Section VI

Guidance/guidelines by source category: Source categories in Part III of Annex C

Part III Source category (a): Open burning of waste, including burning of landfill sites

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VI.A Open burning of waste, including burning of landfill sites

Summary

Open burning is an environmentally unacceptable process that generates chemicals listed in Annex C of the Stockholm Convention and numerous other pollutant products of incomplete combustion. Consistent with Annex C, Part V, section A, subparagraph (f) of the Stockholm Convention, the best guidance is to reduce the amount of material disposed of via this method with the goal of elimination altogether.

Other techniques which may effect improvement include, with respect to the materials burned: avoid including non-combustible materials, such as glass and bulk metals, wet waste and materials of low combustibility; avoid waste loads containing high chlorine content, whether inorganic chloride such as salt, or chlorinated organics such as PVC; and avoid materials containing catalytic metals such as copper, iron, chromium and aluminum, even in small amounts. Materials to be burned should be dry, homogeneous or well blended, and of low density, such as non-compacted waste.

With respect to the burning process, aims should include: supply sufficient air; maintain steady burning or rate of mass loss; minimize smouldering, possibly with direct extinguishment; and limit burning to small, actively turned, well-ventilated fires, rather than large poorly ventilated dumps or containers.

1. General guidance

Open burning covers a wide range of different uncontrolled waste combustion practices, including dump fires, pit burning, fires on plain soil and barrel burning. For people in many parts of the world, open burning is the cheapest, easiest, most sanitary means of volume reduction and disposal of combustible materials. This is especially true for people with no access to organized waste handling and who have been left to their own devices for materials disposal.

1.1 Public health threats of open burning

Current research indicates that open burning is a more serious threat to public health and the environment than previously thought. The low temperature burning and smouldering conditions typical of open burning promote the formation of many toxic and potentially harmful chemicals, including chemicals listed in Annex C of the Stockholm Convention. These compounds may form during open burning regardless of the composition of the material being burnt. The compounds produced from sources of open burning can travel long distances and deposit on soil, plants, and in water.

The remaining ash in the burn pile also contains pollutants, which can spread into the soil and water. Animals and fish ingest the pollutants and accumulate them in their tissues, while plants can absorb them through their leaf surfaces. When this contaminated food is eaten, the pollutants are passed on to humans. Additionally, smoke and particulates from open burning sources can trigger respiratory health problems, particularly among children, the elderly, and people with asthma or other respiratory diseases, and those with chronic heart or lung disease.

1.2 Status of open burning

While this document provides guidance for open burning practices, it recognizes the environmental harm resulting from open burning, and should not be taken as licence to continue the practice, which should be minimized and eliminated as soon as possible and wherever feasible. Open burning may still be a last resort where there are no alternative disposal or recovery methods due to inadequate infrastructure; where sanitary disposal is required to control disease or pests; or in the case of disaster or other emergency (Great Lakes Binational Toxics Strategy 2004). However, household wastes

should never be burnt in indoor residential combustion devices such as stoves, fireplaces or furnaces (see section VI.C of the present guidelines).

Open burning of waste, including burning at landfill sites for volume reduction, is listed as an inadvertent source of persistent organic pollutants in Annex C, Part III of the Stockholm Convention. Most importantly, subparagraph (f) of Annex C, Part V, section A refers aspirationally to "… the aim of cessation of open and other uncontrolled burning of wastes, including the burning of landfill sites".

Although the Stockholm Convention is concerned with persistent organic pollutants such as polychlorinated dibenzo-*p*-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), polychlorinated biphenyls (PCB) and hexachlorobenzene (HCB) as products of incomplete combustion, open burning is responsible for generation of toxic by-products of combustion well beyond the named chemicals. Other by-products include polycyclic aromatic hydrocarbons, particulate matter, benzene and carbon monoxide. Regardless of specific chemistry, smoke and unpleasant odours always accompany open burning, and are at best a nuisance and at worst a health hazard. Elimination of the persistent organic pollutants listed in the Stockholm Convention would not sufficiently improve the emissions from open burning to make it an environmentally preferred means of waste disposal. It is imperative that the focus of implementation of the Stockholm Convention be on establishing alternatives to open burning rather than simply trying to improve a bad practice. Provision of this guidance should not be construed as acceptance or justification.

