Merck & Co., Inc
P.O. Box 7
Elkton VA 22827
Tel 540 298 1211

MERCK
Manufacturing Division

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To: Merck Project XL Stakeholders

From: Tedd Jett

Subject: **Final Project XL Permit Support Document**

The final Merck Project XL PSD Permit Support Document, excluding the appendices which have not changed since the 2/7/97 distribution, is enclosed. A few final changes to the document that were made at the request of EPA Region III or the National Park Service are highlighted with revision marks on the affected pages, which are also enclosed.

Tedd

Merck Project XL
PSD Permit Support Document

This document was prepared by Merck & Co., Inc.
on behalf of EPA and the Merck XL Project team.

Revised 2/14/97

Merck Project XL
PSD Permit Support Document

Table of Contents

I. Introduction

A. Overview Of Project

In March 1995, President Clinton announced several new initiatives for reinventing government, including Project XL, an approach to allow companies, communities and government to achieve better environmental progress at less cost, outside the constraints of existing regulations. The Environmental Protection Agency (EPA) selected Merck & Co., Inc.'s (Merck's) proposal as one of the initial pilot projects in the United States for this new initiative. On February 7, 1996, Merck kicked off a project to deliver superior environmental protection while allowing flexible operation at its pharmaceutical manufacturing facility in Elkton, Virginia.

Merck, along with representatives from EPA, the Virginia Department of Environmental Quality (VADEQ), the National Park Service (NPS), and the local community (the project signatories), and other interested parties, developed a simplified air permit for the facility that will cap total air emissions of criteria pollutants at less than recent actual levels and allow the facility to make changes and additions to its manufacturing processes as soon as they are needed without prior approval. The upfront environmental benefit which will enable Merck to operate flexibly under the emissions cap will come from converting the powerhouse from burning coal to natural gas. This conversion will significantly reduce the site's actual air emissions for several pollutants.

The XL project will provide the Stonewall plant with an incentive to minimize actual emissions, thus preserving an operating margin for future growth and expansion when production is needed for new products. It will allow Merck to avoid the costs associated with months of permitting delays in the introduction of new medicines to the market.

This document describes this innovative Prevention of Significant Deterioration (PSD) permit (herein referred to as the permit). It provides an overview of how the permit will operate, and the underlying intent of various permit terms.

B. Description Of Stonewall Site

Merck & Co., Inc. is a worldwide research-intensive health products company that discovers, develops, manufactures, and markets human and animal health products. Merck's Stonewall Plant (herein referred to as the site or facility), located near Elkton, Virginia, was established in 1941. Currently, the plant employs about 800 people in a range of pharmaceutical manufacturing (batch processing) activities such as fermentation, solvent extraction, organic chemical synthesis, finishing and packaging operations. The facility's products include broad spectrum antibiotics, anti-parasitic drugs for human and animal health, a cholesterol lowering drug, and medicines for the treatment of Parkinson's disease and human immunodeficiency virus (HIV).

The Stonewall Plant is located within 2 kilometers of the Shenandoah National Park, a federal Class I area. The facility's proximity to this important natural resource highlights the need for serious consideration of opportunities for better protection of the environment.

C. Description Of Implementation Mechanisms

The PSD permit is the primary mechanism to implement this innovative XL project. All requirements and operational flexibility provided under the project are specified in the permit. A number of mechanisms will be needed to allow the permit to be issued as drafted by the Project XL stakeholders.

First, EPA plans to promulgate a rule that applies specifically to the Stonewall site which modifies regulations promulgated under certain sections of the Clean Air Act (CAA), including the federal New Source Review (NSR) rules, as well as modification of the Resource Conservation and Recovery Act (RCRA) regulations, pertaining to the RCRA organic air emission standards. Second, the Virginia State Air Pollution Control Board intends to issue a variance to the Stonewall site that provides the legal basis for the Virginia Department of Environmental Quality (VADEQ) to issue the PSD permit. The site-specific rule and the variance will provide the legal framework for the innovative permit to be issued and to take effect.

In addition to these administrative actions, VADEQ will issue a letter to Merck clarifying the regulatory interpretations that it intends to make with regard to the site's Title V operating permit application. EPA intends to express their concurrence with these interpretations in a letter. The site is expected to submit a Title V permit application in mid-1997. VADEQ also intends in the near future to promulgate a site-specific rule to incorporate in the Virginia regulations the various regulatory actions taken in the Air Board's variance. This rule would be submitted to EPA for approval in the Virginia State Implementation Plan (SIP). EPA agrees with this approach and intends to propose approval of such a SIP change. In this way, the legal basis for issuance of the permit will reside in both Virginia and EPA regulations.

II. Description Of PSD Permit

A. Overview

The PSD permit consists of 12 sections, containing all the requirements that will be imposed on the Stonewall site related to this project:

- Section 1 establishes the site-wide emissions caps, the mechanisms for adjusting those caps, and requirements for operation under the caps.
- Section 2 contains the requirement to convert the existing powerhouse from burning coal to natural gas. It also describes the regulatory status of the new boilers.
- Section **3** specifies the rules which the site-specific rule and variance replace; thus compliance with the permit constitutes compliance with these rules.
- Section 4 and Table 4.2 contain the monitoring, recordkeeping, and reporting requirements associated with the permit.
- Section 5 specifies how the main sections of the permit will be phased in.
- Section 6 provides a mechanism for periodic review of the permit by the project stakeholders.
- Section 7 specifies the duration of the permit.

- Section 8 describes the circumstances under which the permit may be terminated, and the procedures for bringing the site back into the current regulatory system.
- Section 9 contains several standard permit provisions relating to inspection and entry of the facility.
- Section 10 specifies the reservation of the project signatories' rights under the permit.
- Section 11 addresses what happens to the permit if the ownership of the site is transferred to another party.

a Section 12 contains definitions relating to the permit.

Each of these sections is discussed below.

B. Tour Through The Permit

1. Site-Wide Emissions caps

a) Setting of the Emissions caps

The permit establishes four site-wide air emission limits: a cap on the site's (1) total criteria pollutant emissions, (2) sulfur dioxide (SO_2) emissions, (3) particulate matter with aerodynamic diameter less than 10 microns (PM-10) emissions, and (4) oxides of nitrogen (NO,) emissions. These caps operate to limit the site's actual emissions of each respective pollutant, calculated on a 12-month rolling basis. They represent permanent limits on the facility's emissions for the life of the permit. Criteria pollutants are defined in the permit (Section 1.1.1) as ozone, using volatile organic compounds (VOC) as a surrogate, SO_2, PM-10, carbon monoxide (CO) and NO,.

For example, the site's total criteria pollutant emissions for the prior 12 months is calculated and compared to the total criteria pollutant emissions cap. The permit requires (Section 1.3.1(a)) that the 12-month total shall not exceed the total criteria pollutant emissions cap. Similar calculations are required to be performed monthly for the SO_2, PM-10 and NO, site-wide totals (Section 1.3.1(c)), and comparisons to the respective caps made (Section 1.3.1(b)).

A cap on lead emissions was not included in this project, because the site's lead emissions are very low, and will be essentially eliminated by the conversion of the powerhouse from coal to natural gas. Instead, the XL project team agreed to exclude lead from the emission caps, and to manage lead emissions according to the existing permitting and environmental control regulations in place.

The caps are based on the site's actual emissions averaged over 1992 and 1993, also known as the baseline. The baseline emission levels and the site-wide caps are provided in Table 1.1 of the permit; the Baseline Emissions Support Document provides the background information in support of this baseline (Appendix 1). The stakeholders have determined that 1992 and 1993 are most representative of recent operating levels at the site. The years 1994, 1995 and 1996 were deemed not representative due to shutdown of a major pharmaceutical process which resulted in site-wide emissions which were not representative of typical production at the plant. The most significant addition to the facility was the process to manufacture CRIXIVAN®, Merck's protease inhibitor drug for the treatment of human immunodeficiency virus (HIV). The process began operating in mid-1996. Other process shutdowns and construction activities during this time prevent these years from being representative of recent facility operating levels.

The baseline level is, in fact, significantly less than the emission levels that are allowed under the site's existing preconstruction permits. For example, the site's powerhouse was operating at an average rate of 60% of its capacity during the baseline years. Allowable[1] emissions of criteria pollutants from the site were approximately 2700 tons per year (TPY), compared to the baseline of 1503 TPY.

Establishing the emissions caps, which essentially will be the site's new permitted emission rates, at a level based on the facility's recent actual emission rates provides environmental benefit upfront. The environmental benefits derived from setting emission caps is explained below. The margin to allow the facility to operate below the baseline level will be provided by converting the powerhouse from burning coal to natural gas. The conversion will be a permanent physical change to the Stonewall site, and will result in an approximate 950 TPY emission decrease of total criteria pollutant emissions.

b) Features of the Emissions caps

The emissions caps differ from traditional source-specific emission limits in a number of ways. First, the caps apply to the whole site, rather than an individual source. The existing air permitting regulations allow certain sources to operate without emission limits, including sources in operation prior to the enactment of air regulations ("grandfathered" sources) and sources that fall below permitting thresholds. Emissions from these sources would be included in site-wide totals when determining compliance with the emissions caps. Compliance with the emissions caps will be determined monthly, on a 12-month rolling total basis. The caps would also immediately apply to any new or modified emission source constructed at the site. The traditional system would allow site-wide emissions to increase without PSD/NSR or minor NSR review by the permitting authority if only projects with emissions increases below permitting thresholds were installed at the site. This permit removes this allowance by including even these small sources in the emissions caps.

Second, the caps represent the maximum emission rate that the entire Stonewall plant can achieve for the life of the permit. The existing permitting program does not limit the site's ability to increase emissions through obtaining new permits. Provided that the facility follows the permitting procedures and installs emission controls as mandated by the permitting authority, the existing permitting system allows the site to obtain a permit for a new source -- essentially increasing the plant's allowable emission rate. This PSD permit will eliminate the site's ability to increase allowable emissions through obtaining new permits. The emissions caps represent the site's permanent limit on emissions for the life of the permit.

Third, the caps are based on the site's recent actual emissions, rather than the source's potential emission rate. Traditional source-specific emission limits are typically set at the new source's emission rate when operating at its maximum capacity -- otherwise known as its potential emission rate. In this way, a new source may operate up to its maximum capacity without

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[1] Allowable emission rates include permitted emissions as well as emissions from unpermitted sources operating at physical capacity.

violating its specific permit limit. Obtaining such a permit limit is often predicated on installation of certain control technology. This PSD permit establishes site-wide emission limits that do not guarantee that sources will be able to operate at their maximum capacity. Rather, the site has a certain operating margin -- the difference between the emissions caps and the site's actual emissions. Installation of a new emission source will consume a certain portion of this margin; under this permit the site would no longer be able to obtain new permits to increase the site-wide emission totals, and it would have to be very judicious about how this margin is used. In this way, this permit provides a direct incentive for the site to minimize emissions, in order to preserve the operating margin. The site has the incentive to install controls on new sources in order to minimize the consumption of the margin. The permit replaces the permitting authority's assessment of what controls should be installed with the direct incentive to minimize emissions in order to preserve the operating margin under the emissions caps.

c) Operation of the Individual Pollutant Caps

The primary effect of the total criteria pollutant emissions cap is to provide a significant incentive to minimize the site's total criteria pollutant emissions. It motivates the facility to find emission reductions in the most cost effective manner, regardless of the location on the site or which criteria pollutant is being emitted. Consequently, it rewards the site with operational flexibility for maintaining a margin between the site's actual criteria pollutant emissions and the cap.

While the individual pollutant emissions caps -- SO_2, PM-10 and NO, -- also provide some incentive for minimizing emissions of these individual pollutants, this is not their primary purpose. The individual pollutant caps were established to ensure that the only significant emission increases allowable at the site over the baseline levels will be for the pollutants not covered by individual caps: VOCs and CO.

The total criteria pollutant emissions cap will be set at 1202 TPY, which is 20% less than the baseline level. The operating margin for the site will be created by converting the powerhouse from burning coal to natural gas, resulting in decreases in SO_2 and NO, emissions by over 900 TPY. This will provide an initial operating margin of approximately 600 TPY. Individual caps are set for SO_2 and NO, at 539 and 262 TPY, respectively, which are 25% and 10% below their baselines, and for PM-10 at the PM-10 baseline of 42 TPY.

After the powerhouse conversion and the resulting substantial emissions decreases, the permit allows emissions at the site to increase, but not over the 1202 TPY total emissions cap. In addition, emissions of SO_2, PM-10 and NO, may not increase over their respective cap levels. VOC and CO emissions may increase above their baseline levels -- since no individual caps were set for these pollutants -- so long as the site's total criteria pollutant emissions do not exceed the total criteria pollutant cap.

The result is that future VOC and CO emission increases will be allowed by upfront decreases of SO_2 and NO, from the powerhouse conversion. This exchange is a more reasonable way to implement the objectives of PSD in this site-specific situation because SO_2 and NO, have a more critical environmental impact in the area than VOCs or CO. SO_2 and NO, contribute to atmospheric visibility problems and acid rain; NO, also contributes to the formation of ozone in the lower atmosphere. Reduction of these pollutants will contribute to an improvement of regional concerns with visibility, acid rain and ozone.

VOC emissions have much less impact on regional air quality in the area affected by the site's emissions. The two main contributors to ozone formation are NO, and VOCs. Since the area is NO, -limited for ozone formation -- meaning that changes in NO, emission levels are the limiting factor in formation of ozone -- VOC increases generally will not result in creation of ground level ozone.

Merck retained Mr. John Calcagni of Systems Application International (Research Triangle Park, NC) to provide the stakeholders with a scientific evaluation of the relative benefits of SO_2, NO„ VOC and CO reductions on regional air quality. This evaluation explains the effects of VOC and CO increases and SO_2 and NO, decreases, and provides support for the basis for the permit (Appendix 2).

Even though the emissions caps represent the site's new permitted emission rates, the permit allows for three circumstances for which the caps could be adjusted, as described below.

d) Initial Adjustment of Emissions caps

Additional upfront environmental benefit will be provided by further reducing the emissions caps once the powerhouse conversion is completed. The powerhouse conversion is estimated to result in the following changes in actual emissions relative to the baseline, based on the 60% powerhouse operating rate that occurred during the baseline period and assuming 20 days per year #2 fuel oil used as the backup fuel:

- SO_2 emissions decrease by 679 TPY (a 94% reduction from the SO_2 baseline).
- PM-10 emissions decrease by 37 TPY (a 98 % reduction from the PM-10 baseline).
- NO, emissions decrease by 254 TPY (an 87% reduction from the NO, baseline).
- CO emissions increase by 4 TPY (a 9% increase over the CO baseline).
- VOC emissions decrease by 1 TPY (a 0.2% reduction from the VOC baseline).
- A total criteria pollutant emission reduction of 967 TPY (a 64% reduction from the total criteria pollutant baseline).

These actual emission reductions will generate an operating margin between the site's actual emissions and the initial emissions caps, so that the facility can operate into the future under the caps. The initial adjustment of the emission caps represent a permanent "retirement" of emissions. In addition, the project is also estimated to result in the reduction of the following pollutants:

- Lead emissions decrease by 0.3 TPY
- Hydrogen chloride emissions decrease by 42 TPY.
- Hydrogen fluoride emissions decrease by 5 TPY.

Once the new gas-fired boilers are installed and operating according to the manufacturer's specifications, the emissions caps will be adjusted as follows:

- The total criteria pollutant emissions cap will be reduced by 20%, from 1503 TPY to 1202 TPY.

- The SO_2 emissions cap will be reduced by 25%, from 719 TPY to 539 TPY.
- The NO, emissions cap will be reduced by 10%, from 291 TPY to 262 TPY.

These adjustments reflect a permanent reduction of criteria pollutant emissions. Under the permit, the Stonewall site will not be allowed to increase emissions above these levels; in this way, 301 TPY of total criteria pollutant emissions, including at least 180 TPY of SO_2 and 29 TPY of NO, will be permanently retired as guaranteed environmental benefit of this project.

It is important to understand the difference between the actual emission reductions resulting from the powerhouse conversion and the initial emissions cap reductions. The actual emission reductions will provide an upfront benefit to the environment by reducing the site's current emissions to well below current levels. The cap adjustments are a reduction in the site's allowable emissions, representing the long-term environmental benefit of the project. The first is an upfront benefit that could be reduced or eliminated over time if the site increases emissions up to the cap; the second is a guaranteed, long-term benefit of the project, since the site will not be allowed to increase emissions over the caps.

The benefits of the actual emission reductions will be enjoyed until the site increases its emissions up to the cap levels. For example, if this increase takes 15 years, the environment will have benefited from 15 years of lower actual emissions. It is very unlikely, however, that emissions will increase all the way up to the caps, since that would eliminate the operational flexibility afforded under the permit, would result in stringent monitoring, recordkeeping and reporting[2], and would prevent any new growth at the site without commensurate emission decreases. Therefore, it is likely that some additional environmental benefit from the actual emission reductions from the powerhouse conversion will be enjoyed into the foreseeable future.

The initial cap reductions, by contrast, represent the amount of environmental benefit that is guaranteed, regardless of how Merck decides to consume the operating margin under the caps. These cap reductions will "lock in" a portion of the environmental benefit from the powerhouse conversion for the life of the permit.

e) *Cap Adjustment for New Regulations*

(1) Overview

The second way that the emissions caps may be adjusted is for new criteria pollutant regulations or existing criteria pollutant regulations that are newly applicable to a source at the site (Section 1.2.2). As described above, the emissions caps provide a direct incentive for the site to minimize emissions in order to preserve a certain operating margin. Lowering the caps will increase this incentive, motivating the site to find the best opportunities at the site to decrease emissions in order to maintain the operating margin.

When a new criteria pollutant regulation is promulgated, or when an existing criteria pollutant regulation becomes applicable to the site, Merck has the option of either complying with the regulation as written, or adjusting the site-wide emissions cap(s) by the amount of emission

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[2] Monitoring, recordkeeping and reporting is described fully in Section 4.

reductions that would have resulted from direct compliance with the rule. Only regulations addressing one or more of the criteria pollutants covered by the emissions caps -- VOCs, SO_2, PM-10, CO and NO, -- can qualify for this alternate compliance mechanism. For example, a new rule establishing emission standards for VOCs from storage tanks would qualify; if the purpose of the rule was to control volatile hazardous air pollutants (HAPs), however, alternate compliance via cap adjustment would not be available.

This adjustment of the cap is based on the concept that operation under the emissions caps represents upfront compliance to any future rules that would have otherwise required such emission reductions. By converting the powerhouse from burning coal to natural gas, the environment receives a significant environmental benefit far in advance of any regulation that would require such reductions. Reducing the cap by the amount that the new regulations would have achieved in effect "locks in" the reductions from that regulation, preventing the site from increasing its emissions to the cap level prior to adjustment. This approach focuses facility efforts on finding emission reductions in the most cost effective manner, rather than on attempting to achieve environmental protection through a "one size fits all" approach or the mandated installation of control equipment. Additionally, it accomplishes equivalent (and potentially greater) emission reductions without time-consuming procedural and administrative requirements that would normally be required[3].

(2) Cap Adjustment Procedure

Section 1.2.2 establishes the procedure for making this cap adjustment. The following steps are required:

- Merck estimates the emission reduction that would result from direct compliance with the rule (1.2.2(a));
- Merck proposes decreasing the corresponding site-wide emissions cap based on that reduction (1.2.2(b));
- Merck submits the estimate and proposed cap adjustment to the regulatory authority that is administering the rule (1.2.2(c)(i));
- The administering agency either approves the cap adjustment, or provides an alternate reduction estimate based on the site's operations. If agreement is not reached on the correct cap adjustment, Merck shall either use the administering agency's estimate or comply with the rule as written. For certain rules EPA may veto the option to comply with the rule by a cap adjustment (1.2.2(c)(ii-vi));
- If approved, the cap adjustments are made final, and such adjustment is deemed compliance with the rule (1.2.2(d, e)).

(3) Emission Reduction Determination

First, Merck must estimate the amount of emission reductions that would result from complying with the regulation as written. This determination must be based on the site's operations and production rate corresponding to the time period defined by the highest emission point (HEP) or another more appropriate emission rate, as agreed to by the regulatory administering agency and

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[3] If the site chooses to comply with a rule via a cap adjustment, Virginia cannot include the cap reduction in any air quality planning/attainment demonstrations.

Merck. The permit defines the HEP as the highest 12-month rolling total of criteria pollutant emissions from the site since 12 months after completion of the powerhouse conversion project. The intent is to provide a reasonable basis for making a determination of what the emission reduction would have been if the rule was implemented at the site as written. In some cases this calculation would be straightforward, especially for rules that would require installation of certain control equipment on certain sources. In other cases, especially for complex rules, a certain amount of judgment will have to be exercised to make the emission reduction estimate. Merck is required to assemble all necessary documentation to justify the reduction estimate, and to provide additional documentation if requested (see Section 1.2.2(c)(i)).

(4) Proposed Cap Adjustment

Merck would propose to reduce the emissions cap(s) by the amount of reductions of each pollutant that the regulation would have achieved. SO_2, PM-10 and NO, reductions would result in adjustment to each respective cap. CO and VOC reductions would be reflected in an adjustment to the total criteria pollutant cap. Of course a regulation could be intended to reduce more than one pollutant; for example, a rule could be focused on reducing PM-10 and VOC emissions from certain process operations. Alternate compliance with that rule via cap adjustment would involve a reduction of both the PM-10 and total criteria pollutant caps.

Incidental emission increases or reductions that would result from complying with the new rule would not have to be accounted for, however. For example, a rule may require the installation of a thermal oxidizer to control VOC emissions from certain process operations. A thermal oxidizer will result in increased CO, NO, and possibly SO_2 emissions. Alternate compliance with the rule would not include cap increases to reflect the unintentional CO, NO, and SO_2 emission increases. In this same way, a rule that requires installation of a wet scrubber to control PM-10 could also achieve some SO_2 reductions, even though the rule was not aimed at controlling this pollutant. The corresponding SO_2 reductions would not have to be reflected in the SO_2 cap in order to have alternate compliance with the rule.

(5) Cap Adjustment Approval: FIPs and NSPSs

The proposed cap adjustment has to be submitted to the agency administering the regulation for approval. If the rule is administered by EPA under a Federal Implementation Plan (FIP), or if it is a new source performance standard (NSPS) other than Subpart Kb, EPA may disapprove the option to comply with the rule by a cap adjustment if EPA provides notice to Merck within a specified timeframe. EPA may only disapprove the cap adjustment if EPA determines that compliance with the regulation instead of the cap adjustment is necessary for achieving the environmental objectives of the regulation.

In the case of FIPs, it is expected that such a determination will be quite rare. EPA administers a FIP only in circumstances where the state fails to submit the required revision to the SIP, or the revision in the opinion of EPA falls short of meeting the minimum criteria required under the CAA. EPA then implements rules to put the necessary protections in place that are mandated by the CAA. One of the factors EPA plans to consider when determining whether the cap adjustment would accomplish the goal of the regulation is whether Merck's contribution to emissions covered by such rules would be significant. It should be fairly unusual that compliance with the rule via cap adjustment would not meet the objectives of the rule, considering that the emission reductions had been attained since the powerhouse conversion. The environmental objectives of the regulation would not extend to things that are not directly related to environmental benefits.

For example, assume that a new regulation requires that certain process equipment of a certain size that emits PM-10 be equipped with a dust collector. The environment is benefited equally whether the emission reductions from such a rule come from the installation of good controls on process equipment, or from reductions of PM-10 that occurred from the powerhouse conversion. The environmental objective of the rule -- to achieve PM-10 reductions -- will be accomplished whether applicable process equipment at Stonewall is equipped with a dust collector, or if PM-10 reductions were previously obtained (and continue to be realized) through the powerhouse conversion, which would have occurred months or years prior to the rule. The environmental objective of the rule is not to ensure that certain process equipment has a dust collector; rather, this is the method to accomplish the real goal of the regulation -- to protect the environment through PM-10 emission reductions.

There may be cases, however, when EPA determines that the FIP rule or NSPS must be complied with directly, rather than through a cap adjustment. In this case, Merck would be prevented from using the cap adjustment to achieve compliance with the rule. In the case of NSPSs, it is not anticipated that the site will be subject to existing NSPS rules other than subparts Db and Kb, based on the types of equipment currently used and reasonably anticipated to be in operation at the facility. It is possible, however, that Merck could be subject to newly-promulgated NSPS.

(6) Cap Adjustment Approval: All Other Regulations

The permit would allow cap adjustment without the EPA "veto" opportunity described above as a means for compliance with any other new or newly applicable criteria pollutant regulation. The agency administering the regulation, most likely the VADEQ, would follow the procedures established in Section 1.2.2(c) for approving Merck's proposed cap adjustment, or propose in writing an alternate adjustment.

The process of agreeing upon the appropriate cap adjustment is expected to be conducted in the spirit of the XL program -- in a cooperative manner, with the common objectives of environmental protection and flexible site operation. Only the correct quantity for the cap adjustment would be subject to debate, not whether this mechanism is an appropriate method for compliance with the rule. This task should not be difficult to complete, considering that Merck engineers routinely perform such calculations to anticipate the potential impact of proposed regulations on its operations. VADEQ also has experience reviewing emission calculations for proposed new and modified processes, and anticipating the effect of a new standard or control requirement on process operations. Despite this intention, the permit provides for the instance when agreement cannot be reached on the proper cap adjustment. In this case, Merck would be required to either use the administering agency's estimate, or comply with the rule as written (Section 1.2.2(c)(vi)).

(7) Timing for Cap Adjustment Approval

Section 1.2.2 specifies the timing for submittal, negotiation and acceptance of the proposed cap adjustment. Figure 1 shows this timeline graphically for both new criteria pollutant regulations and existing regulations to which a source at the site is newly subject.

For new criteria pollutant regulations, Merck is required to submit the proposed cap adjustment and any necessary documentation to support this calculation no later than 120 days prior to the compliance date of the new regulation. Of course Merck may elect to submit the reduction estimate sooner than the 120 days, in case more time is needed to comply with the rule as written if the cap adjustment is rejected. The permit requires, however, that the reduction estimate be submitted no later than 120 days prior to the rule's compliance date.

The regulatory agency administering the new rule must respond to this proposed cap adjustment within *60* days of this notice, or else the cap adjustment is automatically approved. If the agency does respond and disagrees with Merck's proposed cap adjustment, an alternate reduction estimate must be provided by the agency at that time. This alternate estimate must be based on the site's operations and production rates corresponding to the HEP or another appropriate agreed-upon rate. It also must be based on the emission estimation techniques specified in Table 4.3 of the permit, which prescribes the calculation techniques for the site's emission sources.

Merck and the regulatory agency will seek agreement on what the actual emission reduction would be from the new regulation. The permit specifies that this negotiation period shall not take more than three months from the agency's response. As shown in Figure 1, the compliance date for the new regulation may pass during this period. However, the permit as authorized by the Merck site-specific rule and variance, specifies that during this time Merck shall comply with the reduced emissions caps that were proposed by Merck, and that compliance with the reduced caps shall be deemed to be compliance with the new regulation. Consequently, in this situation Merck shall not be subject to enforcement by the regulatory agency, nor subject to third party suits for not complying with the new rule as written by the compliance date because the permit provides for an alternate method of compliance.

The stakeholders expect that this negotiation period should take much less than three months; in fact, as discussed above, the process of determining the expected emission reductions from the new rule is likely to be very straightforward. The permit does specify that it should be completed within three months, or else Merck must either accept the agency's reduction estimate or comply with the rule as written.

If after this negotiation Merck elects to comply with the rule as written, the agency and Merck must agree on a new compliance deadline, especially if the rule's original deadline has passed. The upfront time needed to prepare to comply with a new rule can vary from months to years, depending on the complexity and stringency of the new rule. In some cases, procurement, installation and startup of new equipment can span years. The permit provides a mechanism for Merck and the agency to agree upon a new compliance deadline to account for the time it could take to prepare to meet the requirements of the new rule. However, the permit specifies that the new compliance date cannot be more than 12 months after the rule's original compliance date. As shown in the timeline, the three month negotiation period would end only 11 months before the latest compliance date.

If Merck is likely to require more than this time to prepare to comply with the new rule, it has the option of making the initial proposed cap reduction earlier than 120 days prior to the rule's original compliance date. For example, if 15 months will be needed to comply with the rule as written, Merck may make the initial notification 240 days prior to the original compliance date. This would put the end of the negotiation period at 90 days prior to the original compliance date. Merck and the agency must agree upon a revised compliance date that is no later than 12 months after the original date, which in this case is 15 months (3 plus 12 months) after the end of the negotiation period.

It is for this reason that the timeline is triggered upon the date that Merck proposes the cap adjustment to the agency -- so if the proposed adjustment is rejected and agreement on the correct level cannot be reached, Merck will still have time to prepare to comply with the new rule as written.

It is possible that a new criteria pollutant regulation would have an effective date less than 120 days after promulgation. As a result, Merck would not be provided enough time after promulgation to submit a proposed cap adjustment 120 days prior to the compliance date. In this case, Merck would submit a proposed cap adjustment based on the most current version of the rule that was available at least 120 days prior to the rule's compliance date. This may be the rule as proposed, or a draft final if available. The proposed cap adjustment would be based on the proposed or draft final rule; the regulatory agency would have the opportunity to propose a revised adjustment based on the final rule once it is published. It is expected that Merck and the regulatory agency would work cooperatively in these situations to agree upon the most appropriate cap adjustment based on the rule.

Figure 1 also shows the timeline for existing criteria pollutant rules to which the site or a source at the site is newly subject. The only difference is that Merck is required to submit the cap reduction 90 days prior to the compliance date of the regulation, rather than 120 days for new regulations. Less time should be needed to prepare for compliance with existing rules, since such regulations would have been implemented elsewhere, and knowledge of the rule's requirements would likely be more accessible. Other than the 30-day difference in the initial notification, the above discussion on timing applies to newly applicable existing regulations.

(8) Cap Adjustment and Regulatory Compliance

The permit addresses two issues with respect to regulatory compliance for new or newly triggered criteria pollutant regulations: compliance during the period when Merck and the regulatory agency are seeking agreement on the appropriate cap adjustment and after the cap adjustment is made final. The permit specifies (Section 1.2.2(c)(v)) that during the period that Merck and the agency are seeking agreement on the cap adjustment, Merck shall comply with the adjusted caps as proposed by Merck in Section 1.2.2(a) and (b), and that compliance with the adjusted caps shall be deemed compliance with the rule.

The permit also specifies that once the cap adjustments are finalized (approved by the regulatory agency), compliance with the adjusted caps represents compliance with the rule.

Merck is required to keep certain records and submit reports relating to the cap adjustments for new or newly triggered criteria pollutant regulations (see Table 4.3, A.12 through A.14), including the adjustments to the emissions caps, the explanation for the adjustment, and the final decision on whether to make the adjustment or implement the rule as written.

(9) Examples of Cap Adjustments for Criteria Pollutant Regulations

The following are several hypothetical examples of cap adjustments to illustrate how this section of the permit is intended to operate.

1) RACT REOUIREMENTS If future ozone concentrations in the vicinity of the Stonewall Plant are such that the area fails to attain the National Ambient Air Quality Standard (NAAQS) for ozone, the state may require emission reductions from existing sources in an effort to achieve attainment. The most effective way to reduce ozone formation by regulating local emissions in a generally NO, -limited area such as rural western Virginia would likely be to reduce local NO, emissions. Assuming, hypothetically, that Merck was included in the list of sources regulated by the NOx Reasonably Available Control Technology (RACT), and that Merck's RACT requirement as determined by VADEQ involves reduction of site-wide NO, emissions by 10%. If Merck chooses to fulfill its requirement by a cap adjustment, the size of the adjustment would be based on operations and emissions which occurred during the 12 month period represented by the HEP[4]. By using the HEP as the basis, the size of the reduction would generally be maximized since the HEP would likely represent the period of maximum historical production. The proposed cap adjustment would be calculated by multiplying the annual NO, emissions from all combustion sources represented in the HEP by 0.10, and the resulting quantity (in tons per year) would be proposed to the permitting agency for reduction from the plant's NO, subcap. The cap reduction proposal would be submitted at least 120 days prior to the compliance date for the new regulation. The agency would either approve the proposed cap adjustment or propose an alternate adjustment within 60 days with an explanation of why its alternate proposal is more appropriate. If agreement between Merck and the permitting agency on the size of the cap adjustment is reached, the NO, subcap would be adjusted accordingly and the site's NO, RACT requirements would be deemed to be satisfied. If Merck does not agree with the agency's cap reduction estimate, it must either apply the agency's cap adjustment anyway, or implement the provisions required by the RACT rule as written with a compliance schedule agreed to by Merck and the agency. Either option would fulfill all of the site's NO, RACT requirements for that particular regulation.

If, in the future, the area becomes VOC-limited for ozone formation, the state might reasonably be expected to require VOC emission reductions of existing sources in order to reach ozone NAAQS attainment. Assume that, under those circumstances, the state requires a VOC emission reduction of Merck to meet the VOC RACT and Merck chooses to meet its obligation by a cap adjustment. As in the example above, the size of the cap adjustment would be based on the HEP. If the site emitted 400 TPY VOC during the 12 months of operations represented by the HEP and the RACT rule required a 10% VOC reduction, Merck could propose adjusting the total criteria pollutant cap downward by 40 TPY. The permitting agency or Merck could propose an alternate adjustment if use of the HEP period is inappropriate or unrepresentative. Once agreement on the

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[4] The HEP is the highest emission point reached by the facility since 12 months after completion of the powerhouse conversion project, as measured by the 12-month rolling total of criteria pollutant emissions.

size of the cap reduction is reached, the total emissions cap would be adjusted and the requirements of the rule would be deemed to have been satisfied. As above, if agreement on the size of the cap adjustment is not reached, Merck would have a choice of using the permitting agency's proposed adjustment or implementing the emission reduction requirements of the VOC RACT rule as written.

2) EQUIPMENT-SPECIFIC REQUIREMENTS Assume that a new regulation requires 95% control of PM-10 emissions from solid waste incinerators, and that Merck operates an incinerator at the Stonewall Plant. If Merck were to choose cap adjustment as the means of compliance with the new regulation, the amount that the PM-10 subcap would be reduced would be based on the solid waste incinerator PM-10 emissions during the 12 month period represented by the HEP (assuming the incinerator was in existence during that period). If the incinerator produced 10 tons of PM-10 and had no emission controls, the cap would be reduced by 9.5 tons (0.95 x 10). If the incinerator did not exist during the HEP period, a cap adjustment based on emissions during some other period of representative operations could be proposed. The permitting agency could offer a counterproposal, with justification. As above, failure to agree on a cap adjustment would leave Merck the options of accepting the agency's estimate or complying with the rule as written to achieve the required reduction.

If a new solid waste incinerator was installed after the PM-10 regulation was in effect and Merck chose to satisfy the requirement with a cap adjustment, the size of the cap adjustment would be based on the projected actual emissions from the unit. Merck would have to include the basis for the projected actual emissions and the reduction no later than 90 days prior to the date that the regulation would be effective.

3) NSPS SUBPART Kb REQUIREMENTS The Merck site-specific rule and PSD permit specifically grant relief from NSPS Subpart Kb requirements for volatile organic liquid storage tanks. The plant does not currently have any tanks with Subpart Kb emission control requirements, but if tanks were modified or constructed such that Subpart Kb controls were required, the requirement could be met by downward adjustment of the total emissions cap. The size of the proposed cap adjustment would be based on the emission reduction for each tank that would be achieved by the rule. As in the other examples, the total emissions cap reduction proposal would be subject to agency review and the agency would have an opportunity to make an alternate reduction proposal. Whether a cap adjustment or installation of controls was chosen to satisfy Subpart Kb, either option would be deemed to satisfy all Subpart Kb requirements for that tank.

4) SPECIFIC HAP REDUCTION REQUIREMENTS Assume EPA passes a rule under Title III of the CAA requiring 95% control of methanol emissions from existing distillation columns. Compliance with the rule *could not* be achieved by a cap adjustment, even though methanol is a VOC, because it is a Hazardous Air Pollutant (HAP), and the PSD permit does not afford alternate compliance with any HAP regulations. Merck would be required to implement the rule as written.

f) Other Emissions cap Adjustments

Besides the initial adjustment at the completion of the powerhouse conversion and as alternate compliance with a new or newly triggered regulation; the site-wide emissions caps can only be adjusted under two other circumstances: upon determination of PM-10 emissions from the gas-fired boilers, and as agreed to by the project signatories.

PM-10 emissions can take two forms, filterable and condensable. The amount of condensable PM-10 from burning natural gas will be measured during the stack test of the new gas-fired boilers. The amount from burning the backup fuel will be estimated either from the test or available emission factors. These emission rates will be expressed as the amount emitted while running the boilers at full load for 345 days on natural gas and 20 days on the backup fuel. In short, the stack test data and an emission factor for backup fuel, if necessary, will be used to calculate the boiler's condensable PM-10 emissions at full load running all year. The lesser of this quantity or 10 TPY will be added to the PM-10 cap to account for these emissions. It is anticipated that the cap adjustment will be closer to one or two TPY. Nevertheless, Section 4.3.2 will operate to ensure that the PM-10 cap accurately reflects the amount of condensable PM-10 from this new emission source.

The permit specifies (4.3.2(c)) that this cap adjustment would be automatic -- no further stakeholder discussion nor regulatory evaluation (except review and approval of the stack test) would be necessary to make this adjustment. Only an administrative permit modification would be required to make final the PM-10 cap adjustment. The permit term would already have been subject to public notice and comment for the initial issuance of the permit. Therefore, the operation of the permit term does not need to have further public notice or review.

The fourth mechanism for considering cap adjustments is pursuant to the periodic review mechanisms under Section 6 of the permit. This section is discussed more fully below; however, it is important to note that various provisions in this section could result in increases or decreases to one or more of the site-wide emissions caps. In all cases, such adjustment would only be made after full consent of the project signatories, as prescribed in that section, and after the permitting authority processes a permit modification according to the procedures specified in the site-specific rulemaking and variance.

g) Site Operation Under the Emissions caps

The permit establishes certain requirements for site operations under the emissions caps. These are described below.

(1) Maintain Emissions Below Caps (1.3.1)

Section 1.3.1 states the basic requirement with regard to the site-wide emissions caps: that the site wide total criteria pollutant emissions shall not exceed the total criteria pollutant cap, and that the site-wide SO,, PM-10 and NO, emissions shall not exceed the respective individual pollutant caps. This section also specifies that compliance with these caps shall be determined using the calculation methods specified in Table 4.3 of the permit.

(2) Install Controls for Certain New or Modified Sources (1.3.2)

The PSD permit is designed to encourage the site to minimize its emissions to allow maximum flexibility under the emissions caps. Merck intends to install good controls, pollution prevention or other technology for new emission sources at the Stonewall site, consistent with Merck's Corporate policies regarding environmental protection. This practice is an extension of Merck's ongoing efforts to be a corporate leader in environmental protection. Besides the incentive in the permit, Section 1.3.2 requires that controls, pollution prevention or other technology must be installed for significant modifications and significant new installations (as defined in Section 1.3.2 of the permit). This permit term does not add to Merck's intention to be environmentally protective; Merck's practices and the incentives provided in the permit will result in the installation of good controls. What Section 1.3.2 does is formalize this commitment for larger installations, and ensures that controls, pollution prevention or other technology will be installed for such new or modified sources ***at a minimum.***

This section does reflect that there are other, sometimes better, approaches to environmental protection than installation of emission controls. In many cases, pollution prevention or other technology initiatives will achieve equivalent or superior protection for lower capital and operating expenses. Merck is fully committed to implementing pollution prevention projects wherever opportunities exist for cost-effective improvements to existing processes. In fact, the site's technical operations department dedicates a majority of its resources looking for such pollution prevention opportunities. Operation under the PSD permit will not alter this commitment to pollution prevention; on the contrary, it will provide an additional incentive to make timely changes to manufacturing operations in order to provide maximum operating flexibility under the emissions cap.

Over the years, Merck has pledged to meet a number of environmental challenges. These challenges included minimizing process and non-process emissions and waste, replacing chlorofluorocarbons, conserving energy, recycling and reducing the use of paper and packaging materials. Merck has reported in its Environment, Health, and Safety Progress Report (Appendix 3) that to date, all projects are in place to meet Merck's goal of reducing worldwide environmental releases of toxic chemicals by 90%; the results of these efforts will be seen in the data reported for calendar year 1996. Merck also has exceeded its voluntary commitment under EPA's 33/50 program by achieving reductions in these emissions by 89% worldwide, well over the 50% target set by EPA.

Historically, Merck has established programs well in advance of regulatory requirements. For example, Merck has stated in its progress report that it's state-of-the-art Process Safety Management program, which controls the risk of potential operational hazards, was implement before any regulatory requirements. Voluntary proactive efforts and industry-government cooperation have proven to be effective alternatives to the current system of regulation. Merck's Environment, Health, and Safety Progress Report provides more information about these programs.

This section requires that for significant modifications and significant new installations, some type of good controls, pollution prevention or other technology must be installed. The permit lists examples of the types of controls that would qualify (Section 1.3.2(c)), including condensation for high concentration VOC streams, dust collection for particulates, and low NO, technology for significant NO, combustion sources. Specific pollution prevention or other technologies are not listed in the permit, since they are likely to be process-specific, and could include technology not yet invented.

This section intentionally does not reference best available control technology (BACT), reasonably available control technology (RACT), Lowest Achievable Emission Rate (LAER), or any other regulatory-based control requirement. The requirements of this section are self-implementing, and not tied to agency approval. Establishing any equivalence to a regulatory program would necessitate some type of agency review and approval, exactly the administrative process that this permit is intended to replace. This section also promotes more creativity for finding environmentally protective solutions than provided in programs like BACT or RACT. It encourages the site to find the best ways to minimize emissions from new and modified sources, regardless of whether they trigger this permit requirement.

The permit requires that Merck describe the new or modified installation, and explain if a technology other than those listed in the permit was selected (Table 4.3, A.17). It also requires that Merck submit a schematic diagram of the new or modified process, equipment identification numbers, location on the plant site, control equipment associated with the new equipment, and the total emissions of each criteria pollutant from each piece of new or modified equipment (Table 4.3, A.18). This information will assure that Merck is keeping to its commitment to install good controls, pollution prevention or other technology for such installations, and will help the signatories to stay abreast of the significant changes that occur at the site.

(3) Continue Operation of Control Devices (1.3.3)

During the stakeholder discussions, concern was raised that if Merck was not specifically required to continue operating control devices previously required by permit, that the operating cushion under the emissions caps would allow these devices to be turned off. Merck has no intention of turning off existing control devices at the Stonewall site. In fact, the site has installed several voluntary control devices. In order to formalize this intention, Section 1.3.3 was placed in the permit, which requires Merck to continue operating the control devices listed in Table 1.3.3 of the permit.

The permit requires Merck to continue operating the devices, considering the technical and physical operational aspects of the equipment and associated processes. All equipment experience periods of downtime due to malfunction, maintenance or other reasons. This provision allows for such downtime, and would not require the site to shut down the associated process during the control device downtime. All emissions during such control device downtime would be counted toward compliance with the emission caps.

This section also requires that the control device operation be based on an operation and maintenance (O&M) program based on the manufacturers' specifications and good engineering practice. This provision is not intended to add a new recordkeeping requirement to the site; rather, it formalizes Merck's existing O&M program currently implemented at the site for certain equipment. The control devices listed in Table 1.3.3 are included in this program.

(4) Emissions Trading and Acid Rain Programs (1.3.4 and 1.3.5)

Sections 1.3.4 and 1.3.5 were inserted in the permit to provide assurances to the stakeholders that Merck will not credit for trade or sale any of the emission reductions achieved under the permit, increase allowable emissions through acquisition of emission credits, nor participate in the acid rain opt-in program under Section 410 of the CAA.

(5) Control Requirements for Certain Units (1.3.6)

As described in Section 3, this permit constitutes compliance with certain requirements contained in the RCRA organic air emission standards (40 CFR 264 Subparts AA, BB and CC and 40 CFR 265 Subparts AA, BB and CC). The substantive requirements of these standards are found in Section 1.3.6 of the permit. In this way, all regulatory requirements that address the criteria pollutants included in the total emissions cap, regardless of whether they are promulgated under the CAA or under RCRA, are covered by the permit. In brief, this section requires:

- units that would otherwise be subject to the Subpart AA standards to be controlled with a secondary brine condenser or thermal oxidizer, and monitored as specified in Section 4;
- continuation of the maintenance and repair program for equipment components that are in contact with VOCs and/or volatile organics;
- maintenance of specified covers on containers and tanks that would otherwise be subject to Subpart CC, and
- maintenance of specified covers on hazardous waste treatment tanks that would otherwise be subject to Subpart CC, control of such tanks with a floating roof, brine condenser or thermal oxidizer, and monitoring of such devices as specified in Section 4.

2. Powerhouse Conversion

The existing Stonewall powerhouse consists of two coal-fired spreader stoker boilers with a rated capacity of 123.5 MMBTU/hour each. These units were installed in 1982. The powerhouse also has a #2 fuel oil-fired boiler, with a rated capacity of 120 MMBTU/hour, which is used as a backup unit. The powerhouse provides both steam for heating and use in the manufacturing areas, as well as a portion of the electricity for the plant site. These units have been well maintained and could continue to operate for at least 25 years into the future. They have the capacity to meet anticipated power needs for the plant as well. In addition, there are no current or anticipated future regulatory requirements that would necessitate a major modification or replacement of these units.

The permit requires that the coal-fired units be replaced by two new natural gas-fired boilers. The new units will burn natural gas as the primary fuel, and will be equipped to burn a backup fuel, either propane or #2 fuel oil. A natural gas pipeline will have to be constructed to bring this fuel to the site; in addition, storage capacity for the backup fuel will also have to be provided as part of the boiler construction project. Merck estimates that the capital cost of the powerhouse conversion project will be approximately $10 million.

The new boilers are to be equipped with low- NO, technology, meaning that the new boilers shall have the equipment necessary to control NO, generated during fuel burning. This requirement does not impose a numerical limit on the amount of NO, the boilers may generate; rather, the total emissions cap provides an incentive for Merck to minimize emissions. In addition, Merck guarantees that the boilers that will be purchased will meet NO, limits that are lower than the NOx limit contained in the Standards of performance for Industrial-Commercial-Institutional Steam Generating Units (NSPS Subpart Db, 40 CFR 60.40b *et. seq.)* when burning natural gas. See letter attached as Appendix 4.

As with any device critical for the ongoing operation of the facility, Merck commits to conducting all necessary maintenance and repairs on the boilers including regular preventative maintenance procedures. Merck considers such activities to be basic for normal business operation of the site and for protection of the company's capital investment in this equipment.

a) Timeframe for Conversion

Section 2.2 provides the timeframe for two events related to the powerhouse conversion: when a contract will be made with a boiler manufacturer, and when the conversion will be completed. The permit lists both an expected timeframe and a required time to complete each of these tasks. Merck expects to contract with a boiler manufacturer within six months of the effective date of the permit. However, it is a permit requirement that this contract be in place no later than 12 months after the effective date of the permit. Likewise, Merck expects the conversion to be completed within 18 months, but is required to complete it no later than 30 months after the permit's effective date.

The expected timeframes are not requirements, and there are no consequences if these dates are not met. They merely provide information about when Merck expects that these activities will take place. The 12 and 30 month times are permit requirements, however, and Section 8.1.3 allows the permit to be terminated if the powerhouse is not converted in accordance with Section 2.

This section also requires Merck to provide notice to the project signatories at certain milestones in the conversion project: when the conversion commenced, when it was completed, and when the stack test on the new units has been performed. Merck has 30 days from the commencement and 30 days from the completion of the conversion project to notify the signatories. These requirements were inserted in this section of the permit rather than Section 4 with the rest of the reporting requirements because, as described below, Section 4 may not be effective at the time that the powerhouse conversion is taking place. If they were in Section 4, Merck would not be obligated to meet these requirements until Section 4 was effective.

Section 12.2 includes a definition for "completion of the powerhouse conversion." It specifies that the conversion is complete when the units are installed, started up, have gone through the shakedown procedures, and are fully operational.

b) Regulatory Compliance for the Powerhouse

The stakeholders agreed to address two regulatory issues that would have otherwise impacted the powerhouse conversion. Section 2.4.1 specifies that this PSD permit is deemed to be the preconstruction permit for the new boilers. This is appropriate since the construction of these units has already undergone review by both VADEQ and EPA, and will be reviewed by the public during the site-specific rule and variance comment periods. Issuance of the PSD permit will be confirmation that construction and operation of such units is in full compliance with regulatory requirements as authorized in the site-specific rule and variance.

