certifications, it is likely that this approach is most applicable to large recovery facilities that handle a significant volume of materials. Under this option, shipments could be made without consent of the governments of the importing or exporting countries. However, the importing and exporting governments would be notified of the shipment(s). ***ISSUE****: Would this option only apply to shipment of used PCs for evaluation and non-hazardous PC wastes, or could option also apply to hazardous PC waste shipments?* There would be an issue of whether and how transit countries would be notified and/or their consent requested. There would also be an issue of how long the certifications would be valid for import purposes. A public database of certified facilities could be maintained.

3. Importing-country certification. Under this approach, the competent authority of the importing country determines whether the facility conforms with the national, regional and local programs, as well as OECD ESM guidelines. Sources of information for the competent authority to use in this determination could include compliance history, questionnaire results, facility self-certification, environmental audit results, non-governmental certifications (e.g., ISO, EMAS), etc. Case-by-case determinations could be made, as well as those for pre-approved facilities. The competent authority of the importing country would have to be notified of all shipments, whether specific consent is needed or not. A public database of pre-approved facilities could be maintained. There would be an issue of how long pre-approval is valid.

4. Exporting-country determination. This approach would involve having the exporting country make a determination of the environmental soundness of the facility in the importing country. An evaluation of the facility operation and the fate of by-products and residues would be made using a the OECD ESM guidelines and/or the level of technology and pollution control in the exporting country as benchmarks. Experience by OECD countries with this approach, comparing the importing-facility operations to the level of technology and pollution control in the exporting

country, has raised concerns that this may be a rather inefficient approach (taking months to complete), as well as raising questions about its legal defensibility. The exporting country would likely require a questionnaire to be completed by the importing facility or the exporter, as well as a questionnaire for completion by the competent authority in the importing country. Other sources of information to enable assessment by the exporting country might include environmental audit results and non-governmental certifications of the company or facility. Case-by-case determinations could be made, as well as those for pre-approved facilities. A public database of pre-approved facilities could be maintained.

ISSUE: *For which facilities is a finding of ESM (using any of the above approaches) necessary? That is, if used PCs or components are to be shipped between OECD countries and at the first destination they are to be dismantled and parts sent to various recyclers, which facilities must be certified or approved? How can this be accomplished in a way to also achieve efficient commerce? This issue is particularly relevant to used PCs, but it has applicability in other cases as well.*

The ultimate fate of a shipment of used PCs that is sent for evaluation of reuse potential is unknown at the time of export. Certainly, the initial destination is known, but no other destinations for potential component parts can be known at the time of export. The same is largely true for shipments whose initial foreign destination is a dismantler. In this case, although it is very likely that the used PCs will be dismantled, it is perhaps impossible to specify the latter destinations of the various component parts, as this, in large part, depends upon the market conditions for recyclables (as well as salvagable parts) at the time of dismantling.

If the third approach discussed above were used, perhaps the competent authority of the importing country could (1) make a finding that the initial receiving facility for the imported PCs is capable of environmentally sound management of the used PCs, and (2) be confident (often based on prior knowledge of the domestic industry or facilities) that either markets for recovered materials or adequate disposal facilities exist for all PC components. Any such markets or disposal facilities that will be used within the importing country should be environmentally sound, however, how can these destinations be known ahead of time and ESM assured? Another option would be to require, under any of the above approaches, that the component parts can only go to ESM-certified (or approved) facilities. There is a real question here about how this would impact efficient recycling. Other approaches also need to be considered.

Transport

NOTE: Guidelines relating to procedures for transport are inextricably linked to decisions that need to be made regarding the selection of options for facility-level assurance of ESM, as discussed in section 3.3. For example, issues of notification and consent are linked to the choice of options for facility-level assurance and are mentioned in section 3.3. Thus, draft guidelines regarding these procedures largely need to await some initial decisions regarding any implementation scheme for facility-level assurance of ESM.

The OECD Control System for Transfrontier Movements of Wastes Destined for Recovery Operations [C(92)39] governs the movement of hazardous wastes between OECD countries. Movement of used PCs and components that are not considered amber wastes, as well as those that are not considered wastes, are not governed by the OECD Control System. However, some individual OECD countries have begun to use the OECD Control System in the case of transboundary movements of used PCs and other used electronics and electronic wastes. For example, Switzerland has issued regulations and guidelines that require use of the amber control system for all exports of used electronic appliances. Of course, other multilateral (e.g., EU Control System) and bilateral arrangements among specific OECD countries also govern waste and materials movements. In addition, UN and other international shipping requirements may be applicable to the movement of used PCs and components between OECD countries.

Removal of Hazardous Substances

The separation of hazardous substances from other components of used PCs is not necessary prior to transboundary shipment (except in the case of shredded circuit boards, see below). However, the procedural and/or packaging requirements relating to a particular transboundary shipment are dependent upon the presence or absence of those hazardous substances and their potential for dispersion in the environment. That is, the greater the potential risks to human health and the environment, the more stringent are the applicable controls.

Packaging

Used and Scrap CRTs and CRT Glass. Whole CRTs should be packaged in a way that minimizes breakage during normal shipping conditions. In addition, the packaging should minimize releases to the environment if unintentional breakage does occur during transport. For example, if CRTs are shrink wrapped onto a pallet in such a way that broken pieces might not be contained, the pallet should be placed in an outside package that will minimize releases. CRTs with broken glass, glass pieces and glass cullet should be packaged in siftproof containers that prevent particles from being released from the package and whose effectiveness will not be reduced during normal shipping conditions.

Shredded Circuit Boards. Shredded circuit boards, not containing batteries, should be packaged in containers that prevent particles from being released from the package and whose effectiveness will not be reduced during normal shipping conditions.