Efforts to reduce open burning should be promoted and such efforts should focus on government, private sector and civil society support of alternative end-of-life and waste management options. Government agencies in charge of public health policy and education should be as deeply involved as those responsible for waste policy. The Basel Convention Technical Guidelines offer basic guidance on alternatives to open burning and how to implement them (Basel Convention Secretariat 1994).

Countries should work diligently to establish and implement sound waste management practices, including resource use reduction, reuse, recycling, composting, modern sanitary landfilling and incineration using best available techniques. The Convention's implementation efforts and its financial mechanism could be used to support the establishment of model waste management systems as alternatives to open burning. In addition, educational programmes and materials designed to educate target audiences (e.g. the public, waste handlers) about the risks to human health and the environment occasioned by open burning should be considered as part of an overall effort towards continuous minimization (Canadian Centre for Pollution Prevention 2006; EPA 2006).

Many countries have formulated regulations and prohibitions covering various open burning practices (Government of New Zealand 2006). A number of these regulations contain specific guidance on categories mentioned in this section, including tyres and waste oil. Enforcement of such provisions depends on the public having access to acceptable waste collection and disposal options.

In this part of the guidance, a number of specific types of open burning are considered in generic categories, typically because means of reducing emissions of persistent organic pollutants in each category are similar (Lemieux, Lutes and Santoianni 2004). Accidental fires and intentional combustion of non-waste materials are not considered; however, they may also be sources of persistent organic pollutants. Parties to the Convention are urged to take steps to reduce accidental biomass burning of all types as well as accidental fires in residences, automobiles and places of business. Parties may wish to consider restrictions on fireworks or other recreational open combustion.

1.3 Scientific basis and general considerations

Waste composition varies by source. Domestic waste may contain more organic material; industrial waste may contain more metals and possibly organic chemicals. Some of the waste itself – even domestic waste such as clothing or leather – may contain persistent organic pollutants (UNEP 2003). Sections III.C (i) and (ii) of the present guidelines describe formation mechanisms of persistent organic pollutants and their relationship to materials that might be contained in waste. Subsection 1.3.1 below contains general guidance on materials and processes; subsections 2–4 contain further information on material composition for different types of waste.

Waste composition also varies among countries, and over time. Accurate waste composition data from each country will aid in overall waste management, increase the amount of material available for recycling or reuse and reduce the amount that is open burnt.

Figure 1. Animals grazing near open burning

Grazing animals may be adversely affected by open burning and may ingest harmful substances. Photo: Kenya POPs Office.

There are few data regarding generation of persistent organic pollutants from uncontrolled waste combustion. Most experimentation has been conducted on so-called barrel burning, but there are limited or no data on dump fires, open burning in pits or waste burning on soil.

The UNEP *Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases* (UNEP 2003) provides a sound basis for calculating emissions of dioxins and furans. A number of parties who have completed their dioxin and furan inventories using the toolkit have found that open burning of waste is one of the four largest sources of dioxins and furans.

1.3.1 Burning process

In the short term, where there are not realistic means to eliminate all open burning, the best guidance is to reduce the amount of material disposed of via this method. This is consistent with the convention and its goal of elimination.

Other techniques that may effect improvement include the following (Gullett 2003):

With respect to the materials burnt:

- Avoid including non-combustible materials, such as glass and bulk metals, wet waste and materials of low combustibility;
- Avoid waste loads containing high chlorine and/or bromine content, whether inorganic such as salts, or halogenated organics such as PVC (Lemieux et al. 2003);[1]
- Avoid materials containing catalytic metals such as copper, iron, chromium and aluminum, even in small amounts;
- Materials to be burnt should be dry, homogeneous or well blended and of low density (e.g. non-compacted waste).

With respect to the burning process:

[1] "No distinction is observed in log (TEQ) for inorganic (7% Cl in $CaCl_2$) versus organic Cl sources (7% Cl in PVC)" (Lemieux et al. 2003).

