Anna Darian

I serve as the Director of Advocacy and Community Engagement for Save the Scenic Santa Ritas.

Since 1996 our organization has been fighting to protect the Santa Rita Mountains from the devastating effects of industrial, open-pit mining. We are 3,000 citizens united to defend the wild mountains we love.

Our team worked alongside the Center for Biological Diversity in developing the comment letter, attached herein. These comments both reflect science-based technical analysis of the draft permit, and the real fears of community members whose home and health depend on ADEQ making a responsible decision with regard to this permit.

By several key measures, we have demonstrated that this should rightfully be a Class I permit and we urge you to consider our requests.

September 15, 2024

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Re: Objection to Draft Air Pollution Permit, Hudbay, Copper World Inc., Copper World Mine, Draft Permit No. 96659, Pima County

Dear Director Peters and Ms. Murrieta:

The Tohono O'odham Nation, Pascua Yaqui Tribe, the Center for Biological Diversity, Save the Scenic Santa Ritas, Sierra Club—Grand Canyon Chapter, Sky Island Alliance, Friends of Madera Canyon, Tucson Audubon, Coalition for Sonoran Desert Protection, Arizona Mining Reform Coalition, Patagonia Area Resource Alliance, Great Old Broads for Wilderness—Tucson Broadband, Calabasas Alliance, Living Desert Alliance, and Wild Earth Guardians join in submitting the attached technical comments on the Arizona Department of Environmental Quality's (ADEQ's) proposal to issue an air pollution permit that would authorize Hudbay subsidiary, Copper World, Inc., to construct and operate the Copper World Project, Permit No. 96659.

The Copper World Project is a massive new open-pit copper mine proposal that would be constructed in the biologically diverse and significant Santa Rita southeast of Tucson in Pima County. The air pollution permit would lead to the construction and operation of hundreds of new sources of harmful air pollution.

The Tribes and organizations joining in these comments object to ADEQ's proposal to issue the permit.

The proposal will lead to the construction and operation of a massive new mining operation that threatens to release hundreds of tons of toxic air pollution, putting public health and communities at risk. The primary pollutants that will be released include particulate matter (including coarse particulate matter, or PM_{10}, and fine particulate matter, or $PM_{2.5}$—both serious risks to public health), nitrogen oxides, carbon monoxide, sulfur dioxide, sulfuric acid, volatile organic compounds, and hazardous air pollutants like benzene, a known carcinogen, and heavy metals like arsenic, manganese, and lead. There is scientific consensus that there is no safe level of lead exposure, particularly for children.[1]

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[1] ADEQ explicitly acknowledged this scientific consensus at the August 14, 2024 public meeting regarding the Copper World Mine air pollution permit.

Copper World's own application and analyses already indicate that construction and operation of the mine will likely interfere with attainment of national ambient air quality standards for PM_{10}. For this reason alone, ADEQ has no legal authority to approve the permit.

Further, as explained in detail in the attached technical comments, the draft permit fails to comply with applicable requirements under the Clean Air Act, including requirements of the applicable Arizona State Implementation Plan (SIP). Accordingly, the draft permit cannot be issued and must be denied.

Of primary concern is that ADEQ is improperly permitting the Copper World Mine as a Class II source of air pollution, rather than a Class I source. According to Copper World's own emission calculations, the Mine will be a Class I source of air pollution, requiring more oversight and scrutiny under the Arizona SIP.

ADEQ appears to have misclassified several emission units at the Copper World Mine as fugitive in nature, when in fact they are not fugitive. ADEQ itself appears to have acknowledged this, stating at a public meeting in August that emissions from ore processing should have been included as non-fugitive emissions. If emissions were properly classified, total non-fugitive emissions of particulate matter would far exceed the 100 ton/year threshold for Class I permitting.

Furthermore, if emissions were properly classified and calculated, then it appears they are likely to exceed 250 tons/year, meaning the Copper World Mine must be permitted as a major source under the Clean Air Act's Prevention of Significant Deterioration (PSD) provisions, as set forth in the Arizona SIP. *See* A.A.C. R18-2-406. A major source must utilize best available air pollution control technology, demonstrate that emissions will protect environmental values, including visibility, and must ensure full protection of health-based air quality standards.

