

## GCI TECH NOTES©

### GCI 的工艺摘要

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#### 水泥厂接受和拒绝的危险废物燃料

### Acceptance and Rejection of Hazardous Waste Fuel

#### at Cement Plants

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#### 引言 Introduction

The acceptance or rejection of individual shipments or drums of hazardous waste at hazardous waste fuel blending or burning facilities must focus on five key factors needed to ensure the success of a project. This review of the parameters associated with each of these five areas will demonstrate the importance of thorough laboratory analysis of each shipment of waste received at the facility. Based on the relative consistency and sources of other alternative fuels and raw materials (AFR) many of these same factors may be applied to other AFR programs as well.

在危险废物调配设施,或者燃烧废物燃料的水泥厂,接受或者拒绝个别批量,或桶装的危险废物,必须特别注意五个关键因素,以保证项目[指 AFR 项目]的成功. 最重要是每批交到设施来的废物,必须由化验室对进行的彻底分析,并对这五方面的每一个参数进行审查. 如果其他另类燃料和原料的相对稠度和来源相同,这些因素可能适用于其它的 AFR【注 1】项目上。

#### 燃料质量 Fuel Quality

The first and perhaps most obvious criteria in the acceptance or rejection of a shipment is whether or not the waste is a fuel. Generally this requires a heat content analysis. Many facilities have added the criterion of total water content to this portion of the evaluation as well.

在接受或拒绝一批交来的废物这问题上,首先最明显的准则就是[确定]那废物是否可以作燃料. 通常就是需要做一个热值的分析. 就是设施[指废物调配厂或水泥厂]有额外的准则;就是评估这部分废物的总含水量。

## 保护产品和工艺过程 Process and Product Protection

Product and process protection requires analysis and control over a wide variety of parameters. These include halogens, sulfur, selected metals, radioactivity and ash as examples that protect the kiln system and clinker product. There is also the need to protect the storage and feed system. Incompatible wastes that can gel or react must be avoided, pH must be controlled to prevent corrosion and viscosity may need to be controlled to maintain pumpability of liquid wastes. All of these parameters can be tested using high-speed methods of analysis. By implementing a system of data quality objectives (DQOs) it is possible to avoid analytical burdens that go beyond what is actually needed.

## 保护人们的健康和安全 Protection of Human Health and Safety

Protection of human health and safety is one of the most important functions performed by the analysis of the waste streams. Unfortunately, it is often the most overlooked both by operators and regulatory authorities. Employees involved in operating the hazardous waste fuel blending, storage and feeding systems as well as laboratory workers and samplers are the most "exposed" and any program for controlling receipt of wastes must take into account the worst case as well as normal exposure levels of these individuals to the waste.

It is for this reason that it is critical that there be an organic analysis of every waste stream prior to shipment to the plant and a second organic analysis upon receipt to confirm that there are no compounds or combinations of compounds that could result in either acute or chronic toxic exposure. Examples of wastes that have been received and potentially endangered employees at hazardous waste facilities are numerous. A few are listed below:

为了保护产品和工艺过程，需要进行分析，并且对广泛的参数加以控制。这些包括卤素、硫、指定的一些重金属、放射性和灰分，是为了保护水泥窑系统和熟料的产品。也是为了要保护储存库和喂料系统。不相容的废物会形成黏胶或者有反应的必须避免，pH 值必须予以控制防止腐蚀，液体废物的粘度可能需要恰当控制以保持液体废物的可泵性。所有这些参数都可以用快速的分析方法测试。只要履行数据质量目标的程序 (DQOs)【注 2】可以避免超过实际需要的繁重分析。

对各种废物进行分析时，最重要的职责就是保护人们的健康和安全。很不幸，那是经常被经营者和监管当局所忽略。员工参与危险废物燃料的调配、储存和喂料系统的工作、还有化验室的工作人员和取样人员，他们是最有可能被‘暴露’于废物中，并且任何控制于收取废物时发生意外的措施，必须考虑到最坏的情况，和这些人暴露于废物中的正常水平。

基于这个理由，最要紧的是于每一批废料在发送前作个有机分析，待收货时再做第二次有机分析，以确证无化合物或者化合物的混合体会使操作人员，急性的或慢性的暴露于有毒物质中。危险废物燃料生产设施所收到的废物，对工作人员有潜在危害的例子有很多，一部分列出如下：

Propylene glycol dinitrate - This is a component in "Otto Fuel II" which is torpedo fuel. In the mid 80s an incinerator in North Carolina receiving this waste allegedly caused the chronic poisoning of a number of employees. At low levels this compound is a chronic nerve toxin. It has an ACGIH skin exposure based TWA TLV of .05 ppm.