- Supply sufficient air;
- Maintain steady burning or rate of mass loss;
- Minimize smouldering, possibly with direct extinguishment. Smouldering is the phase of burning associated with the largest production of persistent organic pollutants (Lemieux et al. 2003);
- Limit burning to small, actively turned, well-ventilated fires, rather than fires in large poorly ventilated dumps or containers.

Figure 2. Typical mode of disposal of mixed waste through open burning

Potentially explosive items (e.g. aerosol cans, partially full containers of flammable liquids) and hazardous materials should be removed, especially those that should be destroyed using best available techniques described in other parts of the guidance (see section V.A (i), subsection 2.2 of the present guidelines).

1.3.2 Handling after burning

Before burnt waste can be handled or covered, it must be completely extinguished. Failure to do this can potentially ignite uncontrolled burning over large areas or allow ongoing smouldering. Ash from mixed waste burning should be kept from forage areas, and landfilled rather than landspread.

1.3.3 Health and safety considerations

In addition to the aforementioned guidance, steps should be taken to mitigate exposure routes to dioxins and furans. As is widely recognized, most human exposure comes through the food chain. Thus, necessary burning sites should be located away from production of plants and animals for food. It is also good practice to locate combustion sites remote from the population or at the very least downwind of residential areas.

In addition to isolating citizens from the odour, nuisance and potential toxics exposure of open burning, in all cases, whether in a landfill or at a secluded facility, personnel tending the fires should position themselves upwind from any burning waste and be clear of the burning waste. Protective clothing such as gloves, boots and overalls, together with smoke masks and goggles, are advisable where possible.

1.3.4 Intermediate burning technologies and practices

Combustion devices, sometimes called “incinerators” by vendors, are sold for the purpose of burning refuse. In some cases these devices may be as simple as steel drums or barrels that contain the waste but do not constitute a best available technique for incineration. For the purposes of this guidance, open burning includes any form of combustion for waste disposal, whether in unconfined piles or

confined in metal barrels or burners, that does not meet the standards for incineration (using best available techniques) of municipal, medical or hazardous waste, as defined by a Party.

Utility of these intermediate burning devices is limited by lack of data on generation of persistent organic pollutants. It is strongly recommended that manufacturers of these devices supply such data, specific to the waste for which they are intended.

2. Intentional biomass burning

2.1 Agricultural/crop residue and land clearing debris

2.1.1 Material composition

In general, this material is biomass: wood, grass and other vegetation. Depending on locality the material may include sisal, coffee husks, corn (maize) cobs and stalks, sugar cane or rice husks. The material may be composed of living plants, deadfalls or plant material that has been cut and dried. Intentional burning does not constitute well-controlled combustion despite the fact that the geographical boundaries of the material to be burnt may be well defined.

Biomass materials will vary in water content (live versus harvested material; wet versus dry season; low versus high humidity), fuel density (mass per hectare and degree of compaction or other measure) and species. Biomass materials vary naturally in chloride content and may have been treated with chemicals (chlorinated pesticides or fertilizers), metals capable of catalysing formation of persistent organic pollutants (copper, for example as copper chromium arsenate-treated wood) or inhibitors (sulphur, nitrogen-containing materials), all of which may impact generation of persistent organic pollutants, particularly dioxin and furans, during uncontrolled combustion (see subsection 1.3 above on general process considerations). Some research on large-scale biomass burning has been published (Lobert et al. 1999; Nussbaumer and Hasler 1998; Gullett and Touati 2003; Gullett and Touati 2002).

2.1.2 Barriers to elimination; remedies or policy to remove barriers

Prescribed burning may be permitted by government for perceived economic benefit (cost reduction), perceived agricultural benefit (ash as soil adjuvant), risk prevention (e.g. to minimize bushfires in Australia), termite, reptile or other pest control, convenience or recreation. In each of these cases the government has the power to remove permission for such burning and to educate the public regarding the health risks of open burning, especially if it is conducted on a large scale. In some cases, as for termite control, open burning of biomass may be the least environmentally problematic approach. Cost and availability of alternative means of disposal or environmental management can be an overarching issue.