Adding to concerns is that a number of terms and conditions in the permit intended to limit the Mine's potential to emit to below PSD and Class I permitting thresholds are not enforceable as a practical matter and/or do not contain sufficient periodic monitoring to assure compliance.

To legitimately limit a source's potential to emit, a permit must contain "[e]nforceable emission limitations and standards, including operational requirements and limitations that ensure compliance with all applicable requirements." A.A.C. R18-2-306(A)(2). Permits must also be "enforceable as a practical matter," particularly where voluntary limits are accepted to limit a source's potential to emit in order to avoid more stringent permitting requirements. A.A.C. R18-2-306.01(A). To this end, permits must include monitoring that assures compliance with applicable requirements. Where applicable requirements do not require monitoring, permits must set forth "periodic monitoring sufficient to yield reliable data from the relevant time period that are representative of the source's compliance with the permit[.]". A.A.C. R18-2-306(A)(3)(c).

In this case, the draft permit contains improper affirmative defenses that undermine the enforceability of permit terms and conditions, fails to set forth sufficiently specific limits on production and emissions, does not establish applicable particulate matter limits for a number of emission units, and does not require sufficient periodic monitoring for a number of emission units.

If ADEQ is to issue any permit for the Copper World Mine, it must, at a minimum, meet the following:

- The Copper World Mine must be permitted as a Class I source of air pollution. The draft Class II permit must be withdrawn and Copper World, Inc. must be instructed to submit a new application for a Class I permit. A new permit must be drafted and subject to appropriate public scrutiny, as required by the Arizona SIP.

- The Copper World Mine must also be permitted as major source under Clean Air Act PSD requirements and Copper World must comply with best available air pollution control technology requirements. As written, the draft permit appears to authorize emissions of particulate matter at levels above major source thresholds. Any permit must assure that best available control technology is used to limit pollution.

- Any permit must establish enforceable limits on air pollution and operational limitations and requirements that assure compliance. To this end, any permit must set forth specific and detailed periodic monitoring and testing requirements to assure compliance for all emission sources at the mine. The permit must also require recordkeeping and reporting of all monitoring to ensure the permit is federally enforceable under the Clean Air Act.

Ultimately, ADEQ must ensure that any permit for the Copper World Mine is understandable, enforceable, and effective in limiting emissions and protecting people, communities, and the environment. As proposed, the current draft permit does not accomplish this. ADEQ is urged to change course and deny Copper World's application or otherwise ensure that the Mine is permitted as a Class I source and that any permit is fully protective of public health and the environment.

Please contact us with any questions or concerns.

Sincerely,

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TECHNICAL COMMENTS

Draft Class II Air Pollution Permit,
Copper World, Inc, Copper World Mining Project
Permit No. 96659, Pima County, Arizona

September 15, 2024

The following technical comments are provided on the Arizona Department of Environmental Quality's (ADEQ's) Air Pollution Control draft Class II air pollution permit (hereafter "draft permit") for Copper World Inc. (hereafter, "Copper World") to construct and operate the Copper World Mining Project (hereafter "Copper World Mine"), Permit No. 96659.

There is overarching concern that the draft permit does not assure compliance with applicable requirements under the Clean Air Act, including requirements under the Arizona State Implementation Plan (SIP). Of primary concern is that ADEQ has inappropriately proposed a Class II permit, when in fact the Copper World Mine is a Class I source of emissions according to the Arizona SIP. ADEQ appears to have incorrectly classified several emission points as sources of "fugitive" emissions, when in fact they are not fugitive and therefore count toward the mine's status as a Class I source of emissions. Further, the draft permit does not appear to appropriately limit the mine's potential to emit to below prevention of significant deterioration (PSD) permitting thresholds set forth in the Arizona SIP.