Section 2.4.2 specifies that compliance with the permit shall be deemed compliance with all requirements of the NSPS Subpart Db (40 CFR 60.40b et. *seq.).* The permit already contains the substantive requirements of this rule as it would apply to the new boilers:

- installation of low- NO, technology on the boilers (Section 2.1),
- performance of a stack test once the units are installed (Table 4.2, B.1), and
- continuous monitoring of NO, and opacity (Table 4.2, B.2).

In the spirit of XL, the signatories agreed that compliance with these substantive requirements in addition to the benefits provided by the whole project warrant alternate compliance with NSPS Subpart Db.

3. Compliance With State And Federal Regulations And Air Permits Under The PSD Permit

a) General

EPA's Project XL is an initiative to assess the extent to which regulatory flexibility, and other innovative environmental approaches, can be implemented to achieve both superior environmental performance and reduced economic and social burdens. Merck's XL project replaces existing regulatory requirements that pertain to criteria pollutants with the provisions of this permit, and specifically the requirements to operate under the site-wide emissions caps and convert the coal-fired powerhouse to natural gas.

Section 3 specifies which rules and permits are addressed under the PSD permit. These include all of the site's minor NSR permits[5] and specific federal and state regulations. The permit specifies that compliance with the permit shall be deemed to satisfy all the requirements of these permits and regulations. It does not mean that compliance with the rules is being waived, or that enforcement discretion is being exercised; rather, it means that compliance with the permit is deemed to satisfy all of the requirements of the listed permits and regulations as authorized in the site-specific rule and variance. In fact, the permit is intended to result in superior environmental performance compared to these requirements.

However, violations of the permit shall not also constitute violation of permits or regulations listed in Section 3. Permit violations may lead to certain enforcement measures in the same manner as would apply to any other permit; to have a violation also trigger non-compliance with one of the rules listed in Section 3 would be penalizing Merck twice for the same circumstances. In order to avoid this outcome, the signatories agreed to include Section 3.6, which specifies that a violation of the permit shall not constitute a violation of regulations listed in Section 3 for which the permit constitutes compliance. This permit term also applies to the preconstruction permits listed in Section 3.1.

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[5] The site does not have any permits issued under the major NSR program.

Section 3.5 clarifies that compliance with the permit does not relieve Merck from compliance with any local, state or federal rule not listed in section 3.

b) Preconstruction Permits

The existing minor preconstruction permits being replaced by the PSD permit are listed in Section 3.1. However, because the site will continue to be obligated to obtain preconstruction permits until Section 3 is effective, this section is worded to include these new permits as well. In this way, all preconstruction permits that are issued to the site will be replaced.

c) Regulations

Compliance with the permit is deemed compliance with all of the provisions of the regulations listed in Sections 3.2 and 3.3 as authorized by the site-specific rule and variance. These rules include the major and minor NSR permitting regulations applicable to the site, the Virginia air toxics rule, Subparts AA and BB of the RCRA organic air emission standards, and certain other emission standards that would otherwise apply to sources at the site.

Compliance with the permit is deemed compliance with only specified sections of the regulations listed in Section 3.4. Each section (3.4.1 through 3.4.7) lists the portions of the regulation, the pollutants and/or sources for which alternate compliance is provided. For example, Section 3.4.4 specifies that compliance with the permit is deemed to be compliance with the Virginia facility and control equipment maintenance or malfunction compliance regulations (9 VAC 5-20-180 and 9 VAC 5-50-20), except for visible emissions and odor. The Stonewall site will still be subject:to these rules as they apply to visible emissions and odor, but not for other pollutants.

Sections 3.2, 3.3 and 3.4 cite certain Virginia air regulations. Facilities in Virginia are also subject to similar or identical requirements listed in Virginia's State Implementation Plan (SIP), which is Virginia's EPA-approved plan for achieving certain objectives of the CAA. The regulations that are cited in Sections 3.2, 3.3 and 3.4 that are also contained in Virginia's SIP are also addressed by Section 3 of the permit. Compliance with the permit will constitute compliance with these SIP requirements as well, as authorized by the Virginia variance[6].

Section 3.4.2 addresses alternate compliance with certain Title V requirements. This section is intended to specify that no additional monitoring, recordkeeping or reporting requirements that would have been applicable to provisions of this permit will apply.[7] This is appropriate because the PSD permit already provides for extensive monitoring, recordkeeping and reporting to assure compliance with its provisions. For example, Title V regulations require that certain monitoring be done in order to verify compliance with applicable requirements listed in the Title V permit. If an applicable requirement does not have a method for demonstrating compliance, the Title V permit will contain a requirement to perform certain monitoring; this is sometimes referred to as "gap filling" monitoring. However, the PSD permit already specifies appropriate monitoring requirements for the provisions of the permit. Therefore, no "gap filling" monitoring will be necessary for any requirements in the PSD permit.

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[6] The Virginia State Air Pollution Control Board variance authority is approved in the Virginia SIP at 40 CFR 52.2420(c)(15) and (89).

[7] The one exception is for deviation reporting, as prescribed by the Title V regulations.

In addition, EPA is planning to promulgate a compliance assurance monitoring (CAM) rule in the near future, which would be applicable to certain sources of criteria pollutants. EPA intends that the provisions of this rule would also not apply to the applicable requirements in the PSD permit for the same reason cited above: additional monitoring requirements beyond those specified in the PSD permit are unnecessary for determining compliance with the PSD permit.

The CAA requires that facilities report the results of monitoring to the permitting authority no less than every six months (CAA Section 504(a)). This statutory requirement will be fulfilled by reporting of the site's 12-month rolling total site-wide criteria pollutant emissions and 12-month rolling total site-wide SO_2, NO„ PM-10, CO and VOC emissions at least semi-annually (see Table 4.2 of the permit, A.7 and A.8).

d) Pollutants Included in Section 3 of the Permit

The pollutants for which alternate compliance is provided in Sections 3.2 through 3.4 are specified in each section. Section 3.2, major NSR permitting and registration, applies to the pollutants listed in Section 1.1 of the permit and particulate matter (PM). If EPA adds any new pollutants to the 40 CFR 52.21(b)(23) list, these pollutants would be excluded from alternate compliance in Section 3.2. This approach provides relief from major NSR permitting and registration for all pollutants included in the total criteria pollutant emissions cap and PM.

Sections 3.3 and 3.4 specify a slightly different list. These sections apply to all pollutants except lead and except any new criteria pollutants listed in 40 CFR 52.21(b)(23)(i) after issuance of this permit. If EPA adds a new pollutant to 40 CFR 52.21(b)(23)(i) before the permit is issued, it is also included for Sections 3.3 and 3.4. Any pollutants listed after permit issuance are excluded from Sections 3.3 and 3.4. The intent is to provide alternate compliance for most requirements for the above pollutants, except from major NSR permitting. The regulations listed in Sections 3.3 and 3.4 still apply to lead and any new 40 CFR 52.21(b)(23)(i) pollutants listed after permit issuance.

Please note that Sections 3.4.4 and 3.4.5 also exclude visible emissions and odor from the pollutants for which alternate compliance applies. This means that in addition to lead and any new 40 CFR 52.21(b)(23)(i) pollutants, visible emissions and odor are also excluded from Sections 3.4.4 and 3.4.5. The regulations listed in Sections 3.4.4 and 3.4.5 still apply to visible emissions and odor.

4. Monitoring Recordkeeping And Reporting

a) General

Section 4 specifies the monitoring, recordkeeping and reporting requirements for the PSD permit. With the exception of Section 2.3, which is discussed above, all monitoring, recordkeeping and reporting requirements of the permit are consolidated in this section. The main list of requirements is in Table 4.2. This table contains seven columns: the specific emission unit to which the requirement applies, an identification number for the requirement, the frequency that applies to the requirement in tier I, II and III (see the explanation of the reporting tiers below), whether the requirement is to monitor, record or report, and a description of the requirement.

For example, Table 4.2, B.5 is listed as follows:

Natural Gas-Fired Boilers	B.5	Annually	Semi-annually	Monthly	Report	Emissions based on stack test, NO, CEM/PEM, emission factors and fuel usage

This provision requires the site to report the emissions from the gas-fired boilers based on stack test, NO, continuous emission monitor (CEM) or predictive emission monitor (PEM) , emission factors and fuel usage on an annual basis in tier I, semi-annually in tier II and monthly in tier III. If one of the frequency columns is blank (indicated by shading), it indicates that the specific requirement does not apply to that specific tier. For example, if the tier I box above were blank, the boiler emission report would not be required for tier I.

Reports required by the permit are sent to the project signatories (Section 4.6). Section 12.8 specifies that all correspondence that is to be sent to the project signatories, including reports required by Section 4, shall be sent to the individual signatory representatives listed in Table 12.8 This table shows each individual representative's name, title, affiliation, address and telephone number. The permit allows for this table to be updated upon written notice to the signatories to ensure that it is current so that Merck may fulfill its obligation to provide reports to the signatories.

Section 4.7 requires that reports submitted in Section 4.5 (annual and semi-annual reports) contain a certification by the site's responsible official. This certification is consistent with that which is required by EPA's Title V regulations (40 CFR 70.5(d)). The wording of the permit could be used by the responsible official for this certification:

> "To my belief, based on reasonable inquiry, the information submitted in the report is true, accurate, and complete."

Section 4.8 requires that records that are required by Section 4 shall be retained onsite for at least five years. Section 4 also specifies a number of other requirements, which are described below.

b) Reporting Tiers

A key innovative feature of the XL project is that the monitoring, recordkeeping and reporting requirements vary in stringency based on how close the site's total criteria pollutant emissions are to the total emissions cap. Section 4.1 establishes three tiers of reporting:

- Tier I applies whenever the site's actual criteria pollutant emissions for the last 12 months are determined to be less than 75% of the total emissions cap, and during the startup of the permit. The startup of the permit is the period between the effective date of Section 4 and 12 months after completion of the powerhouse conversion project. During this time, the facility may elect to operate under the emissions caps, even though the emission reductions from the powerhouse conversion have not yet been realized. In this case, the site's emissions may be very close to the total cap; if a higher tier would otherwise apply during this period, electing to operate under the cap during this startup period would be prohibitively difficult.

- Tier II applies whenever the site's actual criteria pollutant emissions for the last 12 months are equal to or greater than 75% and less than **90%** of the total emissions cap.
- Tier III applies whenever the site's actual criteria pollutant emissions for the last 12 months are equal to or greater than **90%** of the total emissions cap.

The monitoring, recordkeeping and reporting requirements increase as the tiers increase. Using the example above, the frequency that the emissions from the gas-fired boilers must be reported increases from annual to monthly from tier I to tier III. Consequently, as the site's total criteria pollutant emissions increase, monitoring, recordkeeping and reporting requirements increase as well. This makes sense because as the site gets closer to the emissions cap, more detailed and comprehensive monitoring and recordkeeping are warranted, and more frequent reporting to verify compliance with the caps is appropriate.

It also has the effect of providing a further incentive for the site to minimize its emissions. Costs of compliance with Tier II or Tier III will be higher than Tier I, because of the additional monitoring, recordkeeping and reporting required in the higher tiers. In some cases, a report or monitoring requirement would have to be performed more frequently in a higher tier. For example, the permit requires the 12-month rolling total of site-wide criteria pollutant emissions to be reported semi-annually in Tier I and Tier II, and monthly in Tier III (see **A.6** in Table 4.2 of the draft permit). This increased frequency would impose additional costs on the site's environmental staff relating to preparation and submittal of reports. Some activities are not required to be performed at all in a lower tier, such as stack testing of all thermal oxidizers onsite (see F.51, Table 4.2 of the draft permit). Within six months of reaching Tier III, all thermal oxidizers must be stack tested. This phased-in requirement places significant additional costs on the site for moving from Tier II to Tier III.

These additional compliance costs associated with higher tiers will provide an incentive to minimize emissions. If a planned project would increase the site's emissions so that it moves from tier 1 to tier II, Merck could evaluate additional control or pollution prevention opportunities to eliminate this increase. Merck would be provided with discretion whether to make the capital and operational investments to meet the higher tier's requirements, or implement emission reduction projects to stay within the lower tier's threshold.

The types of requirements that are triggered in each tier are designed to provide enough data to assure compliance with the emissions caps and other provisions of the permit. The tier I requirements provide data to measure compliance with the cap, with control device operational requirements, and with certain requirements for new equipment installed under the significant modification and significant new installation permit provision (Section 1.3.2).

The tier II requirements add to the tier I provisions the requirement to validate certain measurement tools and more frequent (semi-annual) reporting because of the proximity of the site's actual emissions to the emissions cap. Tier III requires additional validation of measurement tools, and monthly reporting in most cases, again because of the proximity of the site's actual emissions to the emissions cap.

c) Monthly Requirements

Merck is required every month to calculate the 12-month rolling total of the site-wide criteria pollutant emissions (Section 4.4). The permit provides one month for these calculations to be completed; in other words, the site has one month from the end of the 12-month period to complete that period's totals. For example, the site would have until February 1 to calculate the 12-month rolling total of criteria pollutant emissions for the 12 month period ending December 31.

If the 12-month rolling total of criteria pollutant emissions triggers a higher tier, the site will have to begin the additional monitoring, recordkeeping and reporting that the new tier requires. For example, if the 12-month rolling total of criteria pollutant emissions increases from 70% to 75% of the total criteria pollutant cap, the site has to change from tier I requirements to tier II requirements. In most cases, the additional effort to prepare to comply with the higher tier's requirements may take a significant amount of time; however, the permit allows one month after calculation of the 12-month rolling total to begin complying with the new tier's provisions. This means that the tier that was triggered for the period ending two months prior is the tier to which the site is subject.

For example, assume that the total criteria pollutant emissions cap is 1202 TPY. 70% of the cap is 840 TPY, and 75% is 902 TPY. Also assume that the site had the following total criteria pollutant emissions:

12-Month Period	12-Month Total Criteria Pollutant Emissions (TPY)	Tier Corresponding to 12-Month Total
1/1/98-12/31/98	840	I
2/1/98-1/31/99	840	I
3/1/98-2/28/99	902	II
4/1/98-3/31/99	910	II
5/1/98-4/30/99	920	II

Section 4.4.1 requires that the site complete these 12-month totals by the following dates:

12-Month Period	12-Month Total Criteria Pollutant Emissions (TPY)	Tier Corresponding to 12-Month Total	Complete Calculation for 12-Month Period by:
1/1/98-12/31/98	840	I	2/1/99
2/1/98-1/31/99	840	I	3/1/99
3/1/98-2/28/99	902	II	4/1/99
4/1/98-3/31/99	910	II	5/1/99
5/1/98-4/30/99	920	II	6/1/99

Since Merck will only determine on 4/1/99 that the site-wide emissions for the period 311198-2/28/99 triggered the tier II requirements, the site will have one month from 4/1/99 to prepare to comply with the tier II provisions, and begin monitoring, recordkeeping and reporting based on tier II by 5/1/99:

12-Month Period	12-Month Total Criteria Pollutant Emissions (TPY)	Tier Corresponding to 12-Month Total	Complete Calculation for 12-Month Period by:	Monitoring, recordkeeping and reporting tier to be used:
1/1/98-12/31/98	840	I	2/1/99	2/1/99: I
2/1/98-1/31/99	840	I	3/1/99	3/1/99: I
3/1/98-2/28/99	902	II	4/1/99	4/1/99: I
4/1/98-3/31/99	910	II	5/1/99	5/1/99: II
5/1/98-4/30/99	920	II	6/1/99	6/1/99: II

This one month "lag" between when the change in tiers is determined and when the new tier's requirements are in effect also applies when emissions decrease; if a lower tier is triggered, the site has to continue the higher tier until one month after the calculation was completed for the lower 12-month total.

d) Semi-Annual and Annual Requirements

In addition to monthly requirements, Table 4.2 contains semi-annual and annual reporting requirements. Section 4.5 prescribes when these reports must be submitted. These provisions allow two months from the end of the annual or semi-annual period to prepare and submit the required reports.

Section 4.9 also requires Merck to prepare an annual progress report, which is to be distributed to the project stakeholders and to other interested parties. This annual report is intended to foster communication between the facility and the community about the progress of the project, how it is working at the site, and what benefits have resulted to date. It is not intended to be a tool for measuring compliance with the permit terms; as such, it will not include a certification statement, for example.

e) Emission Calculation Techniques

Accurate emission calculations is a key element in assessing compliance with emission limits. The permit contains several provisions which will assure that current emission calculation techniques are used to determine the site's compliance with the site-wide emissions caps. These include Section 6.1.1, which is the primary mechanism for assuring that current emission calculation techniques will continue to be used throughout the life of the permit. This section is discussed further in Section 6 below. Section 4.3 also pertains to emission calculation techniques, including which factors are to be used, adjustment for condensable PM-10 from the gas-fired boilers, and use of updated AP-42 emission factors.

(1) Specified Calculation Techniques

. Table 4.3 specifies the emission calculation techniques which shall be used to assess compliance with the emission requirements of the permit. It specifies the method of calculation by type of emission source and pollutant. This is necessary to provide assurance to the stakeholders and the public that methods that have been reviewed by EPA and VADEQ and approved by the signatories are the only methods that will be used to assess compliance with the permit's emission limits.

(2) Emission Calculations for Sources with Control Devices

Process emission calculation techniques for batch manufacturing operations involves in general calculating the uncontrolled emission rate, determining the control efficiency for any control devices, and applying that efficiency to the uncontrolled emission rate. The site typically uses four types of control devices: condensers, scrubbers, thermal oxidizers/fume incinerators, and dust collectors. When monitoring is required by the PSD permit, the data are used in conjunction with the efficiency determinations for each of these units, as discussed below.

(a) For AN Units

For all units, the efficiency determinations are refined as the monitoring tiers increase from I to III. Until the PSD permit requires monitoring for a particular unit, an estimated control efficiency is relied upon to determine the effectiveness of that unit. Once parametric monitoring is required, the monitored parameters are used to verify that the unit is meeting the performance conditions on which the efficiency was estimated. For example, a thermal oxidizer manufacturer may specify a 99% control efficiency for a unit, providing that the combustion chamber temperature is at least 1450°F. The monitoring requirement will determine during which periods the 99% efficiency can be claimed for the thermal oxidizer. If the combustion chamber temperature is monitored to be less than 1450°F, a lower efficiency must be used in emission calculations for the period between the last 1450°F reading and the next time 1450°F is reached. The lower efficiency must have some documented basis -- either assumed to be zero, or some other value based on manufacturer's or published data.

Once the Tier III technical evaluation is triggered (either a stack test or detailed engineering evaluation), the basis for the efficiency estimates for most of the site's control devices are confirmed. If the Tier III evaluation determines that a unit is performing differently than previously predicted, the Tier 111 evaluation will be used for all future emission calculations for that unit, even if the monitoring tier drops to Tier I or II.

(b) Condensers

Control efficiencies for process condensers are determined using the MacEmit program and the operating characteristics of the device. For a vent controlled by a condenser, the exit vapor temperature is assumed to be at 10°C above the exit coolant temperature (a "10 degree approach assumption"). The process emission factors are adjusted based on the cooled exit vapor temperature, and the thermodynamic properties of the cooled vapor, after the condenser.

When monitoring is required for the device, the coolant flow is verified to ensure that the unit is operating properly. Verifying coolant flow is often all that is necessary to ensure proper operation. The emission calculations are based on the exit vapor temperature, or derived from the exit coolant temperature data. The MacEmit program estimates vapor emissions based on these data and thermodynamic properties of the streak.

At Tier III monitoring, this "10 degree approach assumption" will be evaluated based on stack tests or detailed engineering modeling.

(c) Scrubbers, Fume Incinerators, Thermal Oxidizers and Dust Collectors

Control efficiencies for these units are determined based on vendor performance guarantees and operating parameters. When monitoring is required for the device, the monitored parameters are used to verify that the unit is operating within the range for which the performance guarantee applies. For example, pressure drop on a scrubber is used as an indicator that the induction fan is operating, that the packing is not plugged, or that no bypass has been inadvertently provided. As with condensers, the ranges for proper operation are based on the unit's design and specified installation; verifying scrubbing liquid flow and pressure drop often will be adequate to confirm that the scrubber is operating. In general, low scrubbing liquid flow or no flow conditions, out-of-range pressure drops, or low combustion chamber temperatures, will be assumed to achieve zero percent removal unless another documented control efficiency is available and applicable.

At Tier III monitoring, the vendor design control efficiency will be evaluated based on stack tests or detailed engineering modeling. This evaluation may also include estimation of control efficiency at other operating conditions.

(d) Other Control Device Types Not Currently In Use at Stonewall

There are, of course, any number of other types of control devices that could be installed at the site in the future -- some still being developed or tested, or not yet invented. Such devices, once installed, will be incorporated into the site's emission calculations. The unit would be specified and installed based on vendor performance guarantees; operating parameters would be monitored to verify that the unit is continuing to operate as installed; Tier III technical evaluation will confirm the accuracy of the vendor performance guarantee, and may help to establish control efficiencies at other operating conditions.

(3) PM-10 Cap Adjustment

As discussed above in Section 1f, the permit allows the PM-10 cap to be adjusted based on the amount of condensable PM-10 that the new gas-fired boilers could generate at their capacity. This provision is in Section **4.3.2** of the permit.

(4) Updating of AP-42 Emission Factors

AP-42 is EPA's primary guidance document for many emission factors. It contains many of the factors that EPA recommends for calculation of source emissions, and is continually being evaluated and updated by EPA's Office of Air Quality Planning and Standards. Table 4.3 specifies that for certain sources and pollutants, the 5th edition (1995) of **AP-42** shall be used to estimate emissions for these sources. If EPA publishes a 6th edition of AP-42, it will very likely contain more accurate or more comprehensive emission factors for sources such as those at the Stonewall site. In this case, updating of the emission calculation techniques will be addressed by the project stakeholders as prescribed in Section 6.1.1. However, this process requires the signatories to achieve full consent on the use of the new factors. If agreement cannot be reached, Section 4.3.3 provides a mechanism for the updated factors to be used to demonstrate compliance.

The use of a new emission factor could significantly affect the site's compliance with the emissions caps. For example, assume an emission factor for a certain source is revised so that the new factor is two times the previous factor. If that source was included in the baseline, use of the new factor should include an increase in the baseline, and a corresponding increase in the emissions cap(s) determined from the baseline. Otherwise, the new factor would consume a portion of the site's operating margin under the cap, potentially resulting in the site violating the cap. Update of emission factors should not have such an effect on the operation of the permit. Consequently, use of updated emission factors must include an evaluation of whether adjustment of the baseline, HEP, current actual emissions and emissions caps is warranted.

Section 4.3.3 is triggered if:
- the AP-42 emission factors described in Table 4.3 are updated,
- the project signatories fail to agree on the appropriate changes to the emission factors, and necessary adjustments to the baseline, HEP, current actual emissions and emissions caps, and
- VADEQ describes to the project stakeholders in writing that use of the updated AP-42 factors is important for the technical validity of the site's emission calculations.

Such circumstances should be rare, considering the stakeholder process described in Section 6.

If it is necessary, VADEQ must obtain from Merck confirmation that the emission source(s) at the site are the same type of sources as those for which the AP-42 emission factor applies. Merck has unique knowledge of the Stonewall site's processes and operations, and therefore should have input into whether it is appropriate to apply the AP-42 emission factor to the site's source(s). In some cases, the sources upon which the AP-42 factors are based may be significantly different in operation and emission characteristics from Merck sources, thus preventing the application of the factor to the site. Merck would have the responsibility of explaining this difference to VADEQ.

VADEQ also shall obtain agreement from Merck on how the emissions caps, HEP and current actual emissions should be adjusted to reflect the updated emission factor. In most cases, adjustment of the emissions caps would be appropriate for units that were included in the site's baseline (1992/1993), since they formed the basis for the emissions caps. There may be other limited circumstances, however, which would warrant some cap adjustment for non-baseline units. If so, Merck will justify to the VADEQ and other stakeholders the reasons for proposing a cap adjustment for non-baseline units.

The change to the AP-42 emission factor would be reflected in the permit as a modification to Table 4.3, and any necessary changes to the emissions caps. If a cap adjustment was necessary, it would have to be incorporated into the permit at the same time that the new AP-42 factor is approved for use by the site. Otherwise, the site could be required to use a new factor without having the appropriate cap(s) under which to operate. Such permit modifications would be initiated by VADEQ according to the permit modification procedures that apply to the PSD permit. Until the change is made final in the permit, Merck would be obligated to follow the emission calculation techniques specified in Table 4.3.

f) HAP Monitoring and Testing Requirements

Merck's XL project does not provide relief from any applicable hazardous air pollutant (HAP) regulation promulgated under Section 112(d) of the CAA. In fact, several of the 112(d) standards, otherwise known as Maximum Achievable Control Technology (MACT) standards, will require that the Stonewall site install certain control devices and monitor and test the operation of certain equipment. If a MACT standard requires monitoring or emission testing for a unit that also has monitoring or testing requirements under this permit, the site could potentially be faced with slightly different but mainly duplicate requirements.

For example, Table 4.2 requires that scrubber water flow and differential pressure be monitored continuously on all scrubbers when tier II and III requirements are effective (Table 4.2, F.41). The objective of this requirement is to assure that these scrubbers are operating properly. Such devices could also be subject to continuous monitoring requirements under a MACT standard, also aimed at assessing the units' performance. These requirements could be similar, but different enough to require a separate set of monitoring equipment or procedures. This duplication would be counterproductive and contrary to the XL approach.

Section 4.11 addresses such situation. If a control device is subject to a monitoring requirement under a MACT standard, compliance with the MACT control device monitoring requirement shall be deemed to be compliance with any Section 4 monitoring requirement applicable to that same control device. This approach is justified on the premise that monitoring under a MACT standard must be accurate enough to assess the unit's performance with regard to HAP emissions, so it certainly would be accurate enough for criteria pollutants. Section 4.11.2 provides similar relief from emission testing requirements, to prevent duplicate testing of the same device to satisfy a MACT standard and this permit. These permit terms reflect the common sense approach encouraged by the XL program.

g) Other Requirements

Section 4 also contains two additional requirements.

Section 4.10 applies to monitoring systems for any individual control device that controls a vent with actual uncontrolled emissions of at least 100 TPY of any individual criteria pollutant. This section requires that the monitoring system collect data at least 75% of the time that the control device is operating. If this percent data collection is not met, it is not considered a permit violation. Rather, two options are available to resolve the missing information: either verify independent of the monitoring system that the control device was operating properly during the time that the system failed to collect data, or assume that the device was not operating during that period. This provision will assure that for large emission sources some verification will be made that the control device is operating, or else it will be assumed to not be running for purposes of emission calculations during that period.

Merck plans to maintain a list of control devices subject to this 75% data collection requirement, and record monthly whether the 75% rate was met. If it was not met, records will document whether independent means were used to verify that the control device was operating properly, or emission calculations were adjusted to assume that the control device was not operating.

Section 4.12 requires Merck to notify the VADEQ of certain control device malfunctions or bypasses. If a control device listed in Table 1.3.3 or required under Section 1.3.2 malfunctions or is bypassed, and the total criteria pollutant emissions resulting from such an event are expected to exceed 5% of the current total emissions cap, Merck is required to provide notification to VADEQ within a certain time period. VADEQ requires this information in order to answer any public questions about such events.

5. Phase In Of PSD Permit Terms

The PSD permit requires Merck to operate under emissions caps, convert the powerhouse and to comply with certain monitoring, recordkeeping and reporting requirements. It also provides relief from regulations governing criteria pollutants, including preconstruction permitting and requirements of existing permits. A basic premise of the project is that the regulatory relief is granted at the same time the additional requirements are imposed. For this reason, some provision to allow the permit terms to be phased in were included in the permit.

Section 5 specifies that all sections of the permit are effective upon the effective date of the permit except Sections 1, 3 and 4. Sections 1,3 and 4 require the site to operate under the cap, provide regulatory relief and require monitoring, recordkeeping and reporting. They are effective 12 months after the powerhouse conversion is completed, or sometime sooner if Merck elects to operate under the caps before this date. The intent of this section is to set a deadline when all sections of the permit will be effective, while providing an incentive to the site to minimize its emissions even prior to the conversion of the powerhouse, with the prospect of obtaining operational flexibility under the permit sooner. The sooner that the caps and the regulatory flexibility are effective, the sooner the environmental benefits from this project will begin to be realized.

However, operation under the emissions caps may be difficult before the conversion is completed, especially considering that the site's emissions in the next few years are not likely to be low enough to provide sufficient operating margin under the emissions caps. It is for this reason that the caps will not be adjusted downward until the powerhouse conversion is completed (see Section 1.2.1).

Figure 2 shows the timeline for the powerhouse conversion and setting and initial adjustment of the emissions caps. All the dates are based on when the permit is effective, shown as month 0 on the figure. The following milestones are listed on this figure:

- 0 months: effective date of permit, as well as the date that the site-wide emissions caps would be established according to section 1.1. The caps would not be effective unless Merck opted in early as described in Section 5.2.
- 6 months: expected date for a contract with a boiler manufacturer (Section 2.2.1)
- 12 months: last date for a contract with a boiler manufacturer (Section 2.2.1)
- 18 months: expected date for completion of the powerhouse conversion (Section 2.2.2)

- 30 months: last date for completion of the powerhouse conversion (Section 2.2.2). It is also this date that the site-wide emissions caps, if effective, would be adjusted downward as prescribed in Section 1.2.1.
- 42 months: date that the emissions caps (as adjusted in Section 1.2.1) would be effective, unless Merck opted in earlier. This date is actually set to 12 months after the conversion is completed; if the conversion was completed sooner than **30** months after permit issuance, the caps would be effective sooner than 42 months.

Until the emissions caps are effective, the existing regulations and preconstruction permits will remain in effect. For example, the preconstruction permitting program would still be in effect during this time; any process modification or new installation that triggers the permitting thresholds in the Virginia regulations or the delegated Virginia PSD program at 40 CFR 52.2451 would require a permit before construction. All such permits and the regulations listed in Section 3 would cease to apply as written[8] once Sections 1,3 and 4 (the caps, the regulatory relief and the monitoring, recordkeeping and reporting) are in effect.

If the emissions caps become effective prior to the completion of the powerhouse conversion -- in other words, if Merck elects to opt into the caps to obtain regulatory relief before the initial adjustment of the caps -- Section 5.3 requires that a performance test be conducted on any control device installed pursuant to Section 1.3.2 excluding condensers and conservation vents. Such control devices are likely to play an important role in ensuring that the site does not violate the emissions caps, since they are controlling sources that meet the significance levels of Section 1.3.2(b). During this interim period, performance tests will help to accurately assess emissions from these units. This requirement will only be in effect if Merck opts into the caps before completion of the powerhouse conversion, and would cease to be applicable once Section 1.2.1 becomes effective.

6. Periodic Review Of The PSD Permit

a) General

One of the most unique features of Merck's XL project and the PSD permit is that it provides for periodic review of the permit by the project stakeholders. Typically, the issuance of a permit and the ongoing compliance with its terms are activities that predominately involve the permittee and the permitting agency. Merck's Project XL is groundbreaking in that it sets a new approach to community involvement, both in the formation of the project, as well as the ongoing operation of the permit.

Merck relied on a local stakeholder process for the formation of the project and development of the draft PSD permit. The stakeholder group included several "signatory teams," representing government agencies, the community and Merck. These signatory teams were: EPA (represented by Region III, Office of Air Quality Planning and Standards, and Office of Pollution Prevention and Evaluation), VADEQ (represented by the Valley Office and Headquarters), the U.S. Department of the Interior Federal Land Manager (represented by the National Park Service

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[8] Meaning that compliance with the permit would be deemed to be compliance with the listed rules and permits.

offices in Washington, D.C. and Denver, Shenandoah National Park, and the Department of Interior), Merck (represented by the Stonewall site, corporate environmental, corporate legal and public affairs), and Rockingham County (represented by the chairman of the Board of Supervisors for Rockingham County, the Elkton Town Manager and two plant neighbors). The County was designated as a project signatory at the request of the community team, in order to ensure long-term representation of community interests. In addition, other parties were included in the stakeholder discussions, including the Southern Environmental Law Center, the Virginia Consortium for Clean Air, and the Natural Resources Defense Council. These groups provided valuable input during the process and raised many issues which were fully considered by the project signatories and that affected the scope of the project.

This group met on a weekly basis for over six months to discuss and resolve the scope of Merck's XL project and how the regulatory system should be changed to accommodate it. While disagreements were encountered, the signatories achieved general consensus on the project and the draft permit attached to the proposed Final Project Agreement (FPA). The signatories strongly supported proceeding to seek public comment on the proposed FPA. Besides the dedication of the group members, this general consensus was possible because the stakeholders were driven by a common goal: to create a project that would provide superior environmental performance while granting the site greater operational flexibility.

Section 6 of the permit continues this stakeholder process in a regular review of the PSD permit. The permit allows the terms and conditions of the permit to be reviewed at certain intervals to assure that it will continue to meet the objectives of the project. The permit provides for a review for certain issues every five years, and others when specified emission levels are reached. Because the permit was the result of a consensus process, changes to the permit resulting from the review can only be made through full consent of the project signatories. This means that the project signatories all have to agree that the change(s) to the permit should be made. In the same way that the group reached consensus in the formation of this project, it is expected consensus will be achievable during the reviews based on the group's shared concern for the environment and interest in the viability of the Stonewall site.

The intent of this section is to foster an open process that provides for ongoing dialogue with people that have a stake in the project. It is expected that the same interaction among stakeholders will occur during the five-year reviews, and that the project signatories will fully consider concerns and issues raised by all the stakeholders before reaching decisions on permit changes. This section states that discussion of issues brought by any stakeholder relating to the PSD permit may occur as needed. However, this section does specify that aspects of the permit other than those described in Sections 6.1 or 6.2 are not subject to review except as otherwise agreed to by full consent of the project signatories. The periodic reviews are not intended to be "permit reinvention sessions." Rather, this section provides for regular review of certain provisions, and adjustment if necessary if unanticipated circumstances arise. These provisions are described in more detail below.

In addition, the circumstances described in this section would not necessarily need to be addressed through a permit change. For example, Section 6.1.2 provides for the consideration of permit changes if EPA adds, deletes, or modifies the list of criteria pollutants or National Ambient Air Quality Standards (NAAQSs). A new or modified criteria pollutant would not require a permit change. A change in a NAAQS may result in new or modified regulations, and may not need any response in the permit at all. If a new criteria pollutant is added by EPA, the signatories would have the option of whether to add that pollutant to the list of those criteria pollutants addressed by this permit. Such a change would require modification of several permit provisions (total emissions caps, Section 3, etc.), as well as the administrative permit modification procedures applicable to the site (which could include public notice and comment). If agreed to by the signatories, however, inclusion of such new pollutant would expand the superior environmental performance approach taken in the permit to the new pollutant as well.

b) Modification of the Permit

Changes to the terms and conditions of the permit, except as described below, are made only through full signatory consent. Once the signatories agree on a change, however, the administrative process prescribed by EPA's site-specific rule and the Virginia variance will govern how the change is incorporated into the permit. For minor changes specified in the site-specific rule and variance, the administrative process would be followed to incorporate the permit change as described by the signatories. For significant changes, the modification would have to undergo public notice and comment. Public comments received on these changes would need to be addressed by either VADEQ or EPA, with the assistance of the stakeholder group if necessary. If the public comment warrants a change to how the modification would be incorporated into the permit, such a decision must be referred back to the stakeholder group for further deliberation. If the permit modification as revised to address public comment is acceptable to the signatories, the modification would be incorporated into the permit. Otherwise, an approach agreeable to the group would have to be formulated. In any case, the exact administrative procedure would be governed by the permit modification process in the site-specific rule and variance.

Section *6* also states that the permit could also be modified pursuant to PSD permit modification procedures generally applicable to all PSD permits. No such permit modification procedures exist at this time. If, however, EPA does promulgate rules that prescribe administrative requirements for making changes to PSD permits, and those rules are generally applicable to PSD permits, these administrative rules would be applicable to the permit. Such a process would not be subject to the consensus procedure described above. Such rules would affect only the procedures used to modify permit terms and conditions, and not the terms and conditions themselves. If PSD permit modification rules could potentially impose substantive requirements on PSD permittees, EPA would not intend for those requirements to apply to Merck's PSD permit, in light of its unique nature, unless they include a site-specific proceeding with full consideration of any impacts on the Merck project (or unless otherwise authorized by the permit, e.g., by full consent of the signatories). EPA also does not intend to adopt requirements that could undermine the objectives of the Merck project to provide superior environmental performance while granting the site operational flexibility.

c) Makeup of the Stakeholder Group

A project stakeholder is someone who has been identified as having a direct stake in the project -- someone who will be directly affected by the success or failure of the project. In addition to the project signatories -- EPA, VADEQ, the Department of the Interior Federal Land Manager

(DOI FLM), Rockingham County, and Merck -- up to one representative from a regional public interest group shall be included as a project stakeholder (see Section 12.6.2). Representatives of EPA, VADEQ, DOI FLM and Merck will be one or more employees of these respective organizations. For Rockingham County, the permit specifies that this signatory team will be comprised of a member or employee of the board of supervisors, plus three additional community representatives (local government and/or community residents). This organization is consistent with the stakeholder group assembled for the development of this project.

The permit intentionally does not specify the exact makeup of the community representatives. By specifying the exact makeup of this group, other parties would be excluded that might be just as appropriate as community representatives. This is left up to the signatories just prior to the 5-year review, based on who is available to commit the time needed to participate, who is interested and has information that would be pertinent to the discussion, etc. These decisions are left to Rockingham County and the signatories at the time of the 5-year review.

Regional public interest groups will be an important part of the ongoing stakeholder process, just as these groups' input was valuable during the drafting of the permit. Including a regional public interest group representative on the stakeholder group is unique in environmental permitting, and will help assure that such local public interest views are fully considered by the stakeholder group.

Shenandoah National Park has many patrons from around the world, and many individuals interested in the preservation of air quality of this area. The permit does give special consideration to local community members. Project XL places significant emphasis on local community involvement, while providing an open process and communication with all interested parties. The Merck XL project preserves this important balance by establishing a signatory team charged with representing local interests. In addition, the permit requires that Merck communicate about the accomplishments of the project to all interested parties on an annual basis.

The individuals who will represent the stakeholders are to be direct employees of the organizations they represent (see Section 12.6). This stipulation will avoid concern raised by stakeholders about contractors, consultants, or other non-employees on the stakeholder group not being fully empowered to represent the intended stakeholder, and perhaps even attempting to represent interests of the organizations that directly employ them rather than those of the stakeholder. If the stakeholder group desires to obtain expertise of someone not represented at the table, such as an independent air quality expert or local botanist, these people could be brought to the group after all signatories agree on their participation. Of course this stipulation does not apply to local citizens, who represent no particular organization. It does apply to Merck, VADEQ, EPA, DOI FLM, Rockingham County Board of Supervisors (a county employee or a member of the board), and for the regional public interest group.

d) Topics For the Five-Year Review

Section 6.1 provides for the project stakeholders to review whether certain changes to the permit are required. This review is to be held within three months of the five year anniversary of completion of the powerhouse conversion, and every five years thereafter. If stakeholders' schedules, especially those of the community representatives, require the review to be sometime slightly before or after this three month period, the process will have enough flexibility to accommodate this.

Discussion of issues brought by the stakeholders relating to the PSD permit may occur as needed. The topics that may be reviewed by the stakeholders are listed at Section 6.1.1 through 6.1.9. They are:

6.1.1. Significant changes in calculation methods: to assure that the emission calculation techniques used by the site reflect current methods for determining the site's emissions.

6.1.2. Change in the list of criteria pollutants or National Ambient Air Quality Standards (NAAQS): to allow the stakeholders to consider whether a new pollutant should be covered by this permit, or whether other adjustments may be appropriate based on changes to the NAAQSs.

6.1.3. Control technologies listed in Section 1.3.2(c): to assure that the list of control technologies that represent good environmental engineering practice reflects the latest advances in control technology applicable to the site.

6.1.4. Adequacy of the monitoring, recordkeeping and reporting requirements: to assure that these requirements provide necessary compliance information, and to review whether any are duplicative or otherwise unnecessary.

6.1.5. Procedure for new criteria pollutant regulations: to allow the stakeholders to consider revising the detailed procedures for review and approval of cap adjustments for new or newly triggered criteria pollutant regulations in Section 1.2.2.

6.1.6. Permit termination criteria: to assure that these termination criteria are appropriate.

6.1.7. Modeling for short-term PM-10 and SO_2 emissions: Merck performed modeling of the site's worst case emissions to demonstrate that the permit would not result in violation of the short-term PM-10 and SO_2 standards (included as Appendix 5[9]). This modeling is to be periodically reviewed to assure that it still reflects the site's configuration and worst case emissions of these pollutants. Merck is obligated to redo the modeling if site conditions have changed significantly and if requested by VADEQ or EPA.

6.1.8. Determination that the area is NO, -limited for ozone formation: if brought to the group by a stakeholder, technical papers or studies will be reviewed to determine if they change the generally recognized determination that the area is NO,-limited for ozone formation. This review condition does not impose an obligation on Merck or another party to perform a literature search or to sponsor studies.

6.1.9. Periodic review criteria: the stakeholders also have the ability to consider revising these review criteria if necessary.

e) Topics Reviewed at Certain Emission Levels

The stakeholders also included in the permit two important reviews that are triggered if certain emission levels are reached: for air quality related values (AQRVs), and for emissions of non-HAP VOCs.

Section 6.2.1 requires AQRV assessments after one of the following events occur:

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[9] The modeling also addressed potential CO impacts.

- if an individual new process or process modification is installed that results in a net emissions increase in the site's actual VOC emissions of 100 TPY or more (6.2.1(a)(i)), or
- the first time the site's VOC emissions exceed two times the baseline VOC level.

The trigger in 6.2.1(a)(i) is based on a net increase in the site's actual VOC emissions of 100 TPY or more. The term "net increase" is not intended to suggest the netting calculations provided in the PSD regulations that allow, for example, consideration of a five-year contemporaneous window. Rather, it is intended to encompass the specific new or modified installation only. Emission increases and decreases occurring at the site as a part of the new or modified installation project would be totaled to determine if the 100 TPY threshold is reached. This XL project is intended to replace these complex regulatory schemes with simple, straightforward requirements.

Section 6.2.1(b) describes the assessment that would be performed if triggered in (a). While Merck would perform the assessment, assistance would be needed from the NPS for the demonstrated AQRV evaluation methods. Any AQRV assessment triggered by the PSD permit will be performed in accordance with established NPS procedures in place at the time of the assessment. These should be quantitative measures that are demonstrated to be accurate, so that little if any qualitative judgment would be necessary to make the evaluation.

Once the AQRV assessment is performed in (b), the stakeholders would evaluate whether Merck's VOC emissions are the cause of adverse impacts on any AQRV in the Class I area. (Section 6.2.1(c)). If the signatories agreed, Merck would be required to implement mitigation measures to address this impact. The measures that would be required must be agreed upon by the signatories.

Section 6.2.2 requires certain modeling the first time the site's VOC emissions reach 125% of the baseline (i.e., 510 TPY). This modeling is also required the first time the site's emissions reach 100 TPY increments above this level; i.e. at 610 TPY, 710 TPY, etc. Remodeling would not be required if the site's emissions reached 510 TPY, dropped below this level, and increased to 510 TPY again, for example. Modeling is only required when the site's emissions reach the level for the first time.

When Section 6.2.2 is triggered, Merck is required to provide the list of non-HAP VOCs emitted from the facility in the previous 12 months. EPA would conduct a review of the scientific literature for any new information pertaining to the health effects of these compounds and provide the information to the stakeholders.

Merck also would be required to perform modeling of the emissions of these compounds to predict average property line concentrations. These concentrations would be compared to levels established by the Virginia air toxics rule. This section would require Merck to take action if any of the Virginia levels were predicted to be exceeded: either to demonstrate that the Virginia level is inappropriate by showing that the emissions produce no endangerment of human health, or to implement changes at the site resulting in ambient concentrations of the compound that are below the Virginia levels or are otherwise acceptable to VADEQ.

This section also would allow this modeling requirement to be changed if necessary, for example if Virginia significantly changes its air toxics program in light of EPA's developing MACT requirements. No changes to this provision would be made without full signatory consent, however.

7. Duration Of The PSD Permit

This XL project is intended to replace certain existing regulatory requirements with requirements in the permit which will result in superior environmental performance. As such, it is a permanent replacement; the permit is not provided with a specific termination date. Section 7 specifies that the permit shall continue to be in effect unless terminated as specified in Section 8 (termination for certain actions) or Section 11 (termination associated with transfer of ownership of the facility). This is especially important because of the large capital investment that Merck will be making in the powerhouse. As mentioned above, this investment is not otherwise necessary for operational or regulatory reasons.

The signatories agreed to give the permit no end date because:

- Merck is making a significant capital investment in the powerhouse conversion;
- the permit is intended to be a permanent, superior replacement for certain existing requirements;
- other PSD permits also do not have a termination date; and
- the permit contains certain provisions which allow for adjustments if certain conditions change in the future (Section 6), and for termination for certain reasons (Section 8).

8. Termination Of The PSD Permit

As discussed above, it is anticipated that the permit will remain in effect long into the future. Nevertheless, the permit provides for its own termination if certain conditions are met. If EPA or VADEQ determine that the plant's operations under the PSD permit result in imminent and substantial endangerment to public health or welfare or the environment, termination may result. Several specific actions by Merck could also result in permit termination, such as failure to implement the powerhouse conversion, knowingly falsifying emissions data, or exceeding the total emissions cap. Accumulation of four consent orders or two judgments against Merck related to permit non-compliance in any five year period could be grounds for termination, if they are deemed material. The decision regarding materiality will be made by the agency initiating the termination action. The signatories may terminate the permit for any reason at any time if there is full consent to do so. In addition, VADEQ reserves whatever statutory authority it has to terminate any air permits.

There is an exemption from termination in situations where the cause of termination is not reasonably foreseeable and is beyond Merck's control. This is known as a "force majeure" exemption. If, for example, the powerhouse conversion is not completed on time because the boiler factory floods, it would be improper to terminate the permit on that basis since Merck could neither foresee nor control the delayed boiler delivery. Under those circumstances, Merck would notify EPA and VADEQ of the delay, its cause, and a revised timeframe for project completion within seven days of becoming aware of the delay.

If a termination action is initiated, the VADEQ or EPA must notify the signatories of their intent in writing. Merck has 30 days after notification to remedy the cause of termination, or to establish a plan to do so. If the remedy is judged to be satisfactory by the terminating agency, the proposal to terminate will be withdrawn; otherwise the permit would be terminated.

Since Merck's Title V permit under Project XL will be substantially simpler than it would be otherwise, termination of the XL PSD permit would require substantial revisions to the plant's Title V permit. In the event of termination, Merck would meet with the Title V permitting agency to agree upon a revised set of Title V applicable requirements. The plant's revised Title V permit application would be filed within one year of notice of intent to terminate the PSD permit, or in some other timeframe agreed to with the agency. Between the time of the notice of intent to terminate the PSD permit and completeness determination of the revised Title V permit application, Merck would continue to abide by all requirements of the PSD permit that were in effect at the time of termination. The Title V permitting agency would then issue an order that Merck should begin operating in accordance with all applicable requirements in the revised Title V application pending issuance of the Title V permit, and the PSD permit would be terminated.

If the plant's emissions exceed the total emissions cap during the termination process, emission increases would only be allowed with prior approval of the permitting agency and receipt of the required preconstruction permits.

9. Inspection And Entry

Authorized EPA and VADEQ employees have a right, as provided in Section 9 of the permit, to enter the plant at reasonable times for the purpose of collecting information relevant to PSD permit compliance. This information collection could take the form of facilities and equipment inspections (including pollution control equipment), observation of work practices that have a bearing on emissions, inspection and/or copying of records required to be kept by the PSD permit, and inspection of other batch records needed to verify emissions. Sampling or monitoring for the purpose of PSD permit compliance verification may be performed. Obstruction or interference in these activities could be considered a permit violation and could result in civil penalties.

Merck has a responsibility to assure the safety of any individual who enters the site, and Merck would require that all inspection activities be performed in accordance with corporate safety policies. Such policies may require the use of personal protective equipment to enter certain areas, or may preclude entry to certain areas during hazardous operations.

Merck also has a responsibility, based on Food and Drug Administration regulations, to assure the safety, purity, and effectiveness of its pharmaceutical products. All inspection activities must be conducted consistent with Good Manufacturing Practices in force at the site in order to assure product integrity.

10. Resewation Of Rights

This section reserves the rights of the project signatories in the same manner as under any other PSD permit. EPA and VADEQ retain the right to enforce the permit and take certain actions necessary as provided under law. Merck also retains what rights and defenses it has to appeal enforcement or termination actions as provided under state and federal regulations and law.