2.1.3 Strategies and policy instruments to avoid, reduce or divert waste

Where possible, machine harvesting paired with alternative, non-destructive uses for harvested materials can reduce the need for wholesale burning. In areas of livestock cultivation materials may be harvested for silage. Grass may be dried for hay; other crop waste may be processed for fodder, fermented, allowed to decompose in situ or composted; wood of sufficient quality may be harvested for timber; yard waste can be composted and utilized as soil amendment; some non-traditional biomass can be used as a raw material for paper. In most cases, these alternatives also require markets and infrastructure for economic feasibility.

Beneficial results can be obtained if agricultural vegetation residues are composted, especially in areas with poor soil. Zero burning techniques, as outlined by the Association of South-East Asian Nations, should be applied where applicable to the region and the crops (ASEAN Secretariat 2003). Reduction and elimination of persistent organic pollutants from open burning may provide an opportunity to reform agricultural practices.

2.1.4 Alternatives, barriers to use and policy instruments to remove barriers

Alternatives vary by situation. Barriers include lack of education, lack of government will to reduce dependence upon open burning to accomplish goals, and lack of alternative machinery or processes

whereby open burning is an integral part of local agriculture. The sometimes high cost of alternatives in any form may be a barrier and, as with any reforms, economic instruments may be necessary or desirable to induce change. Demonstration projects and research in the regions may help understanding of the feasibility of alternatives.

2.1.5 Burning techniques and attributes, and means of improvement

Where open burning of biomass is permitted by government policy the process improvements noted in the general guidance should be implemented. Careful planning of prescribed burns modulated by weather conditions will allow greater control and the potential exposure of air pollutants to downwind populations should be minimized. After the fires, residue management may be an issue.

Application of chemicals in agriculture and forestry should be minimized consistent with local needs and good management. Where mechanical clearing and alternative use of harvested material is possible, incidental burns can be avoided; however, in certain local situations prescribed small burns may have a place in an overall land management scheme if used to prevent more devastating inadvertent burning with concomitant larger emissions of persistent organic pollutants. Recognizing that control of prescribed burns can be lost, fire abatement procedures (training, equipment, planning), infrastructure (access, roads) and management planning are all reasonable secondary support measures.

3. Open burning of mixed consumer waste

3.1 Household waste, landfill/dump fires, industrial non-hazardous waste

3.1.1 Material composition

Household waste and the composition of landfills and dumps may be qualitatively very similar. They differ importantly where modulated by programmes (such as recycling, scavenging, composting or other segregation) that remove specific streams from waste between collection point and repository. Non-hazardous waste may arise from commercial establishments such as shops, restaurants and light manufacturing. It will differ according to the exact commercial source but may contain many of the same materials found in household waste.

Open burning of waste has been the topic of significant study (Lemieux et al. 2003). However, there seem to be very few data regarding dump fires and persistent organic pollutants (Lemieux, Lutes and Santoianni 2004). Waste composition studies show variation in waste among countries and especially between developed and developing countries. In developing countries as much as 50% of waste composition may be putrescibles such as kitchen waste. In developed countries, more convenience packaging and electronics may be found unless these materials have been removed by other end-of-life systems. Significant differences may also exist between urban and rural waste and among wastes from different regions, regardless of development. In general, household waste streams and landfill waste will contain paper, plastic, organics such as food refuse, glass, metal, wood, leather and miscellaneous other materials. Under poorly controlled conditions, household hazardous waste such as cleaners, paints and solvents may find its way into a non-hazardous-rated landfill or dump.

Moreover, negative management approaches will change the composition and performance of a landfill or dump. In a modern, compartmentalized landfill, daily cover consisting of soil or clay will be added to the refuse to reduce not only the moisture content of the landfill but also the likelihood of spontaneous ignition. A traditional dump, by comparison, is rarely well organized and is more likely to burn spontaneously.

All disposal sites will generate some combustible gas (e.g. methane) from anaerobic degradation of organic materials contained within. Unless this gas is controlled it constitutes a highly combustible fuel for either spontaneous or illicit anthropogenic ignition. It is also a potent greenhouse gas. Methane collection systems have been designed and implemented as part of modern landfill technology, both for reasons of safety and potential energy recovery.