The draft permit is also unenforceable in a number of areas and lacks sufficient monitoring to assure compliance with all applicable reuqirements. By all appearances, it seems the Copper World Mine will interfere with attainment and maintenance of the national ambient air quality standards (NAAQS). ADEQ's must deny the draft permit over its failure to assure compliance with applicable requirements.

I. The Copper World Mine is a Class I Source of Emissions

It appears that ADEQ has inappropriately classified the Copper World Mine as a Class II source under the Arizona SIP's PSD requirements. In calculating the Mine's potential to emit, ADEQ and Copper World both assert that potential emissions of pollutants will be below the Class I threshold of 100 tons per year. This does not appear to be supported by the draft permit and Copper World's application with regards to particulate matter (PM) emissions and particulate matter less than 10 microns in diameter (PM_{10}).

Of primary concern is that Copper World and ADEQ have not properly categorized fugitive emissions. While fugitive emissions are excluded from the calculation of whether a source is major, non-fugitive emissions are not. Here, it appears non-fugitive emissions have been erroneously excluded from the calculation of potential and that ADEQ has erroneously claimed the Copper World Project will not be a major source and not require a Class I permit.

Under the Arizona SIP, fugitive emissions are defined as, "those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening." A.A.C. R18-2-101.59.[1] In interpreting this definition, the U.S. Environmental Protection Agency (EPA) has consistently explained that a determination of whether emissions can "reasonably pass through a stack, chimney, vent, or other functionally equivalent opening" is based on an assessment of whether emissions can reasonably be collected and passed through a stack, chimney, vent, or other functionally equivalent opening. *See* Exhibit 1, U.S. EPA, "Interpretation of the definition of fugitive emissions in Parts 70 and 71," Memo from Thomas C. Curran to Judith Katz (Feb. 10, 1999) at 2. When assessing whether emissions can reasonably be collected, EPA has further held that a determination of "reasonableness" should be construed "broadly." Exhibit 2, U.S. EPA, "Classification of emissions from landfills for NSR applicability purposes," Memo from John S. Seitz to Regional Air Division Directors (Oct. 21, 1994) at 2. EPA has generally held that where emission collection technology is in use by other sources within the same source category or by a similar pollutant emitting activity, there is a presumption that collection is reasonable. *Id*.

First and foremost, it appears that Copper World and ADEQ appear to believe that a determination of whether emissions are fugitive is based on whether emissions are passing or will pass through a stack, chimney, vent, or other functionally equivalent opening, not whether they "could" reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

In response to a May 2, 2023 ADEQ request for additional information, Copper World asserted that PM emissions from "rock breakers and associated material transfer points" were fugitive because they "are not emitted into the atmosphere through a 'vent, stack or functionally equivalent opening.'" Copper World Response to Comprehensive Request for Additional Information (May 31, 2023) at 4. However, a determination of whether emissions are fugitive is not based on whether emissions ***are*** passing or ***will pass*** through an opening. Rather, a determination of whether emissions are fugitive is based on whether emissions ***can*** "reasonably pass through" a "vent, stack or functionally equivalent opening," meaning ***can*** emissions reasonably be collected and passed through an opening. Here, as Copper World notes in its application, PM emissions from the rock breakers and material transfer points can be collected using dust collectors, enclosures, and other techniques. *See* Copper World Air Permit Application, at 4-9—4-10. This means the emissions are not fugitive.

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[1] This definition echoes the definition of "fugitive emissions" found in federal regulations implementing various stationary source permitting requirements of the Clean Air Act. *See* 40 C.F.R. § 51.165(a)(1)(ix), 40 C.F.R. § 51.166(b)(20), 40 C.F.R. 52.21(b)(20), 40 C.F.R. § 63.2, 40 C.F.R. § 70.2, and 40 C.F.R. § 71.2.

Secondly, Copper World classifies a number of pollutant emitting activities as sources of fugitive emissions, even though these emissions could reasonably pass through vents, stacks or functionally equivalent openings.