11. Transfer Of Ownership

Environmental permits are an important part of a facility's production capability; without permits, the facility's processes would not be allowed to operate. As a result, they are as valuable as the site's manufacturing equipment, and an important asset to the facility's owner. If a facility is sold, virtually all permits allow for the transfer of the permits to the new owner.

On the other hand, Merck's selection for participation in EPA's XL program was premised on Merck's reputation as a progressive environmental company. Opportunities for operational flexibility while providing superior environmental protection under Project XL are not afforded to companies with a poor environmental performance history. Therefore, transfer of the XL permit cannot be automatic. A new facility owner would have to be reviewed by the project stakeholders before continuation of the permit would be allowed.

Section 11 of the PSD permit contains this provision. It allows for the permit to be transferred to a new owner upon sale of the site. It requires Merck to notify the stakeholders of the sale, and the new owner to submit the 12-month rolling total of criteria pollutant emissions on a monthly basis for the first 12 months of ownership. This monthly report would be required regardless of the reporting tier that the facility was operating under during that time. It would give the new owner the opportunity to demonstrate to the stakeholders his intent to operate the facility in the same environmentally protective manner that Merck had been operating.

After 12 months, the stakeholder group (minus Merck and including a representative of the new owner) would reconvene to review the permit as provided in Section 6.1. Essentially, the five-year review would be moved up to take place at 12 months after the change in ownership.[10] The review would also include the affirmative renewal of the permit by the project signatories; in other words, the project signatories would have to agree that the permit should continue, or else the permit would be terminated as provided in Section 8.4. It is expected that the new owner would be given an impartial assessment by the stakeholders, considering the owner's good faith efforts over the first 12-month period and the permit's long term environmental benefits.

12. Definitions For Terms In The PSD Permit

This section contains definitions that pertain to the permit. These definitions are either self-explanatory or are discussed above.

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[10] The next five-year review would take place five years after this review.

Figures.

Appendices

Figure 1
Timeline for Approval of Cap Adjustments in Section 1.2.2
(Days)

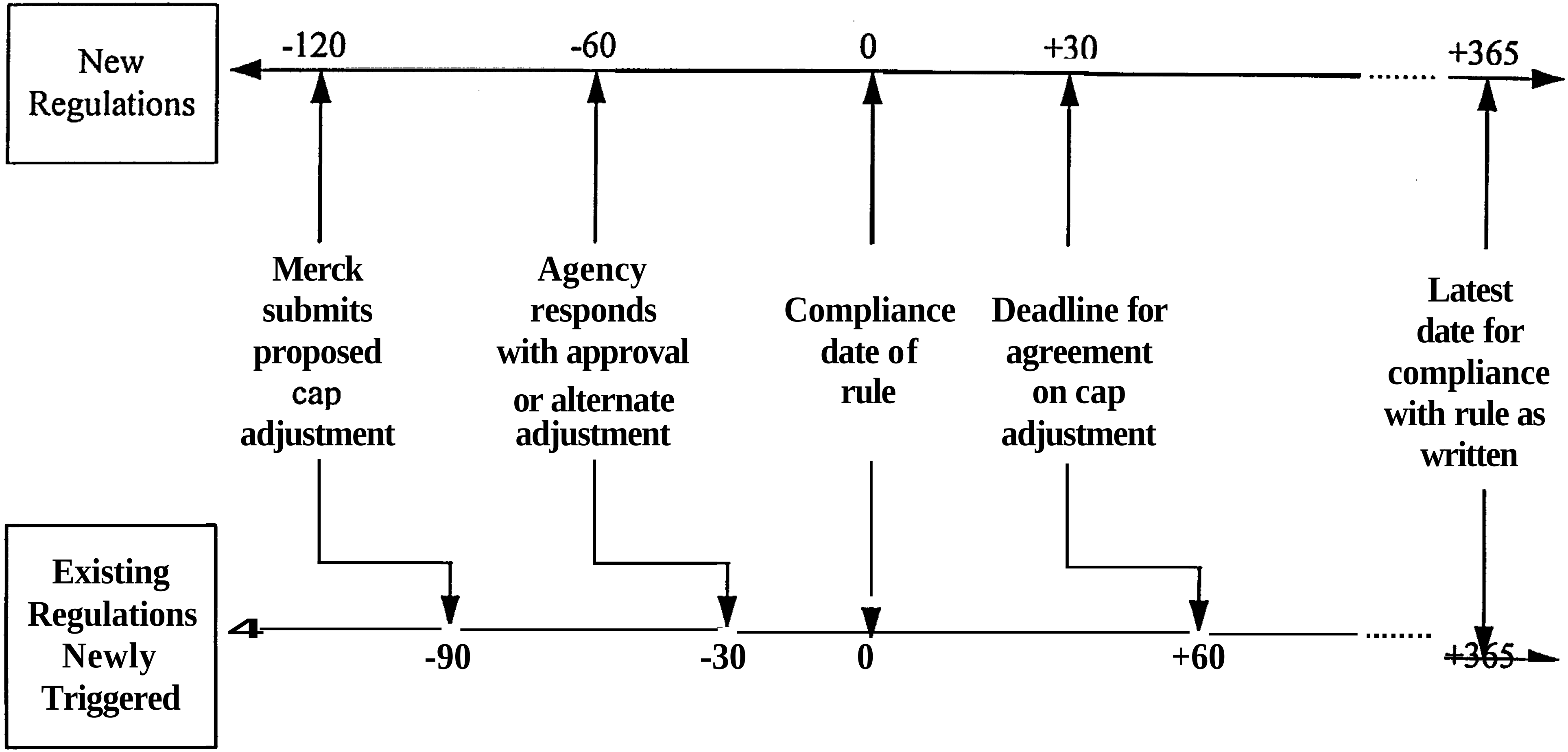
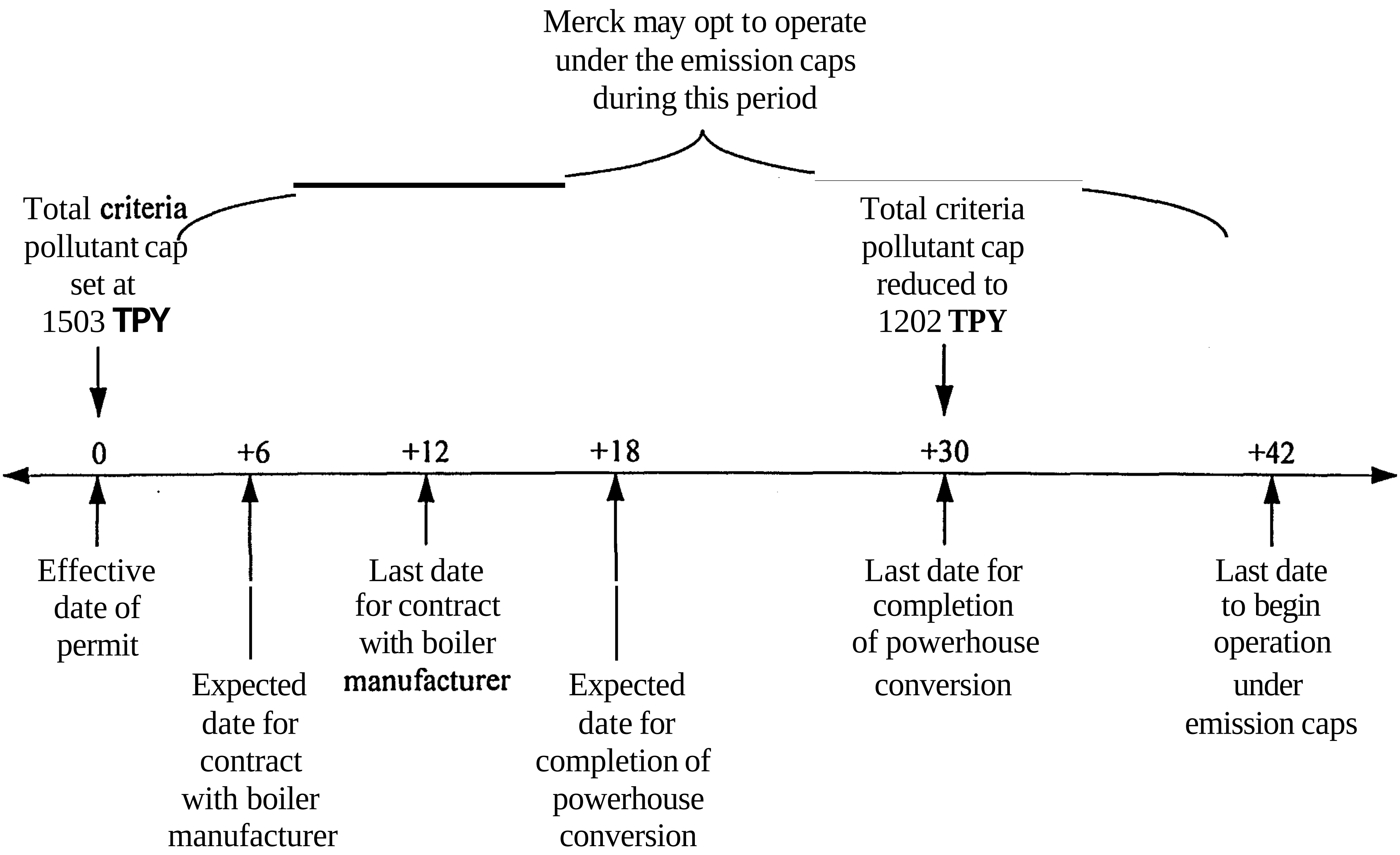


Figure 2

Timeline for Powerhouse Conversion and Emission Caps

(Months)



APPENDIX 1

BASELINE EMISSIONS SUPPORT DOCUMENT

PROJECT XL - Merck Stonewall Plant

Support Documentation for Baseline Air Emissions of Criteria Pollutants - 1992 - 1993 Operations

Background:

The Merck Stonewall Plant employs about 770 people in a range of **pharmaceutical** manufacturing activities such as fermentation, solvent extraction, organic synthesis, and finishing operations. Under Project XL the Merck Stonewall Plant proposes to operate under site-wide criteria pollutant emissions caps (limits) **as** described in the draft XL permit. The total criteria pollutant emissions cap is the average of actual total criteria pollutant emissions from the site for 1992 and 1993 shown in Attachment I. Emissions of acetone were not included in the baseline since this chemical is no longer a regulated air pollutant. The purpose of this document is to **summarize** the basis of the calculations used to develop the total emissions cap and to serve **as** technical support for the emissions in the 1992 - 1993 criteria pollutant baseline.

Discussion of Emissions Calculations

General

The Stonewall plant pharmaceutical manufacturing processes are primarily batch operations from which the majority of site-wide emissions of volatile organic compounds **(VOCs)** are emitted. The pharmaceutical processes are supported by utilities including a powerhouse (two coal-fired boilers and one oil-fired standby boiler), wastewater treatment system, bulk storage tanks, central solvent recovery operations, sludge incinerator, solid waste incinerator, and internal combustion engines which serve **as** emergency generators. Each of these emission sources and the basis for calculating emissions is described in more detail in the following sections. Because of the fundamental differences in calculating emissions associated with batch pharmaceutical manufacturing (and support facilities) and calculating emissions **from** combustion sources, each of these categories of emission sources is discussed separately.

1. **Batch Pharmaceutical Manufacturing**

1.1 Process Vent Emissions

Batch pharmaceutical facilities are complex operations which emit VOCs **from** a variety of process vessels and operations. Merck & Co., Inc. **uses** the unit operation-based engineering equations in **EPA's** Control Techniques **Guideline (CTG) series entitled** "Control of Volatile Organic Emissions from Manufacture of Synthesized Pharmaceutical Products" (EPA **-450/2-78-029)** to quantify emissions from these processes. This is ~~an~~ the only EPA approved ~~method~~ Control Techniques Guideline containing methods for quantifying VOC emissions from ~~these~~ pharmaceutical manufacturing operations. Merck has developed two computer ~~models~~ programs, MacEmit and Emit 10, ~~based on~~ which incorporate the emission estimating equations in ~~the 1978~~ EPA's CTG. MacEmit and EMIT 10 may be used for all process operations except bulk tank breathing losses, which are only computed using the EMIT 10 model. These programs were demonstrated to be equivalent to manually using the CTG equations; this validation is documented in Attachments II-V. Attachment II provides a summary comparing the results of using hand calculations, EMIT 10, and MacEmit for the various operations associated with pharmaceutical batch processes. Attachments III through V provide the results of using hand calculations, and data output from EMIT 10 and MacEmit for the example calculations summarized in Attachment II. These attachments provide examples of the type of calculations required for these operations and demonstrate that the computerized emission calculation programs EMIT 10 and MacEmit utilize the ~~1978~~ CTG algorithms and are equivalent. These ~~models~~ programs are the most proficient, cost effective method of determining emissions from our complex batch operations and were used to compute VOC emissions for 1992 - 1993.

~~It should be noted that VOC emissions calculations from batch operations provide a result which is equivalent to an emission factor (i.e. lbs VOC per batch of product).~~ All pharmaceuticals are manufactured within rigid quality assurance controls required by the U.S. Food and Drug Administration; ~~which~~ such controls establish the strict parameters for processing each batch of product. For a particular product, one batch is run in the same manner as any other batch. Therefore, the emissions calculated for one batch will be comparable to those of any other batch of the same product. Such emissions can be considered an emission factor for a specific product (i.e., lbs VOC per batch of product). Thus ~~Therefore~~ annual emissions from a given manufacturing process depends primarily on the number of batches manufactured, assuming the basis for the emission factor has not changed (i.e. the manufacturing process has not changed and the emission controls are the same). The emission factor and number of batches manufactured for each pharmaceutical manufacturing process is used to establish the VOC emissions for a given operating year. Because each pharmaceutical manufacturing process is registered with the Virginia Department of Environmental Quality, VOC emissions from process vents for each process have either been reviewed and approved by the DEQ through the issuance of preconstruction air permits or by review of emissions data submitted in the annual air emissions inventory.

VOC emissions from fermentation processes at the Stonewall Plant are negligible. Attachment VI provides a description of the fermentation operations at the Stonewall Plant and the basis for this determination.

1.2 VOC Emissions from Bulk Storage Tanks

VOC emissions from bulk storage tanks include filling losses and breathing losses. The Stonewall Plant uses the EMIT 10 model to compute bulk tank breathing losses. As discussed in Section 1.1 this validated computer ~~model~~ program uses the algorithms in

EPA's ~~1978~~ CTG entitled "Control of Volatile Organic Emissions from Manufacture of Synthesized Pharmaceutical Products" (EPA -45012-78-029). This CTG ~~is an~~ contains the only **approved** EPA method for computing emissions from these operations. Attachment **III** provides the example calculations for both filling and breathing losses from **tanks,** including each of the parameters considered **(i.e.** size of **tank,** solvent type, vapor pressure, etc.) and the assumptions. As noted above for VOC emissions from process vents, since each pharmaceutical manufacturing process is registered with the Virginia Department of Environmental Quality, VOC emissions from bulk storage tanks for each pharmaceutical manufacturing process have either been reviewed and approved by the DEQ through the issuance of **preconstruction** air permits or by review of emissions data submitted in the annual air emissions inventory.

1.3 VOC Emissions from Central Solvent Recovery

During 1992 -1993 the Stonewall plant used atmospheric distillation columns to recover several solvents for **re-use,** including ethyl acetate, methanol, isopropyl acetate, xylene and ethanol. VOC emissions from central solvent recovery were determined by using **a.)** knowledge of process operations during this period, b.) application of heat exchanger **software** developed by B-JAC International, Inc. to determine the condensing efficiencies of the primary condenser systems for the chemicals recovered by this process **(i.e.** the ability to condense all of the VOCs present in the condensable gas phase, and c.) engineering principles to determine the emissions of VOCs present in the noncondensable gas phase. The procedure used to calculate VOC emissions from the noncondensable gas phase is provided in Attachment VII.

1.4 VOC Emissions from Equipment Leaks

The Merck Stonewall plant has developed an emission factor for component leaks based on actual measurements of 8,000 components (flanges, valves, pumps, etc.) conducted in 1990 and 1992. The method of developing component - specific factors is known as the "EPA correlation Approach" and is one of four EPA approved methods for estimating equipment leaks as described in the **EPA's** document entitled "Protocol for Equipment Leak Emission Estimates", June 1993 **(EPA-453/R-93-026).** The "EPA Correlation Approach" which is summarized in Section 2.3.3 of that document, is second in accuracy only to the "Unit Specific Correlation Approach" described in the same document. The methodology using these emission factors for **determining** emissions from process components has been approved by the DEQ and currently provides the basis for determining emissions in preconstruction permitting. Attachment VIII provides an example of the computer calculations used to determine the emissions for equipment leaks from the **Amprolium** process. It also serves as an example of how equipment leak computations are done for the other processes.

1.5 VOC Emissions from Wastewater Treatment

VOC emissions **from** the on-site wastewater treatment system were determined through the use of the TOXCHEM model developed by Enviromega, Ltd. TOXCHEM is an EPA approved method for computing emissions from wastewater treatment **systems when used, as Merck does, in accordance with the stipulations summarized in Appendix C of** 40 CFR Part 63. This model **requires** various input parameters representative of actual operations. These data are described in Attachment IX which provides a description of the **model,** the algorithms used for calculating VOC emissions, and an example calculation to illustrate the **functionality** of the model. TOXCHEM modeling for existing processes is based on actual influent test data **(i.e.** VOC concentration and wastewater flow) and existing wastewater treatment configuration. The emission rate calculated by TOXCHEM is directly proportional to the influent loading, which is proportional to the number of batches of product manufactured in a given process. Therefore, the VOC emission rate determined by **TOXCHEM** resulting fiom actual influent loading in a given year can be used to determine emissions for other years based on production. Accordingly, actual influent loading data together with process-specific production rates were used to determine emissions from wastewater treatment for 1992 - 1993.

2. Powerhouse Boilers

Boilers No. 5 and 6 combust bituminous coal and supply steam to the plant. These identical units were installed in 1982. Each spreader stoker unit has a maximum heat input rating of 123.5 **MMBtu** per hr. Particulate matter (PM) emissions **from** these units are controlled using baghouses, and **overfire** air is used to minimize nitrogen oxides **(NOx)** formation.

During startup of the boilers, the standard operating procedures specify that the **baghouse** must be bypassed for safety purposes and to avoid blinding these devices from by-products of incomplete combustion (soot). Emission factors for such startup events are not available. Emissions during these episodes are assumed to be equal to normal PM-10 boiler emissions at typical fuel usage rates, except without application of the **baghouse** removal efficiency. This is a conservative assumption because emissions during startup are higher than normal, requiring bypass of the control device.

A third boiler is used on a standby basis. This unit was installed in 1941 and **combusts** No. 2 fuel oil. This unit is registered as an existing source and has no emissions control equipment. The unit's energy input rate was estimated to be approximately 120 **MMBtu.** per hr.

Methodology for Emissions Calculations

Emission rates for criteria pollutants were calculated using EPA approved emission factors or other available emissions data as the product of the stated emission factor and the mass of coal or volume of fuel oil combusted. The following emissions data spreadsheet provides a complete summary of the fuel throughput (coal and No. 2 fuel oil), the emission factors used and the source and rating of each emission factor. The pages following the emissions data spreadsheet provide example calculations to illustrate **how** the emission rates were calculated in the spreadsheet. By following the directions provided in the example calculations and using the data in the spreadsheet, one can calculate the emission rate for each criteria pollutant in the spreadsheet.

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Summary of Emissions from the Powerhouse for the 1992 - 1993 Baseline

Operating Year	Pollutant	Fuel Consumption	Energy Input (1) (MM Btu/Yr)	Emission Factor (E F)	Source of E F.	E F. Rating	Calculated Emissions (2) (Tons/Yr)
1992	Sulfur Dioxide	44.320 tons Coal	NA	30 (S) lbs SO2/ton (3)	EPA - AP-42, 5th Ed	B	*690.5*
	Sulfur Dioxide	66,000 gals No 2	NA	142(S)lbs SO2/kgal (4)	EPA - AP-42, 5th Ed	A	*2.3*
	Nitrogen Oxides	44,320 tons Coal	*1178912*	0 478 lbs NOx/MMbtu	CEMS Data (5)	NA	*281.8*
	Nitrogen Oxides	66,000 gals No. 2	NA	20 lbs NOx/kgal	EPA - AP-42, 5th Ed	A	*0.7*
	Carbon Monoxide	44,320 tons Coal	NA	1 lb CO/ton	NA (Permit)	NA	22.2
	Carbon Monoxide	66,000 gals No 2	NA	5lbs CO/kgal	EPA - AP-42, 5th Ed.	A	0.2
	PM10	44.320 tons Coal	1178912	0 08 lbs PM10/mmbtu	OAQPS Guidance (6)	NA	35.4
	PM10	(see 7)	NA	13 2 lb PM10/ton	EPA - AP-42, 5th Ed.	E	0.3
	PM10	66,000 gals No 2	NA	1 0 lbs PM10/kgal	EPA - AP-42, 5th Ed	A	0 0
	PM10 (8)	NA	NA	1 6 lbs PM/AC/Hr(U)	EPA - AP-42, 5th Ed	C	4 3
	VOC	44,320 tons Coal	NA	0 06lbs VOC/ton	EPA - AP-42, 5th Ed	B	1 3
	VOC	66.000 gals No. 2	NA	0 2 lbs VOC/kgal	EPA - AP-42, 5th Ed.	A	0.0
						Emissions for 1992:	1038.9
1993	Sulfur Dioxide	44,050 tons Coal	NA	38 (S) lbs SO2/ton (3)	EPA - AP-42, 5th Ed.	B	703.0
	Sulfur Dioxide	21,000 gals No. 2	NA	142(S)lbs SO2/kgal (4)	EPA - AP-42, 5th Ed	A	0.7
	Nitrogen Oxides	44,050 tons Coal	1171730	0 478 lbs NOx/MMbtu	CEMS Data	NA	280.0
	Nitrogen Oxides	21,000 gals No. 2	NA	20 lbs NOx/kgal	EPA - AP-42, 5th Ed	A	0.2
	Carbon Monoxide	44,050 tons Coal	NA	1lb CO/ton	NA (Permit)	NA	22.0
	Carbon Monoxide	21,000 gals No. 2	NA	5lbs CO/kgal	EPA - AP-42, 5th Ed	A	0.1
	PM10	44,050 tons Coal	1171730	0 06 lbs PM10/mmbtu	OAQPS Guidance (6)	NA	35.2
	PM10	(see 7)	NA	13 2 lb PM10/ton	EPA - AP-42, 5th Ed.	E	0.4
	PM10	21,000 gals No 2	NA	1 0 lbs PM/kgal	EPA - AP-42, 5th Ed	A	0.0
	PM10 (8)	NA	NA	1 6 lbs PM/AC/Hr(U)	EPA - AP-42, 5th Ed	C	4.3
	VOC	44.W tons Coal	NA	0 06lbs VOC/ton	EPA - AP-42, 5th Ed.	B	1.3
	VOC	21,000 gals No 2	NA	0 2 lbs VOC/kgal	EPA - AP-42, 5th Ed	A	0.0
						Emissions for 1933:	1047.3
					Emissions Average for 1992-1993:		1043.1

Notes:

(1) Calculate the total energy input as the product of the tons of coal combusted in the operating year times the energy value of the coal (13.300 Btu's per pound of coal)

(2) Calculate emissions as the product of the stated emission factor and the energy input value (or the mass of the coal or volume of the fuel oil combusted) Example calculations are provided for emissions results which are underlined and in italics.

(3) The average sulfur content of the coal for 1992 and 1933 war 0 82% and 0 84% by weight, respectively.

(4) The sulfur content in the auxiliary fuel is less than or equal to 0 5% by weight

(5) CEMS Data Source: Performance Specification Testing by Entropy Environmentalists, Inc., July 1989.

(6) See EPA 7117196 guidance memo concerning PM-10 emissions from spreader-stoker boilers with baghouse control (Attachment X)

(7) PM-10 emissions from boiler start-ups were determined using EPA AP-42 factor of 13 2 lb PM-10 per ton of coal actual number of start-up. (8 and 12 for 1892 and 1993, respectively), and the m a g s coal usage per start-up of 5 tons of coal

(8) Particulate emissions from the coal pile are based on an average wind speed of 1 09 meters per second (the value for "U" in the AP-42 factor) and a coal pile area of 0.566 acres.

Example Calculations - Powerhouse Emissions

Example A:

Calculate the annual emissions of SO_2 for 1992;

1. Calculate SO_2 emissions from coal combustion as the product of actual tons of coal combusted and the selected SO_2 emission factor for coal combustion: use the actual sulfur content of **0.82%** for the "S" value in the emission factor for the operating year.

$$\frac{44.320\text{ tons}}{\text{(coal)}} \times \frac{38\,(0.82)\text{ lbs. SO2}}{\text{ton coal}} \times \frac{1\text{ ton}}{2{,}000\text{lbs}} = 690.5\text{ tons SO2}$$

2. Calculate SO_2 emissions from the combustion of No. 2 fuel oil as the product of actual oil combusted and the selected SO_2 emission factor for oil: use a sulfur content of 0.5% for the "S" value in the emission factor.

$$\frac{66.000\text{ gals}}{\text{(oil)}} \times \frac{142\,(0.5)\text{ lbs. SO2}}{1\text{ kgal}} \times \frac{1\text{ kgal.}}{1{,}000\text{ gals}} \times \frac{1\text{ ton}}{2.000\text{ lbs}} = 2.3\text{ tons SO2}$$

3. Calculate the total annual SO_2 emissions by adding the results of 1 and 2 above:

$$690.5\text{ tons SO2} + 2.3\text{ tons SO2} = 692.8\text{ tons SO2}$$

Example B

Calculate the annual emissions of NO_x for 1992:

Calculate the annual emissions of NO_x emissions from the combustion of coal using actual CEM data:

1. Calculate the annual energy input for coal as the product of actual tons of coal combusted and actual energy value of the coal combusted:

$$\frac{44.320\text{ tons}}{\text{(Coal)}} \times \frac{2.000\text{ lbs.}}{\text{Ton}} \times \frac{13.300\text{ Btu}}{\text{lb coal}} = 1.179\text{x}10^{12}\text{ Btu}$$

2. Use the actual CEM data from performance testing in 1989 and the annual energy input calculated in I above to calculate annual NOx emissions from coal:

$$\frac{1{,}178{,}912\ \text{MMBtu}}{\text{(coal)}} \times \frac{0.478\ \text{lbs. NOx}}{\text{MMBtu}} \times \frac{1\ \text{ton}}{2{,}000\ \text{lbs.}} = 281.8\ \text{tons NOx}$$

3. Calculate NOx emissions from the combustion of No. 2 fuel oil as the product of actual oil combusted and the selected NOx emission factor for oil:

$$\frac{66{,}000\ \text{gals}}{\text{(oil)}} \times \frac{20\ \text{lbs. NOx}}{\text{kgal oil}} \times \frac{1\ \text{kgal.}}{1{,}000\ \text{gals}} \times \frac{1\ \text{ton}}{2{,}000\ \text{lbs}} = 0.7\ \text{tons NOx}$$

4. Calculate the total annual NOx emissions by adding the results of 1.2 and 3 above:

$$281.8\ \text{tons NOx} + 0.7\ \text{tons NOx} = 282.4\ \text{tons NOx}$$

Methods for Other Calculations:

Calculation of emissions for sulfur dioxide. carbon monoxide. PM-10, and volatile organic compounds (VOCs for each operating year is completed by selecting the proper emission factor and applying it to the actual annual fuel throughput as described in Example A above. Calculation of emissions of NOx for the 1993 operating year is completed using actual fuel throughput data for 1993 in the same manner as that described in Example B above. The data analysis spreadsheet provides a complete summary of the results of these calculations and the basis.

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3. Sludge Incinerator

The multiple hearth sludge incinerator thermally destroys wastewater sludge generated at the wastewater treatment plant. The unit consists of an Envirotech seven hearth furnace and burns No. 2 fuel oil to supplement the heating value of the sludge. Its maximum energy input rate is approximately 8 MMBtu per hr. Sludge solids primarily consist of biomass generated by the biological secondary treatment process. Emissions of particulate matter are controlled using venturi and impingement scrubbers.

Methodology for Emissions Calculations

Emission rates for criteria pollutants were calculated using EPA approved emission factors or other available emission data as the product of the stated emission factors and the mass of sludge and volume of fuel oil combusted, respectively. The following emissions data spreadsheet provides a complete summary of the throughput of sludge and No. 2 fuel oil, the value of the emission factors used and the source and rating of each emission factor. The pages following the emissions data spreadsheet provide example calculations to illustrate how the emission rates were calculated in the spreadsheet. By following the directions provided in the example calculations and using the data in the spreadsheet, one can calculate the emission rate for each criteria pollutant summarized in the spreadsheet.

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Summary of Emissions from the Sludge Incinerator for the 1992 - 1993 Baseline

5/17/96

Operating Year	**Pollutant**	**Fuel** Consumption (Gals. of No. 2 Fuel **Oil**)	Material Throughput (Dry Tons Sludge)	**Emission Factor** (E.F.)	Source of E.F.	E.F. **Rating**	Calculated Emissions (1) **(Tons/Year)**
1992	Sulfur Dioxide	NA	**1090**	0.2 **lbs. SO2/ton**	**EPA - AP-42, 5th ed.**	E	***0.1***
	Sulfur Dioxide	**408,200**	NA	142 **(S) lbs.SO2/kgal (2)**	EPA - **AP-42, 5th** ed.	A	***14.5***
	Nitrogen Oxides	NA	**1090**	5.0 **lbs NOx/dry** ton	EPA - **AP-42, 5th** ed.	C	***2.7***
	Nitrogen Oxides	**408,200**	NA	20 **lbs NOx/kgal**	EPA - **AP-42, 5th** ed.	**A**	***4.1***
	Carbon Monoxide	NA	**1090**	31 **lb CO/ton**	EPA - **AP-42, 5th** ed.	E	16.9
	Carbon Monoxide	**408,200**	NA	**5lbs.CO/kgal**	EPA - AP-42. **5th** ed.	A	1.0
	PM10	NA	**1090**	**1.3 lbsPM/ton** (3)	**Permit Limit**	NA	0.7
	PM10	**408,200**	NA	1.0 **lbs PM/kgal**	EPA - **AP-42, 5th** ed.	A	0.2
	VOC	NA	**1090**	17 **lbs.VOC/ton**	**EPA - AP-42, 5th** ed.	**D**	0.9
	VOC	**408,200**	NA	0.34 **lbs VOC/kgal**	EPA - **AP-42, 5th** ed.	A	0.1
						Emissions for 1992:	41.2
1993	Sulfur Dioxide	**NA**	**980**	0.2 **lbs. SO2/ton**	EPA - **AP-42, 5th** ed.	E	**0.1**
	Sulfur Dioxide	**392,833**	**NA**	142 (S) **lbs.SO2/kgal (2)**	EPA - **AP-42, 5th** ed.	A	**13.9**
	Nitrogen Oxides	**NA**	**980**	5.0 **lbs NOx/dry** ton	EPA - **AP-42, 5th** ed.	C	**2.5**
	Nitrogen Oxides	**392,833**	**NA**	20 lbs **NOx/kgal**	EPA - **AP-42, 5th** ed.	A	**3.9**
	Carbon Monoxide	**NA**	**980**	31 **lb CO/ton**	**EPA - AP-42, 5th** ed.	E	**15.2**
	Carbon Monoxide	**392,833**	**NA**	**5lbs.CO/kgal**	EPA - **AP-42, 5th ed.**	A	**1.0**
	PM10	**NA**	**980**	13 **lbsPM/ton**	**Permit** Limit	NA	**0.6**
	PM10	**392,833**	**NA**	1.0 lbs **PM/kgal**	EPA - **AP-42, 5th** ed.	A	**0.2**
	VOC	**NA**	**980**	17 **lbs.VOC/ton**	EPA - **AP-42, 5th** ed.	D	**0.8**
	VOC	**392,833**	**NA**	0.34 **lbs VOC/kgal**	EPA - **AP-42, 5th** ed.	A	**0.1**
						Emissions for 1993:	**38.3**
					Emissions Average for **1992 - 1993:**		**39.8**

Notes:

(1) Emissions are calculated as the **product** of the stated emission factor and the mass of **the** sludge or the volume of the fuel oil **combusted. Example** calculations are provided for **emissions results which** are underlined and in *italics.*

(2) The sulfur content in the auxiliary fuel is **less** than or equal to 0.5% by **weight.**

(3) Particulates are **controlled with** a **venturi** scrubber followed **by impingement scrubber.**

Example Calculations - Sludge Incinerator Emissions

Example A:

Calculate the annual emissions of SO2 for 1992:

1. Calculate SO2 emissions from sludge incineration as the product of actual tons dry sludge incinerated and the selected SO2 emission factor for sludge incineration.

$$\underset{\text{(sludge)}}{\underline{\text{1,090 tons}}} \times \frac{\text{0.2 lbs. SO2}}{\text{ton sludge}} \times \frac{\text{1 ton}}{\text{2,000 lbs}} = \text{0.1 tons SO2}$$

2. Calculate SO2 emissions from the combustion of No. 2 fuel oil as the product of the actual volume of oil combusted and the selected SO2 emission factor for oil; use a sulfur content of 0.5% for the "S" value in the emission factor.

$$\underset{\text{(oil)}}{\underline{\text{408.200 gals}}} \times \frac{\text{142 (0.5) lbs. SO2}}{\text{1 kgal}} \times \frac{\text{1 kgal.}}{\text{1.000 gals}} \times \frac{\text{1 ton}}{\text{2.000 lbs}} = \text{14.5 tons SO2}$$

3. Calculate the total annual SO2 emissions by adding the results of 1 and 2 above:

0.11 tons SO2 ÷ 14.49 tons SO2 = 14.6 tons SO2

Example B

Calculate the annual emissions of NOx for 1992:

1. Calculate NOx emissions from sludge incineration as the product of actual tons dry sludge incinerated and the selected NOx emission factor for sludge incineration.

$$\underset{\text{(sludge)}}{\underline{\text{1,090 tons}}} \times \frac{\text{5 lbs. NOx}}{\text{ton sludge}} \times \frac{\text{1 ton}}{\text{2,000 lbs}} = \text{2.7 tons NOx}$$

2. **Calculate NOx** emissions from the combustion of No. 2 fuel oil as the product of actual volume of oil combusted and the selected **NOx** emission factor for oil.

$$\frac{\text{408.200 gals}}{\text{(oil)}} \quad \text{x} \quad \frac{\text{0 lbs. N O}}{\text{1 kgal}} \quad \text{x} \quad \frac{\text{1 kgal.}}{\text{1.000 gals}} \quad \text{x} \quad \frac{\text{1 ton}}{\text{2,000 lbs}} \quad = \text{4.1 tons NOx}$$

3. Calculate the total **annual NOx** emissions by adding the results of 1.2 and 3 above:

$$\text{2.73 tons NOx} \quad + \quad \text{4.08 tons NOx} \quad = \text{6.8 tons NOx}$$

Methods for Other Calculations:

Calculation of emissions for sulfur dioxide. carbon monoxide. **PM-10, NOx,** and volatile organic compounds **(VOCs)** for each operating year is completed by selecting the proper emission factor and applying it to the actual annual fuel and sludge throughput in the same manner as described in Examples A and B above. The data analysis spreadsheet provides a complete summary of the results of these calculations and the basis.

4. Solid Waste Incinerator

The solid waste incinerator thermally destroys Type "0" solid wastes generated by the plant (consisting principally of paper, wood, and fiber drums). The unit was installed in 1981 and incorporates a negative air design (negative pressure combustion chamber), and primary, secondary, and tertiary combustion chambers. Its permitted maximum waste combustion rate is approximately one ton per hour. The unit fires No. 2 fuel oil as a supplemental fuel in order to reach the required minimum secondary combustion chamber temperature of 1,600 F. Its maximum burner energy rate is approximately 5 MMBtu per hr., based on the fuel throughput limitation described in the permit.

Methodolow for Emissions Calculations

Emission rates for criteria pollutants were calculated using EPA approved emission factors or other available emissions data as the product of the stated emission factors and the mass of solid waste and volume of fuel oil combusted, respectively. The following emissions data spreadsheet provides a complete summary of the throughput of solid waste and No. 2 fuel oil, the value of the emission factors used and the source and rating of each emission factor. The pages following the emissions data spreadsheet provide example calculations to illustrate how the emission rates were calculated in the spreadsheet. By following the directions provided in the example calculation and using the data in the spreadsheet, one can calculate the emission rate for each criteria pollutant summarized in the spreadsheet.

XLSWCALC

Summary of Emissions from the Solid Waste Incinerator for Ihe 1992 - 1993 Baseline

5/17/96

Operating Year	Pollutant	Fuel consumption (Gals. of No. 2 Fud Oil)	Material Throughput (Tons Solid Waste)	Emission Factor (E.F.)	Source of E.F.	E.F. Rating	Calculated Emissions (1)
1992	Sulfur Dioxide	NA	430	2.5 lbs. SO2/ton	EPA - AP-42, 5th ed.	D	*0.5*
	Sulfur Dioxide	124,000	NA	142(S) lbs.SO2/kgal	EPA - AP-42, 5th ed.	A	*4.4*
	Nitrogen Oxides	NA	430	3.0 lbs NOx/ ton	EPA - AP-42, 5th ed.	D	*0.6*
	Nitrogen Oxides	124,000	NA	20 lbs NOx/kgal	EPA - AP-42, 5th ed.	A	*1.2*
	Carbon Monoxide	NA	430	10 lbs CO/ton	EPA - AP-42, 5th ed.	D	2.2
	Carbon Monoxide	124,000	NA	5 lbs.CO/kgal	EPA - AP-42, 5th ed.	A	0.3
	PMIO	NA	430	3.9 lbsPM/ton (3)	Permit	NA	0.8
	PMIO	124,000	NA	1.0 lbs PM/kgal	EPA - AP-42, 5th ed.	A	0.1
	VOC	NA	430	3.0 lbs.VOC/ton	EPA - AP-42, 5th ed.	D	0.6
	VOC	124,000	NA	0.34 lbs VOC/kgal	EPA - AP-42, 5th ed.	A	0.0
						Emissions for 1882:	10.9
1993	Sulfur Dioxide	NA	365	2.5 lbs. SO2/ton	EPA - AP-42, 5th ed.	D	0.5
	Sulfur Dioxide	104,000	NA	142(S) lbs.SO2/kgal	EPA - AP-42, 5th ed.	A	3.7
	Nitrogen Oxides	NA	365	3.0 lbs NOx/ ton	EPA - AP-42, 5th ed.	D	0.5
	Nitrogen Oxides	104,000	NA	20 lbs NOx/kgal	EPA - AP-42, 5th ed.	A	1.0
	Carbon Monoxide	NA	365	10 lbs CO/ton	EPA - AP-42, 5th ed.	D	1.8
	Carbon Monoxide	104,000	NA	5 lbs.CO/kgal	EPA - AP-42, 5th ed.	A	0.3
	PMIO	NA	365	3.9 lbsPM/ton	Permit	NA	0.7
	PMIO	104,000	NA	1.0 lbs PM/kgal	EPA - AP-42, 5th ed.	A	0.1
	VOC	NA	365	3.0 lbs.VOC/ton	EPA - AP-42, 5th ed.	D	0.5
	VOC	104,000	NA	0.34 lbs VOC/kgal	EPA - AP-42, 5th ed.	A	0.0
						Emissions for 1993:	9.1
						Emissions Average for 1882 - 1883:	10.0

Notes:

(1) Emissions are calculated as the product of the stated emission faclor and Ihe mass of the solid waste or the volume of the fuel oil combusted. Example calculations are provided for emisson results which are underlined and in italics.

(2) The sulfur content in Ihe auxiliary fuel is less than or equal lo 0.5% by weight.

(3) Particulate emissions are controlled with an afterburner operating at a minimum temperature of 1600 F.

Example Calculations - Solid Waste Incinerator Emissions

Example A:

Calculate the annual emissions of SO_2 for 1992:

1. Calculate SO_2 emissions from solid waste **incineration** as the product of actual tons solid waste incinerated and the selected SO_2 emission factor for solid waste incineration.

$$\frac{\text{430 tons}}{\text{(solid waste)}} \times \frac{\text{2.5 lbs. } SO_2}{\text{ton solid waste}} \times \frac{\text{1 ton}}{\text{2,000 lbs}} = \text{0.5 tons } SO_2$$

2. Calculate SO_2 emissions from the combustion of No. 2 fuel oil as the product of the actual volume of oil combusted and the selected SO_2 emission factor for oil; use a sulfur content of **0.5%** for the "S" value in the emission factor.

$$\frac{\text{124.000 gals}}{\text{(oil)}} \times \frac{\text{J42 (0.5) lbs. } SO_2}{\text{1 kgal}} \times \frac{\text{1 kgal.}}{\text{1.000 gals}} \times \frac{\text{1 ton}}{\text{2,000 lbs}} = \text{4.4 tons } SO_2$$

3. Calculate the total annual SO_2 emissions by adding the results of 1 and 2 above:

$$\text{0.5 tons } SO_2 + \text{4.4 tons } SO_2 = \text{4.9 tons } SO_2$$

Example B

Calculate the annual emissions of NO_x for 1992:

1. Calculate NO_x emissions from solid waste **incineration** as the product of actual tons of solid waste incinerated **and** the selected NO_x emission factor for solid waste incineration.

$$\frac{\text{430 tons}}{\text{(solid waste)}} \times \frac{\text{3 lbs. } NO_x}{\text{ton solid waste}} \times \frac{\text{1 ton}}{\text{2,000 lbs}} = \text{0.6 tons } NO_x$$

2. Calculate **NOx** emissions from the combustion of No. 2 fuel oil as the product of actual volume of oil combusted and the selected **NOx** emission factor for oil.

$$\frac{124.000 \text{ gals}}{\text{(oil)}} \times \frac{20 \text{ lbs. NOx}}{1 \text{ kgal}} \times \frac{1 \text{ kgal.}}{1.000 \text{ gals}} \times \frac{1 \text{ ton}}{2.000 \text{ lbs}} = 1.2 \text{ tons NOx}$$

3. Calculate the total annual **NOx emissions** by adding the results of 1.2 and 3 above:

0.6 tons **NOx** + 1.2 tons **NOx** = 1.8 tons **NOx**

Methods for Other Cnlculations:

Calculation of emissions for sulfur dioxide, carbon monoxide. PM-10, **NOx,** and volatile organic compounds **(VOCs)** for each operating year is completed by selecting the proper emission factor and applying it to the actual annual fuel and solid waste throughput in the same manner as described in Examples **A** and B above. The data analysis spreadsheet provides a complete summary of the basis and results of these calculations.

XLCHSW2

5. Emergency Generators/Internal Combustion Engines

The site operates several stationary internal combustion engines for the purpose of supplying emergency power to various process operations in the case of power interruption. The units in operation during 1992 and 1993 include: 1) one diesel generator greater than 600 hp, 2) nine diesel generators of less than 600 hp, and 3) two LP gas generators.

Methodology for Emissions Calculations

Emission rates for criteria pollutants were calculated using EPA approved emission factors or emission factors from vendor emissions data as the product of the stated emission factor (lbs. of pollutant per MMBtu per hour), fuel input and the time of operation. The following emissions data spreadsheet provides a complete summary of the fuel input rating for each size unit, the value of the emissions factors used and the source of each emission factor. The basis of emissions for the 1992 - 1993 baseline includes operation of each unit for testing and maintenance purposes once a week for approximately one half hour (i.e. 26 hours per year). The pages following the emissions data spreadsheet provide example calculations to illustrate how the emission rates were calculated in the spreadsheet. By following the directions provided in the example calculation and using the data in the spreadsheet, one can calculate the emission rate for each criteria pollutant summarized in the spreadsheet.

XLWCALC

Summary of Emissions From Emergency Generators for the 1992 - 1993 Baseline

Engine	Type	Output, Hp	Pollutant	Emission Factor (E.F.) (lb./MMBtu)	E. F. Source	EF. Rating	Fuel Input (MMBtu/hr)	Hours of Operation	Calculated Emissions (Tons per Year)	No. Units	Total Emissons (Tons per Year)
Diesel Generators	(<600 Hp)	152	so2	0.29	EPA - AP-42, 5th Ed.	D	1.1	26	*0.004*	3	0.01
			NOx	4.41	EPA - AP-42, 5th Ed	D	1.1	26	*0.06*	3	0.19
			CO	0.95	EPA - AP-42, 5th Ed.	D	1.1	26	*0.01*	3	0.04
			PM-10	0.31	EPA - AP-42, 5th Ed.	D	1.1	26	*0.004*	3	0.01
			VOC	0.36	EPA - AP-42, 5th Ed.	D	1.1	26	*0.01*	3	0.02
Subtotal									*0.09*	3	*0.27*
Diesel Generators	(<600 Hp)	250	so2	0.29	EPA - AP-42, 5th Ed.	D	2.1	26	0.01	1	0.01
			NOx	4.41	EPA - AP-42, 5th Ed.	D	2.1	26	0.12	1	0.12
			CO	0.95	EPA - AP-42, 5th Ed.	D	2.1	26	0.03	1	0.03
			PM-10	0.31	EPA - AP-42, 5th Ed	D	2.1	26	0.01	1	0.01
			VOC	0.36	EPA . AP-42, 5th Ed.	D	2.1	26	0.01	1	0.01
Subtotal									0.17	1	0.17
Diesel Generators	(<600 Hp)	124	so2	0.29	EPA - AP-42, 5th Ed	D	1.1	26	0.00	1	0.00
			NOx	4.41	EPA . AP-42, 5th Ed.	D	1.1	26	0.06	1	0.06
			CO	0.95	EPA - AP-42, 5th Ed	D	1.1	26	0.01	1	0.01
			PM-10	0.31	EPA - AP-42, 5th Ed	D	1.1	26	0.00	1	0.00
			VOC	0.36	EPA - AP-42, 5th Ed	D	1.1	26	0.01	1	0.01
Subtotal									0.09	1	0.09
Diesel Generators	(<600 Hp)	190	S02	0.29	EPA - AP-42, 5th Ed.	D	1.37	26	0.01	1	0.01
			NOx	4.41	EPA . AP-42, 5th Ed	D	1.37	26	0.06	1	0.06
			CO	0.95	EPA - AP-42, 5th Ed	D	1.37	26	0.02	1	0.02
			PM-10	0.31	EPA . AP-42, 5th Ed	D	1.37	26	0.01	1	0.01
			VOC	0.36	EPA - AP-42, 5th Ed.	D	1.37	26	0.01	1	0.01
Subtotal									0.11	1	0.11
Diesel Generators	(<600 Hp)	575	SO2	0.51	Vendor	NA	4.20	26	0.03	1	0.03
			NOx	5.17	Vendor	NA	4.20	26	0.28	1	0.28
			CO	6.48	Vendor	NA	4.20	26	0.35	1	0.35
			PM-10	0.24	Vendor	NA	4.20	26	0.01	1	0.01
			VOC	0.36	Vendor	NA	4.20	26	0.02	1	0.02
Subtotal									0.70	1	0.70
Diesel Generators	(<600 Hp)	59	so2	0.29	EPA - AP-42, 5th Ed	D	0.47	26	0.00	1	0.00
			NOx	4.41	EPA - AP-42, 5th Ed	D	0.47	26	0.03	1	0.03
			CO	0.95	EPA - AP-42, 5th Ed	D	0.47	26	0.01	1	0.01
			PM-10	0.31	EPA . AP-42, 5th Ed	D	0.47	26	0.00	1	0.00
			VOC	0.36	EPA - AP-42. 5th Ed.	D	0.47	26	0.00	1	0.00
Subtotal									0.04		0.04
Diesel Generators	(>600Hp)	900	SO2	0.51	EPA . AP-42, 5th Ed	B	6.5	26	0.04	1	0.04
			NOx	3.1	EPA . AP-42, 5th Ed	C	6.5	26	0.26	1	0.26
			CO	0.81	EPA . AP-42, 5th Ed	C	6.5	26	0.07	1	0.07
			PM-10	0.06	EPA - AP-42, 5th Ed.	E	6.5	26	0.01	1	0.01
			VOC	0.09	EPA . AP-42, 5th Ed	C	6.5	26	0.01	1	0.01
Subtotal									0.39		0.39

Engine	Type	Output, Hp	Pollutant	Emission Factor (E.F.) (lb./MMBtu)	E. F. Source	E.F. Rating	Fuel Input (MMBtu/hr)	Hours of Operation	Calculated Emissions (Tons per Year)	No. Units	Total Emissons (Tons per Year)
Ancilary Diesel Generators	(<600Hp)	27	502	0 29	EPA - AP-42, 5th Ed.	D	0 14	26	0 00	1	0 00
			NOx	4 41	EPA - AP-42, 5th Ed.	D	0 14	26	0 01	1	0.01
			CO	0 95	EPA - AP-42, 5th Ed	D	0 14	26	0 00	1	0.00
			PM-10	0 31	EPA - AP-42, 5th Ed.	O	0 14	26	0 00	1	0 00
			VOC	2 1	EPA - AP-42, 5th Ed	D	0 14	26	0 00	1	0.00
Subtotal											0.01
Ancilary LP Gas Generators (3)	(<250 Hp)	65 (kw)	SO2	0 084	EPA - AP-42, 5th Ed	D	1 0	26	0 00	1	0 00
			NOx	1 63	EPA - AP-42, 5th Ed	O	1 0	26	0 02	1	0 02
			CO	62 7	EPA - AP-42, 5th Ed	O	1 0	26	0 82	1	0 82
			PM-10	0 1	EPA - AP-42, 5th Ed	D	1 0	26	0.00	1	0 00
			VOC	2 1	EPA - AP-42, 5th Ed	D	1 0	26	0.03	1	0 03
Subtotal											0 84
Ancilary LP Gas Generators (3)	(<250 Hp)	65 (kw)	SO2	0 084	EPA - AP-42, 5th Ed	D	0 7	26	0 00	1	0 00
			NOx	1 63	EPA - AP-42, 5th Ed	O	0 7	26	0 02	1	0 02
			CO	62 7	EPA - AP-42, 5th Ed	D	0.7	26	0 60	1	0 60
			PM-10	0 1	EPA - AP-42, 5th Ed	D	0.7	26	0 00	1	0 00
			VOC	0 36	EPA - AP-42, 5th Ed	D	0.7	26	0.00	1	0 00
Subtotal											0 61
								Overall Emissions Summary (T/Y)		SO2	0 10
										NOx	1 05
										CO	1 34
										PM-10	0 05
										VOC	0.10
								Subtotals			2 65

Notes:

1. Actual emissions for 1992 - 1993 baseline are based on 26 hours of operation for each year for all internal combustion engines in use at that time. This level of use is typical for testing and operation to maintain these units in an acceptable state of readiness.