3.1.2 Barriers to elimination; remedies or policy to remove barriers

3.1.2.1 Household waste

Household waste will be burnt in the open where cost, convenience or local custom and social acceptability make that option attractive to individuals or groups of citizens. In cases where people live far outside municipal governance, options for waste disposal will undoubtedly be *ad hoc*. Without appropriate systems in place waste disposal may be *ad hoc* even within municipal governance.

In order to eliminate open burning, reasonable alternatives must exist and the public must be educated regarding their availability as well as the consequences of open burning.

Figure 3. Centralized sorting of waste for reuse and recycle

At-source or centralized collection, recycling, transport or other disposal must be made affordable, convenient and effective. Landfills must be designed and operated according to modern standards (Hickman and Eldredge 2004). If combustion is to be used, incineration using best available techniques, with energy recovery, is strongly preferable.

Governments must accept responsibility to create waste reclamation and disposal systems as a public utility or service. Countries and municipalities must then have the will to mandate an end to waste burning and accept the responsibility for enforcement of those laws. Additionally, where modern landfilling is an option, waste management plans and regulations must include provisions for establishing new landfills so as to maintain disposal capacity.

Simply accepting the responsibility for providing waste management systems may not in itself mean the end of open burning. Waste could be collected and deposited in landfills or dumps, which can themselves be sites for open burning. Policies and practices must be developed and applied to these centralized services. Spontaneous ignition and combustion can be reduced by collection of landfill gas or regulations requiring modern landfill construction techniques along with the permanent closing of obsolete dumps.

3.1.2.2 Accidental anthropogenic combustion

Accidental anthropogenic combustion in dumps can be reduced by prohibiting, licensing or limiting access to landfills and dumps. In many cases fires are set by scavengers living and working in these areas. Fires, accidental or intentional, can ignite discarded materials or landfill gas. Authorities must accept responsibility and enact regulations organizing scavenging activities, providing safe conditions for workers and limiting access to and overt residence on landfills.

3.1.2.3 Intentional anthropogenic combustion

Intentional anthropogenic combustion, that is, burning dump contents for volume reduction, must be prohibited by authorities. In order to avoid the need for dump burning sufficient planning must be

given to landfill size, space, location and management, as well as to waste reduction and elimination programmes so as to obviate the need.

Waste management is a system. Where the system works to make final disposal of true waste a collective responsibility rather than an individual responsibility, direct economic costs may rise, but in general environmental costs and impacts will fall.

3.1.3 Strategies and policy instruments to avoid, reduce or divert waste

3.1.3.1 Source reduction

Careful study of local waste composition may lead to specific programmes for reduction of large volume streams. As an example, in certain cases bulk purchase of products can reduce the need for individual product packaging. This and other strategies may be modulated by population density.

3.1.3.2 Composting

Where significant fractions of household waste will biodegrade, and where the population density will allow it, municipalities should provide education on cost- and space-effective composting. Included in this strategy is appropriate diversion of organic waste to animal feed or other similar productive use, modulated by a concern for spread of disease. Education must include means for vermin and disease vector control. Some organic wastes may contain persistent organic pollutants or materials that could be converted to persistent organic pollutants under composting conditions, and they should be treated separately in order to guarantee high-quality compost with low content of such pollutants (EPA 2005). In some cases, composting can be enhanced by substitution of certain biodegradable materials for alternatives.

3.1.3.3 Reuse

Where parts or entire devices can be recovered, washed, repaired or reclaimed as fabricated articles the need for disposal can be reduced. In many cases, involvement of labour in such reclamation and value creation can be more cost-effective and economically beneficial than the purchase of new devices.

3.1.3.4 Recycling

Many waste streams contain valuable, reclaimable items. Metals, glass, clean dry paper, corrugated board, cloth, plastics and wood are recyclable streams. Depending on the situation, centralized collection and recycling infrastructure can be cost effective. In other situations, simply providing a safe staging area at a disposal site and encouraging the development of markets for recycled materials can facilitate recovery by scavengers. This can greatly support employment creation, conservation of resources and poverty reduction strategies.