For instance, Copper World appears to classify all stockpiles, including the run of mine stockpile, oxide stockpile, and sulfide stockpile, as sources of fugitive PM, including PM_{10} and $PM_{2.5}$, yet stockpiles can be enclosed, which allows for the capture of emissions and the ability to vent them through a vent, stack or functionally equivalent opening. Enclosed stockpiles are utilized at mining operations around the world and companies offer custom-engineered enclosures. *See e.g.* Exhibit 3, Bulk Storage Domes offered by Geometrica, website available at https://www.geometrica.com/en/bulk-subsection-english. As Geometrica explains on its website:

> Power plants, grain dealers, mines, cement plants, ports and many other industries need to stock large quantities of dry bulk materials. These are often left uncovered, or stored in vertical silos. But silos are small and expensive, while open stockpiles are subject to material spoilage, and pollute with dust and runoff. A dome is a smart investment. Organizations that store feed, ores or solid fuels have looked for and found a cost effective way to solve their large storage needs: Geometrica's geodesic domes.

Id. Copper World itself discloses in its application that it intends to enclose the copper concentrate stockpile at the proposed mine, indicating that enclosed stockpiles are presumed reasonable.[2]

Similarly, Copper World discloses in its application that several loading and unloading transfer points associated with mining (i.e., not hauling-related sources), including the emission points MN03a, MN03b, MN04a, MN04b, MN05a, MN05b, MN09, MN10, and MN11, are considered sources of fugitive particulate matter when in fact enclosures can be utilized to capture and control emissions. Indeed, there are many companies offering dust collection systems for use in the mining industry and in particular for material transfer points. The company, Donaldson Filtration Solutions, offers dust collection systems for truck dumps, crushers, screens, conveyor belt transfer points, silos or bin filling, and truck loading. *See* Exhibit 4, Donaldson Filtration Solutions, “Mining and Mineral Processing,” website available at https://www.donaldson.com/en-us/industrial-dust-fume-mist/industries/mining-mineral-processing/. The company RoboVent also offers dust collection systems for excavation sites, conveyors, belt transfer points, weigh-belt feeders, ore storage bins and silos, crushers and grinders, hammer mills and ball mills, screeners, and blenders. *See* Exhibit 5, RoboVent, “Dust Collection for Mining and Mineral Processing,” website available at https://www.robovent.com/industrial-dust-collection/mining/. Again, this

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[2] In spite of the fact that the copper concentrate stockpile will be enclosed, Copper World classifies emissions from the stockpile as “fugitive” in its application, further underscoring that the company has not accurately characterized fugitive and non-fugitive emissions.

confirms that emissions from material transfer points can reasonably be collected and controlled, meaning they are not fugitive.

Even for tailings storage, it appears that covering and controlling wind erosion-related emissions is not only feasible, but will also be utilized by Copper World. According to Copper World's application, only a portion of the tailings storage (500 acres) was considered to be susceptible to wind erosion and particulate emissions while the area of tailings storage "that is not actively wetted or covered with ponded tailings fluid" was not considered to be a source of particulate matter emissions. Clearly it is possible to cover tailings and control emissions. Given that PM, PM_{10}, and $PM_{2.5}$ emissions associated with tailings storage will be substantial, it is concerning that these emissions were discounted as fugitive when they are not.

Although it may be claimed that the cost of constructing emission collection systems, such as enclosures, etc., argues against considering emissions to be non-fugitive, the EPA has cautioned that cost considerations should not "be given any more weight than other factors." Exhibit 1 at 3. This is especially true given that a determination that emissions from the Copper World Project are non-fugitive would not require Copper World to construct collection systems. Rather, it would simply require Copper World to either take steps to limit the facilities' potential to emit non-fugitive emissions or to employ other control strategies to comply with applicable permitting requirements.