2. The example calculations for the selected emissions results (indicated by italics and underlined) incorporate the variety of calculation iterations used throughout the spreadsheet.

3. AP-42 fuel combustion emission factors for **liquified** propane emergency generators are adapted from **stationary** gasoline engines < 250 **hp.**

Example Calculations - Stationary Internal Combustion Engines

Calculate criteria pollutant emissions from each internal combustion engine as the product of the fuel input rate (MMBtu/hr), the emission factor (lbs. pollutant/MMBtu/hr) and the hours of operation. The 1992 - 1993 baseline calculations are based on 26 hours of operation per year.

1. Calculate the emissions of SO2 for internal combustion engines with 152 hp output:

$$\frac{1.1\text{ MMBtu/hr}}{\text{(fuel input)}} \times \frac{0.29\text{ lbs. SO2}}{\text{MMBtu/hr}} \times \frac{26\text{ hrs}}{\text{yr}} \times \frac{1\text{ ton}}{2{,}000\text{ lbs.}} = \frac{0.004\text{ tons SO2}}{\text{engine}}$$

2. Calculate the emissions of NOx for internal combustion engines with 152 hp output:

$$\frac{1.1\text{ MMBtu/hr}}{\text{(fuel input)}} \times \frac{4.41\text{ lbs. NOx}}{\text{MMBtu/hr}} \times \frac{26\text{ hrs}}{\text{yr}} \times \frac{}{2.000\text{ lbs.}} = \frac{0.06\text{ tons NOx}}{\text{engine}}$$

3. Calculate the emissions of CO for internal combustion engines with 152 hp output:

$$\frac{1.1\text{ MMBtu/hr}}{\text{(fuel input)}} \times \frac{0.95\text{ lbs. CO}}{\text{MMBtu/hr}} \times \frac{26\text{ hrs}}{\text{yr}} \times \frac{1\text{ ton}}{2{,}000\text{ lbs.}} = \frac{0.01\text{ tons CO}}{\text{engine}}$$

4. Calculate the emissions of PM-10 for internal combustion engines with 152 hp output:

$$\frac{1.1\text{ MMBtu/hr}}{\text{(fuel input)}} \times \frac{0.31\text{ lbs. PM-10}}{\text{MMBtu/hr}} \times \frac{26\text{ hrs}}{\text{yr}} \times \frac{1\text{ ton}}{2.000\text{ lbs.}} = \frac{0.061\text{ tons PM-10}}{\text{engine}}$$

5. Calculate the emissions of VOCs for internal combustion engines with 152 hp output:

$$\frac{1.1\text{ MMBtu/hr}}{\text{(fuel input)}} \times \frac{0.36\text{ lbs. VOCs}}{\text{MMBtu/hr}} \times \frac{26\text{ hrs}}{\text{yr}} \times \frac{}{2.000\text{ lbs.}} = \frac{0.01\text{ tons VOCs}}{\text{engine}}$$

6. Calculate the total annual emissions for criteria pollutants for each internal combustion engine:

$$0.004\text{ tons SO2} + 0.06\text{ tons NOx} + 0.01\text{ tons CO} + 0.004\text{ tons PM-10} + 0.01\text{ tons VOCs} = 0.09\text{ Tons/yr}$$

7. Calculate the total combined annual emissions for criteria **pollutants** for internal **combustion engines** of 152 **hp:**

3 engines **x** *0.09* **tons/yr** = *0.27* **Tons/yr**
(@ *152* hp) (per engine)

Methods for Other Calculations:

Calculation of emissions for sulfur dioxide, nitrogen oxides, carbon monoxide, PM-10, and volatile organic compounds for each operating year is completed by selecting the proper **emission** factor and fuel input and applying them to the estimated hours of operation as described in the above example. The data analysis spreadsheet provides a complete summary of the results of these calculations and the basis.

XLCHDG

SUMMARY OF ATTACHMENTS

Attachment I.	Actual Criteria Pollutant Emissions for 1992 - 1993.
Attachment II.	EPA 1978 Batch CTG - Equivalency Validation of EMIT 10 and MacEmit.
Attachment III.	VOC Emission Calculations (Equations and Example Hand Calculations).
Attachment IV.	EMIT 10 DATA Output for Example Calculations.
Attachment V.	MacEmit Data Output for Example Calculations.
Attachment VI.	Merck Stonewall Plant VOC Emissions from Fermentation Processes.
Attachment VII.	Basis of Calculating VOC Emissions from Central Solvent Recovery.
Attachment VIII.	Example of Calculations for Fugitive Emissions from Equipment Leaks.
Attachment IX.	Toxchem Model Description and Example Calculation.
Attachment X.	EPA Memorandum Dated July 17, 1996 from C. Leatherwood & C. Burklin (E.R.G.) to R. Huntley & D. Beck (EPA. OAQPS) entitled "PM Emission Factor Estimates From Bituminous-Fired Spreader Stoker Boilers With Baghouse Control".

ATTDOC2

ATTACHMENT

ACTUAL CRITERIA POLLUTANT EMISSIONS
MERCK STONEWALL PLANT - ELKTON, VA

12/11/96

Manufacturing Area(s)	Pollutant	1992 Actuals	1993 Actuals	Average (1992 - 1993)
Amprolium				
Process Vents	VOC	200	153	177
Bulk Storage Tanks	VOC	8	6	7
Central Sol. Rec.	VOC	19	16	18
Equipment Leaks	VOC	13	13	13
WWTP	VOC	32	26	29
Subtotal	VOC	272	214	243
Amprolium Process Heaters	SO2	2	1	1
	NOx	0	0	0
	CO	0	0	0
	PM-10	0	0	0
Lovastatin				
Process Vents	VOC	8	5	7
Bulk Storage Tanks	VOC	0	0	0
Central Sol. Rec.	VOC	4	3	3
Equipment Leaks	VOC	7	7	7
WWTP	VOC	13	8	10
Subtotal		32	23	28
Carbidopa				
Process Vents	VOC	21	12	17
Bulk Storage Tanks	VOC	0	0	0
Central Sol. Rec.	VOC	0	0	0
Equipment Leaks	VOC	2	2	2
WWTP	VOC	1	0	0
Subtotal		24	14	19
Cefoxitin Sterile (A,B,2nd Crop)				
Process Vents	VOC	4	5	4
Bulk Storage Tanks	VOC	1	1	1
Central Sol. Rec.	VOC	9	8	9
Equipment Leaks	VOC	1	1	1
WWTP	VOC	0	0	0
Subtotal	VOC	15	15	15
DCHA Salt				
Process Vents	VOC	64	81	72
Bulk Storage Tanks	VOC	1	1	1
Central Sol. Rec.	VOC	1	1	1
Equipment Leaks	VOC	10	10	10
WWTP	VOC	4	5	4
Subtotal	VOC	79	97	88
Multiproduct Semiworks				
Process Vents	VOC	0	0	0
Bulk Storage Tanks	VOC	0	0	0
Central Sol. Rec.	VOC	0	0	0
Equipment Leaks	VOC	0	0	0
WWTP	VOC	0	0	0
Subtotal	VOC	0	0	0
Finishing				
Process Vents	VOC	15	6	10
Bulk Storage Tanks	VOC	0	0	0
Central Sol. Rec.	VOC	0	0	0
Equipment Leaks	VOC	1	1	1
WWTP	VOC	0	0	0
Subtotal	VOC	15	7	11
Primaxin				
Process Vents	VOC	1	1	1
Bulk Storage Tanks	VOC	0	0	0
Central Sol. Rec.	VOC	0	0	0
Equipment Leaks	VOC	0	0	0
WWTP	VOC	0	0	0
Subtotal		1	1	1

ACTUAL CRITERIA POLLUTANT EMISSIONS
MERCK STONEWAU PLANT - ELKTON, VA

Manufacturing Area(s)	Pollutant	1992 Actuals	1993 Actuals	Average (1992-1993)
Powerhouse Emissions				
	SO2	693	704	698
	NOx	262	280	281
	CO	22	22	22
	PM-10	40	40	40
	VOC	1	1	1
Subtotal		1039	1047	1043
Sludge Incinerator				
	SO2	15	14	14
	NOx	7	6	7
	CO	18	16	17
	PM-10	1	1	1
	VOC	1	1	1
Subtotal		41	38	40
Trash Incinerator				
	SO2	5	4	5
	NOx	2	2	2
	CO	2	2	2
	PM-10	1	1	1
	VOC	1	1	1
Subtotal		11	9	10
Diesel Generators				
	SO2	0	0	0
	NO*	1	1	1
	CO	1	1	1
	PM-10	0	0	0
	VOC	0	0	0
Subtotal		3	3	3
Emissions Summary		1992 Actuals	1993 Actuals	Average
	SO2	714	723	719
	NOx	293	290	291
	CO	44	42	43
	PM-10	42	42	42
	VOC	442	374	408
Total Criteria **Pollutants**		1536	1471	1603

ATTACHMENT II

Equivalency Validation of EMIT 10 and MacEMIT

Operation	Hand Calculation (lbs. VOC/ batch)	EMIT 10 (lbs. VOC/ batch)	MacEMIT (lbs. VOC/ batch)
Filling	0.95	0.95	0.95
Evacuation	1.46	1.46	1.46
Sweep	0.66	0.66	0.66
Heat	1.05	1.06	1.06
Gas Evolution	82.60	82.61	82.60
Vacuum Operation	14.29	14.28	14.28
Vacuum Drying	2.72	2.72	2.72
Air Drying	250.00	250.00	250.00
Tank Breathing Losses	2.30	2.30	NA*

MacEMIT does not contain the tank breathing losses algorithm. Computerized calculations must be provided by EMIT 10.

C:\EXCEL\EMITVAL1.XLS

ATTACHMENT III

VOC MISSION CALCUIATIONS

The following methods have been developed to calculate the uncontrolled emissions from the following pharmaceutical process operations. These process operations are:

I. Charging/Filling
II. Evacuation (Depressuring)
III. Nitrogen or Air Sweep
IV. Heating
V. Gas Evolution
VI. Vacuum Distillation
VII. Drying

Some simplifying assumptions have been made; the general assumption for most of the following calculations is that the Ideal Gas Law applies.

Eauation #1:

$$n = \frac{PV}{RT}$$

where:
n = # of pound moles;
P = absolute pressure, in mm Hg;
V = volume, in ft.^{3} ;
T = temperature, in °K (°K = °C + 273)
R = gas Law constant. 999 $\frac{(\text{ft.}^3)\ (\text{mm He})}{(°\text{K})\ (\text{lb-moles})}$

The Ideal Gas Law is used to calculate the lbs/hr of VOC emitted, as follows:

Equation No. 2:

$$Se = \frac{(Pi)\ (Xi)\ (Vr)\ (MWi)}{RT}$$

where:
Se = lbs/hr of VOC emitted;
Pi = vapor pressure of VOCi at T, in mm Hg;
Xi = mole fraction of VOCi in liquid mix:
Vr = rate of displacement, in ft^3/hr:
R = 999 $\frac{(\text{mm He})\ (\text{ft}^3)}{(\text{lb-mole})\ (°\text{K})}$
T = temperature in °K;
MWi = molecular weight of VOCi, in lbs/lb-mole.

The mole fraction. Xi, above must be included in the case of a liquid mix. Mole fraction is calculated as follows:

Equation No. 3:

$$X_i = \frac{\text{moles of } i \text{ in liquid mix}}{\text{total moles of liquid mix}}$$

where: X_i = mole fraction of i;
i = denotes the VOC in question

For one component systems, $X_i = 1$.

The vapor pressure. Pi, is calculated using Antoine's equation or taken from tables of vapor pressure.

Equation No. 4:

$$\log_{10} P_i = a - \left(\frac{b}{c+T_i}\right)$$

where: P_i = vapor pressure of the VOC (mm Hg);
T_i = temperature of the air containing the VOC vapor (°C);
a, b, c = Antoine's equation constants. See Lange's Handbook of chemistry.[1]

Vapor Pressure Tables

Vapor pressures from Perry's[2] are interpolated or extrapolated using a Cox chart.

METHODS AND CALCULATIONS

I. Filling

This method can be used to calculate emissions from a vessel containing a Liquid VOC when a Liquid is charged into the vessel.

Assumptions · The volume of gas displaced from the vessel is equal to the volume of liquid charged into the vessel. The air displaced from the vessel is saturated with the VOC vapor at the exit temperature. (Note: if data are available to calculate concentration, then this can be used in place of saturation.)

Calculations -

1. Calculate the rate of air displacement in ft^3/hr:

Equation No. 5:

$$Vr = Lr\ (0.134\ ft^3/gal)\ (60\ \frac{min}{hr})$$

where: Vr = the rate of air displacement, in ft^3/hr;
Lr = liquid pumping rate, in gpm.

2. Determine the mole fraction of each VOC in the vessel during the pumping, Xi, using Equation No. 3.

3. Calculate the vapor pressure of each pure VOC, Pi, using Equation No. 4.

4. Calculate the lbs/hr of each VOC emitted, Se, using Equation No. 2.

II. Evacuation (Depressuring)

This method is used to calculate emissions from the evacuation (or depressuring) of any vessel containing a VOC and a "noncondensable." Usually the vessel will be a still and the "noncondensable" will be air or nitrogen.

Assumptions - The absolute pressure in the vessel decreases linearly with time. There is no air leakage into the vessel. The composition of the VOC mix does not change during the evacuation (or depressuring) and there is no temperarure change. The air displaced is saturated with the VOC vapor at the vessel temperature.

Calculations -

1. Calculate the mole fraction, Xi, for each VOC in solution using Equation No. 3.

2. Calculate the vapor pressure, pi, of each VOC at the vessel temperature using Equation No. 4.

3. Calculate the initial volume of the air in the vessel:

$$Vi = \left[\frac{Pa_1 - \sum(PiXi)}{760}\right] F_s$$

where: Vi = the initial air volume in the vessel. ft^3 (standard);

$\sum(PiXi)$ = the sum of the products of the vapor pressures and the mole fractions of each VOC in the solution;

Pa_1 = initial pressure, in mm Hg,

760 = atmospheric pressure, in mm Hg.

F_s = free space in the still, in ft.^{3}

4. Calculate the final air volume in the vessel:

$$V_f = \left[\frac{Pa_2 - \sum(PiXi)}{760}\right] F_s$$

V_f = the final air volume in vessel, in ft^3 (standard);

where: Pa_2 = final air pressure in the vessel, mm Hg.

5. Calculate the rate of air removal from the vessel:

$$Vr = \frac{Vi - Vf}{t}$$

where: Vr = the rate of air removal from the vessel, in ft^3/hr;

t = time of evacuation of vessel. in hrs.

6. Calculate initial ratio of air to total VOC vapor:

$$Ri = \frac{760 - \sum(PiXi)}{\sum(PiXi)}$$

where: $Ri = \dfrac{\text{moles air}}{\text{moles VOC}}$

7. Calculate Final ratio of moles air to moles total VOC vapor:

$$Rf = \left[\frac{Pa_2 - \sum(PiXi)}{\sum(PiXi)}\right]$$

where: $Rf = \dfrac{\text{moles air}}{\text{moles VOC}}$

8. Calculate the average ratio of moles air to moles total VOC vapor:

$$Ra = \frac{Ri + Rf}{2}$$

9. Calculate volume of total VOC vapor discharged, ft^3/hr:

$$VRS = \frac{Vr}{Ra}$$

where: VRS = VOC emission from the system, ft^3/hr.

10. Calculate the emission rate, Se, for each VOC in lbs/hr using Equation No. 2 substituting VRS for Vr and use pressure of one atmosphere.

III. <u>Nitrogen or Air Sweep</u>

This method is used to calculate emissions when nitrogen, air, or other "noncondensable" is used to purge or sweep a vessel or other device.,

<u>Assumptions</u> - The nitrogen gas exiting the vessel is saturated with VOC vapor at the exit temperature.

<u>Calculations</u> -

1. Calculate the rate of nitrogen sweep in ft^3/hr:

<u>Equation No. 6</u>: $Vr_1 = Ns \times 60$ min/hr

where: Vr_1 = the rate of nitrogen sweep in ft^3/hr, standard;

Ns = the rate of nitrogen sweep in ft^3/min, standard.

2. Calculate the mole fraction, Xi. for each VOC using Equation No. 3.

3. Calculate the vapor pressure. Pi. for each VOC at the exit temperature using Equation No. 4.

4. Calculate the rate of total gas displaced from the vessel. ft^3/hr.

<u>Equation No. 7</u>:

$$Vr_2 = Vr_1 \left[\frac{760}{760 - \sum (PiXi)}\right]$$

where: Vr_2 = rate of gas displaced from vessel, in ft^3/hr, standard.

Vr_1 = rate of nitrogen sweep;, in ft^3/hr:

$\sum(PiXi)$ = the sum of the products of the vapor pressures and mole fractions for each VOC;

760 = vapor pressure of nitrogen sweep. in mm Hg.

5. Calculate the rate of VOC emission in lbs/hr, Se. For each VOC using Equation No. 2 substituting Vr_2 for Vr.

IV. **Heating**

This method is used to calculate the emissions from the heating of a **still containing** a VOC and a "noncondensable." usually air.

Assumptions - The moles of air displaced from the still are a result of (1) the expansion of air upon heating and (2) an increase in VOC vapor pressure. The moles of air displaced from the receiver are equal to the moles of air displaced from the still. The air displaced from the receiver is saturated with VOC vapor in equilibrium with the VOC mixture in the receiver at the temperature of the receiver.

Calculations -

1. Calculate the mole fraction, X_i, for each VOC in the still using Equation No. 3.
2. Calculate the vapor pressure, P_i, of each pure VOC at the initial temperature (T_1) using Equation No. 4.
3. Calculate the initial pressure of the air in the still:

Equation No. 8:

$$Pa_1 = 760 - \sum(P_iX_i)_{T1}$$

where:

Pa_1 = the initial air pressure in the still in mm Hg;

$\sum(P_iX_i)_{T1}$ = the sum of the products of the vapor pressures and the mole fractions of each VOC at the initial temperature;

760 = atmospheric pressure. in mm Hg.

4. Calculate the vapor pressure, p_i, of each pure VOC at the final temperature (T_2) using Equation No. 4.
5. Calculate the final pressure of air in the still:

Equation No. 9: $Pa_2 = 760 - \sum(PiXi)_{T2}$

where:

Pa_2 = final air pressure in the still, in mm Hg;

$\sum(PiXi)_{T2}$ = the sum of the products of the vapor pressures and the mole fractions of each VOC at the final temperature;

760 = atmospheric pressure, in mm Hg.

6. Calculate the moles of air displaced to the receiver (and to the environment):

Equation No. 10:

$$(n_1 - n_2) = \frac{V}{R}\left[\frac{Pa_1}{T_1} - \frac{Pa_2}{T_2}\right]$$

where:

$(n_1 - n_2)$ = number of lb-moles of air displaced to the receiver;

V = volume of free space in still, in $ft.^3$;

R = gas law constant, 999 $\frac{(mm\ Hg)\ (ft^3)}{(lb\text{-}moles)\ (°K)}$

Pa_1 = initial air pressure in still, in mm Hg:

Pa_2 = final air pressure in still, in mm Hg;

T_1 = initial temperature in still, in °K;

T_2 = final temperature in still, in °K.

7. Calculate the number of lb-moles of VOC vapor displaced:

$$ns = \frac{\sum(PiXi)_{TR}}{760 - \sum(PiXi)_{TR}}\ (n_1 - n_2)$$

where:

ns = pound moles of VOC vapor displaced from the receiver;

$\sum(PiXi)_{TR}$ = sum of products of vapor pressures and mole fractions for each VOC ac the temperature of the receiver.

8. Calculate the lbs of each VOC vapor emitted, Se:

Equation No. 11: $(Se)_i = (n_s)\ MW_{si}\ (X_i)$

where:

$(Se)_i$ = Lbs of VOC (i) vapor emitted:

n = number of lb-moles of all VOC vapor emitted;

MW_{si} = molecular weight of VOC (i);

X_i = mole fraction of VOC (i) in the vapor.

V. Gas Evolution

This method is used to calculate emissions when a gas is generated as the result of a chemical reaction. The gas comes into contact with one or more VOC, usually solvents, and is saturated.

Assumptions - The gas is saturated with VOC vapor at the exit temperature.

Calculations -

1. Determine the rate of gas evolution. Wg, in lbs/hr, from the stoichiometry of the chemical reaction, and the reaction time.
2. Calculate the rate of gas evolution in ft^3/hr:

Equation No. 12:

$$Vr_1 = \frac{(W_g)\ RT}{(P)\ (MW_g)}$$

where:

Vr_1 = the rate of gas evolution, in ft^3/hr;

R = the gas law constant, 1.314 $\frac{(\text{atm})\ (\text{ft}^3)}{(\text{lb-mole})\ (^\circ\text{K})}$

T = the temperature at the exit, in °K (°C + 273);

Wg = the rate of gas evolution, in lbs/hr;

P = the pressure in the vessel, in atm.;

MWg = the molecular weight of the gas, in lb/lb-mole.

3. Calculate the mole fractions. Xi, of the VOC in solution using Equation No. 3.
4. Calculate the vapor pressures. Pi, of the pure VOC at the exit temperature using Equation No. 4.
5. Calculate the rate of gas displacement in ft^3/hr:

Equation No. 13:

$$Vr_2 = Vr_1 \left[\frac{760}{760 - \sum(PiXi)}\right]$$

where:

Vr_2 = rate of gas displacement, in ft^3/hr;

Vr_1 = rate of gas evolution, in ft^3/hr:

760 = atmospheric pressure, in mm Hg;

$\sum(PiXI)$ = the sum of the productf of the vapor pressure and the mole fraction of each VOC at the exit temperature, in mm Hg.

6. Calculate the VOC emission rate. Se, in lbs/hr using Equation No. 2.

VI. **Vacuum Operations:**

This method is used to calculate emissions from vacuum operations. Air leaks into the system and becomes saturated with the **VOC** vapor at the receiver temperature and is subsequently discharged **by** the vacuum source **to** the atmosphere.

The air leak rate is best determined by closing off the vacuum source from the still, condenser, and receiver and noting the rise in absolute pressure over a short period **of** time. The air leak rate can then be calculated using Equation **No. 14** below. Maximum air leakage has also been estimated for "commercially **tight** system" for various system volume and pressures.[3]

Assumptions - The air **that** leaves the system is saturated with solvent vapor at the receiver temperature.

Calculations ·

1. Calculate the air leak rate into **the** system:

Equation No. 14:

$$Vr_1 = \frac{273\ Fs}{Tt} \times \left(\frac{P_2 - P_1}{760}\right)$$

where:
Vr_1 = air leak rate, in ft^3/hr (standard);
Fs = total free space under vacuum. **in** ft.':
P_1 = absolute pressure **at start** of test. in mm Hg;
P_2 = absolute pressure at end of test, in mm Hg;
t = time of test, in hrs;
T = temperature of still, in °K;
273– temperature at standard conditions, in °K.

2. Calculate the rate of VOC emissions, **lbs/hr:**

Equation No. 15:

$$Se = \frac{MWs}{359}\left(\frac{P\ system}{P\ system - Ps} - 1\right)$$

where:
Se = rate of **VOC** emission, in **lbs/hr;**
P system– absolute pressure of receiver. in mm Hg;
Ps = vapor pressure of the VOC at the receiver temperature, in mm Hg;
MWs–**molecular** weight of VOC. in **lb/lb-mole;**
359–the volume that 1 lb-mole **of** gas occupies at standard conditions, in **ft.**^{3}.

3. If leak rate is obtained in lbs/hr from reference 3, calculate VOC emissions. lbs/hr:

Equation No. 16:

$$Se = \frac{La\ MWs}{29}\left[\frac{P\ system}{P\ system - Ps} - 1\right]$$

where:
La = Leak of air into the systems, in lb/hr;
29 = molecular weight of air. in lb/lb-mole.

VII. Drying

This method is used to calculate VOC emissions from either batch or continuous drying operations. Although it is possible to determine emissions from an analysis of the dryer off-gas, it is usually simpler and more accurate to use a material balance.

Assumptions - Samples of the product before and after the dryer are analyzed for VOC content.

Calculations -

1. Calculate the rate of VOC emissions. lbs/hr:

Equation No. 17:

$$Se = \frac{B}{t}\left[\frac{PS_1}{100 - PS_1} - \frac{PS_2}{100 - PS_2}\right]$$

where:
Se = rate of VOC emission, lbs/hr;
B = weight of batch (dry), lbs;
t = time of drying operation, hrs:
PS_1 = percent of VOC in wet material into dryer:
PS_2 = percent of VOC in less wet material from dryer.

REFERENCES

1. Lange's Handbook of Chemistry, John A. Dean, Editor, 11th Edition, 1973, McGraw-Hill Book Company, New York, New York, pp. 10-31 to 10-45.

2. Chemical Engineer's Handbook, Perry and Chilton, Editors. Fifth Edition. 1973, McGraw-Hill Book Company, New York, New York, p. 3-54.

3. Power. R. B., "Steam-Jet Air Ejector," Hydrocarbon Processing and Petroleum Refiner, March, 1964, Vol. 43, No. 3., p. 59.

EXAMPLE CALCULATIONS

I. Filling

Operation Pump 250 gallons of Isopropyl Acetate in RE-100

Conditions:
Pumping rate of 30 gpm
RE-100 is empty prior to pumping
Vessel is vented to atmosphere (uncontrolled)
Exit temperature is 32°C.

Assumptions: The volume of gas displaced from the vessel is equal to the volume of liquid charged into the vessel. The air displaced from the vessel is saturated with the VOC vapor at the exit temperature.

Calculations

1. Calculate the rate of air displacement (Vr) in ft^3/hr

$Vr = Lr\ (0.134\ ft^3/gal)\ (60\ min/hr)$

where: Lr = liquid pumping rate, gpm

$Vr = 30\ (0.134)\ (60)$

$Vr = 241\ ft^3/hr$

2. Calculate mole fraction, Xi; for each VOC in solution using Equation #3

Equation No. 3:

$$Xi = \frac{\text{moles of i in liquid solution}}{\text{total number of moles of liquid solution}}$$

For one component systems, Xi = 1.

3. Calculate the vapor pressure of each VOC using Equation #4.

Equation NO. 4:

$$Log_{10}Pi = a - \left(\frac{b}{c+Ti}\right)$$

where: Pi = vapor pressure of the VOC in question;
Ti = exit temperature of air saturated with VOC (°C);
a,b,c = Antoine's equation constants., See Lange's

Isopropyl Acetate: $Log_{10}Pi = 7.180 - \left(\frac{1353.6}{225.824 + 32}\right)$

$Log_{10}Pi = 1.9299069$

$Pi = 85.10\ mm\ Hg$

4. Calculate lbs/hr of each VOC emitted using Equation #2.

$$Se = \frac{(Pi)\ (Xi)\ (Vr)\ (MWi)}{RT}$$

where: Se = lbs/hr of VOCi emitted
Pi = vapor pressure of VOCi; at T in mm Hg
Xi = mole fraction of VOCi in solution .
Vr = rate of VOCi saturated air, ft^3/hr
R = gas law constant
$999 \frac{mm\ Hg\ ft^3}{lb\ mole\ °K}$
T = temperature, °K
MWi = molecular weight of VOCi in lbs/lb-mole

$$Se = \frac{(85.1)(1)(241)(102.1)}{(999)\ (305)}$$

Se = 6.8724 lbs/hr

Since 250 gal. are pumped at a rate of 30 gpm, the total emission time per batch is:

$$250 \text{ gal} \times \left(\frac{1 \text{ min}}{30 \text{ gal}}\right) = 8.33 \text{ min.}$$

$$6.87 \frac{\text{lbs}}{\text{hr}} \times \frac{8.33 \text{ min}}{60 \text{ min/hr}} = 0.95 \text{ lbs VOC emitted/batch}$$

II. Evacuation

Operation Release of pressure in RE-400 after transfer of batch to ST-400

Conditions: Batch temperature maintained at 30°C.
RE-400 is pressurized to 15 psig with nitrogen to blow batch to ST-400
RE-400 is 750 gallon vessel, batch volume is 200 gal.
All emissions from release of pressure Exit RE-400 vent (uncontrolled)
VOC = Dichloroethane
Time for evacuation is 10 minutes

Assumption: The nitrogen displaced from RE-400 is saturated with VOC vapor at the exit temperature.

Calculations:

1. Calculate mole fraction for each VOC in solution using Equation #3. Mole fraction of a one component system is 1.

2. Calculate the vapor pressure, Pi, of each VOC at the vessel temperature using Equation #4

$$\mathrm{Log_{10}Pi} = a - \left(\frac{b}{c + Ti}\right)$$

where:
Pi = vapor pressure of VOCi
Ti = exit temperature of the air containing the VOC vapor, °C
a,b,c = Antoine's equation constants

$$\mathrm{Log_{10}Pi} = 7.8109 - \left(\frac{1696.889}{262.5 + 30}\right)$$

$$\mathrm{Log_{10}Pi} = 2.00957$$

$$\mathrm{Pi} = 102.2 \text{ mm Hg}$$

3. Calculate the initial volume of nitrogen in the vessel:

$$\mathrm{Vi} = \left[\frac{(\mathrm{Pa_1}) - \Sigma(\mathrm{PiXi})}{760}\right] \mathrm{Fs}$$

where:
Vi = The initial nitrogen volume in the vessel, ft^3 (standard)
$\Sigma(\mathrm{PiXi})$ = sum of products of vapor pressure and mole fractions for all VOC's in solution
$\mathrm{Pa_1}$= Initial pressure in mm Hg
760= atmospheric pressure in mm Hg
Fs = initial free space in the vessel in ft^3

(NOTE: Since the discharge of 200 gal. of batch will reduce the pressure in the reactor, PA, must be calculated.)

A. Pressure prior to transfer

$$15 \text{ psig} \times \frac{760 \text{ mm Hg}}{14.7 \text{psi}} + 760 \text{ mm Hg} = 1536 \text{ mm Hg}$$

B. Pressure after transfer

$$P_1V_1 = P_2V_2$$

Initial Fs = 550 gal = 73 ft^3

Final Fs = 750 gal = 100 ft^3

$$(1536 \text{ mm Hg})(550) = P_2 (750)$$

$$1126 \text{mm Hg} = P_2$$

$$\mathrm{Vi} = \left[\frac{1126 - 102.2}{760}\right](100)$$

$$\mathrm{Vi} = 134.7 \ ft^3$$

4. Calculate the final nitrogen volume in the vessel:

$$Vf = \left[\frac{Pa_2 - \Sigma(PiXi)}{760}\right] Fs$$

where: $Vf =$ final nitrogen volume in vessel

$Fs =$ final free space in vessel

$$Vf = \left[\frac{760 - 102.2}{760}\right](100)$$

$$Vf = 86.6\ ft^3$$

5. Calculate the rate of nitrogen removal from the vessel:

$$Vr = \frac{Vi - Vf}{t}$$

where: $Vr =$ the rate of nitrogen removal from the vessel in ft^3/hr

$t =$ time for evacuation, hrs

$$Vr = \frac{134.7 - 86.6}{0.167}$$

$$Vr = 288.0\ ft^3/hr$$

6. Calculate the initial ratio of nitrogen to total VOC vapor:

$$Ri = \frac{1126 - \Sigma(PiXi)}{\Sigma(PiXi)}$$

where: $Ri = \frac{\text{moles } N_2}{\text{moles VOC}}$

$$Ri = \frac{1126 - (102.2)}{102.2} = 10.02$$

7. Calculate the final ratio of moles nitrogen to moles total VOC vapor:

$$Rf = \frac{Pa_2 - \Sigma(PiXi)}{\Sigma(PiXi)}$$

where: $Rf = \frac{\text{Moles } N_2}{\text{Moles VOC}}$

$$Rf = \frac{760 - (102.2)}{102.2} = 64$$

8. Calculate the average ratio of moles nitrogen to moles VOC vapor:

$$Ra = \frac{Ri + Rf}{2}$$

$$Ra = \frac{10.02 + 6.4}{2} = 8.2$$

9. 'calculate the volume of VOC vapor discharged, ft^3/hr

$$VRS = \frac{Vr}{Ra}$$

$$VRS = \frac{288.0\ ft^3/hr}{8.2} = 35.1\ ft^3/hr$$

10. Calculate the VOC emission rate, Se, using Equation #2.

$$Se = \frac{\Sigma(PiXi)(Vr)(MWi)}{RT}$$

NOTE: Substitute 760 mm Hg for (PiXi) and VRS for Vr

$$Se = \frac{(760)(35.1)(99)}{(999)(303)}$$

$$Se = 8.72 \text{ lbs/hr}$$

$$8.72 \frac{\text{lbs}}{\text{hr}} \times 0.167 \text{ hrs} = 1.46 \text{ lbs/batch}$$

III. Nitrogen or Air Sweep

Operation Nitrogen sweep of RE-100

Conditions: Flowrate is 2 SCFM for 10 minutes at inlet temperature of
Isopropyl Acetate is only VOC in RE-100
Exit temperature is 32°C
RE-100 is vented to atmosphere (uncontrolled)

Assumption: Gas volume displaced from RE-100 by sweep is saturated with VOC at the exit temperature.

Calculation:

1. Calculate the rate of nitrogen sweep in ft^3/hr, at exit temperature

$$Vr_1 = N_s \times 60 \text{ min/hr} \times \frac{T_2}{T_1}$$

where:
Vr_1 = rate of nitrogen sweep in ft^3/hr
N_s = rate of nitrogen sweep in ft^3/min
T_2 = exit temperature, °K
T_1 = inlet temperature, °K

$$Vr_1 = 2(60)\left(\frac{273+32}{273+25}\right)$$

$$Vr_1 = 122.8 \ ft^3/hr$$

2. Calculate the mole fraction for each VOC using Equation #3. Mole fraction, Xi, for one component system is 1.

3. Calculate the vapor pressure for each VOC at the exit temperature using Equation #4.

$$Log_{10}Pi = a - \left(\frac{b}{c+Ti}\right)$$

where:
Pi = Vapor pressure of VOC in question
Ti = exit temperature of air saturated with VOC
a,b,c = Antoine's equation constants

3. Continued

$$\mathrm{Log}_{10}Pi = 7.180 - \left(\frac{1353.6}{225.824+32°C}\right)$$

$$\mathrm{Log}_{10}Pi = 1.9299069$$

$$Pi = 85.1 \text{ mm Hg}$$

4. Calculate the rate of total gas displaced from the vessel, ft^3/hr from Equation #7.

$$Vr_2 = Vr_1 \left(\frac{760}{760 - \Sigma(PiXi)}\right)$$

where:

Vr_2 = rate of gas displaced from vessel, ft^3/hr

Vr, = rate of nitrogen sweep, in ft^3/hr

$\Sigma(PiXi)$ = the sum of the products of the vapor pressure and the mole fractions for each VOC.

$$Vr_2 = 122.8 \left(\frac{760}{760 - 85.1}\right)$$

$$Vr_2 = 138.3 \ ft^3/hr$$

5. Calculate the rate of VOCi emission in lbs/hr, for each VOC using Equation #2 substituting Vr, for Vr.

$$Se = \frac{(Pi)(Xi)(Vr_2)(MWi)}{RT}$$

$$Se = \frac{(85.1)(1)(138.3)(102.1)}{(999)(305)} = 3.944 \text{ lbs/hr}$$

$$3.944 \frac{\text{lbs}}{\text{hr}} \times 10 \text{ min} \times \frac{1 \text{ hr}}{60 \text{ min}} = 0.66 \text{ lbs VOC emitted per batch}$$

IV. Heating

Operation — Heat contents in ST-1000 to distill Isopropyl Acetate off of batch

Conditions: Initial temperature = 30°C.
Final temperature = 80°C*
ST-1000 volume is 1,000 gal.
Batch volume prior to distillation is 600 gal.
Exit temperature of system equals 30°C.

Assumption: Air displaced from system is saturated with solvent at exit temperature of the system.

Calculations:

1. Calculate the mole fraction for each VOC in the still. Mole fraction, Xi, for a one component system is 1.

2. Calculate the vapor pressure, Pi, of each VOC at the initial temperature (T_1) using Equation #4.

$$\text{Log}_{10}Pi = a - \left(\frac{b}{c + Ti}\right)$$

where:

Pi = VOCi vapor pressure

Ti = temperature of the air containing the VOC vapor (°C) (exit temperature of the system)

a,b,c, = Antoine's equation constants.

$$\text{Log}_{10}Pi = 7.180 - \left(\frac{1353.6}{225.824 + 30}\right)$$

$$\text{Log}_{10}Pi = 1.8889$$

$$Pi = 77.4 \text{ mm Hg}$$

3. Calculate the initial air pressure in the still

$$Pa, = 760 - \Sigma(PiXi)_{T1}$$

where:

Pa, = the initial air pressure in the still, mm Hg

(PiXi) = the sum of the products of vapor pressure and mole fraction

$$Pa, = 760 - 77.4 = 682.6 \text{ mm Hg}$$

4. Calculate the vapor pressure of each VOC in the still at the final temperatur (T_2) using Equation #4.

$$\text{Log}_{10}Pi = a - \left(\frac{b}{c + Ti}\right)$$

$$\text{Log}_{10}Pi = 7.180 - \left(\frac{1353.6}{225.824 + 80}\right)$$

$$\text{Log}_{10}Pi = 2.753925$$

$$Pi = 567.4 \text{ mm Hg}$$

*NOTE: @T_2 = 90°C, vapor pressure of IPAc > pressure of system. In MacEMIT this results in a "FLASH" warning and the user must manually adjust the final temperature such that $P_{IPAc} = P_{system}$

5. Calculate the final air pressure in the still

$$Pa, = 760 - (PiXi)_{T2}$$

where:

Pa, = Final air pressure in the still, mm Hg

(PiXi) = The sum of products of vapor pressure and mole fraction for each VOC in the still at the final temperature.

$$Pa, = 760 - 567.4 = 192.6$$

6. Calculate the moles of air displaced from the system

$$(n_1 - n_2) = \frac{V}{R}\left(\frac{Pa_1}{T_1} - \frac{Pa_2}{T_2}\right)$$

where:

$(n_1 - n_2)$ = number of lb-moles of air displaced from the system

6. Continued

V = volume of free space in, the still; ft^3
R = gas law constant, 999
T, = initial temperature, °K
T_2 = final temperature, °K

$$(n_1 - n_2) = \frac{\left(\frac{682.6}{303} - \frac{192.6}{353}\right)}{999}$$

$(n_1 - n_2)$ = 0.091 lb-moles

7. Calculate the number of lb-moles of VOC vapor displaced from system, ns:

$$ns = \frac{\Sigma(PiXi)_{Te}}{760 - \Sigma(PiXi)_{Te}} (n_1 - n_2)$$

where: $\Sigma(PiXi)_{Te}$ = the sum of products of the vapor pressures and mole fractions for each VOC in solution at the exit temperature of the system.

$$ns = \frac{77.4}{760 - 77.4} (0.091) = 0.0103 \text{ lb-moles}$$

8. Calculate the lbs of each VOC vapor emitted, Se, from Equation #11.

$(Se)_i$ = (ns) MWi (Xiv)

where:
$(Se)_i$ = lbs of VOCi vapor emitted;
ns = number of lb-moles of total VOC vapor emitted;
MWi = molecular weight of i
Xiv = mole fraction of VOCi in the vapor

$(Se)_i$ = (0.0103) (102.1)(1)
$(Se)_i$ = 1.05 lbs VOC_i emitted per batch

V. Gas Evolution

Operation Ammonia gas is generated from a reaction in RE-2000.

Conditions:
System exit temperature is 30°C
Solvent in vessel is hexane
Reaction occurs for 10 hours
Based on the stoichiometry of the chemical reaction and the reaction time, the rate of gas evolution, Wg, equals 5 lbs/hr.

Assumption: The gas is saturated with VOC vapor at the system exit temperature.

Calculation:

1. Determine the rate of gas evolution → See conditions above

2. Calculate the rate of gas evolution in ft^3/hr from Equation #12

$$Vr_1 = \frac{(Wg)RT}{(P)(MWg)}$$

where:

Vr_1 = the rate of gas evolution, in ft^3/hr

R = gas law constant, 1.314 $\frac{(atm)(ft^3)}{(lb\text{-}mole)(°K)}$

T = the temperature at the exit, in °K

Wg- the rate of gas evolution, in lbs/hr

P = the pressure of the vessel, in atm.

MWg = the molecular weight of the gas, in lbs/lb-mol

$$Vr_1 = \frac{(5)(1.314)(303)}{(1)(17)} = 117.1 \ ft^3/hr$$

3. Calculate the mole fraction, Xi, of each VOC in solution. Mole fraction of a 1 component system = 1.

. Calculate the vapor pressure. Pi, of each VOC at the system exit temperature using Equation #4.

$$\log_{10} Pi = a - \left[\frac{b}{c + Ti}\right]$$

where:

Pi = vapor pressure of VOC_i

Ti = temperature of gas containing VOC_i vapor. °C

a,b,c = Antoine equation constants

$$\log_{10} Pi = 6.858 - \left[\frac{1160.6}{223.043 + 30}\right]$$

$$\log_{10} Pi = 2.271$$

$$Pi = 186.8 \text{ mm Hg}$$

5. Calculate the rate of gas displacement in ft^3/hr

$$Vr_2 = Vr_1 \left[\frac{760}{760 - \sum(PiXi)}\right]$$

where:

Vr_2 = rate of gas displacement. ft^3/hr

Vr_1 = rate of gas evolution, ft^3/hr

$\sum(PiXi)$- the sum of product of vapor pressures and mole fractions of each VOC at the exit temperature

$$Vr_2 = 117.1 \left[\frac{760}{760 - 186.8}\right] = 155.3 \ ft^3/hr$$

6. Calculate the VOC emission rate, Se, in lbs/hr using Equation #2.

$$Se = \frac{\sum(P_iX_i)(V_r)(MW_i)}{RT}$$

where:

$\sum(P_iX_i)$ = the sum of product of vapor pressures and mole fractions of each VOC at the exit temperature

R = gas law constant. 999

T = exit temperature of system, °K

MW_i = molecular weight of VOC_i

$$Se = \frac{(186.8)(155.3)(86.17)}{(999)(303)} = 8.26 \text{ lbs/hr}$$

$$8.26 \ \frac{\text{lbs}}{\text{hr}} \times 10 \text{ hrs} = 82.60 \text{ lbs VOC emitted per batc}$$

VI. Vacuum Operations

Operation: Vacuum distillation of batch in ST-200

Conditions: ST-200 is a 750 gal. vessel with 400 gal. of liquid in it at the start of distillation.
System pressure during vacuum operation is 400 mm Hg
Distillation time is 8 hours
System exit temperature is 10°C
Solvent in ST-200 is Dichloroethane

Assumption: Air discharged from system by the vacuum source is saturated with VOC vapor at the system exit temperature.

Calculation:

1. Calculate the air leak rate into the system by performing a pressure test or vessel and using Equation #14. (Note: A vacuum leak rate test is an alternative.)

$$Vr_1 = \frac{273(Fs)}{(T)(t)} \left[\frac{(P_2 - P_1)}{760}\right]$$

where:

Vr_1 = air leak rate into system. ft^3/hr (standard) (SCFH)

Fs = Free space in vessel, ft^3

P_1 = initial absolute pressure, mm Hg

P_2 = final absolute pressure, mm Hg

t = time of test, hrs

T = temperature of still. °K

Pressure Test Conditions:

P_1 = 600 mm Hg
P_2 = 701 mm Hg
t = 15 minutes
T = 64°C
Fs = 350 gal.

Based on this pressure test, the following is obtained:

$$Vr_1 = \frac{(273)(47)}{337\ (0.25)} \left[\frac{704-400}{760}\right] = 61\ ft^3/hr \text{ (standard)}$$

2. Calculate the rate of VOC emissions in **lbs/hr** using **Equation #15**

$$Se = MWs \left(\frac{Vr_1}{359}\right) \left(\frac{P_{system}}{P_{system} - P_s} - 1\right)$$

where:

Se = rate of VOC emissions, **lbs/hr**

P_{system} = absolute pressure of system, mm Hg

P_s = vapor pressure of the VOC at the system exit temperature, mm Hg

MWs = molecular weight of the **VOC, lbs/lb-mole**

359 = the volume that 1 lb-mole of gas occupies at standard conditions, ft^3

Calculate vapor pressure, **Pi,** at the system exit temperature

$$Log_{10}\ Pi = a - \left(\frac{b}{c + Ti}\right)$$

$$Log_{10}\ Pi = 7.811 - \left(\frac{1696.9}{262.500 + 10}\right)$$

$$Log_{10}\ Pi = 1.584$$

$$Pi = 38.4 \text{ mm Hg}$$

$$Se = 99 \left(\frac{61}{359}\right) \left(\frac{400}{400 - 38.4} - 1\right) = 1.786\ lbs/hr$$

$$1.786\ \frac{lbs}{hr} \times 8 \text{ hours} = 14.29 \text{ lbs VOC emitted per batch}$$

VII. Vacuum Drying

Operation: Vacuum dry product wet cake in DR-550

Conditions: Produce wet cake is 1.250 **lbs with** a Loss on Drying **(LOD) of 20%**
System pressure during vacuum drying is **400 mm Hg**
Drying time is **4** hours
System exit temperature is **15°C**
Solvent in **product** wet cake is ethanol
Free space in dryer = 350 gals.

Assumption: Air discharged from the system by the vacuum source **is** saturated with VOC vapor at the system exit temperature.

NOTE: **EMIT 10** and **MacEMIT** perform vacuum drying emission calculations as listed below and also calculate drying emission based on % **LOD.** If the **vacuum** drying calculation emission is greater **than** the % **LOD** emission, the computer reports the % LOD emission.

<u>Calculation</u>:

1. Calculate the air leak rate into the system by performing a pressure test on vessel and using Equation #14. (NOTE: A vacuum leak rate test is an alternative.)

$$Vr_1 = \frac{273(Fs)}{(T)(t)} \left(\frac{P_2 - P_1}{760}\right)$$

where: Vr_1 = air leak rate into system, ft^3/hr (standard) (SCFH)
Fs = Free space in vessel, ft^3
P_1 = initial absolute pressure, mm Hg
P_2 = final absolute pressure, mm Hg
t = time of test, hr
T = temperature of dryer. °K

<u>Pressure Test Conditions</u>:

P_1 = 400 mm Hg
P_2 = 704 mm Hg
t = 15 minutes
T = 64°C
Fs- 350 gal.