3.1.3.5 Incineration

In some situations incineration using best available techniques, especially with energy recovery, and open burning may coexist. Where they do, incineration is preferable to open burning, but may not be the only alternative. Authorities must take care to understand specific local barriers to the elimination of open burning in favour of less environmentally burdensome disposal, including source reduction, reuse, recycling and incineration using best available techniques. Collection and cost may be one such barrier; however, incineration using best available techniques, when coupled with energy recovery, may mitigate that cost and provide significant energy benefit.

3.1.3.6 Modern landfill

Given the differences between modern engineered landfills and unorganized dumps, modern landfill construction with collection of gas and leachate, and appropriate opportunity for recycling and reuse, is preferable to open burning. As noted above, authorities will need to accept that education and cost-effective waste disposal options must be provided if open burning is to be eliminated.

Modern landfills differ from dumps in many ways. As engineered constructions, they are typically safer, more sanitary and less prone to anthropogenic combustion. They also require active

management and security measures to exclude unauthorized people (e.g. scavengers) and may be relatively more expensive than open burning or low-tech dumping.

Policies that prohibit disposal of hazardous industrial and infectious wastes in the normal waste stream will enhance the safety of the municipal disposal system. Governments can encourage effective use of alternative methods listed above by implementing legal restrictions on open burning; mandates for composting, recycling or recovery; taxes on excessive waste placed into the disposal system; or institution of lower-cost and more convenient resource management systems.

3.1.4 Alternatives, barriers to use and policy instruments to remove barriers

Strategies for waste reduction and available alternatives to open burning are largely the same.

3.1.5 Burning techniques and attributes, and means of improvement

Where none of the previously mentioned alternatives are feasible or when alternatives cannot be implemented in a timely fashion, governments may wish to educate citizens on ways to reduce the impacts of open burning. Those process improvements have been outlined in the general guidance.

3.2 Construction, demolition and post-disaster debris

3.2.1 Material composition

3.2.1.1 Construction waste

Construction waste will consist of the usual materials of construction and potentially the packaging in which the materials are brought to the site (e.g. pallets and sacks). Materials of construction of buildings vary by size, type and geographical location. Types of buildings, whether commercial, office, or residential, will differ significantly between developed and developing countries and among regions. Common combustible materials of construction include wood, paper and other cellulosics, asphalt, paint and various plastics. Metal contamination of combustibles is not unknown.

3.2.1.2 Demolition waste

Demolition waste, particularly post-disaster debris, will contain other occupant belongings. These materials also vary with the type of building, geography and development of the economy. Partially burnt remains of a fire in an industrial operation may also qualify as post-disaster debris or hazardous waste.

For dwellings, this similarity will be to household waste, and will be greater in developing countries; in developed countries there will be a greater proportion of fabric (clothes), foam (furniture), rigid plastics (appliances) and fibre (carpeting).

For commercial buildings the contents will be representative of the business and will include furnishings and fibre similar to those in dwellings, as well as electronics and volumes of paper (offices) or concentrations of products for sale.

3.2.2 Barriers to elimination; remedies or policy to remove barriers

Intentional combustion of waste derived from construction or demolition is a matter of low cost and convenience at the job site. It is done due to sanitary needs, the cost of removal, the inconvenience of on-site burial or unavailability of alternatives. While it is a poor practice and should be avoided under any but the worst circumstances regarding public health, the intentional combustion of post-disaster debris is known due to unavailability of alternatives, desire to avoid massive use of landfill space or for convenience in clearing areas after earthquake (Nakao et al. 1997). The issue, nominally, is cost, whether expressed as direct cost or the cost of development or use of other disposal means.

3.2.3 Strategies and policy instruments to avoid, reduce or divert waste

Clean, uncontaminated construction waste can be collected and sorted with usable materials diverted to other construction, shredding for mulch and material recycling. Demolition, when done as disassembly, can yield many fixtures suitable for resale and reuse. Materials from demolition that cannot be reused or reprocessed can be separated and disposed of, much as construction wastes.