Toluene diisocyanate (TDI) - TDI is a common industrial chemical used in numerous chemical manufacturing processes including the production of polyurethane foams. It has an ACGIH TWA TLV of .005 ppm. A few years ago it in combination with other TDI production wastes and chlorobenzene was involved in the explosion of a rail car at a cement plant where it was being used as waste fuel. This material is highly water reactive and can react with itself when heated producing gas, heat and pressure. The resulting explosion caused considerable damage at the plant.

Amines - As a general class there are many amines with ACGIH TWA TLVs of close to 1ppm. Further, amines can be involved in hazardous polymerization reactions with some compounds found in liquid hazardous waste fuels such as vinyl acetate. In one case amines were added to a tanker of hazardous waste fuel to adjust the pH of the material. It was then shipped to the cement plant. Upon arrival at the cement plant the increase in temperature that had occurred inside the insulated tanker created fumes that almost overwhelmed the truck sampler when he opened the truck hatch even though he was wearing a full-face organic cartridge respirator. The hot tanker required implementation of the facility's emergency response plan.

丙二醇二硝酸盐 (Propylene glycol dinitrate) - 这是“Otto Fuel II”的组成部分，是鱼雷的燃料。上世纪80年代中期在[美国]北卡罗里那州的一个焚烧废物的设施里收到这种废料，据说令一部分的员工慢性中毒。于低水平时这种化合物是一种慢性的神经毒素。它有一个最高核准的暴露浓度【注3】为 .05 ppm (百万分之0.05)

二异氰酸甲苯 (Toluene diisocyanate - TDI) 是一种通用的化工品，用于多种化学制造工艺程序中，包括生产聚氨酯泡沫塑料 (Polyurethane foams)。它的最高核准的暴露浓度是 .005 ppm (即百万分之 0.005)。几年前一辆铁路卡车在一家使用废物燃料的水泥厂内发生爆炸，卡车内载有它与其他生产 TDI 的废料和氯苯 (Chlorobenzene) 混合是爆炸的原因。这种废料对水有高度的反应，而且经加热后会有自身反应，产生热量和压力。爆炸对水泥厂造成重大的损失。

胺 (Amine) - 作为一个通常的级别胺有好多种，它的最高核准的暴露浓度是 1ppm (即百万分之一)。还有，胺与一些液体的危险废物中找到的混合物，如乙烯基乙酸盐 (Vinyl Acetate)，会促成危险的聚合反应。曾经有一次，胺被注入载有危险废物的罐车中以调较物料的 pH 值，然后运送到水泥厂。到达水泥厂的时候由于温度上升，在密封的罐车里产生烟雾，当打开罐车的舱盖时，那个卡车上的取样人员几乎晕倒，虽然当时他配载着覆盖整个面部的有机呼吸装备。水泥厂需要启动紧急应变步骤来处理那辆罐车。

There are numerous other examples. Only through thorough analysis of the waste and expert review of the resulting data can these types of incidents be avoided. Our next issue will discuss options for setting up a system to fully utilize the results of organic analyses to protect employee health and safety.

## 保护环境 Environmental Protection

Generally speaking if the process and product are protected and the individuals handling the waste are protected there are only a few additional concerns that need to be addressed relative to protecting the environment. One of these is mercury (Hg). Other semivolatile heavy metals such as cadmium (Cd) and lead (Pb) may also need controls beyond that required to protect product quality in order to protect the environment. As with all the analytical requirements discussed, careful development of DQOs can significantly reduce the analytical burden and make the testing of every shipment of waste received a cost effective option for reducing costs attributable to actual and potential liability.