Based on the pressure test, the following is obtained

$$Vr_1 = \frac{(273)(47)}{(337)(0.25)} \left(\frac{704 - 400}{760}\right) = 61\ ft^3/hr\ \text{(standard)}$$

2. Calculate the rate of VOC emission in lbs/hr:

$$Se = MWs \left(\frac{Vr_1}{359}\right) \left(\frac{P_{system}}{P_{system} - P_s} - 1\right)$$

where: Se = rate of VOC emission, lbs/hr
P_{system} = absolute pressure of system. mm Hg
P_s = vapor pressure of the VOC at the system exit temperature, mm Hg
MWs = molecular weight of the VOC, lbs/lb-mole
359 = the volume that 1 lb-mole of gas occupies at standard conditions, ft^3

Calculate vapor pressure, Pi, at the system exit temperature:

$$Log_{10}\ Pi -\ a - \left[\frac{b}{c + Ti}\right]$$

$$Log_{10}\ Pi -\ 8.045 - \left[\frac{1554.3}{222.650 + 15}\right]$$

$$Log_{10}\ Pi -\ 1.505$$

$$Pi -\ 32\ mm\ Hg$$

$$Se -\ 46.1 \left[\frac{61}{359}\right] \left[\frac{400}{400 - 32} - 1\right] = 0.681\ lbs/hr$$

$$0.681\ \frac{lbs}{hr} \times 4\ hours = 2.72\ lbs\ VOC\ emitted\ per\ batch$$

Check vs. available solvent:

1. Calculate the rate of VOC emissions, lbs/hr using Equation #17

$$Se = \frac{B}{t} \left[\frac{P_{s1}}{100 - P_{s1}} - \frac{P_{s2}}{100 - P_{s2}}\right]$$

where:

Se = rate of VOC emissions, lbs/hr
B = weight of batch (dry), lbs
t = time of drying operation, hrs
P_{s1} = percent of VOC in wet material charged to drye
P_{s2} = percent of VOC in material discharged from dryer.

NOTE:

wet cake weight = 1.250 lbs
dry cake weight = 1,000 lbs
wet cake LOD = 20%
"dry" cake LOD ≤ 0.05% → 0

$$Se = \frac{1{,}000\ lbs}{4\ hrs} \left[\frac{20\%}{100 - 20} - \frac{0}{100 - 0}\right] = 62.5\ lbs/hr$$

$$Se = 62.5\ \frac{lbs}{hr}$$

$$62.5\ \frac{lbs}{hr} \times 4\ hrs = 250.0\ lbs/batch$$

Since losses associated with leak rate into dryer are less th total solvent available, emission loss during drying operatio is 2.72 lbs/batch.

VIII. Air Drying

Operation: Air dry product wet cake in DR-510

Conditions:
Wet cake weight is 1.250 lbs with LOD of 20%
Dry cake weight is 1,000 lbs
Drying time is 6 hrs

Calculations:

1. Calculate the rate of VOC emissions, lbs/hr using Equation #17 -

$$Se = \frac{B}{t}\left[\frac{P_{s1}}{100-P_{s1}} - \frac{P_{s2}}{100-P_{s2}}\right]$$

where:

Se = rate of VOC emission, lbs/hr
B = weight of batch (dry), lbs.
t = time of drying operation, hrs
P_{s1} = percent of VOC in wet material charged to drye
P_{s2} = percent of VOC in material discharged from dryer.

$$Se = \frac{1{,}000 \text{ lbs}}{6 \text{ hrs}}\left[\frac{20\%}{100-20} - \frac{0}{100-0}\right] = 62.5 \text{ lbs/hr}$$

$$62.5 \frac{\text{lbs}}{\text{hr}} \times 4 \text{ hrs} = 250 \text{ lbs VOC emitted per batch}$$

IX. Tank Breathing Losses

Operation: Breathing Losses from TA-800 (Bulk Storage Tank)

Conditions:
TA-800 is equipped with a conservation vent and is painted white
The average bulk liquid temperature is 15°C
The tank diameter is 14 ft.
The average tank free space (outage) is 4 ft.
The average daily change in temperature is 20°F
Solvent in TA-800 is Isopropyl Acetate

Assumptions: Air displaced by tank breathing losses is saturated with VOC at the average bulk liquid temperature.

Calculation:

$$L = 1.45 \left(\frac{P}{14.7 - P}\right)^{0.68} \times D^{1.73} \times H^{0.51} \times T^{0.5} \times Z \quad (1)$$

where:
L = gallons per year of VOC loss
P = vapor pressure of VOC at bulk liquid
D = tank diameter, ft.
H = average outage, ft.
T = average daily ambient temperature change in °F
Z = correction factor for tank diameter and paint factor calculated as follows:

Size Correction Factor (C)

TANK DIAMETER (FT)	VENT TYPE	
	CONSERVATION	OPEN
6	0.30	0.45
8	0.42	0.63
10	0.52	0.78
12	0.62	0.93
14	0.70	1.05
16	0.77	1.16
18	0.83	1.25
20	0.88	1.32

Paint Factors for Fixed Roof Tanks

TANK COLOR		PAINT FACTOR (FP)
ROOF	SHELL	
White	White	1.00
Aluminum (specular)	White	1.04
White	Aluminum (specular)	1.16
Aluminum (specular)	Aluminum (specular)	1.20
White	Aluminum (Diffuse)	1.30
Aluminum (Diffuse)	Aluminum (Diffuse)	1.39
White	Gray	1.30
Light Gray	Light Gray	1.33
Medium Gray	Medium Gray	1.40

Calculate Z

$$Z = (C \times Fp) = 0.70 \times 1.0 = 0.7$$

Calculate vapor pressure, Pi, at average bulk liquid temperature

$$\text{Log}_{10}\ Pi = a - \left(\frac{b}{c + Ti}\right)$$

$$\text{Log}_{10}\ Pi = 7.180 - \left(\frac{1353.6}{225.824 + 15}\right)$$

Log,, Pi = 1.559

$$Pi = 36.2\text{mm Hg}$$

Convert to psi

$$36.2\ \text{mm Hg} \times \frac{14.7\ \text{psi}}{760\ \text{mm Hg}} = 0.70\ \text{psi}$$

$$L = 1.45 \left(\frac{0.70}{14.7 - 0.70}\right)^{0.68} \times 14^{1.73} \times 4^{0.51} \times 20^{0.5} \times 0.7$$

$$L = 0.189 \times 96.12 \times 2.03 \times 4.47 \times 0.7$$

L = 115.4 gallons/yr

$$115.4\ \frac{\text{gals}}{\text{yr}} \times 7.28\ \frac{\text{lbs}}{\text{gal}} \times \frac{1\ \text{yr}}{365\ \text{days}} = 2.30$$ lbs VOC emitted per day

(1) Breathing loss equation from API Bulletin #2518, June 1962, "Evaporation Loss from Fixed Roof Tanks," Chapter 2, "Breathing Loss of Gasoline."

ATTACHMENT IV

```
File name missing or blank - please enter file name
UNIT 13? title
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UNIT 14? filval10
                   EMISSION CALCULATION PROGRAM (H.C.)
.............................................................
 PROJECT:EMIT VALIDATION                    LOCATION:STONEWALL
 PROCESS:EMIT10                             INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :5/28/96                 CYCLE :  24.0 HRS
----------------------------------------------------------------------


.............................................................
 EQUIPMENT:RE-100   -REACTOR                             -500 GALLONS
.............................................................
STEP DISPLACEMENT                               V.P. EMIS"N CYCLE TOTAL
NO. METHOD                SOLVENT              MM-HG LBS/HR HRS   LBS
---- --------------- ----------------  ----- ------ -----  --------
  1  1 FILLING            ISOPROPYLACETATE   85.   6.87    .14    1.0
                                      ADDITIONAL EMISSIONS:      .0
.............................................................
                                           TOTAL EMISSIONS:     .95
----------------------------------------------------------------------


                              SOURCE SUMMARY
                              -------------
                                              UNLIMITED PERMITTED
E M I S S I O N S  LBS/HOUR   LBS/DAY   TONS/YR   TONS/YR    REMARKS
-----------------  ---------  --------  --------  --------  ---------
POTENTIAL                .04       1.0       .17       .17
W/EXIST./SELECTED:       .04       1.0       .17       .17
ALLOWED/DESIRED  :    100.00    1000.0    182.50    182.50
RECOMMENDED              .04       1.0       .17       .17
.............................................................
     NO AIR EMISSION CONTROLS REQUIRED ]
----------------------------------------------------------------------


                             OVERALL SUMMARY
                             --------------
                  GENERAL CLASS
                  --------------------------------------
              POTENTIAL        ALLOWED / DESIRED
EQUIP.  UNLMTD PRMTD                     UNLMTD PRMTD
TAG NO. TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR  S O L V E N T S
------- ------ ------ ------ ------ ------ ------ --------------------
RE-100     .17    .17 100.001000.00 182.50 182.50
------- ------ ------ ------ ------ ------ ------ --------------------
TOTAL:     .17    .17                182.50 182.50
----------------------------------------------------------------------


          W/EXIST./SELECT. CONTROLS        RECOMMENDED
EQUIP.                    UNLMTD PRMT                UNLMTD PRMTD
```

```
TAG NO. LBS/HR LBS/DY TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR
------- ------ ------ ------ ------ ------ ------ ------ ------
RE-100     .04    .95    .17    .17    .04    .95    .17    .17
------- ------ ------ ------ ------ ------ ------ ------ ------
TOTAL :                  .17    .17                  .17    .17
--------------------------------------------------------------------


                     EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                     -----------------------------------
EQUIP.  POTENTIAL  EXIST/ COOLING CHILLED          SUBCOOLED SUPERCOOL
TAG NO.            SELECT WATER   WATER    BRINE   BRINE     BRINE
------- --------- -------- ------- ------- ------- --------- ---------
RE-100        .95      .95     .87     .43     .25       .11       .05
------- --------- -------- ------- ------- ------- --------- ---------
TOTAL :       .95      .95     .87     .43     .25       .11       .05
------- --------- -------- ------- ------- ------- --------- ---------


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Stop - Program terminated.
```

```
File name missing or blank - please enter file name
UNIT 14? EVAVAL10
                   EMISSION CALCULATION PROGRAM (H.C.)
----------------------------------------------------------------------
 PROJECT:EMIT VALIDATION                  LOCATION:STONEWALL
 PROCESS:EMIT10                           INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :10/18/94              CYCLE :  24.0 HRS
----------------------------------------------------------------------


----------------------------------------------------------------------
 EQUIPMENT:RE-400  -REACTOR                             -750 GALLONS
----------------------------------------------------------------------
STEP DISPLACEMENT                            V.P. EMIS"N CYCLE TOTAL
NO. METHOD               SOLVENT            MM-HG LBS/HR HRS   LBS
---- ---------------- ----------------     ----- ------ ----- --------
  1  2 EVACUATION        ETHYLENDICHLORID 102.   8.76    .17    1.5
                                    ADDITIONAL EMISSIONS:        .0
----------------------------------------------------------------------
                                         TOTAL EMISSIONS:    1.46
----------------------------------------------------------------------


                                 SOURCE SUMMARY
                                 --------------
                                             UNLIMITED PERMITTED
E M I S S I O N S    LBS/HOUR    LBS/DAY    TONS/YR   TONS/YR    REMARKS
-----------------    ---------   -------    --------  --------  ---------
POTENTIAL        :        .06        1.5        .27       .27
W/EXIST./SELECTED:        .06        1.5        .27       .27
ALLOWED/DESIRED  :     100.00     1000.0     182.50    182.50
RECOMMENDED      :        .06        1.5        .27       .27
----------------------------------------------------------------------
     NO AIR EMISSION CONTROLS REQUIRED ]
----------------------------------------------------------------------


                              OVERALL SUMMARY
                              ---------------
                    GENERAL CLASS
                    ----------------------------------------
                POTENTIAL         ALLOWED / DESIRED
EQUIP.  UNLMTD PRMTD                    UNLMTD PRMTD
TAG NO. TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR  S O L V E N T S
------- ------ ------ ------ ------ ------ ------ ------------------
RE-400     .27    .27 100.001000.00 182.50 182.50
------- ------ ------ ------ ------ ------ ------ ------------------
TOTAL:     .27    .27               182.50 182.50
----------------------------------------------------------------------


        W/EXIST./SELECT. CONTROLS        RECOMMENDED
EQUIP.                 UNLMTD PRMT                    UNLMTD PRMTD
TAG NO. LBS/HR LBS/DY TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR
------- ------ ------ ------ ------ ------ ------ ------ ------
```

```
RE-400      .06   1.46    .27     .27     .06   1.46     .27     .27
------- ------ ------ ------ ------ ------ ------ ------ ------
TOTAL :                   .27     .27                    .27     .27
------------------------------------------------------------------------


                    EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                    -----------------------------------
EQUIP.  POTENTIAL  EXIST/ COOLING CHILLED         SUBCOOLED SUPERCOOL
TAG NO.            SELECT WATER   WATER    BRINE  BRINE       BRINE
------- --------- -------- ------- ------- ------- --------- ---------
RE-400       1.46     1.46    1.46     .70     .42       .18       .10
------- --------- -------- ------- ------- ------- --------- ---------
TOTAL :      1.46     1.46    1.46     .70     .42       .18       .10
------- --------- -------- ------- ------- ------- --------- ---------


SIGNED:--------------- TITLE:-------------------- DATE:---------------


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Stop - Program terminated.

C:\EMIT>
```

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File name missing or blank - please enter file name
UNIT 13? title
File name missing or blank - please enter file name
UNIT 14? sweval10
                         EMISSION CALCULATION PROGRAM (H.C.)

 PROJECT:EMIT VALIDATION                        LOCATION:STONEWALL
 PROCESS:EMIT10                                 INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :5/28/96                     CYCLE :  24.0 HRS
----------------------------------------------------------------------


.............................................................
 EQUIPMENT:RE-100   -REACTOR                              -500 GALLONS
.............................................................
STEP DISPLACEMENT                                V.P. EMIS"N CYCLE TOTAL
NO. METHOD                SOLVENT              MM-HG LBS/HR HRS   LBS
---- ---------------- ----------------         ----- ------ -----  --------
  1  3 GAS SWEEP          ISOPROPYLACETATE      85.    3.94    .17      .7
                                         ADDITIONAL EMISSIONS:      .0
.............................................................
                                              TOTAL EMISSIONS:     .66
.............................................................


                                 SOURCE SUMMARY
                                 --------------
                                              UNLIMITED PERMITTED
EMISSIONS        LBS/HOUR     LBS/DAY     TONS/YR   TONS/YR     REMARKS
-----------------  ---------  --------  --------  --------  ---------
POTENTIAL               .03          .7       .12        .12
W/EXIST./SELECTED:      .03          .7       .12        .12
ALLOWED/DESIRED   :  100.00      1000.0    182.S0     182.50
RECOMMENDED             .03          .7       .12        .12
.............................................................
     NO AIR EMISSION CONTROLS REQUIRED I
----------------------------------------------------------------------


                              OVERALL SUMMARY
                              ---------------
                    GENERAL CLASS
                    ----------------------------------------
          POTENTIAL         ALLOWED / DESIRED
EQUIP.  UNLMTD PRMTD                 UNLMTD PRMTD
TAG NO. TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR  S O L V E N T S
------- ------ ------ ------ ------ ------ ------ ------------------
RE-100     .12    .12 100.001000.00 182.50 182.50
------- ------ ------ ------ ------ ------ ------ ------------------
TOTAL:     .12    .12               182.50 182.50
----------------------------------------------------------------------


          W/EXIST./SELECT. CONTROLS       RECOMMENDED
EQUIP.                  UNLMTD PRMT                UNLMTD PRMTD
```

```
TAG NO. LBS/HR LBS/DY TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR
------- ------ ------ ------ ------ ------ ------ ------ ------
RE-100     .03    .66    .12    .12    .03    .66    .12    .12
------- ------ ------ ------ ------ ------ ------ ------ ------
TOTAL :                  .12    .12                  .12    .12
-----------------------------------------------------------------------


                    EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                    -----------------------------------
EQUIP.  POTENTIAL  EXIST/ COOLING CHILLED          SUBCOOLED SUPERCOOL
TAG NO.            SELECT WATER   WATER    BRINE  BRINE     BRINE
------- --------- -------- ------- ------- ------- --------- ---------
RE-100        .66      .66     .59     .26     .14       .05       .02
------- --------- -------- ------- ------- ------- --------- ---------
TOTAL :       .66      .66     .59     .26     .14       .05       .02
------- --------- -------- ------- ------- ------- --------- ---------


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Stop - Program terminated.
```

```
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UNIT 13? title
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UNIT 14? heaval10
                     EMISSION CALCULATION PROGRAM (H.C.)

 PROJECT:EMIT VALIDATION.                     LOCATION:STONEWALL
 PROCESS:EMIT10                               INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :5/28/96                   CYCLE :  24.0 HRS
............................................................



--------------------------------------------------------------------
 EQUIPMENT:ST-1000 -STILL                               -1000 GALLONS
............................................................
STEP DISPLACEMENT                              V.P. EMIS"N CYCLE TOTAL
NO. METHOD               SOLVENT             MM-HG LBS/HR HRS   LBS
---- ---------------- ----------------       ----- ------ -----  --------
  1  4 HEATING           ISOPROPYLACETATE   77.    .35   3.00    1.1
                                       ADDITIONAL EMISSIONS:      .0
--------------------------------------------------------------------
                                            TOTAL EMISSIONS:    1.06
--------------------------------------------------------------------



                              SOURCE SUMMARY
                              --------------
                                             UNLIMITED PERMITTED
E M I S S I O N S  LBS/HOUR   LBS/DAY   TONS/YR   TONS/YR    REMARKS
-----------------  --------   --------  --------  --------  ---------
POTENTIAL               .04       1.1        .19       .19
W/EXIST./SELECTED:      .04       1.1        .19       .19
ALLOWED/DESIRED  :   100.00    1000.0     182.50    182.50
RECOMMENDED             .04       1.1        .19       .19
............................................................
     NO AIR EMISSION CONTROLS REQUIRED ]
............................................................



                           OVERALL SUMMARY
                           ---------------
                  GENERAL CLASS
                  ----------------------------------------
           POTENTIAL          ALLOWED / DESIRED
EQUIP.  UNLMTD PRMTD                   UNLMTD PRMTD
TAG NO. TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR  S O L V E N T S
------- ------ ------ ------ ------ ------ ------ -------------------
ST-1000    .19    .19 100.001000.00 182.50 182.50
------- ------ ------ ------ ------ ------ ------ -------------------
TOTAL:     .19    .19               182.50 182.50
--------------------------------------------------------------------
```

```
          W/EXIST./SELECT. CONTROLS       RECOMMENDED
EQUIP.                UNLMTD PRMT                UNLMTD PRMTD
TAG NO. LBS/HR LBS/DY TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR
------- ------ ------ ------ ------ ------ ------ ------ ------
ST-1000    .04   1.06    .19    .19    .04   1.06    .19    .19
------- ------ ------ ------ ------ ------ ------ ------ ------
TOTAL :                  .19    .19                  .19    .19
----------------------------------------------------------------------


                    EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                    -----------------------------------
EQUIP.  POTENTIAL  EXIST/ COOLING CHILLED          SUBCOOLED SUPERCOOL
TAG NO.            SELECT WATER   WATER    BRINE  BRINE     BRINE
------- --------- -------- ------- ------- ------- --------- ---------
ST-1000      1.06     1.06    1.06     .47     .26       .10       .05
------- --------- -------- ------- ------- ------- --------- ---------
TOTAL :      1.06     1.06    1.06     .47     .26       .10       .05
------- --------- -------- ------- ------- ------- --------- ---------


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Stop - Program terminated.
```

```
File name missing or blank - please enter file name
UNIT 14? GASVAL10
                        EMISSION CALCULATION PROGRAM (H.C.)
.....................................................................
 PROJECT:EMIT VALIDATION                          LOCATION:STONEWALL
 PROCESS:EMIT10                                   INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :10/18/94                      CYCLE :  24.0 HRS
--------------------------------------------------------------------------


--------------------------------------------------------------------------
 EQUIPMENT:TA-2000 -TANK                                     -? GALLONS
--------------------------------------------------------------------------
STEP DISPLACEMENT                                V.P. EMIS"N CYCLE TOTAL
NO. METHOD                SOLVENT               MM-HG LBS/HR HRS    LBS
---- ---------------- ----------------          ----- ------ ----- --------
  1  5 GAS EVOLUTION      HEXANE                 187.    8.26  10.00    82.6
                                          ADDITIONAL EMISSIONS:        .0
--------------------------------------------------------------------------
                                              TOTAL EMISSIONS:    82.61
--------------------------------------------------------------------------


                                 SOURCE SUMMARY
                                 --------------
                                              UNLIMITED PERMITTED
E M I S S I O N S  LBS/HOUR    LBS/DAY     TONS/YR   TONS/YR     REMARKS
-----------------  --------    --------    --------  --------   ---------
POTENTIAL              3.44       82.6       15.08      15.08
W/EXIST./SELECTED:     3.44       82.6       15.08      15.08
ALLOWED/DESIRED  :   100.00     1000.0      182.50     182.50
RECOMMENDED            3.44       82.6       15.08      15.08
............................................         ------------------
     NO AIR EMISSION CONTROLS REQUIRED ]
--------------------------------------------------------------------------


                              OVERALL SUMMARY
                              ---------------
                   GENERAL CLASS
                   ..................................
               POTENTIAL          ALLOWED / DESIRED
EQUIP.  UNLMTD PRMTD                      UNLMTD PRMTD
TAG NO. TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR  S O L V E N T S
------- ------ ------ ------ ------ ------ ------ -------------------
TA-2000  15.08  15.08 100.001000.00 182.50 182.50
------- ------ ------ ------ ------ ------ ------ ...................
TOTAL:   15.08  15.08               182.50 182.50
--------------------------------------------------------------------------


           W/EXIST./SELECT. CONTROLS          RECOMMENDED
EQUIP.                   UNLMTD PRMT                      UNLMTD PRMTD
TAG NO. LBS/HR LBS/DY TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR
------- ------ ------ ------ ------ ------ ------ ------ ------
```

```
TA-2000   3.44  82.61  15.08  15.08   3.44  82.61  15.08  15.08
------- ------ ------ ------ ------ ------ ------ ------ ------
TOTAL :                15.08  15.08                15.08  15.08
-----------------------------------------------------------------------


                    EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                    -----------------------------------
EQUIP.  POTENTIAL  EXIST/ COOLING CHILLED         SUBCOOLED SUPERCOOL
TAG NO.            SELECT WATER   WATER    BRINE  BRINE     BRINE
------- --------- -------- ------- ------- ------- --------- ---------
TA-2000     82.61    82.61   82.61   36.66   20.16      7.74      3.57
------- --------- -------- ------- ------- ------- --------- ---------
TOTAL :     82.61    82.61   82.61   36.66   20.16      7.74      3.57
------- --------- -------- ------- ------- ------- --------- ---------


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Stop - Program terminated.

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UNIT 14? VOPVAL10
                    EMISSION CALCULATION PROGRAM (H.C.)
.................................................................
 PROJECT:EMIT VALIDATION                      LOCATION:STONEWALL
 PROCESS:EMIT10                               INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :10/18/94                  CYCLE :  24.0  HRS
------------------------------------------------------------------------


.................................................................
 EQUIPMENT:ST-200  -STILL                                -750 GALLONS
.................................................................
STEP DISPLACEMENT                              V.P.  EMIS"N CYCLE TOTAL
NO. METHOD                  SOLVENT           MM-HG LBS/HR HRS   LBS
---- --------------- ----------------        ----- ------ ----- --------
  1  6 VAC. DISTIL'N     ETHYLENDICHLORID   38.    1.79   8.00   14.3
                                       ADDITIONAL EMISSIONS:        .0
------------------------------------------------------------------------
                                            TOTAL EMISSIONS:   14.28
------------------------------------------------------------------------


                              SOURCE SUMMARY
                              --------------
                                            UNLIMITED PERMITTED
E M I S S I O N S   LBS/HOUR    LBS/DAY     TONS/YR   TONS/YR    REMARKS
-----------------   ---------   --------    --------  --------   ---------
POTENTIAL                .60       14.3        2.61      2.61
W/EXIST./SELECTED:       .60       14.3        2.61      2.61
ALLOWED/DESIRED   :   100.00     1000.0      182.50    182.50
RECOMMENDED              .60       14.3        2.61      2.61
------------------------------------------------------------------------
     NO AIR EMISSION CONTROLS REQUIRED ]
.................................................................


                            OVERALL SUMMARY
                            ---------------
                  GENERAL CLASS
                  .....................................
               POTENTIAL           ALLOWED / DESIRED
EQUIP.      UNLMTD PRMTD                     UNLMTD PRMTD
TAG NO.     TNS/YR TNS/YR LBS/HR LBS/DY   TNS/YR TNS/YR   S O L V E N T S
-------     ------ ------ ------ ------   ------ ------   ...................
ST-200        2.61   2.61 100.001000.00   182.50 182.50
-------     ------ ------ ------ ------   ------ ------   -------------------
TOTAL:        2.61   2.61                 182.50 182.50
.................................................................


              W/EXIST./SELECT. CONTROLS          RECOMMENDED
EQUIP.                       UNLMTD PRMT                      UNLMTD PRMTD
TAG NO.   LBS/HR LBS/DY   TNS/YR TNS/YR   LBS/HR LBS/DY   TNS/YR TNS/YR
-------   ------ ------   ------ ------   ------ ------   ------ ------
```

```
ST-200      .60  14.28   2.61   2.61    .60  14.28   2.61  __2.61
------- ------ ------ ------ ------ ------ ------ ------
TOTAL :                  2.61   2.61                 2.61   2.61
..............................................................


                     EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                     -----------------------------------
EQUIP.   POTENTIAL  EXIST/ COOLING CHILLED          SUBCOOLED SUPERCOOL
TAG NO.             SELECT WATER   WATER     BRINE  BRINE     BRINE
-------  ---------  -------- ------- ------- ------- --------- ---------
ST-200       14.28     14.28   46.23   19.09   10.66      4.28      2.23
-------  ---------  -------- ------- ------- ------- --------- ---------
TOTAL :      14.28     14.28   46.23   19.09   10.66      4.28      2.23
-------  ---------  -------- ------- ------- ------- --------- ---------


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Stop - Program terminated.

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```

```
File name missing or blank - please enter file name
UNIT 14? VDRVAL10
                    EMISSION CALCULATION PROGRAM (H.C.)
..........................................................
 PROJECT:EMIT VALIDATION                    LOCATION:STONEWALL
 PROCESS:EMIT10                             INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :10/18/94                CYCLE :   24.0  HRS
----------------------------------------------------------------------


----------------------------------------------------------------------
 EQUIPMENT:DR-550   -DRYER                               -500 GALLONS
----------------------------------------------------------------------
STEP DISPLACEMENT                           V.P. EMIS"N CYCLE TOTAL
NO. METHOD                 SOLVENT         MM-HG LBS/HR HRS    LBS
---- ---------------- ---------------- ----- ------ ----- --------
  1  7 VAC. DRYING         ETHYL ALCOHOL     32.    .68   4.00    2.7
                                         ADDITIONAL EMISSIONS:      .0
----------------------------------------------------------------------
                                              TOTAL EMISSIONS:    2.72
----------------------------------------------------------------------


                                SOURCE SUMMARY
                                --------------
                                              UNLIMITED PERMITTED
E M I S S I O N S  LBS/HOUR   LBS/DAY    TONS/YR   TONS/YR   _REMARKS_
-----------------  ---------  --------   --------  --------
POTENTIAL                 .11      2.7        .50       .50
W/EXIST./SELECTED:        .11      2.7        .50       .50
ALLOWED/DESIRED  :     100.00   1000.0     182.50    182.50
RECOMMENDED               .11      2.7        .50       .50
----------------------------------------------------------------------
     NO AIR EMISSION CONTROLS REQUIRED ]
..........................................................


                             OVERALL SUMMARY
                             ---------------
                   GENERAL CLASS
                   ................................
               POTENTIAL        ALLOWED / DESIRED
LQUIP.   UNLMTD PRMTD                   UNLMTD PRMTD
TAG NO.  TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR _S_O_L_V_E_N_T_S____
-------  ------ ------ ------ ------ ------ ------ ____________________
DR-550      .50    .50 100.001000.00 182.50 182.50
-------  ------ ------ ------ ------ ------ ------ --------------------
TOTAL:      .50    .50               182.50 182.50
----------------------------------------------------------------------


          W/EXIST./SELECT. CONTROLS        RECOMMENDED
EQUIP.                   UNLMTD PRMT                  UNLMTD PRMTD
TAG NO. LBS/HR LBS/DY TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR
------- ------ ------ ------ ------ ------ ------ ------ ------
```

```
DR-550      .11    2.72     .50     .50     .11    2.72     .50     .50
------- ------ ------ ------ ------ ------ ------ ------ ------
TOTAL :                     .50     .50                     .50     .50
----------------------------------------------------------------------


                   EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                   -----------------------------------
EQUIP.  POTENTIAL  EXIST/ COOLING CHILLED         SUBCOOLED SUPERCOOL
TAG NO.            SELECT WATER   WATER   BRINE   BRINE       BRINE
------- --------- -------- ------- ------- ------- --------- ---------
DR-550       2.72     2.72    7.61    2.72    1.35       .43       .19
------- --------- -------- ------- ------- ------- --------- ---------
TOTAL :      2.72     2.72    7.61    2.72    1.35       .43       .19
------- --------- -------- ------- ------- ------- --------- ---------


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Stop - Program terminated.

C:\EMIT>
```

```
File name missing or blank - please enter file name
UNIT 14? ADRVAL10
                   EMISSION CALCULATION PROGRAM (H.C.)
----------------------------------------------------------------------
 PROJECT:EMIT VALIDATION                  LOCATION:STONEWALL
 PROCESS:EMIT10                           INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :10/18/94              CYCLE :  24.0  HRS
----------------------------------------------------------------------



----------------------------------------------------------------------
 EQUIPMENT:DR-510  -DRYER                           -500 GALLONS
----------------------------------------------------------------------
STEP DISPLACEMENT                          V.P. EMIS"N CYCLE TOTAL
NO. METHOD              SOLVENT          MM-HG LBS/HR HRS   LBS
---- ---------------- ----------------    ----- ------ ----- --------
  1  9 AIR DRYING       METHYL ALCOHOL           62.5  4.00    250.0
                                   ADDITIONAL EMISSIONS:       .0
----------------------------------------------------------------------
                                        TOTAL EMISSIONS:  250.00
----------------------------------------------------------------------


                           SOURCE SUMMARY
                           ==============
                                        UNLIMITED PERMITTED
E M I S S I O N S  LBS/HOUR   LBS/DAY   TONS/YR   TONS/YR     REMARKS
-----------------  --------   --------  --------  --------   ---------
POTENTIAL        :   10.42    250.0       45.63     45.63
W/EXIST./SELECTED:   10.42    250.0       45.63     45.63
ALLOWED/DESIRED  :  100.00   1000.0      182.50    182.50
RECOMMENDED          10.42    250.0       45.63     45.63
..........................................................
     NO AIR EMISSION CONTROLS REQUIRED ]
..........................................................


                        OVERALL SUMMARY
                        ===============
              GENERAL CLASS
              ----------------------------------------
          POTENTIAL        ALLOWED / DESIRED
EQUIP.  UNLMTD PRMTD                UNLMTD PRMTD
TAG NO. TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR  S O L V E N T S
------- ------ ------ ------ ------ ------ ------ --------------------
DR-510   45.63  45.63 100.001000.00 182.50 182.50
------- ------ ------ ------ ------ ------ ------ ................
TOTAL:   45.63  45.63               182.50 182.50
----------------------------------------------------------------------


          W/EXIST./SELECT. CONTROLS       RECOMMENDED
EQUIP.                UNLMTD PRMT                UNLMTD PRMTD
TAG NO. LBS/HR LBS/DY TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR
------- ------ ------ ------ ------ ------ ------ ------ ------
```

```
DR-510    10.42 250.00  45.63   45.63  10.42 250.00  45.63  45.63
-------  ------ ------ ------  ------ ------ ------ ------ ------
TOTAL :                 45.63   45.63                45.63  45.63
--------------------------------------------------------------------------


                     EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                     ...................................
EQUIP.   POTENTIAL  EXIST/  COOLING  CHILLED           SUBCOOLED  SUPERCOOL
TAG NO.             SELECT  WATER    WATER     BRINE  BRINE      BRINE
-------  ---------  ------- -------  -------  ------- ---------  ---------
DR-510     250.00    250.00  250.00   250.00   250.00    250.00     250.00
-------  ---------  ------- -------  -------  ------- ---------  ---------
TOTAL :    250.00    250.00  250.00   250.00   250.00    250.00     250.00
-------  ---------  ------- -------  -------  ------- ---------  ---------


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Stop - Program terminated.

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UNIT 13? TITLE
File name missing or blank - please enter file name
UNIT 14? BREVAL10
                         EMISSION CALCULATION PROGRAM (H.C.)
...................................................................
 PROJECT:EMIT VALIDATION                     LOCATION:STONEWALL
 PROCESS:EMIT10                              INT.:HYPOTHETICAL CASE
 BATCH SHEET/ REF. :5/28/96                  CYCLE :  24.0 HRS
----------------------------------------------------------------------



----------------------------------------------------------------------
 EQUIPMENT:TA-800  -TANK                                  -7500 GAL
----------------------------------------------------------------------
STEP DISPLACEMENT                                V.P. EMIS"N CYCLE TOTAL
NO. METHOD                SOLVENT              MM-HG LBS/HR HRS   LBS
---- ---------------- ----------------         ----- ------ ----- --------
  1  8 BREATHING LOSS    ISOPROPYLACETATE   36.    .10  24.00    2.3
                                          ADDITIONAL EMISSIONS:      .0
----------------------------------------------------------------------
                                             TOTAL EMISSIONS:    2.30
----------------------------------------------------------------------


                                SOURCE SUMMARY
                                --------------
                                            UNLIMITED PERMITTED
EMISSIONS         LBS/HOUR   LBS/DAY    TONS/YR   TONS/YR    REMARKS
----------------- ---------  --------   --------  --------  ---------
POTENTIAL               .10      2.3        .42       .42
W/EXIST./SELECTED:      .10      2.3        .42       .42
ALLOWED/DESIRED  :   100.00   1000.0     182.50    182.50
RECOMMENDED             .10      2.3        .42       .42
...................................................................
     NO AIR EMISSION CONTROLS REQUIRED ]
----------------------------------------------------------------------


                             OVERALL SUMMARY
                             ---------------
                   GENERAL CLASS
                   ....................................
          POTENTIAL          ALLOWED / DESIRED
EQUIP.  UNLMTD PRMTD                  UNLMTD PRMTD
TAG NO. TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR  S O L V E N T S
------- ------ ------ ------ ------ ------ ------ -------------------
TA-800     .42    .42 100.001000.00 182.50 182.50
------- ------ ------ ------ ------ ------ ------ ...................
TOTAL:     .42    .42               182.50 182.50
----------------------------------------------------------------------


          W/EXIST./SELECT. CONTROLS       RECOMMENDED
EQUIP.                 UNLMTD PRMT                   UNLMTD PRMTD
```

```
TAG NO. LBS/HR LBS/DY TNS/YR TNS/YR LBS/HR LBS/DY TNS/YR TNS/YR
------- ------ ------ ------ ------ ------ ------ ------ ------
TA-800     .10   2.30    .42    .42    .10   2.30    .42    .42
------- ------ ------ ------ ------ ------ ------ ------ ------
TOTAL :                  .42    .42                  .42    .42
------------------------------------------------------------------------


                   EMISSIONS(LBS/BATCH) VS. EXIT TEMP.
                   ....................................
EQUIP.  POTENTIAL  EXIST/ COOLING CHILLED         SUBCOOLED SUPERCOOL
TAG NO.            SELECT WATER   WATER   BRINE   BRINE     BRINE
------- --------- -------- ------- ------- ------- --------- ---------
TA-800       2.30     2.30    4.02    2.30    1.55       .81       .50
------- --------- -------- ------- ------- ------- --------- ---------
TOTAL :      2.30     2.30    4.02    2.30    1.55       .81       .SO
------- --------- -------- ------- ------- ------- --------- ---------


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Stop - Program terminated.
```

ATTACHMENT V

Step Information		Vessel	Emission Type		Solvent Name	VOC	NVOC
No.	Description	ID	ID	Name		(lbs)	(lbs)
		All vessels					
1	Filling of RE-100	RE-100	1	Fill	ISOPROPYL ACETATE	0.95	
2	Evacuation of RE-400	RE-400	2	Evacuate	DICHLOROETHANE, 1,2-	1.46	
3	N2 Sweep of RE-100	RE-100	3	Gas Sweep	ISOPROPYL ACETATE	0.66	
4	Heat of batch in ST-1000	ST-1000	4	Heat	ISOPROPYL ACETATE	1.06	
5	Gas Evolution from TA-2000	TA-2000	5	Gas Evolution	HEXANE	82.60	
6	Vacuum Operation in ST-200	ST-200	6	Vac. Distill	DICHLOROETHANE, 1,2-	14.28	
7	Vacuum Drying in DR-550	DR-550	8	Vac. Dry	ETHYL ALCOHOL	2.72	
8	Air Drying in DR-510	DR-510	7	Air Dry	ETHYL ALCOHOL	250.00	

ATTACHMENT VI

June 6.1996

Merck Stonewall Plant
VOC Emissions from Fermentation Processes

In addition to organic synthesis, pharmaceutical finishing, and various ancillary support facilities, the Stonewall Plant includes Merck's largest pharmaceutical fermentation facility, and is considered the company's 'Center for Excellence' in fermentation technology. In addition to a modem, large scale industrial fermentation plant with considerable computer monitoring and control capabilities, the site includes extensive biotechnology research facilities which optimize existing processes and develop new ones.

The site currently runs three large scale pharmaceutical fermentation processes:

1) Lovastatin: In the lovastatin fermentation process. the fungal microorganism *Aspergillus terreus* is used to biologically produce a chemical precursor for Merck's cholesterol-reducing drugs **Mevacor®** and **Zocor®.**

2) Cefoxitin: A filamentous bacterium, *Nocardia lactamdurans*, is employed to produce the antibiotic cephamycin C by fermentation. which is the starting material for production of Merck's semi-synthetic broad spectrum injectable antibiotic **Mefoxin®.**

3) **Avermectin[1]:** Another filamentous bacterium, *Streptomyces avermitilis*, is used to produce a broad spectrum human and veterinary antiparasitic chemical called Avermectin by fermentation.

The three fermentation processes are similar to each other in several ways. All are submerged fermentations carried out at near ambient temperatures in large stirred tank reactors. **Sterilized** mixtures of various sugars and proteins in water provide the nutrients for cell growth and synthesis of the drug products of interest. All are highly ***aerobic*** fermentations; oxygen is a required nutrient, and it is supplied by pumping large amounts of compressed air into the bottom of the stirred tanks and through the liquid medium. All are ***batch*** fermentation processes (as opposed to ***continuous*** fermentations), where a discrete quantity of nutrient mixture is inoculated with the appropriate organism, incubated under prescribed conditions, and transferred batchwise to downstream processing areas for extraction of the drug product. All are relatively slow growing organisms, with batch cycles ranging from one to three weeks.

There are two possible mechanisms by which VOCs (volatile organic compounds) could be emitted from an aerobic pharmaceutical fermentation. First, if VOCs are added to the fermentation nutrient mixture, there would be VOC emissions from the reactor vent due to vapor displacement during filling and transfers, and due to stripping by the airflow during aeration. Secondly, even if no VOCs are added to the process, VOCs could

---

[1] **Avermectin fermentation was initiated at the Stonewall Plant in 1994.**

potentially be synthesized by the microorganisms during fermentation and emitted from the vent by the stripping action of the airflow.

Unlike some industrial fermentations, Merck does not add any VOCs to any of the three fermentation processes at Stonewall either before, during, or after batch processing, therefore there are no simple displacement or stripping VOC emissions as would typically occur in chemical synthesis operations or in fermentation operations containing added VOCs.

Probably the most common example of VOC synthesis during industrial fermentations is the production of ethanol in fermentations to produce beer and wine. Ethanol is produced by yeast cells from pyruvate under anaerobic (low oxygen) conditions. The biochemical pathway responsible for this conversion does not function under the highly aerobic conditions of Merck's fermentations.

Although the microbial biochemistry that occurs in industrial fermentations is extremely complex with many interrelated reactions occuring simultaneously, much is known about the biochemical reactions employed by microorganisms to produce energy, synthesize cellular components, and synthesize our drug products. All of Merck's fermentations, for example, produce cellular energy in the form-of ATP (adenosine triphosphate) by converting glucose to pyruvate in an eight step sequence of biochemical reactions known as glycolysis. The chemical structures and control mechanisms involved in glycolysis are well known. The next step in energy production under aerobic conditions, a series of reactions called the citric acid cycle, is also at work in Merck's fermentations. As with glycolysis, the chemical structures and the control of the citric acid cycle and many other biochemical pathways applicable to Merck's fermentations are very well known. Of the metabolic and biosynthetic pathways that have been elucidated for Merck's fermentations, none are known to synthesize VOCs.

VOCs are often relatively odorous compounds, with well known odors associated with various alcohols, ketones, and esters. The low odor level normally associated with Merck's fermentations despite their extremely high aeration levels is additional empirical evidence that VOC emissions from the present fermentation processes are not significant.

ATTACHMENT VII

Basis of Calculating VOC Emissions From Central Solvent Recovery Atmospheric Fractional Distillation Columns

Assumptions:

- Distillation column condenser(s) are total condensers (Verified by B-JAC modeling - see Step I. below).
- Assume Henry's Law when predicting the amount of non-condensable gases (e.g. air) saturated in the feed stream.
- The solubility of air in the mixture is equal to the sum of the solubility of air in each component.
- Assume (where applicable) ideal immiscible liquid behavior (each phase exerts its own vapor pressure).
- Assume ideal vapor behavior as predicted by Raoult's Law.
- Assume the total amount of dissolved air calculated will be liberated and travel through the top of the distillation column and exit to the atmosphere via the column condenser(s).

Calculation Procedure:

I. Utilize B-JAC Modeling to Determine Distillation Column Condensers to be Total Condensers.

II. Calculate the Quantity of Dissolved Non-Condensable Gases (e.g. air) in the Feed Stream Material.

1. Calculate the partial pressure of each solvent by using Raoult's Law and the component liquid mole fraction.

2. Calculate the partial pressure of air by subtracting the partial pressures of the solvents from the system total pressure (e.g. 760 mmHg).

3. Utilize Henry's Law to calculate the quantity of dissolved air in a specific solvent. Since the partial pressure of air has been calculated. the Henry's Law constant is the only parameter to be determined. This can be done using physical characteristics of the solvent such as molecular weight. molar volume. surface tension. parachor. and Ostwald coefficient.

4. Calculate the mole fraction of air in the solvent of interest using the partial pressure of air and Henry's Law constant.

5. Repeat Steps 3 and 4 for each solvent in the feed stream.

6. Calculate the total flow of air (dissolved in the feed stream) into the distillation column system utilizing solvent composition of the feed stream and the mole fraction of air in each component.

III. Calculate the Theoretical Potential Quantity of VOC Emissions Exiting the Distillation Column Condenser(s).

1. Calculate the partial pressure of each solvent at the exit of the distillation column condenser(s).

2. Calculate the partial pressure of air by subtracting the partial pressures of the solvents from the system total pressure (e.g. 760 mmHg).

3. Calculate the mole fraction of air in the vapor using the partial pressure of air and the system total pressure.

4. Calculate the total gas flow rate exiting the distillation column condenser(s) utilizing the mole fraction and the flow rate of the air exiting the condenser(s).

5. Calculate the mole fraction of each solvent component in the vapor exiting the condenser(s) using the partial pressure of each component along with the system total pressure.

6. Calculate the emission rate of each solvent based on the mole fraction of each component and the total gas flow rate.

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ATTACHMENT VIII

Merck & Co. Inc

Amprolium Process Fugitive Emissions

Summary of VOC Fugitives, 1993 & 1994

1993

COMPONENT TYPE	*COMPONENT COUNT*	*TOTAL SERVICE HOURS*	*TOTAL VOC EMISSIONS (LB/YR)*
Valves	2739	9,907,949	2574.97
Sampling Devices	90	484,653	41.05
Pressure Relief Valves	137	641,026	655.00
Pumps	126	581,480	9062.56
Open Lines	443	1,430,759	5134.25
Flanges	7904	31,934,535	7985.48
Agitator Seals	26	99,122	147.73
TOTALS:	11465	45,079,524	25,601

1994

COMPONENT TYPE	*COMPONENT COUNT*	*TOTAL SERVICE HOURS*	*TOTAL VOC EMISSIONS (LB/YR)*
Valves	2739	11,668,613	3032.69
Sampling Devices	90	599,356	50.76
Pressure Relief Valves	137	732,003	769.09
Pumps	126	669,808	9928.28
Open Lines	443	1,369,163	4680.78
Flanges	7904	37,323,961	9333.27
Agitator Seals	26	119,007	182.69
	11,465	52,481,911	27,978

Average annual emissions, 1993/94: (25,601 lb + 27,978 lb) / 2 = 26,790 lb/year (13.4 TPY)

Merck & Co. Inc

Amprolium Process Fugitive Emissions

Valves

1993

REFERENCE FILE	TOTAL VALVES	TOTAL SERVICE HOURS	TOTAL VOC EMISSIONS (LB/YR)	VOC EMISSIONS (LB/VALVE/HR)
93ACRYL1.WK1	40	116,905	0.11	9.49E-07
93ACRYL2.WK1	32	4,368	0.62	1.43E-04
93MEOH1.WK1	96	590,534	246.38	4.17E-04
93MEOH2.WK1	94	550,787	131.27	2.38E-04
93MEOH2S.WK1	88	237,512	45.48	1.91E-04
93MEOH3.WK1	18	157,680	39.26	2.49E-04
93MEOH3S.WK1	136	259,587	403.83	1.56E-03
93AMINO1.WK1	68	194,682	16.08	8.26E-05
93AMINO2.WK1	78	366,951	57.33	1.56E-04
93AMINO3.WK1	77	510,526	162.28	3.18E-04
93AMPRL1.WK1	63	438,669	14.39	3.28E-05
93AMPRL2.WK1	94	638,965	80.42	1.26E-04
93METHX1.WK1	101	372,222	19.63	5.27E-05
93METHX2.WK1	112	724,617	121.39	1.68E-04
93METHX3.WK1	104	331,334	14.08	4.25E-05
93METHX4.WK1	78	399,239	104.82	2.63E-04
93RECOV1.WK1	98	586,043	371.17	6.33E-04
93RECOV2.WK1	38	167,091	11.47	6.86E-05
93STFXYL.WK1	76	665,760	60.67	9.11E-05
93CYHEX.WK1 *	269	288,364	74.94	2.60E-04
93DMS.WK1 *	93	102,176	26.55	2.60E-04
ERCSR1.WK1 *	218	831,473	216.09	2.60E-04
ERCSR3.WK1 *	392	558,264	145.09	2.60E-04
ERCSR5.WK1 *	276	814,200	211.60	2.60E-04
TOTALS:	2739	9,907,949	2574.97	2.60E-04

1994

REFERENCE FILE	TOTAL VALVES	TOTAL SERVICE HOURS	TOTAL VOC EMISSIONS (LB/YR)	VOC EMISSIONS (LB/VALVE/HR)
94ACRYL1.WK1	40	144,573	0.14	9.49E-07
94ACRYL2.WK1	32	5,402	0.77	1.43E-04
94MEOH1.WK1	96	730,296	304.69	4.17E-04
94MEOH2.WK1	94	681,142	162.34	2.38E-04
94MEOH2S.WK1	88	293,724	56.24	1.91E-04
94MEOH3.WK1	18	194,998	48.55	2.49E-04
94MEOH3S.WK1	136	321,023	499.41	1.56E-03
94AMINO1.WK1	68	240,757	19.89	8.26E-05
94AMINO2.WK1	78	453,797	70.90	1.56E-04
94AMINO3.WK1	77	631,352	200.69	3.18E-04
94AMPRL1.WK1	63	542,489	17.80	3.28E-05
94AMPRL2.WK1	94	790,189	99.46	1.26E-04
94METHX1.WK1	101	460,316	24.27	5.27E-05
94METHX2.WK1	112	896,112	150.12	1.68E-04
94METHX3.WK1	104	409,751	17.42	4.25E-05
94METHX4.WK1	78	493,727	129.62	2.63E-04
94RECOV1.WK1	98	724,742	459.02	6.33E-04
94RECOV2.WK1	38	206,636	14.18	6.86E-05
94STFXYL.WK1	76	823,325	75.03	9.11E-05
94CYHEX.WK1 *	269	356,611	92.68	2.60E-04
94DMS.WK1 *	93	126,358	32.84	2.60E-04
ERCSR2.WK1 *	218	956,148	248.60	2.60E-04
ERCSR4.WK1 *	392	370,944	96.45	2.60E-04
ERCSR6.WK1 *	276	814,200	211.60	2.60E-04
	2739	11,668,613	3032.69	2.60E-04

Average leak rate for valves = (2574.97 lb + 3032.69 lb) / (9,907,949 hr + 11,668,613 hr) = 2.60E-04 lb/hr

Average annual total VOC emissions from valves in 1993/94 = (2574.97 lb + 3032.69 lb) / 2 = 2803.83 lb/year

* Components were not screened. The mean leak rate from screened components was applied to calculate emissions.