Most concerning is that emissions from several units at the Copper World Mine classified as fugitive by Copper World will actually be collected and controlled. This appears to include virtually all emissions associated with oxide ore processing and sulfide ore processing, including emissions from crushers, rock breakers, and related activities. For example, emissions from several crushers, including the oxide primary crusher, the oxide secondary crusher, and the sulfide primary crusher, will be captured and controlled with a dust collector, yet Copper World claims these emissions will be fugitive. Emissions from other crushers, rock breakers, conveyors, transfers, feeders, chutes, and screens are also similarly classified as fugitive, yet Copper World's own application discloses that emissions from these sources will be captured and controlled with dust collectors. It is telling that Copper World claims emissions from these activities will largely be controlled by 99% or more, an extremely high control efficiency reflecting the fact that emissions will be contained and controlled, making them non-fugitive.

The draft permit itself confirms that emissions from the oxide primary crusher and associated emission points, oxide secondary crusher and associated emission points, sulfide primary crusher and associated emission points, and sulfide pebble crusher and associated emissions points will all be capture and controlled using cartridge dust collectors. *See* Draft Permit at 25-28.

Perhaps more telling is that ADEQ disclosed to the public on August 14, 2024 that emissions form ore processing should in fact be reclassified as non-fugitive emissions. In response to a question from a concerned member of the public regarding ore processing emissions and whether they were properly classified, ADEQ Permit Engineer Jeff Christensen stated:

> All of the emission sources for ore processing are ventilated to dust collection equipment and each of these dust collection equipment are having a grain loading limit in the permit which the facility will require to conduct their performance testing for.
>
> So I think what you're referring to is the 99% pickup efficiency that they reference for a lot of those control devices. **And I don't think it would be unreasonable to count those as non-fugitive emissions**. **In fact, I think going back, we should probably have included those as non-fugitive emissions from the total potential to emit**.

Video and audio of the public question and Mr. Christensen's response is available online here, https://www.youtube.com/watch?v=ub-94ElOAFc. Mr. Christensen went on to state, "I agree, I think that we could reclassify those operations as non-fugitive and present those numbers to the public."

The failure to properly characterize fugitive and non-fugitive emissions refutes ADEQ's claim that the Copper World Mine is a Class II source of air pollution. Indeed, accounting for particulate matter emissions that should be classified as non-fugitive, the potential to emit for the Copper World Mine is well above Class I thresholds, with potential PM and PM_{10} emissions well above 100 tons/year. Total non-fugitive PM would be 135.59 tons/year just from ore processing. Total non-fugitive emissions would be 433.39 tons/year, exceeding the PSD major source threshold of 250 tons/year.

The table below, which is based on the emission inventory data provided in Appendix F of Copper World's application, underscores the consequences of failing to properly classify particulate matter emissions as non-fugitive.

Total Non-fugitive Particulate Matter Emissions Associated with Copper World Mine in Tons/Year.

*Data from Appendix F to Copper World Permit Application, Year 8 Potential to Emit Spreadsheet. Ore Processing Emissions are Based on Calculations of Controlled Emissions Disclosed in Copper World's Application***.**

	PM	PM_{10}	$PM_{2.5}$
Total non-fugitive emissions disclosed in TSD	62.18	35.60	23.86
Total controlled non-fugitive emissions form oxide ore processing	70.89	16.45	2.88
Total controlled non-fugitive emissions from sulfide ore processing	64.70	8.77	1.52
Total non-fugitive emissions from mining loading and unloading	51.82	24.51	3.71
Total non-fugitive emissions from run of mine stockpile	2.54	1.27	0.38
Total non-fugitive emissions from tailings storage	181.26	90.63	13.59
TOTALS	**433.39**	**177.23**	**45.94**

In light of this, ADEQ cannot proceed with permitting the Copper World Mine as a Class II source of emissions. ADEQ must withdraw the draft permit. If Copper World wishes to proceed with its proposed Copper World Mine, it must submit an application for a Class I permit and ensure submission of all required plans and schedules required for Class I permit applications.