## 遵守许可和法规 Compliance with Permits and Regulations

One might be tempted to believe that these criteria would have already been covered by protecting people and the environment. Sadly this is not the case. Quite often the regulatory authorities implement requirements that are unrelated to protecting human health and safety or the environment. A good example is the common restrictions on PCBs and dioxins in waste fuel used in cement kilns. While these compounds are completely destroyed in cement kilns it is nevertheless common to see their receipt restricted at waste fuel facilities due to public misconceptions regarding toxicity of (non-existent) emissions. It is therefore virtually always a requirement that an analysis for PCBs be performed on a waste fuel sample prior acceptance as fuel.

The method for rapidly doing this using gas chromatography was developed by this author over 20 years ago and current technology allows this to be done within 20 minutes of receipt of the sample in the lab.

还有好多其他的例子。只有对废物进行彻底的测试, 和专家的审查得到的数据才能避免这类事故。我们以后再讨论选择建立一个系统, 尽量利用有机分析的结果来保护员工的健康和安全。

总的来说, 如果保护了工艺程序和产品, 并且也保护了处理废物的人员, 那么剩下需要关心的事, 就是与保护环境有关。其中之一就是水银(Hg)。其他半挥发性的重金属如镉(Cd)和铅(Pb)也需要在范围内, 以保护产品的质量, 也为了保护环境。就像已经讨论过的所有关于分析的要求, 审慎发展数据质量目标 (DQO) 能在很大的长度上减轻繁重的分析, 而实际上对每批交来的废物进行测试是一个节约的选择, 甚至会减少由于实际事故责任导致的赔偿。

也许有人会想说那些准则和法规早就有了。可惜并非如此。经常规管当局履行规定与保护人们的健康和安全, 或者是与保护环境扯不上关系。在美国有一个很好的例子, 就是限制水泥厂使用的废物燃料中的多氯联苯(PCB)和二恶英, 虽然实际上这些化合物最终可在水泥窑里彻底被销毁, 然而由于公众对排放的毒性(其实不存在)的误解和政治压力(见下面【后记】), 法规终于被通过, 所以一直以来都规定, 在接受废物燃料的样品时须作 PCB 的分析。既然有法律那也只好遵守。

有一个加快的办法来做这个分析, 是用本文作者于 20 年前发展出的气相色谱法, 现代的科技可以使这项工作收到样品后的 20 分钟内完成。

**【注1】** AFR = Alternative Fuel and Raw Material 即另类燃料和原料，指水泥厂利用废物提炼而成的另类燃料和作为补原料。AFR 项目指水泥厂利用废物的项目。

**【注2】** 数据质量目标的程序有七个步骤，下列网页有概括的说明  
The DQO process is a seven-step process summarized at  
<http://gcisolutions.com/AWMADG99.htm>

**【注3】**原文 ACGIH TWA TLVs 最高核准的浓度（化学污染物浓度在人体代谢仍未受影响情况下之最高值），也就是人在一个 8 小时的工作天内[毒素]的浓度绝对不能超过这个限度，以保障工作人员不会受到伤害。

**ACGIH (American Conference of Governmental Industrial Hygienists  
Threshold Limit ...** 美国政府工业卫生专家会议所订的[毒气浓度]门槛限度

**TWA (Time-Weighted Average)** 时间与重量平均[暴露]

**TLV (Threshold Limit Value)** 最高允许的浓度

### 【后记】

It is not uncommon in the US (and elsewhere I think) for regulations to be based on public perceptions and political decision rather than real scientific data. That is certainly the case with PCBs. PCBs are not really that toxic to humans - they do cause problems with birds. Because of misconceptions EPA passed very tough regulations banning PCBs and regulating their disposal. In most situations it is just not wise for a cement kiln to burn or even consider burning PCBs because of the negative publicity. Only in Norway is this done - and very successfully - they paid more attention to real science.

有一种情况在美国那并非不普遍(相信其他国家都一样)，那就是法规往往是根据公众的感受和政治的决定，而非基于真正的科学数据。对 PCB (多氯联苯)的情况就是这样。PCB 对人类不是那么有毒 - 但是对鸟类却有问題。由于公众的误解[美国]环保当局通过了严厉的法规，严禁 PCB 并控制它的处置。在几乎所有的情况下由于负面的宣扬，水泥厂焚烧含 PCB 的废物燃料是属不智之举。当今世上只有挪威王国是利用水泥窑处置含 PCB 的废物，而且很成功，因为他们更注重真正的科学。

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