Merck & Co. Inc

Amprolium Process Fugitive Emissions

Sampling Devices

1993

REFERENCE FILE	TOTAL SAMPLING DEVICES	TOTAL SERVICE HOURS	TOTAL VOC EMISSIONS (LB/YR)	VOC EMISSIONS (LB/DEVICE/HR)
93ACRYL1.WK1	1	156	0.00	0.00E+00
93ACRYL2.WK1	4	624	0.01	9.13E-06
93MEOH1.WK1	1	7,488	0.01	1.34E-06
93MEOH2.WK1	5	30,646	2.78	9.07E-05
93MEOH2S.WK1	0	0	0.00	N/A
93MEOH3.WK1	3	26,280	2.62	9.97E-05
93MEOH3S.WK1	1	630	0.00	0.00E+00
93AMINO1.WK1	10	36,651	0.25	6.95E-06
93AMINO2.WK1	6	27,165	0.03	1.07E-06
93AMINO3.WK1	7	48,293	2.57	5.32E-05
93AMPRL1.WK1	3	20,889	0.02	9.57E-07
93AMPRL2.WK1	7	48,741	20.51	4.21E-04
93METHX1.WK1	9	25,897	0.23	9.04E-06
93METHX2.WK1	5	35,090	0.33	9.26E-06
93METHX3.WK1	6	14,040	1.22	8.69E-05
93METHX4.WK1	6	44,928	0.34	7.57E-06
93RECOV1.WK1	6	35,975	2.57	7.14E-05
93RECOV2.WK1	1	2,320	3.93	1.69E-03
93STFXYL.WK1	9	78,840	3.63	4.60E-05
93CYHEX.WK1 •	0	0	0.00	N/A
93DMS.WK1 •	0	0	0.00	N/A
ERCSR1.WK1 •	0	0	0.00	N/A
ERCSR3.WK1 •	0	0	0.00	N/A
ERCSR5.WK1 •	0	0	0.00	N/A
TOTALS:	90	484,653	41.05	8.47E-05

1994

REFERENCE FILE	TOTAL SAMPLING DEVICES	TOTAL SERVICE HOURS	TOTAL VOC EMISSIONS (LB/YR)	VOC EMISSIONS (LB/DEVICE/HR)
94ACRYL1.WK1	1	193	0.00	0.00E+00
94ACRYL2.WK1	4	772	0.01	9.13E-06
94MEOH1.WK1	1	9,260	0.01	1.34E-06
94MEOH2.WK1	5	37,899	3.44	9.07E-05
94MEOH2S.WK1	0	0	0.00	N/A
94MEOH3.WK1	3	32,500	3.24	9.97E-05
94MEOH3S.WK1	1	779	0.00	0.00E+00
94AMINO1.WK1	10	45,325	0.32	6.95E-06
94AMINO2.WK1	6	33,594	0.04	1.07E-06
94AMINO3.WK1	7	59,723	3.18	5.32E-05
94AMPRL1.WK1	3	25,833	0.02	9.57E-07
94AMPRL2.WK1	7	60,277	25.36	4.21E-04
94METHX1.WK1	9	32,026	0.29	9.04E-06
94METHX2.WK1	5	43,395	0.40	9.26E-06
94METHX3.WK1	6	17,363	1.51	8.69E-05
94METHX4.WK1	6	55,561	0.42	7.57E-06
94RECOV1.WK1	6	44,489	3.18	7.14E-05
94RECOV2.WK1	1	2,869	4.86	1.69E-03
94STFXYL.WK1	9	97,499	4.49	4.60E-05
94CYHEX.WK1 •	0	0	0.00	N/A
94DMS.WK1 •	0	0	0.00	N/A
ERCSR2.WK1 •	0	0	0.00	N/A
ERCSR4.WK1 •	0	0	0.00	N/A
ERCSR6.WK1 •	0	0	0.00	N/A
	90	599,356	50.76	8.47E-05

Average leak rate for sampling devices = (41.05 lb + 50.76 lb) / (484,653 hr + 599.356 hr) = 8.47E-05 lb/hr

Average annual total VOC emissions from sampling devices in 1993194 = (41.05 lb + 50.76 lb) 12 = 45.91 lb/year

• Components were not screened. The mean leak rate from screened components was applied to calculate emissions.

Merck & Co. Inc

Amprolium Process Fugitive Emissions

Pressure Relief Devices

1993

REFERENCE FILE	*TOTAL PRVs*	*TOTAL SERVICE HOURS*	*TOTAL VOC EMISSIONS (LB/YR)*	*VOC EMISSIONS (LB/PRV/HR)*
93ACRYL1.WK1	1	8,760	0.01	1.14E-06
93ACRYL2.WK1	0	0	0.00	N/A
93MEOH1.WK1	1	7,488	0.01	1.34E-06
93MEOH2.WK1	6	22,727	9.75	4.29E-04
93MEOH2S.WK1	4	10,796	150.00	1.39E-02
93MEOH3.WK1	3	26,280	14.48	5.51E-04
93MEOH3S.WK1	2	1,260	0.84	6.67E-04
93AMINO1.WK1	8	24,578	168.64	6.86E-03
93AMINO2.WK1	10	50,450	115.96	2.30E-03
93AMINO3.WK1	10	68,990	8.64	1.25E-04
93AMPRL1.WK1	7	48,741	4.64	9.52E-05
93AMPRL2.WK1	5	34,153	0.06	1.76E-06
93METHX1.WK1	3	22,464	0.03	1.34E-06
93METHX2.WK1	8	48,893	7.46	1.53E-04
93METHX3.WK1	6	16,536	0.01	6.05E-07
93METHX4.WK1	4	29,952	30.58	1.02E-03
93RECOV1.WK1	5	34,815	3.37	9.68E-05
93RECOV2.WK1	0	0	0.00	N/A
93STFXYL.WK1	10	87,600	42.05	4.80E-04
93CYHEX.WK1 •	12	11,320	11.55	1.02E-03
93DMS.WK1 •	0	0	0.00	N/A
ERCSR1.WK1 •	13	49,583	50.57	1.02E-03
ERCSR3.WK1 •	13	17,940	18.30	1.02E-03
ERCSR5.WK1 •	6	17,700	18.05	1.02E-03
TOTALS:	137	641,026	655.00	1.02E-03

1994

REFERENCE FILE	*TOTAL PRVS*	*TOTAL SERVICE HOURS*	*TOTAL VOC EMISSIONS (LB/YR)*	*VOC EMISSIONS (LB/PRV/HR)*
94ACRYL1.WK1	1	8,760	0.01	1.14E-06
94ACRYL2.WK1	0	0	0.00	N/A
94MEOH1.WK1	1	8,760	0.01	1.34E-06
94MEOH2.WK1	6	28,106	12.06	4.29E-04
94MEOH2S.WK1	4	13,351	185.50	1.39E-02
94MEOH3.WK1	3	26,280	14.48	5.51E-04
94MEOH3S.WK1	2	1,558	1.04	6.67E-04
94AMINO1.WK1	8	30,395	208.55	6.86E-03
94AMINO2.WK1	10	62,390	143.40	2.30E-03
94AMINO3.WK1	10	85,318	10.68	1.25E-04
94AMPRL1.WK1	7	60,277	5.74	9.52E-05
94AMPRL2.WK1	5	42,236	0.07	1.76E-06
94METHX1.WK1	3	26,280	0.04	1.34E-06
94METHX2.WK1	8	60,465	9.23	1.53E-04
94METHX3.WK1	6	20,450	0.01	6.05E-07
94METHX4.WK1	4	35,040	35.77	1.02E-03
94RECOV1.WK1	5	43,055	4.17	9.68E-05
94RECOV2.WK1	0	0	0.00	N/A
94STFXYL.WK1	10	87,600	42.05	4.80E-04
94CYHEX.WK1 •	12	13,999	14.70	1.05E-03
94DMS.WK1 •	0	0	0.00	N/A
ERCSR2.WK1 •	13	56,667	59.50	1.05E-03
ERCSR4.WK1 •	13	13,008	13.66	1.05E-03
ERCSR6.WK1 •	6	8,010	8.41	1.05E-03
	137	732,003	769.09	1.05E-03

Average leak rate for PRVs = (655.00 lb + 769.09 lb) / (641,026 hr + 723,003 hr) = 1.04E-03 lb/hr

Average annual VOC emissions from PRVs in 1993/94 = (655.00 lb + 769.09 lb) / 2 = 712.05 lb/yr

'Components were not screened. The mean leak rate from screened components was applied to determine emissions.

Merck & Co. Inc

Amprolium Process Fugitive Emissions

Pumps

1993					1994				
REFERENCE FILE	*TOTAL PUMPS*	*TOTAL SERVICE HOURS*	*TOTAL VOC EMISSIONS (LB/YR)*	*VOC EMISSIONS (LB/PUMP/HR)*	*REFERENCE FILE*	*TOTAL PUMPS*	*TOTAL SERVICE HOURS*	*TOTAL VOC EMISSIONS (LB/YR)*	*VOC EMISSIONS (LB/PUMP/HR)*
93ACRYL1.WK1	1	7,446	0.00	0.00E+00	94ACRYL1.WK1	1	8,760	0.00	0.00E+00
93ACRYL2.WK1	0	0	0.00	N/A	94ACRYL2.WK1	0	0	N/A	#VALUE!
93MEOH1.WK1	2	14,976	19.64	1.31E-03	94MEOH1.WK1	2	17,520	22.98	1.31E-03
93MEOH2.WK1	8	44,339	670.44	1.51E-02	94MEOH2.WK1	8	54,833	829.11	1.51E-02
93MEOH2S.WK1	0	0	0.00	N/A	94MEOH2S.WK1	0	0	N/A	#VALUE!
93MEOH3.WK1	2	17,520	2785.00	1.59E-01	94MEOH3.WK1	2	17,520	2785.00	1.59E-01
93MEOH3S.WK1	7	15,927	891.87	5.60E-02	94MEOH3S.WK1	7	19,696	1102.95	5.60E-02
93AMINO1.WK1	5	19,188	28.49	1.48E-03	94AMINO1.WK1	5	23,729	35.23	1.48E-03
93AMINO2.WK1	6	25,010	1.89	7.56E-05	94AMINO2.WK1	6	30,929	2.34	7.56E-05
93AMINO3.WK1	6	41,394	142.91	3.45E-03	94AMINO3.WK1	6	51,191	176.73	3.45E-03
93AMPRL1.WK1	3	20,889	26.09	1.25E-03	94AMPRL1.WK1	3	25,833	32.26	1.25E-03
93AMPRL2.WK1	10	68,306	1363.11	2.00E-02	94AMPRL2.WK1	10	84,472	1685.72	2.00E-02
93METHX1.WK1	2	7,956	10.94	1.38E-03	94METHX1.WK1	2	9,839	13.53	1.38E-03
93METHX2.WK1	5	29,413	95.99	3.26E-03	94METHX2.WK1	5	36,374	118.71	3.26E-03
93METHX3.WK1	7	28,704	5.25	1.83E-04	94METHX3.WK1	7	35,497	6.49	1.83E-04
93METHX4.WK1	8	45,072	159.19	3.53E-03	94METHX4.WK1	8	55,739	196.87	3.53E-03
93RECOV1.WK1	4	22,049	11.92	5.41E-04	94RECOV1.WK1	4	27,267	14.74	5.41E-04
93RECOV2.WK1	4	18,566	934.83	5.04E-02	94RECOV2.WK1	4	22,960	1156.08	5.04E-02
93STFXYL.WK1	9	78,840	731.19	9.27E-03	94STFXYL.WK1	9	78,840	731.19	9.27E-03
93CYHEX.WK1 *	9	8,490	132.44	1.56E-02	94CYHEX.WK1 *	9	10,499	155.39	1.48E-02
93DMS.WK1 *	2	20	0.31	1.56E-02	94DMS.WK1 *	2	25	0.37	1.48E-02
ERCSR1.WK1 *	9	34,327	535.50	1.56E-02	ERCSR2.WK1 *	9	39,474	584.22	1.48E-02
ERCSR3.WK1 *	11	15,348	239.43	1.56E-02	ERCSR4.WK1 *	11	10,800	159.84	1.48E-02
ERCSR5.WK1 *	6	17,700	276.12	1.56E-02	ERCSR6.WK1 *	6	8,010	118.55	1.48E-02
TOTALS:	126	581,480	9062.56	1.56E-02		126	669,808	9928.28	1.48E-02

Average leak rate for pumps = (9062.56 lb + 9928.28 lb) / (581,480 hr + 669,808 hr) = 1.51E-02 lb/hr

Average annual total VOC emissions from pumps in 1993/94 = (9062.56 lb + 9928.28 lb) / 2 = 9495.42 lb/year

* Components were not screened. The mean leak rate from screened components was applied to calculate emissions.

Merck & Co. Inc

Amprolium Process Fugitive Emissions

Open Lines

1993					1994				
REFERENCE FILE	*TOTAL LINES*	*TOTAL SERVICE HOURS*	*TOTAL VOC EMISSIONS (LB/YR)*	*VOC EMISSIONS (LB/LINE/HR)*	*REFERENCE FILE*	*TOTAL LINES*	*TOTAL SERVICE HOURS*	*TOTAL VOC EMISSIONS (LB/YR)*	*VOC EMISSIONS (LB/LINE/HR)*
93ACRYL1.WK1	3	17,765	58.76	3.31E-03	94ACRYL1.WK1	3	21,969	72.67	3.31E-03
93ACRYL2.WK1	0	0	0.00	N/A	94ACRYL2.WK1	0	0	N/A	N/A
93MEOH1.WK1	2	9,228	30.51	3.31E-03	94MEOH1.WK1	2	11,412	37.73	3.31E-03
93MEOH2.WK1	7	47,736	157.86	3.31E-03	94MEOH2.WK1	7	59,034	195.22	3.31E-03
93MEOH2S.WK1	20	48,582	160.89	N/A	94MEOH2S.WK1	20	60,080	N/A	N/A
93MEOH3.WK1	4	35,040	115.87	3.31E-03	94MEOH3.WK1	4	35,040	115.87	3.31E-03
93MEOH3S.WK1	58	109,163	474.45	4.35E-03	94MEOH3S.WK1	58	134,999	586.74	4.35E-03
93AMINO1.WK1	14	40,241	114.33	2.84E-03	94AMINO1.WK1	14	49,765	141.39	2.84E-03
93AMINO2.WK1	7	29,321	89.83	3.06E-03	94AMINO2.WK1	7	36,260	111.09	3.06E-03
93AMINO3.WK1	2	13,798	45.62	3.31E-03	94AMINO3.WK1	2	17,064	56.42	3.31E-03
93AMPRL1.WK1	6	41,778	138.16	3.31E-03	94AMPRL1.WK1	6	51,666	170.86	3.31E-03
93AMPRL2.WK1	15	102,459	341.75	3.34E-03	94AMPRL2.WK1	15	126,708	422.63	3.34E-03
93METHX1.WK1	5	5,148	17.16	3.33E-03	94METHX1.WK1	5	6,366	21.22	3.33E-03
93METHX2.WK1	3	14,046	46.45	3.31E-03	94METHX2.WK1	3	17,370	57.44	3.31E-03
93METHX3.WK1	14	59,904	208.00	3.47E-03	94METHX3.WK1	14	74,081	257.23	3.47E-03
93METHX4.WK1	6	44,928	148.56	3.31E-03	94METHX4.WK1	6	52,560	173.80	3.31E-03
93RECOV1.WK1	28	160,146	690.00	4.31E-03	94RECOV1.WK1	28	198,048	853.30	4.31E-03
93RECOV2.WK1	8	37,132	122.79	3.31E-03	94RECOV2.WK1	8	45,920	151.85	3.31E-03
93STFXYL.WK1	13	113,880	376.59	3.31E-03	94STFXYL.WK1	13	113,880	376.59	3.31E-03
93CYHEX.WK1 *	0	0	0.00	N/A	94CYHEX.WK1 *	0	0	0.00	N/A
93DMS.WK1 *	6	8,956	32.15	3.59E-03	94DMS.WK1 *	6	11,076	37.88	3.42E-03
ERCSR1.WK1 *	0	0	0.00	N/A	ERCSR2.WK1 *	0	0	0.00	N/A
ERCSR3.WK1 *	111	164,058	588.97	3.59E-03	ERCSR4.WK1 *	111	97,680	334.07	3.42E-03
ERCSR5.WK1 *	111	327,450	1175.55	3.59E-03	ERCSR6.WK1 *	111	148,185	506.79	3.42E-03
TOTALS:	4431	1,430,759	5134.251	3.59E-03		4431	1,369,163	4680.78	3.42E-03

Average leak rate for open lines = (5134.25 lb + 4680.78 lb) / (1,430,759 hr + 1,369,163 hr) = 3.51E-03 lb/hr

Average annual total VOC emissions from open lines in 1993194 = (5134.25 lb + 4680.78 lb) / 2 = 4907.52 lb/year

* Components were not screened. The mean leak rate from screened components was applied to calculate emissions.

Merck & Co. Inc

Amprolium Process Fugitive Emissions

Flanges

1993

REFERENCE FILE	TOTAL FLANGES	TOTAL SERVICE HOURS	TOTAL VOC EMISSIONS (LB/YR)	VOC EMISSIONS (LB/FLANGE/HR)
93ACRYL1.WK1	133	599,140	8.42	1.41E-05
93ACRYL2.WK1	110	13,572	3.45	2.54E-04
93MEOH1.WK1	239	1,620,154	538.21	3.32E-04
93MEOH2.WK1	297	1,644,965	414.82	2.52E-04
93MEOH2S.WK1	292	772,732	809.03	1.05E-03
93MEOH3.WK1	61	534,360	130.51	2.44E-04
93MEOH3S.WK1	265	525,919	888.45	1.69E-03
93AMINO1.WK1	246	681,918	144.70	2.12E-04
93AMINO2.WK1	309	1,416,496	137.92	9.74E-05
93AMINO3.WK1	269	1,855,831	360.54	1.94E-04
93AMPRL1.WK1	348	2,374,383	72.35	3.05E-05
93AMPRL2.WK1	382	2,582,743	191.03	7.40E-05
93METHX1.WK1	331	1,126,466	84.67	7.52E-05
93METHX2.WK1	360	2,304,881	613.31	2.66E-04
93METHX3.WK1	298	848,015	34.86	4.11E-05
93METHX4.WK1	215	1,153,968	472.28	4.09E-04
93RECOV1.WK1	410	2,280,303	1148.33	5.04E-04
93RECOV2.WK1	94	431,658	87.51	2.03E-04
93STFXYL.WK1	305	2,663,040	219.09	8.23E-05
93CYHEX.WK1 *	621	585,810	146.45	2.50E-04
93DMS.WK1 *	192	215,238	53.81	2.50E-04
ERCSR1.WK1 *	699	2,666,055	666.51	2.50E-04
ERCSR3.WK1 *	792	1,160,688	290.17	2.50E-04
ERCSR5.WK1 *	636	1,876,200	469.05	2.50E-04
TOTALS:	7904	31,934,535	7985.48	2.50E-04

1994

REFERENCE FILE	TOTAL FLANGES	TOTAL SERVICE HOURS	TOTAL VOC EMISSIONS (LB/YR)	VOC EMISSIONS (LB/FLANGE/HR)
94ACRYL1.WK1	133	740,938	10.41	1.41E-05
94ACRYL2.WK1	110	16,784	4.27	N/A
94MEOH1.WK1	239	2,003,596	665.59	3.32E-04
94MEOH2.WK1	297	2,034,279	513.00	2.52E-04
94MEOH2S.WK1	292	955,614	1000.50	N/A
94MEOH3.WK1	61	660,827	161.40	2.44E-04
94MEOH3S.WK1	265	650,388	1098.72	1.69E-03
94AMINO1.WK1	246	843,308	178.95	2.12E-04
94AMINO2.WK1	309	1,751,738	170.56	9.74E-05
94AMINO3.WK1	269	2,295,051	445.87	1.94E-04
94AMPRL1.WK1	348	2,936,328	89.47	3.05E-05
94AMPRL2.WK1	382	3,194,001	236.24	7.40E-05
94METHX1.WK1	331	1,393,067	104.71	7.52E-05
94METHX2.WK1	360	2,850,377	758.46	2.66E-04
94METHX3.WK1	298	1,048,715	43.11	4.11E-05
94METHX4.WK1	215	1,427,078	584.05	4.09E-04
94RECOV1.WK1	410	2,819,982	1420.11	5.04E-04
94RECOV2.WK1	94	533,818	108.22	2.03E-04
94STFXYL.WK1	305	3,293,302	270.94	8.23E-05
94CYHEX.WK1 *	621	724,454	181.11	2.50E-04
94DMS.WK1 *	192	266,178	66.54	2.50E-04
ERCSR2.WK1 *	699	3,065,814	766.45	2.50E-04
ERCSR4.WK1 *	792	969,264	242.32	2.50E-04
ERCSR6.WK1 *	636	849,060	212.27	2.50E-04
	7904	37,323,961	9333.27	2.50E-04

Average leak rate for flanges = (7985.48 lb + 9333.27 lb) / (31,934,535 hr + 37,323,961 hr) = 2.50E-04 lb/hr

Average annual total VOC emissions from flanges in 1993/94 = (7985.48 lb + 9333.27 lb) / 2 = 8659.38 lb/year

#VALUE!

* Components were not screened. The mean leak rate from screened components was applied to calculate emissions.

Merck & Co. Inc

Amprolium Process Fugitive Emissions

Agitator Seals

1993

REFERENCE FILE	TOTAL AGITATOR SEALS	TOTAL SERVICE HOURS	TOTAL VOC EMISSIONS (LB/YR)	VOC EMISSIONS (LB/SEAL/HR)
93ACRYL1.WK1	1	156	0.00	0.00E+00
93ACRYL2.WK1	6	624	0.02	2.71E-05
93MEOH1.WK1	3	22,464	94.39	4.20E-03
93MEOH2.WK1	2	12,168	1.80	1.48E-04
93MEOH2S.WK1	0	0	0.00	N/A
93MEOH3.WK1	0	0	0.00	N/A
93MEOH3S.WK1	0	0	0.00	N/A
93AMINO1.WK1	0	0	0.00	N/A
93AMINO2.WK1	0	0	0.00	N/A
93AMINO3.WK1	0	0	0.00	N/A
93AMPRL1.WK1	0	0	0.00	N/A
93AMPRL2.WK1	0	0	0.00	N/A
93METHX1.WK1	7	17,785	1.31	7.37E-05
93METHX2.WK1	4	26,869	50.20	1.87E-03
93METHX3.WK1	2	10,296	0.00	0.00E+00
93METHX4.WK1	0	0	0.00	N/A
93RECOV1.WK1	0	0	0.00	N/A
93RECOV2.WK1	0	0	0.00	N/A
93STFXYL.WK1	1	8,760	0.01	1.14E-06
93CYHEX.WK1 *	0	0	0.00	N/A
93DMS.WK1 *	0	0	0.00	N/A
ERCSR1.WK1 *	0	0	0.00	N/A
ERCSR3.WK1 *	0	0	0.00	N/A
ERCSR5.WK1 *	0	0	0.00	N/A
TOTALS:	26	99,122	147.73	1.49E-03

1994

REFERENCE FILE	TOTAL AGITATOR SEALS	TOTAL SERVICE HOURS	TOTAL VOC EMISSIONS (LB/YR)	VOC EMISSIONS (LB/SEAL/HR)
94ACRYL1.WK1	1	193	0.00	0.00E+00
94ACRYL2.WK1	6	772	0.02	2.71E-05
94MEOH1.WK1	3	26,280	116.73	4.44E-03
94MEOH2.WK1	2	15,048	2.23	1.48E-04
94MEOH2S.WK1	0	0	0.00	N/A
94MEOH3.WK1	0	0	0.00	N/A
94MEOH3S.WK1	0	0	0.00	N/A
94AMINO1.WK1	0	0	0.00	N/A
94AMINO2.WK1	0	0	0.00	N/A
94AMINO3.WK1	0	0	0.00	N/A
94AMPRL1.WK1	0	0	0.00	N/A
94AMPRL2.WK1	0	0	0.00	N/A
94METHX1.WK1	7	21,994	1.62	7.37E-05
94METHX2.WK1	4	33,228	62.08	1.87E-03
94METHX3.WK1	2	12,733	0.00	0.00E+00
94METHX4.WK1	0	0	0.00	N/A
94RECOV1.WK1	0	0	0.00	N/A
94RECOV2.WK1	0	0	0.00	N/A
94STFXYL.WK1	1	8,760	0.01	1.41E-06
94CYHEX.WK1 *	0	0	0.00	N/A
94DMS.WK1 *	0	0	0.00	N/A
ERCSR2.WK1 *	0	0	0.00	N/A
ERCSR4.WK1 *	0	0	0.00	N/A
ERCSR6.WK1 *	0	0	0.00	N/A
	26	119,007	182.69	1.54E-03

Average leak rate for agitator seals = (147.73 lb + 182.69 lb) / (99,122 hr + 119.007 hr) = 1.51E-03 lb/hr

Average annual total VOC emissions from agitator seals in 1993194 = (147.73 lb + 182.69lb) / 2 = 165.21 lb/year

* Components were not screened. The mean leak rate from screened components was applied to calculate emissions.

ATTACHMENT IX

MERCK WASTEWATER AIR EMISSIONS MODEL

DESCRIPTION AND BACKGROUND

Description of the Model

The Clean Air Act specifically targets control of emissions from wastewater. Merck has begun to customize a model which was developed to quantify air emissions from a wastewater treatment plant. This model determines the fate of volatile organic compounds introduced into the wastewater treatment plant by calculating the amount of material which sorbs onto the solids, biodegrades, is emitted into the atmosphere or is passed-through the plant.

Available Emission Models for Wastewater Treatment

SARA

When the SARA program was initiated, EPA provided guidance on estimating SARA emissions from wastewater in "Estimating Releases and Waste Treatment Efficiencies for the Toxic Chemical Release Inventory Form" (EPA/560-4-88-002, December 1987). This guidance has been used by Merck to quantify air emissions from wastewater. The information in the table was extracted from the 1986 "Report to Congress on the Discharge of Hazardous Waste to Publicly Owned Treatment Works" (EPA/530-SW-86-004) and as such was never intended to be used as a predictive tool to estimate emissions. The guidance applies only to compounds in the influent at less than 500 ppb and estimates zero emissions for most non-chlorinated compounds in wastewater.

Significant study has been done on emissions from wastewater treatment plants since 1987. EPA has been moving ahead to regulate emissions from wastewater collection and treatment systems. The Hazardous Organic NESHAPS (HON) rule for the Synthetic Organic Chemical Manufacturing Industry (SOCMI) codifies EPA's expectation that industry quantify and control emissions from wastewater. These regulations do not apply to the pharmaceutical industry but they are a model for what may be proposed next year in the Pharmaceutical Effluent Guidelines. Because our plants will be required to quantify and control secondary emissions in the near future, we need to begin now to develop the tools to understand and control secondary emissions.

EPA's Water7 Model

Water 7 is an EPA model which was originally used for estimating emissions from Hazardous Waste Treatment Storage and Disposal Facilities. Water 7 was used by EPA during development of the Hazardous Organic NESHAP (HON) to predict air emissions from wastewater treatment plants. EPA has stated that this model is adequate for their uses in evaluating nationwide trends for air emissions. Numerous limitations and incorrect technical features of the model have been recognized by regulated industries including the Chemical Manufacturing Association (CMA). These include technical flaws in the mathematical models of liquid mass transfer, biodegradation rates, trickling filters, clarifiers, mechanical aeration and diffused aeration.

Other Models

There are several additional models available to predict secondary emissions from wastewater treatment plants. Most of the models are limited in flexibility, type of treatment units and compounds included. The NOCEPM model includes activated sludge and aerated lagoons only in the pulp and paper industry; the PAVE model, developed by a member of CMA, models only completely mixed activated sludge and does not account for sorption nor variation in the mixed liquor suspended solids concentration; SIMS is based on Water 7 and does not account for sorption.

TOXCHEM was developed by Enviromega, Ltd. to provide a comprehensive computer based fate and transport model using the latest scientific information. Through pilot plant and full scale plant studies with municipal and industrial wastewater, the model has grown to be the most complete and representative of the fate models. This model allows calculation of existing treatment plant emissions, biodegradation, sorption and pass-through of organics and metals as well as the ability to evaluate the benefit of emission suppression or process changes. Comprehensive testing programs have been carried out by Enviromega to estimate VOC emissions from treatment processes including equalization basins, aerated tanks and dissolved air floatation units at petrochemical plants in Texas, West Virginia and Ontario. This experience with VOC emissions testing has been accessed by the Chemical Manufacturers Association (CMA) to critically review wastewater treatment provisions proposed by EPA under the Clean Air Act Amendments. CMA also retained Enviromega to estimate VOC emissions from floor drains in a pilot wastewater collection system, and to measure the ventilation rate and emissions from a collection system at Dupont in Tennessee. TOXCHEM has been approved by EPA as an alternative to Water 7 in the SOCMI HON (59 FR 19606).

Merck Model

Merck's model is a user friendly version of TOXCHEM that allows the user flexibility to model any treatment train. The model has a mass balance approach which addresses sorption, biodegradation, air emissions and pass-through. The consultant specifically developed the cooling tower model for Merck but all other pieces of the model have been used and validated over the past six years. Our version incorporates the basic equations of TOXCHEM (attached) with adjustments for Merck specific parameters such as the organic compounds and treatment processes at our plants. The model requires information on the physical dimensions of the treatment units, the influent concentrations and other equipment specifications such as ventilation rates, oxygen transfer and horsepower requirements. Parameters can be adjusted for site specific data such as biodegradation rate, octanol water partitioning coefficients, etc. Merck's model is a scientifically accepted and peer reviewed mathematical representation of the fate of organic compounds in a wastewater treatment plant. Pilot testing and testing at full scale treatment plants show that the equations in the model closely represent actual emissions.

Predictive Models

Predictive models are an increasingly important tool to understand the impact of environmental releases and develop cost effective compliance strategies. Frequently, model outputs are estimates, however, the value of a model must be weighed against the alternative for obtaining the desired information. Models offer a relatively inexpensive method of making first estimates of emissions and can direct the allocation of scarce funding to the most critical areas. In the case of secondary emissions, actual measurement of losses from a wastewater treatment plant is difficult and extremely expensive. Reliable estimates of the fate of contaminants through field measurements would require: a large number of liquid and gas phase samples to be taken at intervals which are substantially shorter than the duration of the batch wastewater discharge, accurate measurements of all process flows, personnel trained in proper collection of the samples, correct sample equipment and accurate laboratory analysis

Characterization of wastewater streams at all Merck facilities under all possible operating conditions by direct monitoring is not possible. Therefore, use of a predictive model is appropriate.

Attachment

Wastewater Air Emissions Model Background
Calculations Used to Calculate Fate and Mass Transfer

Type of VOC Removal	Empirical	Comments
Surface Volatilization - partitioning between dissolved and gaseous phases - temperature adjustment	Henry's Law $K_H = \frac{Cg}{Cw}$ VAN't Hoff Relationship $1.044^{(t-20)}$	K_H - varies for wastewater vs. clean water
- rate of mass transfer (same as HON)	Overall Mass Transfer Coefficient (Resistance) $\frac{1}{K_L} = \frac{1}{k_L} + \frac{1}{k_g K_H}$ Mass Transfer Flux $F = K_L\left(C_L - \frac{C_g}{K_H}\right)$	k_l = liquid phase transfer coefficient k_g = gas phase transfer coefficient early models assumed k_g was negligible but its been shown that k_g can be high for aerated systems or covered treatment. C_g is still assumed to be zero for open processes.
	Rate of Mass Transfer (two film theory) $\frac{-dM}{dt} = K_L A\left(C_L - \frac{C_g}{K_H}\right)$ Need K_L for each compound Mackay and Yeun: $k_g = 0.001 + 46.2 \times 10^{-3} U^* Sc_G{}^{-0.67}$ $k_L = 1 \times 10^{-6} + 24.1 \times 10^{-4} U^* Sc_L (U^* > 0.3)$ $k_L = 1 \times 10^{-6} + 144 \times 10^{-4} U^{*2.2} Sc_L{}^{-0.5} (U^* < 0.3)$	A = area across which mass transfer occurs U^* = air side friction velocity (m/s) $= 10^{-2}(6.1 + 0.63U_{10})^{0.5} U_{10}$ U_{10} = wind 10 m above liquid (m/s) Sc_G = gas phase Schmidt # = viscosity/(density*diffusivity) Sc_L = liquid phase Schmidt #

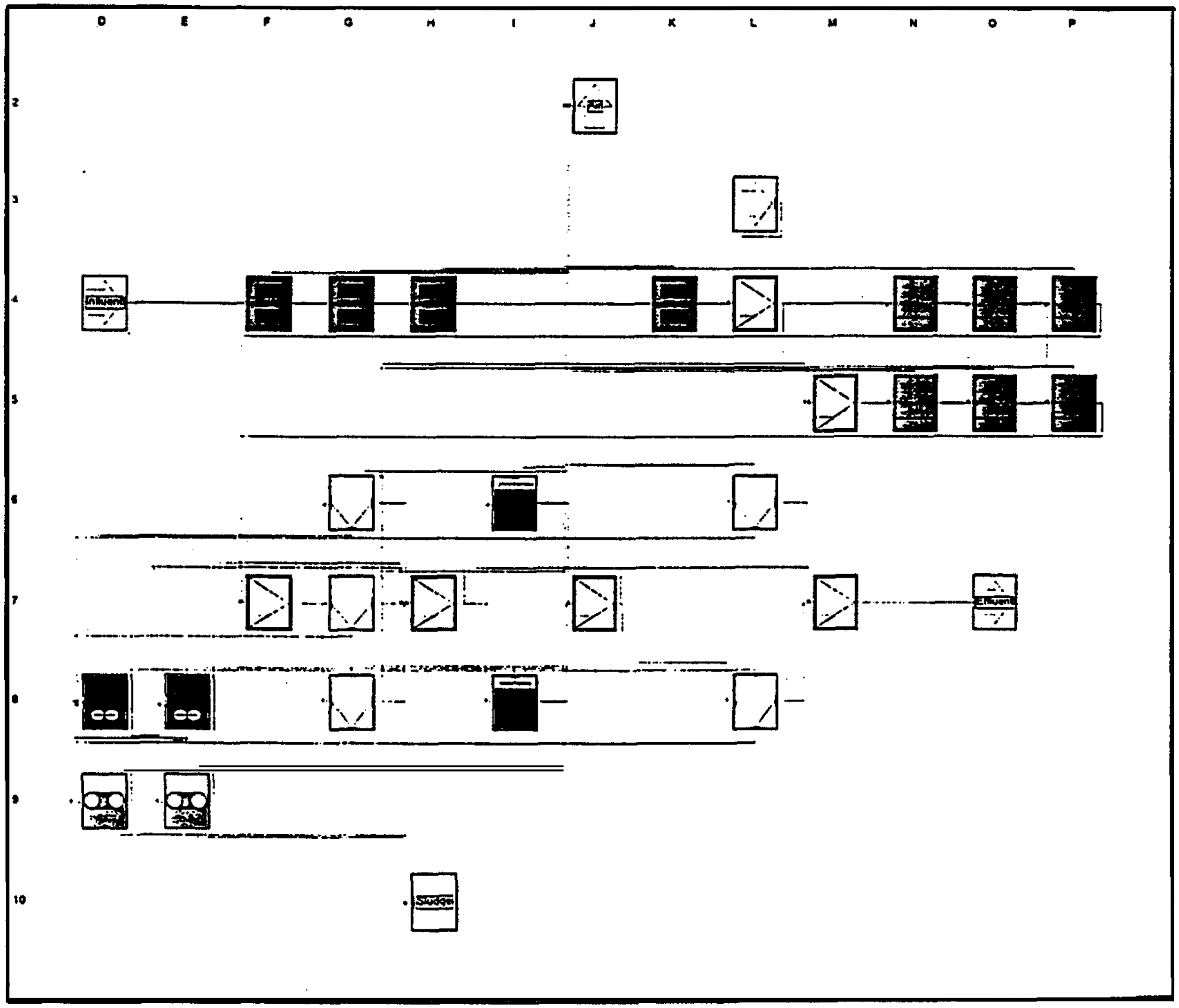
Mechanical Aeration	Aerator O_2 Mass Transfer Rating: N_o(kgO_2/KW·hr) under STD. conditions (c=o, T=20°C, clean water) $K_L a = \frac{PNo}{C_s V}$ Needs to be corrected for dirty/clean water ratio (Metcalf and Eddy) $k_L = K_L^{oxygen}\left(\frac{D_c}{D_{oxy}}\right)^n$ $n = 0.5$ *to* 1 *Experiments say* $\frac{k_g}{k_L} = 20$ *to* $40 = R$ *so* $K_L a = \frac{RK_H k_L a}{(RK_H + 1)}$ = *Mass Transfer For Mechanical Aeration*	-A is dependent on aerator type -K_L is highly dependent on aerator P = Aerator HP, in KW C_s = Conc of O_2 in water at saturation, kg/m^3 V = Tank volume, m^3 O_2 has high K_H so liquid phase mass transfer limited D_c = diffusivity of compound of interest D_{oxy} = diffusivity of oxygen
Diffused Aeration	Completely saturated bubbles (low K_H, fine bubble) Rate of stripping: $\frac{dm}{dt} = Q_g K_H C$ Incomplete Saturation: $\frac{dm}{dt} = Q_g K_H\left[1-\exp\left(\frac{-VK_L a}{K_H Q_g}\right)\right]C$ $K_L a_{oxy} = \frac{Q_g d_{oxy}(OTE)Y_{oxy}}{C^*_{oxy} - C_{oxy}}$ $\frac{k_g}{k_l} = 20$ *to* $40 = R$ $n = 0.5$ *to* 1 $K_{La} = K_{La\,oxy}\left(\frac{D_c}{D_{oxy}}\right)^n\left(\frac{RK_H}{RK_H + 1}\right)$	Q_g = aeration rate as $K_H Q_g$ becomes small the bracket approaches unity showing the saturation assumption to be true d_{oxy} = density of oxygen at mid-depth Y_{oxy} = mol fraction of oxygen in air C^*_{oxy} = equilibrium concentration of oxygen in water at mid-depth C_{oxy} = concentration of oxygen in water at mid-depth OTE = Oxygen Transfer Efficiency

Drop Structures	Pincince determine: Primary Clarifier $\ln r_o - 0.042 Z^{0.872} q^{0.509}$ Secondary Clarifier: $\ln r_o - 0.077 Z^{0.623} q^{0.66}$ $r_o = \frac{C_s - C_u}{C_s - C_d}$ for plug flow: $\ln r_v = \ln r_o \left(\frac{K_{Lv}}{K_{Lo}} \right)$ $\frac{K_{L_v}}{K_{L_o}} = \left(\frac{D_v}{D_{O_2}} \right)^n \left(\frac{RK_H}{RK_H + 1} \right)$	Drops provide a variety of mechanisms for mass transfer Z = distance of fall q = flow rate per length of weir C_s = saturation O_2 concentration C_u = upstream O_2 concentration C_d = downstream O_2 concentration $r_v = C_1/C_2$ C_1, C_2 = upstream and downstream VOC concentration Mass flow volatilized from the drop is equal to product of flow over the drop and the change in concentration across the weir.
Biodegradation	Monod equation r = rate of compound disappearance S = concentration of compound X_a = active microbial cell mass K_s = saturation coefficient μm = maximum microbial growth rate y = cell yield coefficient (g, cells/g substitute) k = first order biodegradation rate constant or $\frac{\mu m}{(yK_s)}$ $r = \mu m\, SX_a/\{Y(K_s+S)\} = \mu m SX_a/(YK_s) = KSX_a$	- Biodegradation rate coefficients can vary by 3 orders of magnitude. Some researchers have used a structure-activity relationship to estimate biodegradation rate - difficult to interpret the active cell concentration, Xa Some models use total or fraction of VSS. Others use a large fraction of total biomass that would degrade VOCs by secondary utilization. - ToxChem includes anaerobic biodegradation

Sorption	Linear isotherms describe sorption equilibrium by first order rate of removal Kp-sorption partition coefficient can be estimated from octonal-water partion coefficients using Dobbs formula. Dobbs Correlation $\text{Log Kp} = 0.58 \text{ Log Kow} + 1.14$	• not a major removal mechanism for VOCs • Properties of primary secondary or digested sludge are not different in sorption of VOCs. • Macroscopic properties should be the same for industrial (unless filamentous sludge).
Potential Calibrations		• Oxygen transfer rates • Biodegradation rate constants • Kow in our wastewater • Wind speed measurements

Example **ToxChem Model** of **WWT** Emissions

Stonewall



Process Influent[L3] - Sanitary Influent		
Wastewater flow rate	1.000e-01	MGD
suspended solids	100.00	
Volatile SS ratio	75.00	%
Oil/Grease concentration	0.000e+00	mg/L
Temperature	59.00	deg F

Process Influent[D4] - Influent		
Wastewater flow rate	1.20	MGD
Suspended solids	500.00	mg/L
Volatile SS ratio	80.00	%
Oil/Grease concentration	0.000e+00	mg/L
Temperature	80.60	deg F

Example ToxChem Model of WWT Emissions

Equalization[F4] - Equalization		
Depth	17.00	ft
Surface area	3848.00	sq ft
Covered	NO	
Ventilation rate	Not Applicable	

Equalization[G4] - Equalization		
Depth	51.00	ft
Surface area	2463.00	sq ft
Covered	NO	
Ventilation rate	Not Applicable	

Equalization[H4] - Equalization		
Depth	51.00	ft
Surface area	2463.00	sq ft
Covered	NO	
Ventilation rate	Not Applicable	

Equalization[K4] - Neutralization		
Depth	11.60	ft
Surface area	384.00	sq ft
Covered	NO	
Ventilation rate	Not Applicable	

Activated Sludge-Diffused Aeration[N4] - Activated Sludge		
Depth	29.50	ft
Surface area	3390.63	sq ft
Number of CSTRs	1	
MLSS	3000.00	mg/L
MLSS volatile SS ratio	90.00	%
Dissolved oxygen	4.00	mg/L
Air flow rate	5874.00	cfm
Oxygen transfer efficiency	14.00	%
Covered	NO	
Ventilation rate	Not Applicable	

Example ToxChem Model of WWT Emissions

Activated Sludge-Diffused Aeration[O4] - Activated Sludge		
Depth	29.50	ft
Surface area	3390.63	sq ft
Number of CSTRs	1	
MLSS	3000.00	mg/L
MLSS volatile SS ratio	90.00	%
Dissolved oxygen	4.00	mg/L
Air flow rate	2448.00	cfm
Oxygen transfer efficiency	14.00	%
Covered	NO	
Ventilation rate	Not Applicable	

Activated Sludge-Diffused Aeration[P4] - Activated Sludge		
Depth	29.50	ft
Surface area	3390.63	sq ft
Number of CSTRs	1	
MLSS	3000.00	mg/L
MLSS volatile SS ratio	90.00	%
Dissolved oxygen	4.00	mg/L
Air flow rate	1471.00	cfm
Oxygen transfer efficiency	14.00	%
Covered	NO	
Ventilation rate	Not Applicable	

Activated Sludge-Diffused Aeration[N5] - Activated Sludge		
Depth	29.50	ft
Surface area	3390.63	sq ft
Number of CSTRs	1	
MLSS	3000.00	mg/L
MLSS volatile SS ratio	90.00	%
Dissolved oxygen	4.00	mg/L
Air flow rate	5874.00	cfm
Oxygen transfer efficiency	14.00	%
Covered	NO	
Ventilation rate	Not Applicable	

Activated Sludge-Diffused Aeration[O5] - Activated Sludge		
Depth	29.50	ft
Surface area	3390.63	sq ft
Number of CSTRs	1	
MLSS	3000.00	mg/L
MLSS volatile SS ratio	90.00	%
Dissolved oxygen	4.00	mg/L
Air flow rate	2448.00	cfm
Oxygen transfer efficiency	14.00	%
Covered	NO	
Ventilation rate	Not Applicable	

Example ToxChem Model of WWT Emissions

Activated Sludge-Diffused Aeration[P5] - Activated Sludge		
Depth	29.50	ft
Surface area	3390.63	sq ft
Number of CSTRs	1	
MLSS	3000.00	mg/L
MLSS volatile SS ratio	90.00	%
Dissolved oxygen	4.00	mg/L
Air flow rate	1471.00	cfm
Oxygen transfer efficiency	14.00	%
Covered	NO	
Ventilation rate	Not Applicable	

Secondary Clarifier/-Sludge Thickener[G6] - Clariflocculator		
Depth	14.00	ft
Surface area	2376.00	sq ft
Weir length	172.90	ft
Waterfall height	5.000e-01	ft
Effluent SS concentration	175.00	mg/L
Sludge SS concentration	10000.00	mg/L
Covered	NO	
Ventilation rate	Not Applicable	

Trickling Filter[I6] - Trickling Filter		
Plan area of filter	18298.60	sq ft
Depth	4.00	ft
Media specific surface area	7.62	sq ft/cu ft
Air flow rate	1.000e-10	cfm
Biomass density	1.000e-10	lbs/cu ft
Kl for oxygen	1.000e-10	ft/d
Internal recycle flow rate	0.000e+00	%

Secondary Clarifier/-Sludge Thickener[L6] - Tertiary Clar.		
Depth	10.00	ft
Surface area	1257.00	sq ft
Weir length	126.00	ft
Waterfall height	5.000e-01	ft
Effluent SS concentration	100.00	mg/L
Sludge SS concentration	13000.00	mg/L
Covered	NO	
Ventilation rate	Not Applicable	

Example ToxChem Model of WWT Emissions

Secondary Clarifier/-Sludge Thickener[G7] - Clariflocculator		
Depth	14.00	ft
Surface area	2376.00	sq ft
Weir length	172.90	ft
Waterfall height	5.000e-01	ft
Effluent SS concentration	175.00	mg/L
Sludge SS concentration	10000.00	mg/L
Covered	NO	
Ventilation rate	Not Applicable	

Aerobic Digester[D8] - Aerobic Digester		
Depth	29.50	ft
Surface area	3390.00	sq ft
Number of CSTRs	1	
Volatile SS reduction	15.00	%
Dissolved oxygen	1.50	mg/L
Air flow rate	1000.00	cfm
Oxygen transfer efficiency	10.00	%
Total aerator power	10.00	hp
Standard oxygen transfer rate	2.50	lbO2/hp.hr
Dirty water/clean water correction	8.000e-01	
Covered	NO	
Ventilation rate	Not Applicable	

Aerobic Digester[E8] - Aerobic Digester		
Depth	11.00	ft
Surface area	2730.00	sq ft
Number of CSTRs	1	
Volatile SS reduction	15.00	%
Dissolved oxygen	1.50	mg/L
Air flow rate	1000.00	cfm
Oxygen transfer efficiency	10.00	%
Total aerator power	10.00	hp
Standard oxygen transfer rate	2.50	lbO2/hp.hr
Dirty water/clean water correction	8.000e-01	
Covered	NO	
Ventilation rate	Not Applicable	

Secondary Clarifier/-Sludge Thickener[G8] - Clariflocculator		
Depth	14.00	ft
Surface area	2376.00	sq ft
Weir length	172.90	ft
Waterfall height	5.000e-01	ft
Effluent SS concentration	175.00	mg/L
Sludge SS concentration	10000.00	mg/L
Covered	NO	
Ventilation rate	Not Applicable	

Example ToxChem Model of WWT Emissions

Trickling Filter[I8] - Trickling Filter		
Plan area of filter	18298.60	sq ft
Depth	4.00	ft
Media specific surface area	7.62	sq ft/cu ft
Air flow rate	1.000e-10	cfm
Biomass density	1.000e-10	lbs/cu ft
Kl for oxygen	1.000e-10	ft/d
Internal recycle flow rate	0.000e+00	%