While in theory the strategies used for treatment of construction and demolition waste can also be used for post-disaster debris, the scale can be enormously different. After a disaster there may be no choice but to move material to a landfill site, allowing scavenging as usual or conducting recovery operations there. Landfilling without scavenging or incineration using best available techniques may be the best options in an emergency, depending on exact circumstances.

Governments can, and some do, prohibit the open burning of construction and demolition debris. Where there is poor waste management infrastructure, many of the same instruments used in the recovery of household waste may be useful for construction and demolition materials.

3.2.4 Alternatives, barriers to use and policy instruments to remove barriers

As outlined above, the alternatives for waste disposal on construction and demolition sites are collection, separation, disassembly, resale, reuse and recycling. These processes can be economically viable or can be made so by changes in laws or regulations governing disposal of these materials. Such instruments include bans on open burning, removal of taxes and other financial barriers on landfill disposal of construction and demolition material, or economic instruments promoting recycling or reuse. In many cases, the resale of building fixtures is encouraged and economically viable; this is particularly true in developing countries.

Additionally, contracts for construction can be written to specify removal of debris as a responsibility of the contractor. Acceptable means of disposal can also be specified by contract.

3.2.5 Burning techniques and attributes, and means of improvement

For these materials the same general guidance holds as outlined elsewhere in the document. Open burning should be a last resort and should actively exclude materials that do not burn well or at all.

4. Open burning of specific materials and miscellaneous

4.1 Agricultural plastic

4.1.1 Material composition

Agricultural film is usually made from polyethylene due to cost but ethylene-vinyl acetate copolymer (EVA) is also often used. PVC has been used previously, but appears to be less common today. Among other uses, agricultural film is used for covering fields in early season to warm the ground; as bale wrap; as bags for silage, fertilizer or agricultural chemicals; and as greenhouse film. Some specialty suppliers offer material specified to be degradable, though this requirement is not universal.

Rigid plastic containers of pesticides or other agricultural chemicals may be found as well. Bags are usually low-density polyethylene; bottles, drums and tubs are usually high-density polyethylene, a multilayer polyethylene, or a polyethylene container whose interior surface has been treated to reduce interaction with the product contents. One report discusses experiments burning bags containing residual pesticide but finds PCDD/PCDF only “at very low levels”, and blanks for both air emissions and solid residual (Oberacker et al. 1992). Following published procedures for rinsing containers and treating the rinse water properly will significantly reduce this already low possibility.

4.1.2 Barriers to elimination; remedies or policy to remove barriers

Material located far from normal waste collection will be discarded using the lowest-cost and most convenient method. Burning could be reduced by institution of a collection scheme for the material, particularly if many farmers in an area use the same material. Governments can also institute education programmes and laws prohibiting burning, supporting recycling and developing economic instruments to support such initiatives.

4.1.3 Strategies and policy instruments to avoid, reduce or divert waste

Agricultural film is recycled extensively in some countries. This is facilitated when material is collected explicitly. Where there is no opportunity for recycling other forms of disposal are utilized, including landfill. Use of additives such as UV-inhibitors can extend the life of greenhouse films and

reduce the need for disposal. In the absence of specific programmes, materials used for wrapping bales or bagging compost is discarded in the same way as any packaging in a particular area. In some areas, film can be recycled explicitly, compounded into wood-plastic composites or processed into refuse-derived fuel for combustion in an incinerator using best available techniques. For plastic bottles, the World Health Organization recommends triple-rinsing, then puncturing and burying them (Rosendaal 1997, ch. 10).

4.1.4 Alternatives, barriers to use and policy instruments to remove barriers

Strategies for waste reduction and available alternatives to open burning are largely congruent.

4.1.5 Burning techniques and attributes, and means of improvement

Agricultural film, while combustible, because of the way it has been manufactured, will tend to melt and shrink. Proper incineration could depend on shredding to increase surface-to-volume ratio or relatively slow feeding of material. High-temperature, well-ventilated combustion is possible, but may be challenging on a large scale if film is the only material burnt.

Bottles may not burn well due to their surface-to-mass ratio even if dry and combustible. Alternative fuel may be required and should be material consistent with the general guidance.