Secondary Clarifier/-Sludge Thickener[L8] - Tertiary Clar.		
Depth	10.00	ft
Surface area	1257.00	sq ft
Weir length	126.00	ft
Waterfall height	5.000e-01	ft
Effluent SS concentration	100.00	mg/L
Sludge SS concentration	13000.00	mg/L
Covered	NO	
Ventilation rate	Not Applicable	

Belt Filter-Press[D9] - Belt Filter		
Final solids concentration	10.00	%
Filtrate/centrate SS concentration	1000.00	mg/L

Belt Filter-Press[E9] - Belt Filter		
Final solids concentration	10.00	%
Filtrate/centrate SS concentration	1000.00	mg/L

TETRAHYDROFURAN

Parameter	Value	Units	Reference
Molecular Weight	72.10	g/mol	6
Density	8.880e-01	g/cm3	13
H @ 25 deg C	1.960e-03	L gas/L liquid	1
log Kow	4.400e-01	L oil/L water	29
Kp	2.550e-02	L/mg	6
Aerobic Kb	8.000e-04	L/mg.hr	11
Anaerobic Kb	-1.000e+00	L/mg.hr	-1

Example ToxChem Model of WWT Emissions

Detailed Emission Summary for TETRAHYDROFURAN

Process Name	**Grid**	**Flow**	**Cl Eff.**	**% Emit**	**Mass Emit**
		MGD	ug/L	%	lbs/day
Sanitary Influent	[L3]	1.000e-01	0.000e+00		
Influent	[D4]	1.20	17110.00		
Equalization	[F4]	1.20	16992.28	6.880e-01	1.18
Equalization	[G4]	1.20	16917.26	4.385e-01	7.513e-01
Equalization	[H4]	1.20	16842.57	4.365e-01	7.480e-01
Neutralization	[K4]	1.20	16830.93	6.801e-02	1.165e-01
Activated Sludge	[N4]	1.01	213.98	1.338e-01	2.292e-01
Activated Sludge	[O4]	1.01	4.58	1.283e-03	2.199e-03
Activated Sludge	[P4]	1.01	9.825e-02	1.783e-05	3.055e-05
Activated Sludge	[N5]	1.01	213.98	1.338e-01	2.292e-01
Activated Sludge	[O5]	1.01	4.58	1.283e-03	2.199e-03
Activated Sludge	[P5]	1.01	9.825e-02	1.783e-05	3.055e-05
Clariflocculator	[G6]	6.730e-01	9.109e-02	2.808e-06	4.812e-06
Trickling Filter	[I6]	6.513e-01	5.031e-02	5.354e-19	9.174e-19
Tertiary Clar.	[L6]	6.513e-01	4.942e-02	1.222e-06	2.094e-06
Clariflocculator	[G7]	6.731e-01	9.109e-02	2.809e-06	4.812e-06
Aerobic Digester	[D8]	6.254e-01	5.742e-04	4.964e-07	8.505e-07
Aerobic Digester	[E8]	6.254e-01	1.129e-05	9.939e-09	1.703e-08
Clariflocculator	[G8]	6.730e-01	9.109e-02	2.808e-06	4.812e-06
Trickling Filter	[I8]	6.513e-01	5.031e-02	5.354e-19	9.174e-19
Tertiary Clar.	[L8]	6.513e-01	4.942e-02	1.222e-06	2.094e-06
Belt Filter	[D9]	3.127e-01	9.844e-06	4.300e-11	7.368e-11
Belt Filter	[E9]	3.127e-01	9.844e-06	4.300e-11	7.368e-11

Emission Summary for TETRAHYDROFURAN

	%	lbs/day
TOTAL Air Emissions	1.90	3.26
TOTAL Treated/Biodegraded	98.10	168.09
TOTAL Sludge Discharges	6.329e-09	1.085e-08
TOTAL Effluent Discharges	3.027e-04	5.186e-04

(*)METHANOL

Parameter	Value	Units	Reference
Molecular Weight	32.00	g/mol	0
Density	7.920e-01	g/cm3	-1
H @ 25 deg C	2.130e-04	L gas/L liquid	-1
log Kow	-6.600e-01	L oil/L water	-1
Kp	4.940e-03	L/mg	-1
Aerobic Kb	4.340e-02	L/mg.hr	-1
Anaerobic Kb	-1.000e+00	L/mg.hr	-1

Detailed Emission Summary for (*)METHANOL

Process Name	Grid	Flow	CI Eff.	% Emit	Mass Emit
		MGD	ug/L	%	lbs/day
Sanitary Influent	[L3]	1.000e-01	0.000e+00		
Influent	[D4]	1.20	1409370.00		
Equalization	[F4]	1.20	1405423.54	2.800e-01	39.52
Equalization	[G4]	1.20	1402902.06	1.789e-01	25.25
Equalization	[H4]	1.20	1400385.09	1.786e-01	25.21
Neutralization	[K4]	1.20	1399992.79	2.784e-02	3.93
Activated Sludge	[N4]	1.01	318.61	3.161e-04	4.461e-02
Activated Sludge	[O4]	1.01	1.220e-01	6.241e-08	8.809e-06
Activated Sludge	[P4]	1.01	4.672e-05	1.750e-11	2.470e-09
Activated Sludge	[N5]	1.01	318.61	3.161e-04	4.461e-02
Activated Sludge	[O5]	1.01	1.220e-01	6.241e-08	8.809e-06
Activated Sludge	[P5]	1.01	4.672e-05	1.750e-11	2.470e-09
Clariflocculator	[G6]	6.730e-01	4.592e-05	6.133e-12	8.656e-10
Trickling Filter	[I6]	6.513e-01	2.536e-05	3.595e-25	5.074e-23
Tertiary Clar.	[L6]	6.513e-01	2.525e-05	2.284e-12	3.224e-10
Clariflocculator	[G7]	6.731e-01	4.592e-05	6.133e-12	8.656e-10
Aerobic Digester	[D8]	6.254e-01	3.929e-09	7.077e-15	9.989e-13
Aerobic Digester	[E8]	6.254e-01	1.290e-12	2.295e-18	3.240e-16
Clariflocculator	[G8]	6.730e-01	4.592e-05	6.133e-12	8.656e-10
Trickling Filter	[I8]	6.513e-01	2.536e-05	3.595e-25	5.074e-23
Tertiary Clar.	[L8]	6.513e-01	2.525e-05	2.284e-12	3.224e-10
Belt Filter	[D9]	3.127e-01	1.254e-12	6.492e-21	9.163e-19
Belt Filter	[E9]	3.127e-01	1.254e-12	6.492e-21	9.163e-19

Emission Summary for (*)METHANOL

	%	lbs/day
TOTAL Air Emissions	6.660e-01	94.00
TOTAL Treated/Biodegraded	99.33	14020.19
TOTAL Sludge Discharges	4.440e-18	6.266e-16
TOTAL Effluent Discharges	1.877e-09	2.650e-07

(*)PROPANOL,N-

Parameter	Value	Units	Reference
Molecular Weight	60.09	g/mol	-1
Density	8.040e-01	g/cm3	-1
H @ 25 deg C	7.440e-04	L gas/L liquid	-1
log Kow	4.913e-01	L oil/L water	-1
Kp	-1.000e+00	L/mg	-1
Aerobic Kb	2.075e-04	L/mg.hr	-1
Anaerobic Kb	-1.000e+00	L/mg.hr	-1

Example ToxChem Model of WWT Emissions

Detailed Emission Summary for (*)PROPANOL,N-					
Process Name	Grid	Flow	Cl Eff.	% Emit	Mass Emit
		MGD	ug/L	%	lbs/day
Sanitary Influent	[L3]	1.000e-01	0.000e+00		
Influent	[D4]	1.20	91050.00		
Equalization	[F4]	1.20	90586.98	5.085e-01	4.64
Equalization	[G4]	1.20	90291.57	3.244e-01	2.96
Equalization	[H4]	1.20	89997.13	3.234e-01	2.95
Neutralization	[K4]	1.20	89951.25	5.039e-02	4.595e-01
Activated Sludge	[N4]	1.01	3999.73	1.947e-01	1.78
Activated Sludge	[O4]	1.01	299.84	6.910e-03	6.301e-02
Activated Sludge	[P4]	1.01	22.49	3.539e-04	3.227e-03
Activated Sludge	[N5]	1.01	3999.73	1.947e-01	1.78
Activated Sludge	[O5]	1.01	299.85	6.911e-03	6.301e-02
Activated Sludge	[P5]	1.01	22.49	3.539e-04	3.227e-03
Clariflocculator	[G6]	6.730e-01	21.74	8.488e-05	7.739e-04
Trickling Filter	[I6]	6.513e-01	12.02	9.189e-18	8.379e-17
Tertiary Clar.	[L6]	6.513e-01	11.91	3.299e-05	3.008e-04
Clariflocculator	[G7]	6.731e-01	21.74	8.488e-05	7.740e-04
Aerobic Digester	[D8]	6.254e-01	4.144e-01	3.117e-05	2.842e-04
Aerobic Digester	[E8]	6.254e-01	2.721e-02	2.045e-06	1.864e-05
Clariflocculator	[G8]	6.730e-01	21.74	8.488e-05	7.739e-04
Trickling Filter	[I8]	6.513e-01	12.02	9.189e-18	8.379e-17
Tertiary Clar.	[L8]	6.513e-01	11.91	3.299e-05	3.008e-04
Belt Filter	[D9]	3.127e-01	2.572e-02	7.401e-09	6.748e-08
Belt Filter	[E9]	3.127e-01	2.572e-02	7.401e-09	6.748e-08

Emission Summary for (*)PROPANOL,N-		
	%	lbs/day
TOTAL Air Emissions	1.61	14.69
TOTAL Treated/Biodegraded	98.38	897.01
TOTAL Sludge Discharges	1.832e-06	1.671e-05
TOTAL Effluent Discharges	1.371e-02	1.250e-01

(*)ISOPROPYL ALCOHOL			
Parameter	Value	Units	Reference
Molecular Weight	60.10	g/mol	0
Density	7.900e-01	g/cm3	-1
H @ 25 deg C	6.140e-04	L gas/L liquid	-1
log Kow	5.000e-02	L oil/L water	-1
Kp	-1.000e+00	L/mg	-1
Aerobic Kb	7.200e-03	L/mg.hr	-1
Anaerobic Kb	-1.000e+00	L/mg.hr	-1

Example ToxChem Model of WWT Emissions

	Detailed Emission Summary for (*)ISOPROPYL ALCOHOL				
Process Name	**Grid**	**Flow**	**Cl Eff.**	**% Emit**	**Mass Emit**
		MGD	ug/L	%	lbs/day
Sanitary Influent	[L3]	1.000e-01	0.000e+00		
Influent	[D4]	1.20	41290.00		
Equalization	[F4]	1.20	41098.39	4.641e-01	1.92
Equalization	[G4]	1.20	40976.11	2.961e-01	1.22
Equalization	[H4]	1.20	40854.20	2.953e-01	1.22
Neutralization	[K4]	1.20	40835.20	4.601e-02	1.903e-01
Activated Sludge	[N4]	1.01	56.66	5.069e-03	2.096e-02
Activated Sludge	[O4]	1.01	1.323e-01	5.665e-06	2.343e-05
Activated Sludge	[P4]	1.01	3.088e-04	9.119e-09	3.771e-08
Activated Sludge	[N5]	1.01	56.66	5.069e-03	2.096e-02
Activated Sludge	[O5]	1.01	1.323e-01	5.665e-06	2.343e-05
Activated Sludge	[P5]	1.01	3.088e-04	9.119e-09	3.771e-08
Clariflocculator	[G6]	6.730e-01	2.988e-04	2.314e-09	9.570e-09
Trickling Filter	[I6]	6.513e-01	1.650e-04	2.296e-22	9.494e-22
Tertiary Clar.	[L6]	6.513e-01	1.637e-04	8.807e-10	3.642e-09
Clariflocculator	[G7]	6.731e-01	2.988e-04	2.314e-09	9.570e-09
Aerobic Digester	[D8]	6.254e-01	1.673e-07	2.304e-11	9.526e-11
Aerobic Digester	[E8]	6.254e-01	3.412e-10	4.689e-14	1.939e-13
Clariflocculator	[G8]	6.730e-01	2.988e-04	2.314e-09	9.570e-09
Trickling Filter	[I8]	6.513e-01	1.650e-04	2.296e-22	9.494e-22
Tertiary Clar.	[L8]	6.513e-01	1.637e-04	8.807e-10	3.642e-09
Belt Filter	[D9]	3.127e-01	3.225e-10	1.689e-16	6.983e-16
Belt Filter	[E9]	3.127e-01	3.225e-10	1.689e-16	6.983e-16

	Emission Summary for (*)ISOPROPYL ALCOHOL	
	%	lbs/day
TOTAL Air Emissions	1.11	4.60
TOTAL Treated/Biodegraded	98.89	408.90
TOTAL Sludge Discharges	5.068e-14	2.095e-13
TOTAL Effluent Discharges	4.154e-07	1.718e-06

ATTACHMENT X

Potential Impact of Increased VOC Emissions from Merck's Elkton, Virginia, Facility

June 1996

Prepared for

Merck Project XL Working Group
Elkton, Virginia

Prepared by

Systems Applications International
Research Triangle Park, North Carolina

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL # of pages ▶ 3

To Scott Alexander	From David Beck
Dept./Agency	Phone #
Fax #	Fax #

NSN 7540-01-317-7368 5099-101 GENERAL SERVICES ADMINISTRATION

MEMORANDUM

To: Roy Huntley, Dave Beck, (EPA, OAQPS)

From: Chad Leatherwood, Clint Burklin, (E.R.G.)

Date: July 17, 1996

Subject: PM Emission Factor Estimates From Bituminous-Fired Spreader-Stoker Boilers With Baghouse Control

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The following discussion documents the approach used to estimate particulate matter (PM) emission factors from bituminous-fired, spreader-stoker boilers equipped with baghouse control. Data used in these calculations were taken from AP-42, results from a set of EPA field tests conducted at stoker boilers, and the Background Information Document (BID) from the New Source Performance Standard (NSPS) for PM standard from utility boilers. (See attachment for data summary)

Total PM emissions are comprised of both filterable PM and condensable PM. The estimate for a filterable PM emission factor was generated by averaging the result from seven bituminous fired, spreader-stoker units operating with baghouse control reported in the NSPS BID.[1] The data ranged from 0.009 to 0.04 lb/MMBtu and averaged 0.02 lb/MMBtu. Data presented in AP-42 from another source, indicates that 60 percent of filterable PM in spreader-stoker units operating with baghouses is PM_{10}.[2] Combining the above two facts, it is estimated that a filterable PM_{10} emission factor fat bituminous fired, spreader-stoker boilers with baghouse control would be approximately 0.012 lb/MMBtu.

Field testing results were used for a condensable PM estimate.[3] The EPA field testing results provide uncontrolled condensable PM data ranging from 0.007 lo 0.19 lb/MMBtu and averaging *0.05* lb/MMBtu. The condensable PM is expected to be higher than the controlled levels of filterable PM and PM_{10} since the baghouse is not assumed to achieve a significant amount of condensable PM control.

Given these assumptions, the total PM_{10} emission factor is estimated as the sum of filterable PM_{10} and condensable PM_{10} (condensable PM is usually under 1 micron in diameter). The PM_{10} emission factors for a spreader-stoker operating with baghouse control are estimated as:

- Filterable PM_{10} = 0.012 lb/MMBtu (+/- a factor of 2) — 0.30 lb/ton
-Condensable PM_{10} = 0.05 lb/MMBtu (+/- a factor of 4) 1.27 lb/ton
-Total PM_{10} = 0.06 lb/MMBtu (+/- a factor of 4) 1.52 " "

*(+/- a factor of 4 gives a range of 25 percent to 400 percent of the estimated value.)

REFERENCES

1. Electric Utility Steam Generating Units: Background Information for Proposed Particulate Matter Emission Standards. EPA-450/2-78-006a.
2. Inhalable Particulate Source Category Report For External Combustion Sources, EPA Contract No. 68-02-3156, Acurex Corp., Mountain View, CA, January 1985.
3. Field Tests of Industrial Stoker Coal-fired Boilers for Emissions Control and Efficiency Improvement. EPA-600/7-81-020a.

ATTACHMENT

PM Emissions From Bituminous Fired Spreader-Wokor **Boilers**

Reference	PM Control*	Units	Filterable PM	Condensable PM**
Field Tests of Industrial Stoker Boilers for Emissions Control and Efficiency Improvement EPA 1980 (seven units)	UNC	lb/MMBtu	0.24 - 0.66 Average=0.42	0.007 - 0.19 Average=0.05
BID for PM from Utility Boilers (EPA 1978) (seven units)	BH	lb/MMBtu	0.009 - 0.04 Average=0.02	

*PM Control: UNC = Uncontrolled, BH = Baghouse

**Condensable PM Assumed to be Less than 1 Micrometer In Diameter

13,000 Btu/lb

APPENDIX 2

POTENTIAL IMPACT OF INCREASED VOC EMISSIONS FROM MERCK'S ELKTON, VIRGINIA FACILITY

POTENTIAL IMPACTS OF INCREASED VOC EMISSIONS FROM MERCK'S ELKTON, VIRGINIA, FACILITY

To improve the stakeholders **understanding** the potential impacts of Merck's proposed Final Project Agreement (FPA) for this project XL initiative, SAI was asked to explore and answer a number of questions relating to the potential risk of air quality degradation due to volatile organic compound (VOC) increases. The questions broadly fell into four areas.

- Local potential for higher ozone levels, particularly in the Shenandoah National Park
- Quantification of the worst case
- Impacts of reactivity on ozone potential
- Other potential local effects of increased VOC emissions

The following analysis presents our assessment of these issues.

Ozone Formation in the Vicinity Of Elkton, Virginia

Ozone formation requires VOC and nitrogen oxides (NO_x) to photochemically interact in the presence of sunlight. The amount of ozone formed depends on the ambient concentrations of VOC and NO_x and the amount of ultraviolet radiation (sunlight) present.

In rural areas, like Elkton, Virginia, the concentrations of VOC and NO_x are not sufficiently elevated to result in significant ozone formation.[1,2,3] Further, because of the presence of biogenic VOCs, and the relative lack of significant local NO_x, the ambient VOC/NO_x ratio tends to be very high. Under these conditions the amount of NO_x available is generally the controlling factor in determining how much ozone will be formed. Reductions in the available NO_x will result in decreased ozone formation and increased NO_x will result in increased ozone

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[1] National Research Council. 1991. *Rethinking the Ozone Problem in Urban and Regional Air Pollution.* pp. 98-107. Washington. DC: National Academy Press.

[2] U.S. Environmental Protection Agency. "Air Quality Criteria for Ozone and Related Photochemical Oxidants." Office of Health and Environmental Assessment. ORD, EPA/600/AP-93/004a. May 1996. Table 4-10.

[3] Lefohn, Allen S. 1994. 'The Characterization of Ozone Exposures in Rural West Virginia and Virginia." *Journal of Air and Waste Management Association* 44:1276-1283.

formation! Since the limited amount of NO_x is the constraining factor in the formation of ozone, all the presently available VOC is not being used in the photochemical formation of ozone. Hence, increasing VOC will not result in any additional ozone formation unless accompanied by additional NO_x. Conversely, it takes substantial VOC reductions (eliminating all the excess VOC) before ozone levels are reduced. In rural areas, because of the high biogenic contribution to ambient VOCs this is usually not possible.

That is not to say that ozone is not being measured in the Elkton, Virginia, area. Even the most remote sites measure 20-40 ppb of ozone background concentrations.[5] Further, because of its location in the eastern U.S., elevated ozone from distant locations is transported into the Elkton, Virginia area. Because of this, levels of 50-120 ppb can be expected.[6] The readings taken by the National Park Service confirm that excursions above background do occur, although no exceedances of the 120 ppb ozone standard have been recorded in recent years. The pattern of the readings is relatively constant with elevated excursions occurring intermittently, sometimes late at night. This is consistent with the pattern observed in other rural areas affected by transport. Sites with significant local formation tend to have low readings at night and in the early morning with significantly higher levels in mid-afternoon when the W (sunlight) is at its highest levels. Conversely, rural areas which do not generate significant local ozone but are impacted by transport tend to have relatively constant ozone levels with only a nominal diurnal variation and occasional spikes of elevated ozone due to transport.

Worst Case Potential — Impacts of Increased Merck Emissions

For comparison purposes Table 1 documents the tons/day of VOC and NO_x at Merck, in Shenandoah National Park, the anthropogenic emissions from sources in the nine-county area which encompasses the park (Shenandoah area) and anthropogenic emissions in Richmond, Virginia, the nearest urban area with the potential to generate significant ozone. It is evident from these values that Merck's emissions contribute in only a minor way to the area's potential to form ozone.

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[4] Ref. 1. p. 186.

[5] Ref. 1, pp. 212-214.

[6] Ref. 4.

Even though there appears to be little potential that additional VOC emissions would result in additional ozone formation because of the high VOC/NO_x ratio prevalent in the area, we assumed for estimating purposes as a worst case, that the local chemistry is VOC limited, like that in Richmond. We have looked at a number of modeling runs developed for SIP purposes for Los Angeles and Richmond and confirmed our Richmond, Virginia, findings with the experience of Virginia DEQ. Figures 1 and 2 illustrate the highest case found. The episode is from Los Angeles for August 27-28,1987, the SIP baseline case. It shows the impact of a 20 ton/day reduction in mobile source emissions on peak ozone levels. In each case investigated, a 20-tons/day change in urban VOC led to a maximum change of approximately a 3-4 ppb (6-8 $\mu g/m^3$) in peak ambient ozone. Hence a 1 $\mu g/m^3$ change in ozone air quality, a level referred to as de minimis for criteria pollutants such as ozone in EPA's permitting guidance, could be generated by an increase in the VOC emission rate of 2.5-3.5 tons/day. This is approximately equal to an annual increase of 900-1250 tons/year, assuming constant operation and assuming the reactivity mix of the increased emissions were similar to typical urban air and the ambient ratios of VOC/NO_x were comparable to Los Angeles or Richmond. Therefore, under worst case assumptions, if the Merck facility in Elkton, Virginia, emitted all the allowed increase at Merck's facility under the cap as VOC's at comparable reactivity to motor vehicles, the expected ozone increase would be less than 1 $\mu g/m^3$.

Reactivity of Merck Emissions

Table 2 lists the relative reactivities of several constituents in the urban environment using the Carter Reactivity Scale for Maximum Incremental Reactivity.[7] This scale is used by the California Air Resources Board to assess reactivity impacts in California. The first three constituents are typical biogenic emissions emitted in forested environments. The middle two values are the relative reactivities of urban air and motor vehicle emissions and the last three values are of the VOCs which constitute the predominant share (over 80 percent) of Merck's present VOC emissions. As is readily apparent from the data, biogenic emissions tend to be quite reactive, with isoprene three times as reactive as urban air. In contrast, Merck's emissions are quite unreactive, averaging about a fifth as reactive as urban air. Based on this data, it would require five times the Merck "typical mix" emissions rate to generate the same ozone as urban "typical mix" emissions. Hence, adjusting for reactivity, to obtain a 1 $\mu g/m^3$-increase in ozone

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[7] Carter, William. FTP Site://CERT.UCR.EDU/PUB/CARTER, file DMSRCT.TXT, updated April 12. 1996.

concentration based on Merck's "typical mix" emissions would require approximately a 12.5-175 ton/day (4500-6000 tons/yr) increase in daily VOC emissions.

It should be noted that there are other reactivity scales looking at total ozone yield and different urban environments which would yield lower absolute results but similar relative comparisons.[8] This analysis looks at the worst case peak ozone formation potential. When one adjusts for reactivity, assuming all allowed emission changes under the cap are VOC increases of comparable reactivity to the existing Merck "typical mix," maximum possible ozone increases from the Merck facility in Elkton, Virginia, are far less than 1 ppb (i.e., 0.1-0.2 $\mu g/m^3$). As noted earlier, even this small quantity is an overstatement because in a NO_x limited environment additional VOC will not result in increased ozone.

Other Impacts of VOC Increases on the Environment

The impacts of individual VOCs on the health and the environment are addressed by OSHA and EPA MACT standards. The processes involved are covered by EPA planned MACT standards for batch processes at pharmaceutical plants and Merck has established procedures to comply with these standards as part of the Project XL permit. EPA does not generically regulate volatile organic compounds under a hydrocarbon standard—in fact, EPA rescinded its ambient hydrocarbon standard because of the lack of a demonstrated health basis to regulate? The most serious potential effects are those attributed to ozone formation. As discussed previously, the Merck VOC are not a significant factor in local ozone formation.

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[8] Carter, William P.L. 1994. "Development of Ozone Reactivity Scales for Volatile Organics Compounds." *Journal of Air and Waste Management Association* 44:881-889.

[9] Federal Register 48FR628, January 5,1983. EPA revocation of NAAQS for Hydrocarbons.

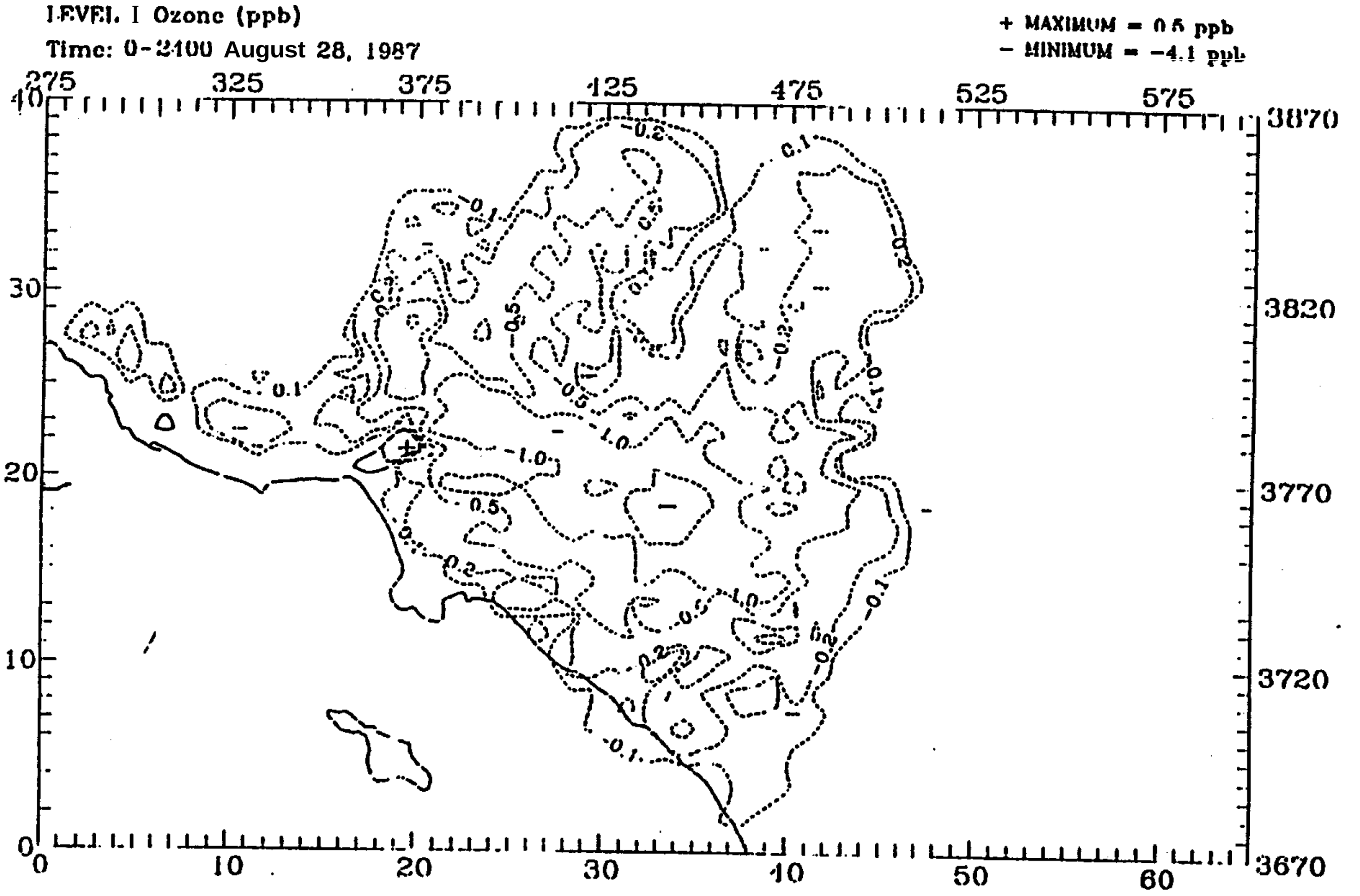
Table 1
Emission Comparisons

	VOC (tons/day)	NOx (tons/day)
Merck	1.12	0.80
Shenandoah Park (Biogenic)	25.1	0.62
Shenandoah Area (Anthropogenic)	132.6	65.3
Richmond MSA (Anthropogenic)	**242.6**	**266.3**

Table 2

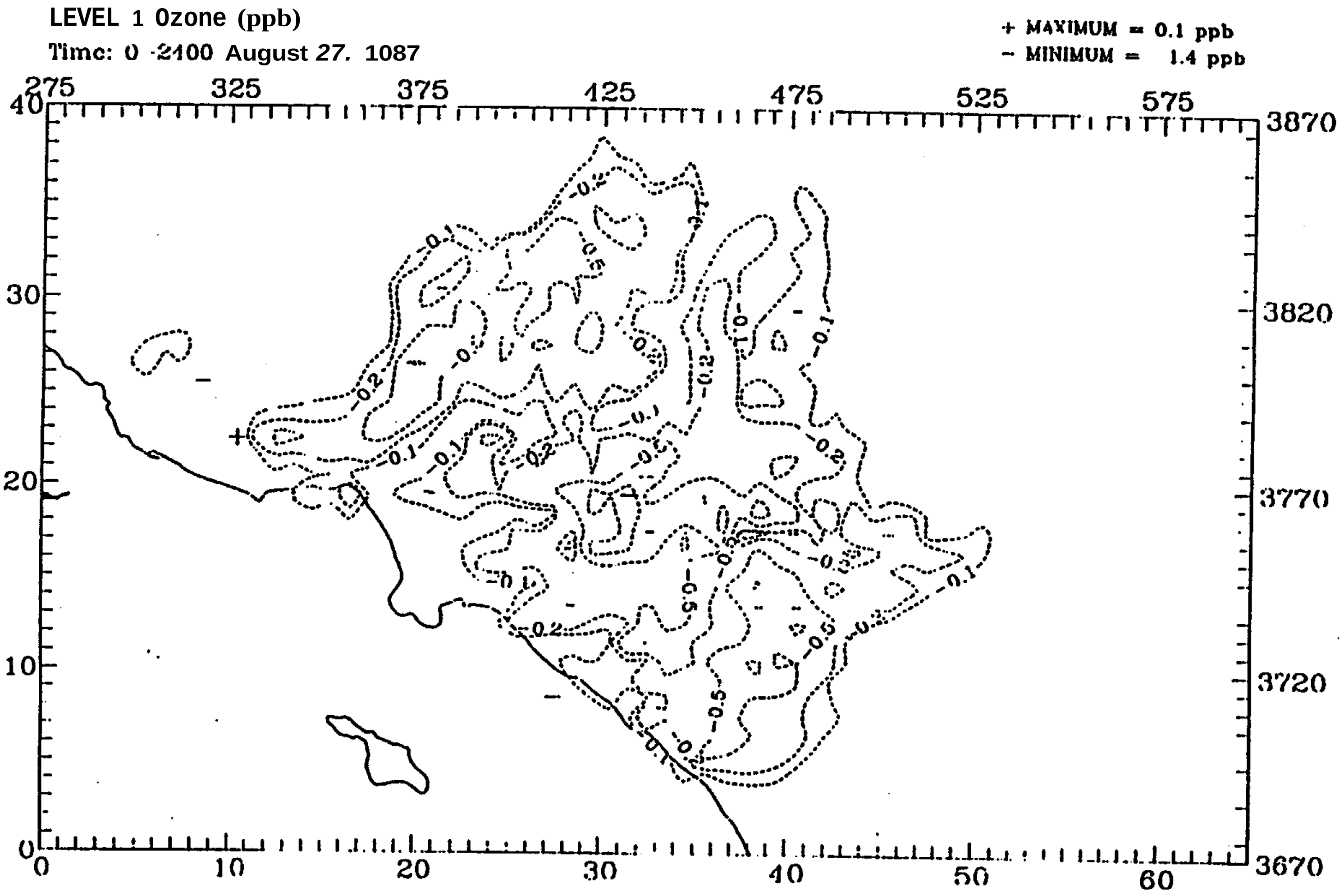
Carter Reactivity Scale (maximum impact):

a-Pinene	3.30
b-Pinene	4.40
Isoprene	9.10
Urban Air	2.50-3.00
Auto Exhaust	3.12
Methanol	0.56
Ethyl Acetate	0.31
Isopropyl Acetate	0.87



Difference in Maximum Simulated Ozone Concentrations
August 28, 1987 (Simulation: VOC reduction minus base)

Figure 1



Difference in Maximum Simulated Ozone Concentrations
August 27, 1987 (Simulation: VOC reduction minus base)

Figure 2

Appendix **3**

Merck & Co., Inc. Environment, Health and Safety Progress Report

MERCK & CO., INC.

ENVIRONMENT, HEALTH, & SAFETY

PROGRESS REPORT

Table of Contents

At Merck, conducting business in a manner that protects the environment and safeguards the health and safety of employees and the public is a top priority Merck's business is to discover, manufacture and market products and services that promote health and well-being.

The fundamental measure of success for Merck is its ability to preserve and improve life. The company accomplishes this goal by sustaining a strong flow of innovative and successful products through both original research in its own laboratories and by acquiring research products from others The spirit of continuous improvement that drives Merck's research programs is pervasive throughout all its operations, including its environmental, health and safety programs It is in this spirit that we present the fourth progress report on environment, health and safety.

This report is presented in two parts:

- a qualitative section that describes policies and practices. This is intended for multi-year use and will be updated only as needed.
- a quantitative section that provides data required to monitor our progress We intend to update this insert annually.

As in the 1993 report. the structure and content of this report have been influenced by the Public Environmental Reporting Initiative Guidelines It presents a comprehensive and balanced perspective on Merck's environment, health and safety policies, performances and practices

If you have questions about the content of this report or would like additional copies, please contact Merck at:

Merck & Co , Inc.
PO Box 100, WSIA-20
Whitehouse Station. NJ 08889-0100

Tel (908)423-7221
Fax (908) 735-1160

In accord with a long standing agreement with an unrelated company, E. Merck of Germany, the Company is designated as Merck, Sharp & Dohme in most countries outside the United States and Canada.

[illegible]

In the context of its operations, Merck is responsible for the protection of the safety and health of its employees, the community and the environment. This responsibility is among its highest business priorities. Recognition of safety and environmental responsibility is reflected in the core values of Merck's Declaration of Strategic Intent, one of which reads:

> "We are committed to the highest standards of ethics and integrity. We are responsible to our customers, to our employees, to the environments we inhabit, and to the societies we serve around the world. In discharging our responsibilities, we do not take professional or ethical shortcuts. Our interactions with all segments of society must reflect the high standards we profess."

Merck has policies that establish requirements for all divisions and subsidiaries worldwide in the areas of safety, occupational health, environment and energy.

[illegible]

Each operating unit is responsible for conducting its business in a manner consistent with Merck's environment, health and safety policies. It is each unit's job to ensure that it operates in full compliance with all laws and regulations. Management believes that focused attention and allocation of funds to occupational safety and environmental protection enhances rather than detracts from other business objectives.

At Merck, line management accepts ultimate responsibility for safety and environmental performance. To support line management in this effort, a central staff of environmental, industrial hygiene and safety professionals provide planning, technical, regulatory and auditing services. This dual accountability works effectively to nurture close interaction and a high degree of cooperation between these groups.

A Corporate Environmental, Safety and Health Advisory Committee (ESHAC), chaired by the Senior Vice President Merck Manufacturing Division Science and Technology and composed of executives representing a cross section of the company, meets regularly to evaluate the company's present environmental, safety and health practices; establishes policies; and recommends new initiatives which foster continuous improvement in safety and environmental performance.

Environment, Health and Safety
GOALS

◆

The following goals provide guidance to Merck personnel worldwide.

Ensure a safe and healthy workplace.

◆

Build and maintain a high level of safety and environmental commitment.

◆

Minimize the release of chemicals into the environment.

◆

Seek and implement innovative routes to waste minimization and resource conservation.

◆

Develop leadership in safety and environmental performance.

[illegible]

As a health products company, Merck must ensure its operarions do nor compromise the safety and health of employees, customers or the public. This requires sound process and facility design to minimize the potential for accidents or chemical exposure.

The commitment of employees and innovative safety initiatives are also important parts of the safety program. More than 200 safety committees, involving 1.500 employees, work to ensure safety in company facilities around the world.

Process Safety Management

The chemicals and operations used in the manufacture of certain pharmaceuticals have the potential to create hazardous reactions To minimize potential hazards, Merck implemented a state-of-the-art Process Safety Management program well in advance of any regulatory requirement

Process Safety management at all of Merck's manufacturing operations focuses on three major areas technology, facilities and personnel The Process Safety Management Program ensures that company facilities are properly designed, operated and maintained to reduce risk. In recent years, Merck expanded its program to include all pharmaceutical operations.

To identify and better manage possible risks, Merck developed a Process Safety Laboratory to test all processes before they move to production facilities for full-scale operations The lab identifies potential hazards and defines the consequences of an unwanted event.

Health Monitoring Programs

Merck has a strong commitment to providing a safe and healthy workplace for its employees. Its occupational health, safety and industrial hygiene professionals work closely to identify potential workplace effects on employee health. Production and laboratory people who regularly work with designated potentially harmful substances undergo medical surveillance examinations. These examinations have been performed at Merck since 1953. The possible effects of low level exposure over a long period of time are evaluated through periodic air monitoring and through this surveillance monitoring program.

Motor Vehicle Safety

Auto accidents are one of the leading causes of lost-time at Merck as well as Industry in general To reduce the incidence of automobile accidents and related employee injuries, Merck developed a comprehensive safe-driving program. This program helps reduce accidents and associated costs.

The educational component of the program trains employees to be safe drivers. Employees first complete a classroom segment. Then they move behind the wheel, where training focuses on collision avoidance, braking exercises, parking lot techniques, and proper backup techniques.

To help sites administer the program, Merck developed a technical guide that details safety techniques and shows sample programs.

The company also adopted safety criteria for automobile purchases. As of 1992, all new cars purchased in the United States must have anti-lock brakes and driver-side airbags. To ensure that its vehicles are in top condition, Merck replaces company cars at 55,000 miles or 36 months.

Environment and Safety Audit Program

Merck safety and environmental professionals conduct worldwide audits of manufacturing facilities, research laboratories and farms on a regular basis The frequency of these audits depends on the size and complexity of the facility as well as performance in past audits

In addition, sites are responsible for self-assessments These assessments help the corporate auditors and site personnel identify issues and outline recommendations to resolve them before problems arise The assessments allow Merck to keep a consistent level of environmental and safety performance throughout the company

In 1994, a third-party audit was done by Price Waterhouse to assess Merck's environmental audit program They concluded that the company's audit program met management's expectations and conformed to best practices. Some suggestions were made by Price Waterhouse to enhance the program

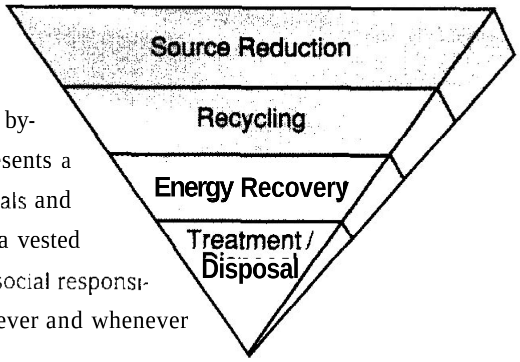
Emergency Response

Merch employees are trained to respond to all types of on-site emergencies. Each site has a plan that is tested and refined through regular drills and training sessions with the aim of preventing the occurrence or minimizing the adverse effects of natural disasters or industrial accidents. Regular drills involve community emergency response teams.

Qualified teams also provide mutual aid to communities when local emergencies occur, even if they don't involve Merck facilities or chemicals. This includes helping community emergency response teams respond to emergencies involving chemical releases from other facilities or transportation systems.

Throughout Merck, employees are finding new ways to reduce waste and conserve resources. From the research lab, where innovative new processes are designed, to the use of advanced technology in our manufacturing operations, to expanding recycling and energy efficiency programs, waste minimization and resource conservation efforts make good environmental sense for the company and its business.

Waste Management



At Merck, the manufacture of life-saving drugs is the result of chemical changes that also create waste by-products Because waste represents a large investment in raw materials and expended supplies, Merck has a vested financial interest, as well as a social responsibility, to reduce its waste wherever and whenever feasible

Merck's first approach toward waste management is to find better ways to operate — to produce more products while using fewer raw materials and generating less waste. Where source reduction is not feasible, the next choice is recycling, then energy recovery where applicable, and finally, treatment or disposal

SARA Goals

Merck established aggressive environmental goals for those chemicals listed under section 313 of the Superfund Amendments and Reauthorization Act (SARA) of 1986. Using the company's 1987 release levels as a baseline, Merck made a voluntary commitment to the following reduction goals for all facilities worldwide:

ACHIEVED Reduce air emissions of carcinogens or suspect carcinogens by 90% by the end of 1991.

ACHIEVED Totally eliminate these air emissions or apply best available technology by the end of **1993.**

ON TARGET Reduce all environmental releases and transfers of toxic chemicals by 90% by the end of 1995.

This final goal is well on the way to being achieved. The company's success will be demonstrated in the data for the 1996 reporting year

Market-Based Opportunity

Recent amendments to the Clean Air Act have increased demands on industry, especially in the Northeastern United States. Exceedances of the health based standard for atmospheric ozone have led the federal government to impose strict limits on omissions of nitrogen oxide (NOx), which contributes to the formation of ozone. Unless the Northeast can demonstrate how it will meet the air quality standard, sanctions will be imposed, including a drastic curtailment of industrial growth.

Federal standards call for the installation of controls on all major sources of nitrogen oxides. However, for some facilities. controls can be very costly and yield small actual reductions, while other facilities can make greater gains at much lower costs.

Merck is working with government, industry and environmental groups to establish a market-based trading system for air emission credits to help the region meet the necessary standards for the least cost.

Under a market-based trading system, facilities that can economically reduce their nitrogen oxide emissions beyond mandated levels will receive credits and will be able to sell or trade credits with other facilities. The region will be able to meet air quality

Recycling

Merck facilities around the world have implemented programs to recycle many types of wastes Paper, plastics, metal, concrete, wood. solvents and cafeteria waste are all Merck recycling targets. The company has been aggressive in promoting recycling as well as the use and purchase of recycled materials. Each Merck site has its own initiatives.

There is a long-standing practice of solvent recycling in the manufacturing processes at Merck Solvents that cannot be recycled for on-site manufacturing operations are recovered wherever possible Merck looks for opportunities to sell these as raw materials to industries that can beneficially re-use them. In some cases, solvents that cannot be used for other purposes are sent to cement companies for blending with other fuel to fire their kilns The solvents are destroyed and, at the same time, the amount of virgin fuel used by the kilns is reduced.

Ozone Depleting Substances

Merck is working toward removal of all chlorofluorocarbons (CFCs)and other ozone-depleting substances (ODS) in its product line. An active CFC reduction program is in place and will be accomplished by reformulation of processes or discontinuation of products. With the exception of an inhaler product, Merck will achieve this goal by 1996.

CFCs are primarily used by the company as refrigerants in site operations. A program has been set up to reduce CFCs. This program includes recycling or re-use measures, installation of gas absorption units or other CFC-free technology, and use of non-CFC refrigerants in existing systems. As a result, Merck is well positioned to reduce dependence on CFCs well ahead of global phase-out targets.

Energy

At Merck's world headquarters in Whitehouse Station, New Jersey the replacement of incandescent fixtures with new compact fluorescent bulbs realized a first year savings of 396 kilowatts per hour. The Environmental Protection Agency gave this site its "Green Lights" seal of approval, a first among Merck's domestic sites. EPA uses its Green Lights program to encourage consumers to use energy-efficient lighting, which helps cut the amount of electricity generating stations need to produce.

Merck is committed to efficient and responsible use of energy in its global operations and is pursuing the following initiatives,

- Implementing effective energy management programs worldwide.
- Considering energy efficiency in the design of manufacturing processes and facilities.
- Including energy efficiency standards in procurement criteria.
- Publicizing Merck's progress in energy conservation,
- Educating employees on energy conservation at home and on the job

Case Studies in Waste Minimization

Waste minimization through the use of innovative technology has always been a way of business at Merck. in 1963, the initial full-scale process for the synthesis of Aldomet. a product for high blood pressure, produced a pair of identical chemical twins known as isomers. One had the activity to reduce hypertension: the other was a useless by-product. Consequently, half of the isolated components were not beneficial. By an ingenious combination of chemistry and engineering, Merck was able to transform the by-product into the useful isomer. Thus eliminating the waste and improving the product yield.

A more recent example was the development of the imipenem manufacturing process for the antibiotic Primaxin. The imipenem chemical process originally required 18-steps which would have generated one ton of waste for every pound of product. Before manufacturing commenced. Merck's chemists and engineers found a way to eliminate one-half million gallons of toxic waste each year. Solvent distillation and internal recovery of an acetone/water mixture cut annual use of acetone in the process by 80%. Improvements in recovery also helped reduce methylene chloride use by 82%.

improvements continued even after the start-up of the *Primaxin* manufacturing process. New chemistry was developed that eliminated the use of methylene chloride as a solvent in the imipenem process. This new chemistry also significantly reduced biological oxidation demand load and dimethylformamide load to the waste treatment plant.

tewardship requires taking responsibility for the total life cycle of the materials Merck uses and the products it manufactures. Stewardship begins in research with the development of a product and its manufacturing process It continues with the design and selection of packaging that uses recycled or recyclable materials and minimizes waste of these materials. Stewardship also includes the responsibility to provide consumers with instructions for proper use of the product and for disposal of any unused product or residue The company's goal is to ensure that it minimizes the impact of its products to the environment throughout the entire product life cycle.

Research

During product development Merck has an opportunity to better understand the active ingredients and learn early on what will happen during the manufacturing phase. Potential drugs are produced on a small scale in a pilot plant. It is here that scientists and engineers work together to review what is used in the process and how it can be modified to address safety and environment concerns. They evaluate all solvents that are used, what by-products are developed, what wastes are produced and what can be recovered and reused. The company uses this information to find alternative ways to produce the product in a more efficient and environmentally sound manner.

Because it is time consuming and costly to change a process once it has been approved by the United States Food and Drug Administration, it is important for the company to create an environmentally sound manufacturing process from the start.

Packaging and the Environment

The purpose of packaging is to ensure the integrity of the company's products. Merck's packaging engineers design packages not only to meet all the requirements of product integrity, but to incorporate environmental concepts where possible.

Merck has an aggressive packaging reduction program. The mission of the "Packaging and the Environment" program is to identify and implement projects that will result in an overall reduction of product packaging weight, therefore reducing the environmental burden of waste generated.

Each Merck site has a team to implement packaging reduction goals. Regional Steering Committees have been formed around the world to oversee and drive packaging reduction activities at each site within the region.

Take-Back and Aid Programs

Pharmacists in the United States and many other countries return expired Human Health Division products to Merck for disposal. Merck also participates in packaging waste take-back and recycling programs in a variety of countries.

Merck also has a program to identify and donate short-dated product that would have to be destroyed if not administered prior to the expiration date. These valuable products are immediately utilized to supplement the Merck Medical Outreach Program which donates lifesaving medicines and vaccines for humanitarian purposes in developing economies. The company also donates medicines to aid in disaster/emergency relief efforts throughout the world.

Remediation

Today. practices and regulations for the disposal of chemical waste are very different from those in the past For years. waste was commonly disposed by burial both by industry and private citizens These practices gave rise to present-day concerns about soil and water contamination. Because of Merck's past practice of treating many of its waste streams on-site, the company believes its liability for remediation of waste at off-site commercial facilities is relatively small. Merck will fulfill its obligation to share in the clean up of these sites as appropriate, as well as the company's own sites where required.

The company's waste minimization efforts have further reduced the need for off-site disposal facilities and will reduce future liabilities. To prevent Future contamination of company sites, Merck designs facilities to prevent contamination. In addition, the company moved underground storage tanks above ground, and rail and tank wagon loading and unloading stations are upgraded with full-spill containment.

Information Access

Merck's responsibility for company products does not end when products are sold to our customers. Merck physicians, pharmacists, toxicologists, veterinarians, environmental and safety specialists are available 24-hours a day, seven days a week, to provide information on products or refer calls to other Merck experts.

To strengthen availability and interaction with its customers, Merck developed the National Service Center to help healthcare professionals obtain prompt, specific information about Merck products and services.

Merck also has a 1-800 number available to customers, transporters and emergency responders in case of an accident or emergency involving any of Merck's products.

INBio

Merck's commitment to the environment goes well beyond reducing chemical use. Merck's scientists have long been interested in developing medicines from natural products. Some of the company's biggest successes have come from nature. Merck has a long history of collaborative agreements to research and preserve natural habitats. Most notable is the current project in Costa Rica.

Through a collaboration with Costa Rica's National Biodiversity Institute (INBio), Merck is funding a search for new medicines in the country's wildlands. If a compound is found that shows promise, scientists will develop methods to produce it in the lab, therefore preserving the natural product. Part of the money donated to INBio goes directly to Costa Rica's National System of Conserved Areas to protect Costa Rica's wildlands. Royalties will be paid to INBio for any products developed as a result of the agreement. These royalties will be used to support conservation efforts in Costa Rica.

The Merck-INBio agreement offers a new paradigm for cooperation between conservationists and industry. While working to develop new pharmaceuticals to benefit society, Merck is protecting the precious biodiversity of Costa Rica.

Coal Mine Reclamation

Merck's Danville, Pennsylvania plant is working with the Pennsylvania Department of Environmental Resources Bureau of Mining to beneficially use bottom ash and fly ash - generated from the site's coal-burning power plant - to reclaim coal strip-mined areas. Federal and state laws require strip mine operators to restore mined lands to original contours after they have finished extracting coal. The area is then revegetated with pine seedlings.

The mine reclamation program is a classic example of the beneficial use of waste material To ensure the environmental integrity of the reclamation site, the site's managers make sure that the coal ash from Merck and other companies is properly compacted, that monthly groundwater samples are in compliance with environmental permits, and that there are no erosion or sedimentation problems.

This program presents a win-win situation for Merck and the environment. Merck continues its philosophy of beneficially erck believes its commitment to environment, health and safety responsibility requires it to look beyond the boundaries of its own facilities and businesses to take a leadership role in the world community. Through a number of voluntary initiatives – cooperative partnerships among government, industry and communities – we will ultimately be successful in helping to ensure a healthy environment for generations to come.

Responsible Care®

The Chemical Manufacturing Association's Responsible Care® program is just one of many industry initiatives Merck supports. Responsible Care® is built around a set of 10 guiding principles and six codes of management practices that provide an ethical framework for the operations of CMA member companies. Merck's internal codes of practice must meet or exceed CMA standards Merck couples its own high standards in these areas with the Responsible Care® codes to ensure that the best safety programs are in place, not only in the United States, but at all sites around the world.

ISO 14000

In preparation for the June 1992, United Nations Conference on Environment and Development (UNCED), a broad cross-section of industries from around the world met and agreed on the need for an international standard on environmental management systems. As a result, the International Organization for Standardization (ISO) is developing the 14000 series of Environmental Management Systems.

If different systems were expected in every country, an international corporation could not develop a single system to manage its worldwide environmental performance. The goal of the ISO is to establish one guideline that can be applied consistently in all countries. Although still in draft form, a pilot of the ISO Environmental Management System is already underway at two of Merck's facilities in the United Kingdom.

Community Advisory Panels

Open communication is the basis for trust between Merck sites and their neighbors. Environment, health and safety information is provided to communities through open houses at plants, employee meetings and training exercises with local emergency responders

Our Rahway, New Jersey facility established the company's first official Community Advisory Panel (CAP) in 1994. The panel allows representatives from different areas of the community to meet with local plant management, on a regular basis, to discuss issues of mutual interest The CAP is used as a forum for open and honest discussion between the community and the plant to help build mutual respect and trust.

Following the success of the Rahway plant CAP, other Merck manufacturing plants are in the process of establishing formal CAPs in their communities.

Champions for the Environment

In 1994, Merck initiated the Merck Champions for the Environment Award program in the United States and Puerto Rico The program fosters collaboration between Merck facilities and the communities that surround them. Merck partners with non-profit organizations to develop environmental improvement and awareness projects that include employee and community involvement. The Merck Company Foundation provides a $2,500 grant to each facility in support of the program.

Projects range from building nature trails to water testing on local rivers and lakes. Some sites have used their awards to support ongoing projects in community schools.

Trust for Public Land

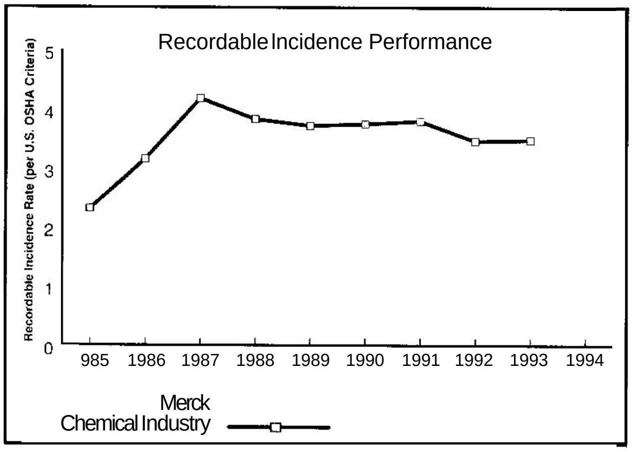
As one of the company's environmental initiatives The Merck Company Foundation made a $200,000 grant to the New Jersey Chapter of The Trust for Public Land to identify land/waterway preservation for recreation in Hunterdon County, home of Merck's corporate headquarters

Environment, Health & Safety Data
April 1995

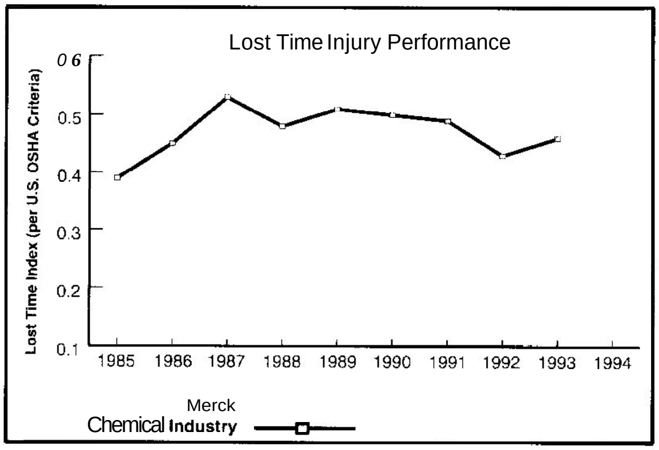
The following pages of charts, illustrations and statistics provide specific information to track Merck's progress.

Contents

At Merck, safety indices serve as a measure of relative performance and provide useful management tools. The Lost Time Injury and Illness Index is a measure of the number and severity of accidents experienced in the workplace. The Recordable Incidence Rate measures the number of recordable injuries in the workplace. Merck uses these worldwide statistics to help safety professionals determine where to concentrate efforts Merck continues to perform better than the industry averages as reported by the National Safety Council's Accident Facts. Many of Merck's sites around the world were honored in 1994 for distinguished safety programs.



Merck's 10 year safety performance as measured by Recordable Incidence Rate Index versus the chemical industry average.



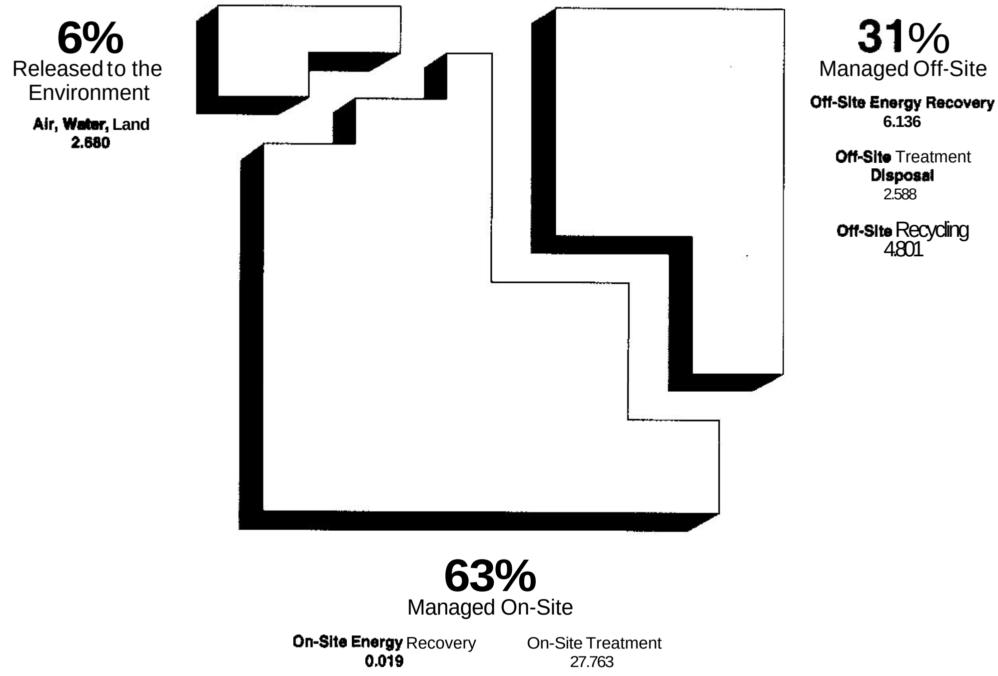
Merck's 10 year safety performance as measured by the Lost Time Injury Index versus the chemical industry average

Merck manufacturing facilities in the United States and Puerto Rico have reported waste management data as required by the Pollution Prevention Act of 1990. The data includes on-site and off-site management of waste and a summation of releases to the environment for 1993.

Ninety-four percent of the toxic chemical components of our wastes are recycled, recovered or treated either on-site or at off-site facilities Only 6 percent is directly released into the environment.

In the last 25 years Merck reduced solid waste from packaging by over 2,400 tons. A program is in place to reduce another 1.500 tons in 1995

How Merck Manages Waste

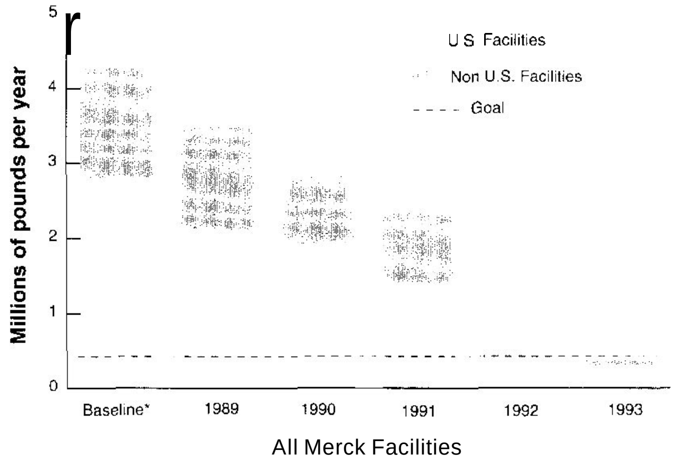


1993 U.S. Pollution Prevention Data as shown here, reported by Merck U.S. Facilities (million pounds)

Merck's pollution prevention and emissions reduction programs aim to control and eliminate releases of chemicals. The goal is to reduce by 90% worldwide all releases of toxic chemicals by the end of 1905. This goal applies to all discharges to air, water or land as well as to materials sent for off-site treatment and disposal Since 1987, the company achieved a 69 percent reduction in releases and transfers of these chemicals.

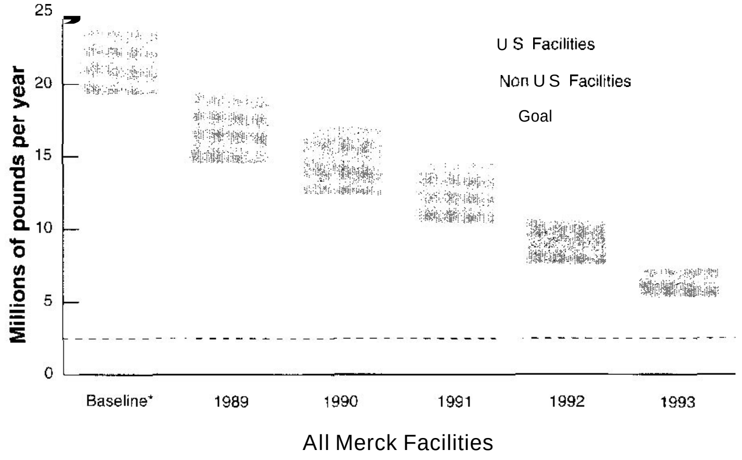
Merck established Intermediate goals to reduce worldwide air emissions of known or suspect carcinogens by 90% by the end of 1991. By the end of 1993. these emissions were to be eliminated or Best Available Technology was to be applied where elimination was not feasible. These goals have been achieved

Worldwide Air Emissions of Known or Suspect Carcinogens



Merck reduced air emissions of known or suspect carcinogens by 92 percent at the end of 1993. This exceeded the goal of 90 percent.

Worldwide Environmental Releases of SARA Toxics



This chart summarizes the toxic chemical release data for U.S. and non-U.S. Merck facilities, and illustrates the annual progress Merck is making toward its 1995 goal of 90% reduction.

'Baseline year 1987 for U.S. operations adjusted for foreign operations.

In 1994, the company incurred capital expenditures of approximately $76 2 million for environmental protection facilities Capital expenditures for this purpose are forecasted to exceed $300 million for the years 1995 through 1999 In addition. the company's operating and maintenance expenditures for pollution control were approximately $64 8 million in 1994 Expenditures for this purpose for the years 1995 through 1999 are forecasted to exceed $180 million.

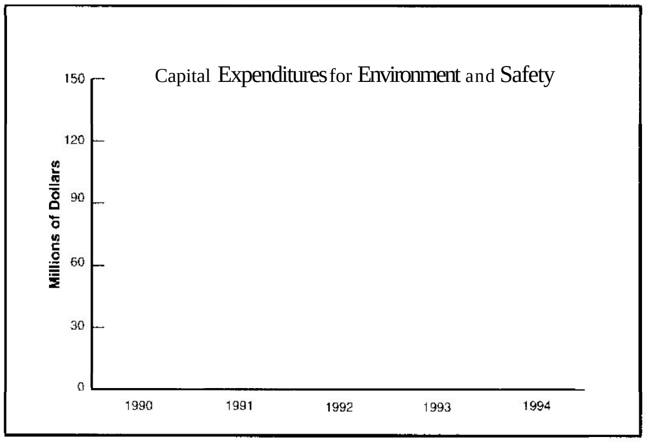
Merck is a party to a number of proceedings brought under the Comprehensive Environmental Response. Compensation and Liability Act. commonly known as Superfund, as well as under other Federal and state statutes. While it is not feasible to predict or determine the outcome of these proceedings. management does not believe that they should ultimately result in a materially adverse effect on the company's financial position, results of operations, liquidity or capital resources

Expenditures for all environmental liabilities were $24 1 million in 1994, and are estimated at $160.0 million for the years 1995 through 1999. The company has taken an active role in identifying and providing for costs associated with the remediation of on-site liabilities. To dare. costs for on-site remediation total approximately $100 million, and are estimated to total an additional $1 38 million for the next 5 years

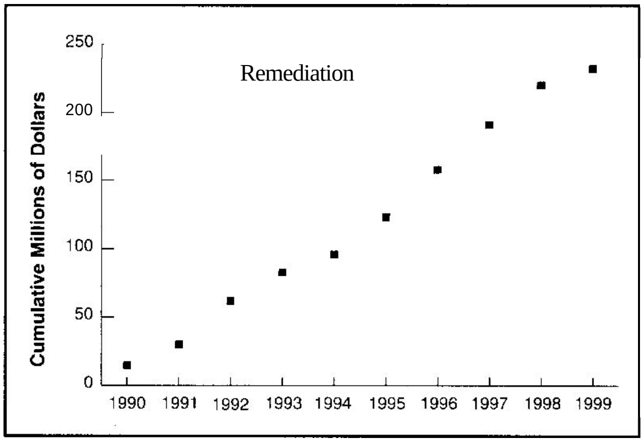
In1994, Merck did not have any safety and environmental penalties to report that exceeded $25,000. For the previous period 1991-1993, the company received the following penalties of more than $25,000:

- Merck paid penalties of $1,042,488 from 1991 through September of 1993 to the New Jersey Department of Environmental Protection and Energy for technical waste water permit discharge violations at the Rahway, New Jersey site. These violations posed no hazard to employees, the community or the receiving waste water treatment plant.
- In 1992, Merck paid $59,000 in fines to the Occupational Safety and Health Administration for an accident that resulted in a fatality at the West Point, Pennsylvania facility.

  In 1992, Merck paid $33.500 to the Environmental Protection Agency, Region II, for failing to immediately report a discharge of benzene to the local waste water treatment plant. The treatment plant was not impacted by this discharge.
- In 1993, Merck's Kelco Division paid $200,000 to the state of California for pH violations of the site's wastewater discharge permit. These discharges posed no hazard to employees and the community or the receiving treatment plant.



Capital expenditures for environment and safety for the years 1990-1994.



The company remediates environmental contamination resulting from past industrial activity.

About Merck

Merck & Co., Inc. is a leading research-driven pharmaceutical products and services company. Merck discovers, develops, manufactures and markets a broad range of innovative products to improve human and animal health. The Merck-Medco Managed Care Division manages pharmacy benefits for more than 40 million Americans, encouraging the appropriate use of medicines and providing disease management programs. Through these complementary capabilities, Merck works to improve quality of life and lower overall health-care costs. In addition to delivering these benefits to society, Merck is committed to providing superior returns for shareholders and a stimulating work environment for employees.

Over the last several years Merck invested approximately $1 billion in research and development each year. That represents approximately 10% of all spending by pharmaceutical companies in the United States and 5% of spending by the industry worldwide.

Today, the company is one of the largest providers of prescription medicines worldwide, with eight major research centers; manufacturing and distribution centers in 15 countries; and operating centers and affiliates in more than 150 countries. Corporate headquarters is located in Whitehouse Station, N.J., U.S.A.

1994 Facts in Brief*

- **47,500 employees**
- **approximately 40% of employees work outside the United States**
- **net income $2,997.0 million**
- **earnings per share $2.38**
- **average shares outstanding 1,257.2 million**
- **sales $15.0 billion**
- **32% of sales outside the United States**
- **annual research spending $1.23 billion**

*** These figures include a full year's impact on results of operations from the Medco acquisition.**

In 1994, Merck was recognized both nationally and internationally for its proactive commitment to environmental and safety excellence.

The 1994 National Safety Award for Occupational Safety

Presented to the Ballydine, Ireland plant by the Minister of Labor.

The 1994 Construction Industry Safety Awards

Two awards were presented to Merck by the Business Roundtable. One for best overall construction safety program to the West Point, Pennsylvania site and one for best individual construction safety program to Merck's Central Engineering department for its Biotechnology Technologic Manufacturing Complex project located at the West Point site.

The 1994 British Safety Council Sword of Honor

Presented to the Ponders End, England plant for the ninth time. Merck is one of only two companies to receive nine swords.

The 1994 Albert-Thomas Award

The Regional Director of Labor and Employment presented a "Special Mention of the Jury" to the MSD-Chibret, France site for dynamic safety policies.

The 1994 National Safety Council Award of Merit

Presented to the La Vallee, France; Ballydine, Ireland; and Ponders End, England plants.

The 1994 President's Occupational Safety Award

Presented to the Barceloneta, Puerto Rico plant by the Puerto Rico Manufacturer's Association.

The 1994 Responsibility Towards the Environment Award

Presented to the MSD-Mexico site by the SEDESOL, the Mexican government environmental agency, in recognition of the environmental management systems the site has implemented.

The 1994 National Safety Council Award of Honor

Presented to the Barceloneta, Puerto Rico plant for achieving three million work hours without a lost time injury.

The 1994 Pennsylvania Governor's Waste Minimization Award

Presented to the West Point, Pennsylvania site for its overall program to reduce and prevent waste.

The 1994 Better Environment Awards for Industry

The Department of the Environment presented the Clean Technology Award to the Ballydine, Ireland plant .

The 1994 Distinguished Safety Performance Award

Presented to the Arecibo, Puerto Rico plant by the Puerto Rico Manufacturer's Association

The 1994 Certificate of Safety Achievement

Presented to the Wilson, North Carolina plant by the North Carolina Department of Transportation for promoting safe working conditions.

The Envirocare 2000 Award

Presented to the Cramlington, England plant by Northern Electric for energy conservation

The 1994 Recycling Award

Presented to the Barceloneta, Puerto Rico plant by the Puerto Rico Solid Waste Authority for recycling initiatives

The 1994 National Safety Belt Award of Honor

Presented to the Elkton, Virginia plant for employee education and use of seat belts.

APPENDIX 4

12/11/96 LOW NOX GUARANTEE LETTER FROM MERCK

Menk & Co. Inc.
P.O. Box 7
Elkton VA 22827
Tel 540 298 1211

MERCK
Manufacturing Division

December 11, 1996

To: Merck Project XL Docket

Re: NOx Emission Performance Specifications for New Boilers

A new PSD permit regulating plantwide air emissions from the Merck & Co., Inc. (Merck) Stonewall Plant will be the primary implementation mechanism for Project XL at the site. In addition to specifying the way in which future air emissions from the plant will be regulated, the permit will require that Merck purchase and install two new natural gas fired boilers (equipped to accommodate propane or #2 fuel oil as a backup fuel) for steam generation to replace the present coal fired boilers. Reduced emissions from the new boilers will support achievement of the environmental improvement required by Project XL. The new boilers will emit less SO2, NOx, VOC, lead, HCl, and HF than the present coal burning equipment.

The NOx reductions achieved by the project are very important, since local ozone formation is limited by the amount of NOx present. After the PSD permit is granted, Merck will enter into a binding contract with an as *yet* undetermined boiler manufacturer for construction and installation of two new gas-fired package boilers. Merck is committed to purchasing equipment that reduces NOx emissions by the greatest extent consistent with safe and reliable performance of the equipment Merck Central Engineering has determined that a NOx emission rate of 0.035 lb/MM BTU can be attained with modem gas fired boilers using low-NOx burners.

When a contract is signed for construction and installation of the new boilers, Merck will specify that the vendor guarantee that NOx emissions will not exceed 0.035 lb/MM B N when burning natural gas. The 0.035 lb/MM BTU rate represents better performance than required by New Source Performance Standards for Industrial-Commercial-Institutional Steam Generating Units (NSPS Subpart Db. 40 CFR 60.40b *et. seq.*). NSPS Subpart Db requires that NOx emissions not exceed 0.10 lb/MM BTU From new, low heat release rate natural gas fired boilers (such as those Merck proposes to install). Attainment of the NOx performance guarantee will be verified by stack test after installation of Be boilers. Installation of low NOx technology as described above. along with other provisions of the PSD permit which provide incentives to minimize actual emissions. will be judged to comprise alternate compliance with NSPS Subpart Db for the powerhouse conversion project

Tedd H. Jett, P.E.

Manager, Environmental Engineering

APPENDIX 5

SHORT-TERM NAAQS MODELING RESULTS FOR THE MERCK XL PROJECT

APPENDIX 5 - SHORT-TERM NAAQS MODELING RESULTS FOR THE MERCK XL PROJECT

Introduction

EPA established the following short-term National Ambient Air Quality Standards (NAAQS) for SO2, PM-10, and CO in 40 CFR Part 50:

Pollutant	**Averaging** Period	**NAAQ (ug/m3)**
SO2	3-hour	1,300
SO2	24-hour	365
PM-10	24-hour	150
CO	1-hour	40,000
CO	8-hour	10,000

Although the Merck Project XL PSD permit establishes caps which limit future annual SO2 and PM-10 emissions, assurance was needed that the plant's worst case future emission rates would not cause or contribute to violation of short-term NAAQS. Merck conducted dispersion modeling of its highest projected short term SO2 and PM-10 emissions to determine the plant's worst case contribution to local NAAQS.

The PSD permit includes an upper annual limit for all criteria pollutant emissions combined, however it does not provide a specific subcap limiting CO emissions. As for SO2 and PM-10, there are also short-term NAAQS for CO. Using a worst case scenario that assumed the entire available unused emission cap would consist of CO emissions (a practical impossibility), Merck modeled its short-term CO impact on the surrounding area.

The plant's worst case short-term NAAQS impacts for all three pollutants were sufficiently low that, when added to conservative background levels consisting of VADEQ monitoring data from areas with worse air quality than Elkton, they were still lower than all applicable short-term NAAQS. The modeling is described in greater detail below. The figures that follow the modeling description are copies of overhead transparencies summarizing the modeling which were presented to the Project XL Workgroup in May, 1996.

SO2 Modeling

Merck's SO2 emissions are formed by it's combustion units, which predominantly consist of two powerhouse boilers, a sludge incinerator, a trash incinerator, and a diesel generator. Worst case hourly SO2 emission rates (post-powerhouse conversion) were determined for each of these sources based on the maximum design capacity of each piece of equipment and current AP-42 emission factors. For the powerhouse boilers, which will be primarily gas fired, worst case SO2 emissions were determined assuming both boilers were firing their #2 fuel oil backup fuel at their design capacity (123.5 MM BTU/hr/boiler).

Dispersion of the SO2 emissions was modeled using ATDM (All Terrain Dispersion Model) which combines EPA's ISCST-2 (Industrial Source Complex, Short-Term) and COMPLEX-1 (a model specifically suited for estimating impacts in complex terrain, as surrounds the Merck plant). The model was used in accordance with the site's VADEQ approved general modeling protocol, a copy of which is contained in EPA's site-specific rulemaking docket. Building downwash effects were modeled using EPA's BPIP (Building Profile Input Program). The modeling used one year of PSD-quality meteorological data collected at the Coors facility, which is also located adjacent to Shenandoah National Park near Elkton, Virginia. Three receptor grids were used in the modeling: 1) a "property line grid" which consists of 86 discrete receptors spaced along the plant property line at 50 meter intervals; 2) a "fine grid* consisting of a 3 km by 3 km grid with 100 meter receptor spacing that extends at least 1 km on all sides of the plant, and; 3) a "coarse grid" which is 22 km by 22 km with 1000 m receptor spacing and extends at least 10 km in all directions from the plant.

EPA established both 3 hour and 24 hour SO2 NAAQS, therefore Merck's worst case 3 hour and 24 hour SO2 emission impacts were modeled. Maximum impacts were assessed on all three receptor grids. The maximum 3 hour modeled impact was 188 ug/m3, and it occured on the property line grid at plant's north property line. The 3 hour SO2 standard is 1300 ug/m3, therefore Merck's worst case modeled 3 hour impact is 14.5% of the standard. The 24 hour SO2 standard is 365 ug/m3. Merck's maximum modeled 24 hour SO2 impact also occured on the property line receptor grid north of the plant. The maximum 24 hour impact was 46.3 ug/m3, which is 12.7% of the standard.

For this modeling exercise, VADEQ provided 3 hour and 24 hour SO2 background levels of 144 ug/m3 and 100 ug/m3 respectively, based on measurements obtained in Fairfax County, Virginia from 1993 to 1995. When Merck's worst case modeled impacts are added to these conservative background concentrations, 3 hour and 24 hour impacts are 26% and 40% of the 3 hour and 24 hour SO2 NAAQS respectively, indicating that Merck's worst case emissions would not cause or contribute to a short-term SO2 NAAQS violation.

PM-10 Modeling

Merck's predominant PM-10 emitting units include all the combustion units modeled for SO2 impact, and additionally include a sludge dryer. Maximum PM-10 emission rates were determined for each unit using current AP-42 emission factors and assuming each unit was running at its design capacity. PM-10 emissions from the sludge dryer were based on the process registration data. As in the SO2 modeling, worst case assumptions for the powerhouse boilers included the burning of #2 fuel oil. The modeling was conducted as described above.

EPA established a 24 hour short-term PM-10 standard, so the plant's wont case 24 hour average impact was modeled on each of the three receptor grids. A maximum PM-10 impact of 14.6 ug/m3 occured on the fine receptor grid about 100 meters north of the plant boundary. The 24 hour PM-10 standard established by EPA is 150 ug/m3, therefore Merck's wont case short-term modeled PM-10 impact would equal 9.7% of the NAAQS.

VADEQ suggested using a conservative 24 hour PM-10 background level of 56 ug/m3, based on PM-10 monitoring conducted in Covington, Virginia from 1993 to 1995. When Merck's wont case modeled impact is added to this background concentration, the maximum 24 hour PM-10 impact is 47% of the NAAQS, indicating that Merck's worst case emissions would not causk or contribute to a short-term PM-10 NAAQS violation.

CO Modeling

In order to demonstrate that the short-term CO NAAQS would not be exceeded as a result of Project XL, Merck modeled the impact of a hypothetical CO emission rate of 600 TPY, which is approximately equal to the plant's entire anticipated operating margin after completion of the powerhouse conversion. Realization of such a high CO emission rate is virtually impossible, since growth of the plant under the criteria pollutant emission cap would likely entail increases of all categories of criteria pollutants. Since the powerhouse is the predominant CO emission source at the plant, the CO emissions were modeled as if they were being emitted from the powerhouse stack. The model, meteorological data, downwash considerations, and receptor grids were the same as those used in the SO2 and PM-10 modeling.

There are 1 hour and 8 hour standards for CO of 40,000 ug/m3 and 10,000 ug/m3 respectively. Merck's maximum modeled 1 hour and 8 hour CO impacts were 351 ug/m3 and 97 ug/m3 respectively, therefore Merck's emissions alone would account for less than 1% of the short term CO NAAQS under the worst case conditions modeled. The maximum modeled impacts occured on the coarse receptor grid at locations approximately 2 km southeast and east of the plant.

VADEQ provided conservative 1 hour and 8 hour CO background levels of 10,971 ug/m3 and 6333 ug/m3 respectively, based on 1993 to 1995 monitoring data obtained in Vinton, Virginia. When Merck's worst case modeled impacts are added to these background concentrations, 1 hour and 8 hour maximum modeled impacts are 28% and 64% of the NAAQS respectively, indicating that Merck's worst case emissions would not cause or contribute to a short-term CO NAAQS violation.

Future Considerations

The short-term NAAQS modeling summarized above provides reasonable certainty that the plant's emissions will not cause or contribute to any short term NAAQS violation for the pollutants regulated under the emissions caps during the first 5 year term of the permit. In addition, the Project XL PSD permit stipulates that, prior to every 5 year review, Merck will provide the project stakeholders with information sufficient to determine whether additional modeling is necessary. Such information will include current building locations and dimensions, stack parameters, and actual and worst case short-term emission rates. If major changes have been made at the site that could affect the results since the previous modeling, Merck will perform updated short-term SO2 and PM-10 modeling if requested to do so by EPA or VADEQ.

Short-term NAAQS Modeling

Post Powerhouse Conversion
Worst Case Air Modeling

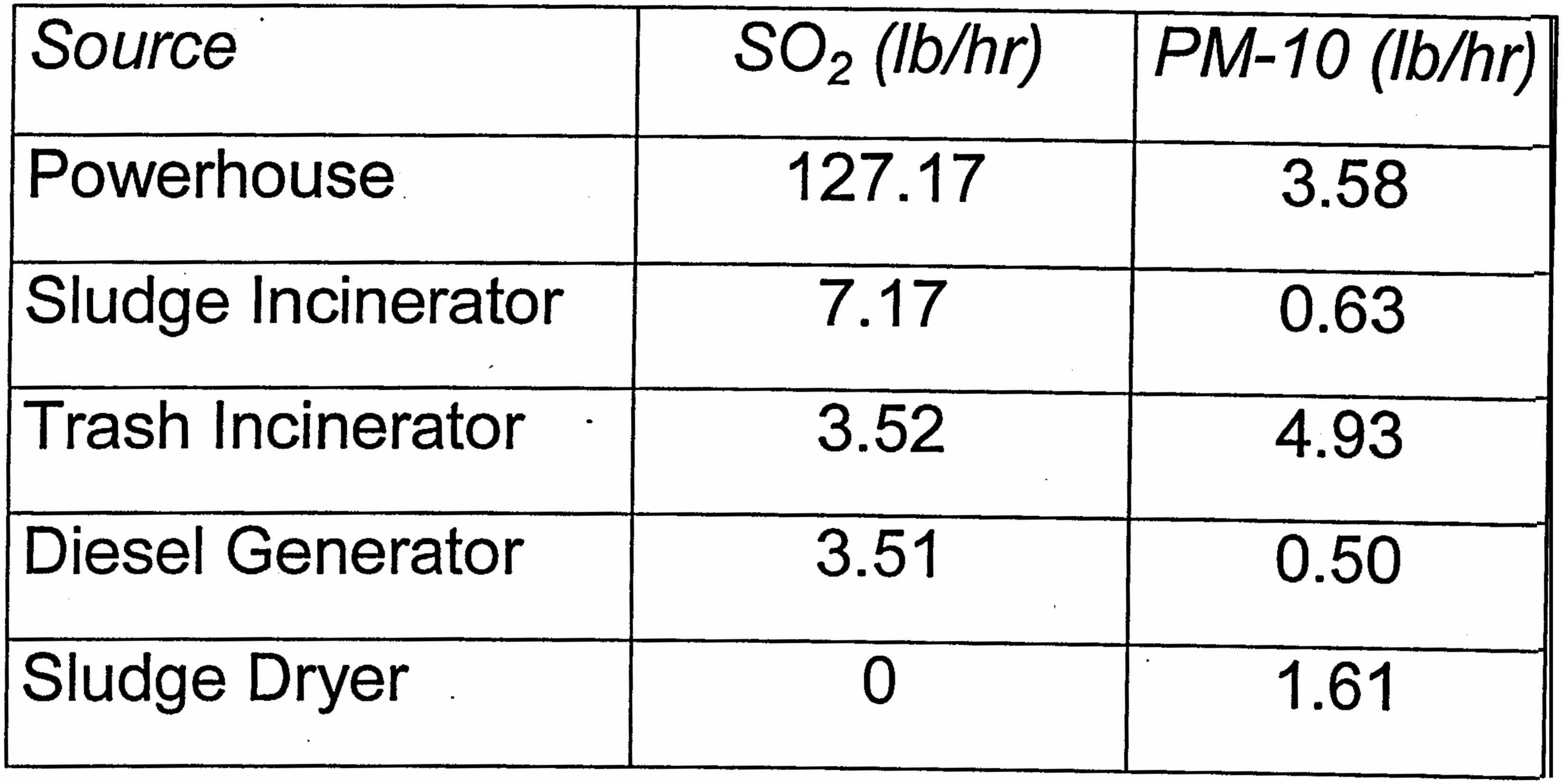
Modeling Overview

- Model: ATDM (ISCST-2)
- Pollutants: SO, and PM-10
- MET Data: Coors' '861'87 data
- Downwash: BPIP used
- Emission basis: Equipment capacities

Sources Modeled

- Powerhouse boilers (using #2 fuel oil)
- Sludge incinerator
- Sludge dryer
- Trash incinerator
- Diesel generator

Maximum Emission Rates



Source	*SO_2 (lb/hr)*	*PM-10 (lb/hr)*
Powerhouse	127.17	3.58
Sludge Incinerator	7.17	0.63
Trash Incinerator	3.52	4.93
Diesel Generator	3.51	0.50
Sludge Dryer	0	1.61

Modeling Summary

Pollutant	*Averaging Period (hr)*	*Impact as a Percent of NAAQS Std.*
SO_2	3	**14.5%**
SO_2	24	**12.6%**
PM-10	24	**9.7%**

Stack Characteristics

Source	*Stack Height (ft)*	*Stack Diameter (ft)*	*Stack Temperature (°F)*	*Exit Velocity (ft/sec)*
Powerhouse	149	6.00	373	69
Sludge Incinerator	57	1.67	1147	124
Trash Incinerator	29	3.83	930	41.4
Diesel Generator (2)	5	0.67	895	92
Sludge Dryer	57	0.5	140	**52**
	57	0.25	77	1.7
	27	0.25	77	0.01

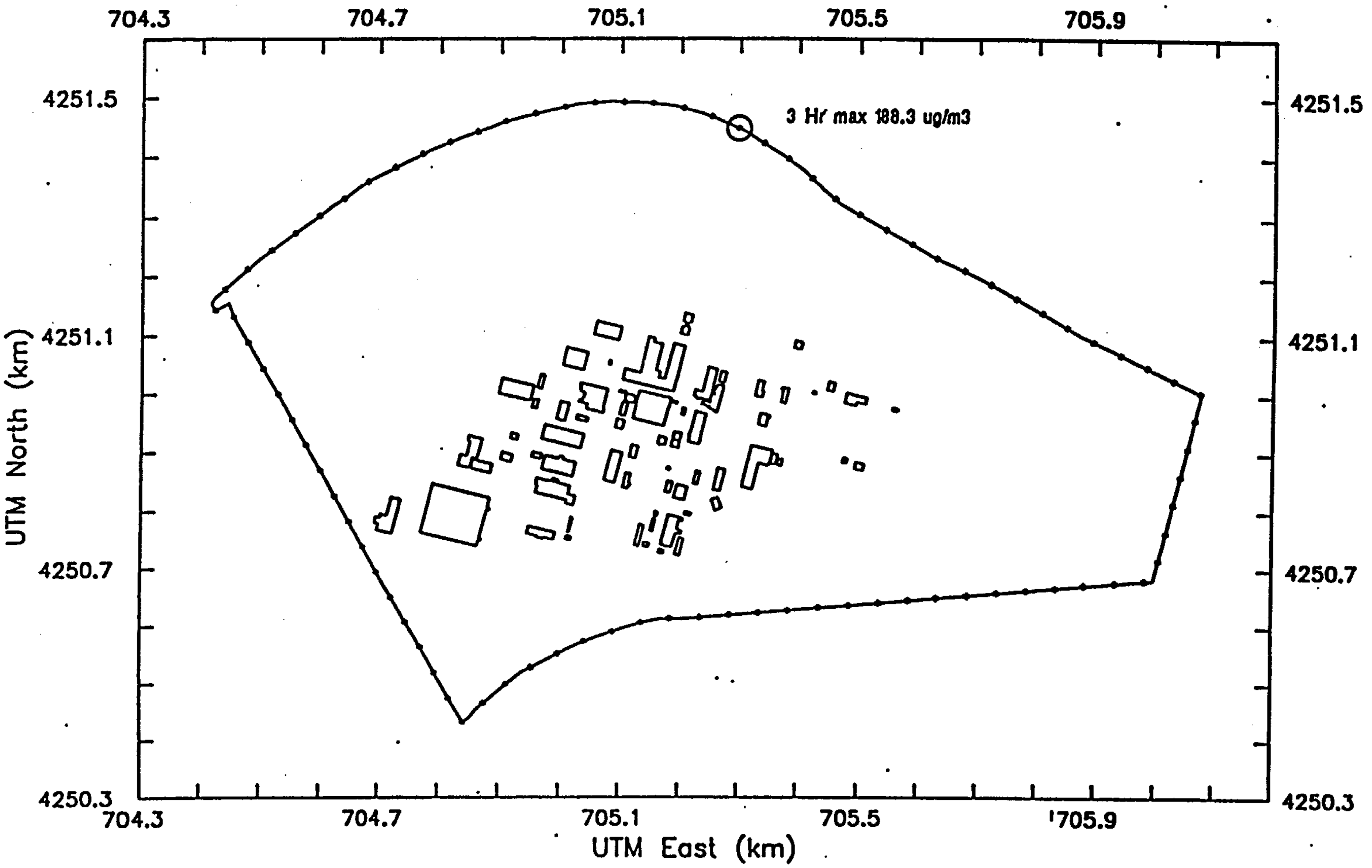
SO, Modeling Results

Pollutant	*Averaging Period (hr)*	*NAAQS Standard (ug/m^3)*	*Maximum Modeled Impact (ug/m^3)*
SO2	*3*	1300	188
	24	365	46

PM-10 Modeling Results

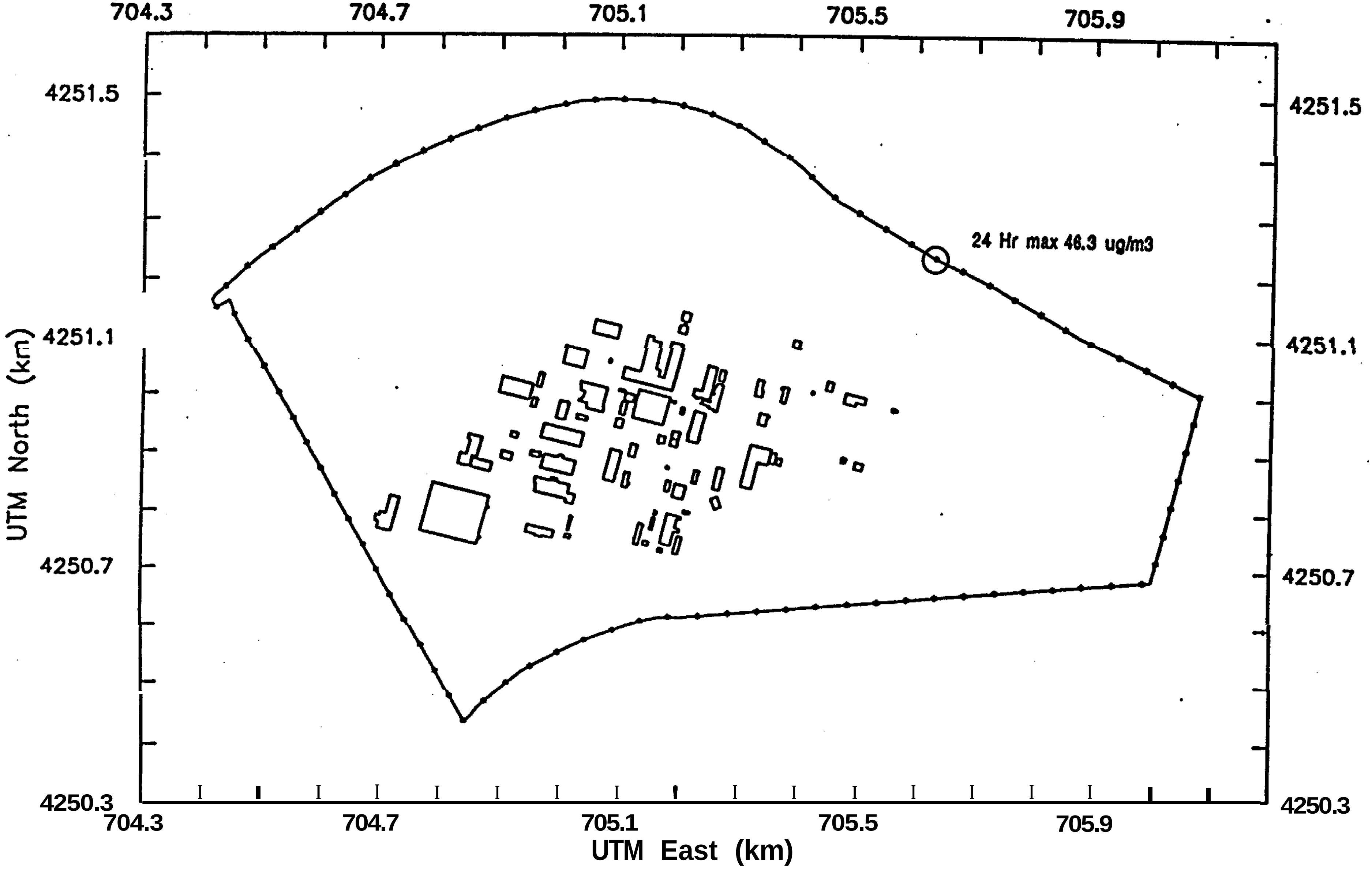
Pollutant	*Averaging Period (hr)*	*NAAQS Standard (ug/m3)*	*Maximum Modeled Impact (ug/m3)*
PM-10	24	150	14.6

SO2 NAAQS MODELING



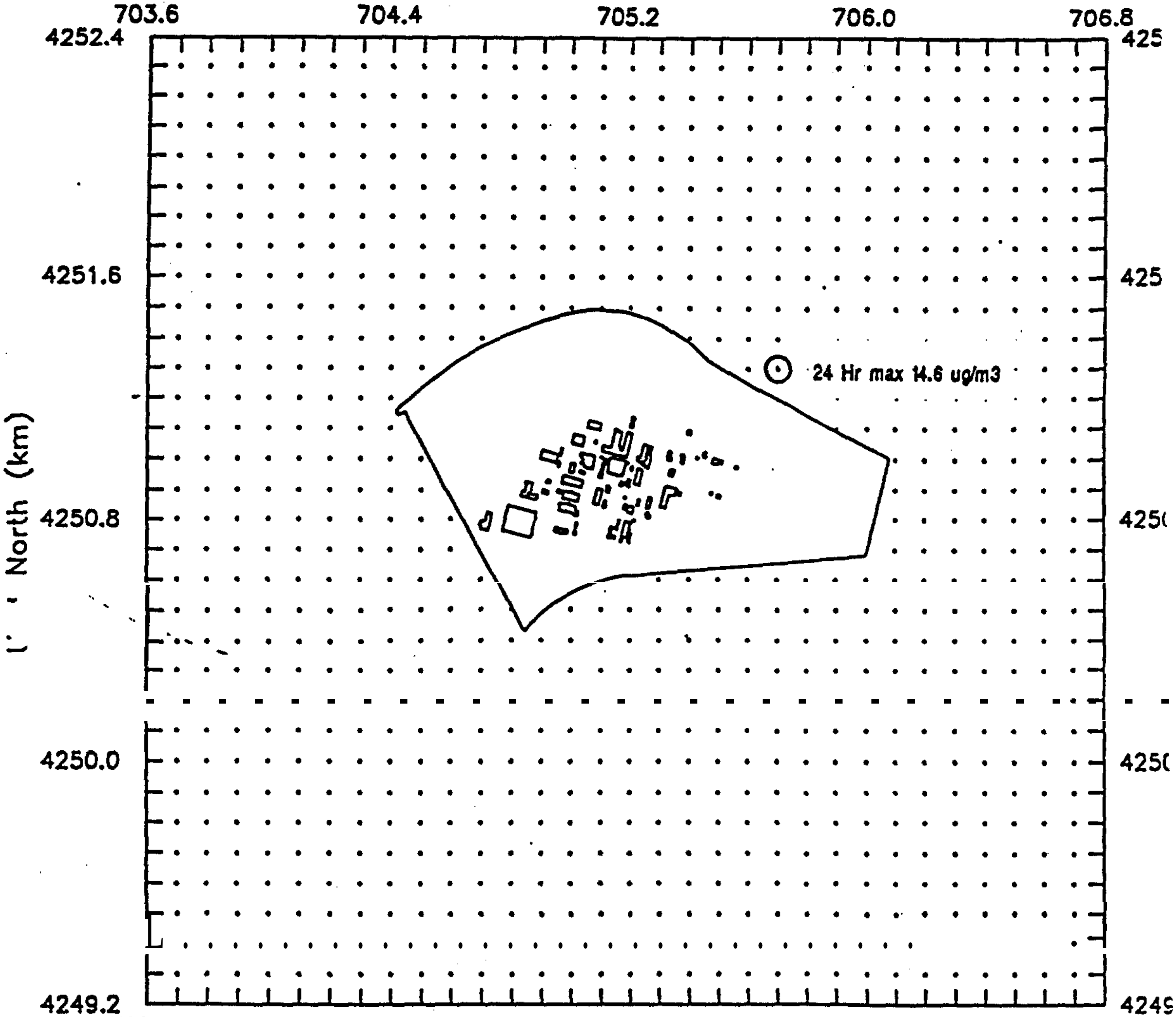
SO2 NAAQS MODELING

Stonewall Plant receptors used in the NAAQS and toxic pollutant modeling.



PM-10 NAAQS MODELING

Fine grid receptors used in the NAAQS and toxic pollutant modeling.



CO NAAQS Modeling

- Existing DEQ-approved modeling protocol used
- ATDM dispersion model used
- Building downwash effects calculated using BPIP
- One year of Coors' PSD-quality meteorological data used

CO NAAQS Modeling

Assumptions:

- 600 TPY emission rate (assume entire available cap was consumed by CO emissions)
- Emissions modeled as if they came from the present Powerhouse stack
- Stack parameters same as existing Powerhouse running flat out

CO Modeling Results

	NAAQS Standard (ug/m3)	Maximum Modeled Impact (ug/m3)
1 Hour	40,000	351
8 Hour	10,000	97

CO MODELING, 5/7/96

Figure 2-9. Coarse grid receptors used in the NAAQS modeling.