4.2 Tyres

4.2.1 Material composition

Tyres are a composite of styrene-butadiene copolymer or natural rubber, chloroprene, polyamide, steel wire, carbon black and numerous other organic and inorganic additives. Tyres contain low concentrations of chlorine; they also contain significant sulphur, similar to that of medium sulphur coal, as a result of vulcanization. Sulphur inhibits formation of persistent organic pollutants in combustion; the probability for generation of chlorinated persistent organic pollutants in this waste is probably lower than for mixed waste. However, poor combustion of large volumes of tyres in open burning situations is a source of PCDD/PCDF and will certainly be a prodigious generator of other hazardous pollutants, including SO_2 and polycyclic aromatic hydrocarbons.

4.2.2 Barriers to elimination; remedies or policy to remove barriers

Ignition of tyre fires can be natural (lightning) or anthropogenic. Tyre dumps present a number of hazards, including culture of insect disease vectors. Additionally, they occupy large spaces. Anthropogenic burning of tyres can and has been undertaken to alleviate either of these problems.

4.2.3 Strategies and policy instruments to avoid, reduce or divert waste

Worn tyres can be retreaded and reused in many cases. Modern technology has extended the life of the average tyre by a factor of ten over the past thirty years. Utilizing tyres with the longest life minimizes the need for disposal. Alternatively, they may be recycled to various uses, either whole or as shredded material. Whole, or preferably shredded, tyres can be landfilled. However, whole tyres and similar articles like uncrushed bottles may tend to float to the surface of a dump. Collection of tyres in above-ground dumps constitutes an eyesore and a hazard for insect control and potential for uncontrolled combustion.

4.2.4 Alternatives, barriers to use and policy instruments to remove barriers

Waste tyres may be reused whole, shredded or cryoground into powder. Processed tyres may be used in rubber-modified asphalt for road surfacing materials. Shredded and ground tyres have also been compressed and used in building materials. Shredded tyres are used as a cushioning material for playgrounds. Additionally, tyres may be pressed into service as materials for fabrication of articles including fencing, reef creation, soil erosion control, sandals, doorstops and waste bins, recognizing that as a composite, thermoset material recycled rubber is subject to certain processing constraints. Use of whole tyres above ground must take into consideration and mitigate their tendency to collect water and harbour insect infestation.

If shredded and whole tyres are to be combusted in cement kilns, it must be done under proper combustion conditions and operation corresponding to best available techniques as described in section V.B of the present guidelines. Thus, kiln should meet the PCDD/PCDF performance level in air emissions associated with best available techniques (< 0.1 ng I-TEQ/Nm^3). Releases of chemicals listed in Annex C via cement kiln dust and possibly clinker have been reported, however, and are currently under further investigation.

4.2.5 Burning techniques and attributes, and means of improvement

Open burning of tyres results in the formation and release of chemicals listed in Annex C. As a mass or in dumps there is virtually no way in which the open burning of tyres can be improved; in addition, extinguishment of large-scale fires is almost impossible and they may burn for years.

4.3 Oil spills and gas flares

4.3.1 Material composition

Crude oil, natural gas and associated gas consist largely of carbon and hydrogen with smaller constituent amounts of oxygen, sulphur and chlorine. As found in nature, or as a result of recovery techniques, they may also contain salt or salt water. Particularly of concern is combustion of oil spilled on ground that contains salt or other chlorinated materials, or on seawater, or combustion of oil contaminated by intrusion of water into wells drilled near a saline body of water. Spilled oil from pipeline breaks has been burnt to mitigate potential contamination of a frozen river (Kruglov, Amirova and Loshkina 1996).

The open burning of oil from off-shore facilities under certain circumstances may be a significant emission source. For accidental spills of oil, biological remediation methods may be useful in some circumstances.

4.3.2 Barriers to elimination; remedies or policy to remove barriers

Barriers to elimination include considerations related to cost, convenience and safety, and lack of alternative recovery or disposal methods.

4.3.3 Strategies and policy instruments to avoid, reduce or divert waste

Gas flaring is common. To the extent that this is a waste issue and not one of recovery from accident, better procedures for handling materials or recovery for sale may improve normal performance.

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