II. ADEQ has not Demonstrated that Approval of the Copper World Mine Air Pollution Permit Will not Interfere With Attainment of the National Ambient Air Quality Standards

ADEQ cannot approve an air pollution permit unless it is demonstrated that the source will not interfere with attainment or maintenance of the NAAQS. A.A.C. R18-2-334(F). Here, it does not appear that ADEQ or Copper World have demonstrated that construction and operation of the Copper World Mine will not interfere with attainment of the NAAQS for PM_{10}.

Attached to these comments is a report by Dr. Eric Betterton, Save the Scenic Santa Ritas Board Member and University of Arizona Distinguished Professor Emeritus in Hydrology and Atmospheric Sciences, detailing serious flaws in Copper World's analysis of PM_{10} impacts and ADEQ's assessment of Copper World's finding. *See* Exhibit 6, Betterton, E., "Comments on Revised AERMOD Modeling Report for Copper World" (Aug. 12, 2024) and Exhibit 7, Dr. Eric Betterton Curriculum Vitae. Among the flaws identified by Dr. Betterton:

- All relevant data supporting Copper World's monitoring has not been made publicly available as part of the documents supporting the draft permit and underlying modeling analysis.

- Copper World did not provide rationale for using inconsistent data sets for assessing PM10 impacts, including meteorological data. The company's methodologies are also not clearly disclosed and appear to be haphazard and statistically invalid.

- Copper World inappropriately and inexplicably excluded PM_{10} monitoring data used to determine background concentrations and assess the Copper World Mine's impacts to ambient air quality. Copper World cited the EPA's Guidelines for Exceptional Events, yet the excluded data does not qualify as "Exceptional Events." Copper World appears to have cherry-picked data in order to generate results favorable for the Copper World Mine, which in turn ignore the reality of the state of air quality in the region.

- Copper World excluded consideration of background particulate matter data on the basis of "high winds," yet provides no information or analysis to suggest that monitored PM_{10} values were the result of any winds outside the range of natural variability. It is inexcusable to ignore the reality that winds occur in Arizona and at times can exacerbate the anthropogenic emission of PM_{10}.

- The data provided by Copper World appears to demonstrate that the Copper World Mine will, in fact, interfere with attainment of the PM_{10} NAAQS. Despite the company's claim otherwise, the data appear to support the conclusion that air quality impacts will be more severe than asserted.

In light of these findings, it appears ADEQ must deny the draft permit due to its interference with attainment of the NAAQS. However, at a minimum, ADEQ must require Copper World to redo its analysis to include excluded PM_{10} monitoring data and require the company to conduct a new analysis using consistent and clearly disclosed methodologies and to provide all underlying data utilized for any new modeling to the public for review.

III. The Draft Permit Contains Improper Affirmative Defenses

The draft permit includes a number of affirmative defense provisions that, with limited exceptions, effectively authorize Copper World to violate applicable emission standards or limitations. These affirmative defense provisions are not only contrary to applicable requirements, but also appear to call into question ADEQ's calculation of the Copper World Mine's potential to emit.

A. The “Emergency Provision” Affirmative Defense is no Longer an Applicable Requirement and Cannot be Included in the Draft Permit

Attachment “A”, Condition XII.C of the draft permit sets forth a federally enforceable affirmative defense for violations of “technology-based emission limitations” during “emergencies,” effectively granting Copper World the ability to violate the terms and conditions of the permit in the event of emergencies. This “Emergency Provision,” however, cannot be included in the permit as a federally enforceable condition.

In July of 2023, the EPA finalized a rule removing the “emergency” affirmative defense provision from Title V regulations at 40 C.F.R. § 70. 88 Fed. Reg. 47,029 (July 21, 2023). This rule became effective August 21, 2023. As part of this rule, EPA instructed states to remove “emergency” affirmative defenses from individual permits “at their earliest convenience.” 88 Fed. Reg. 47,029, 47,046.

While the “Emergency Provision” condition is currently contained in ADEQ’s regulations at A.A.C. R18-2-306(E), the EPA’s final rule clearly instructs states to comply with 40 C.F.R. § 70 and remove any “emergency” affirmative defense provisions from individual permits.

Simply because the “Emergency Provision” may continue to exist at A.A.C. R18-2-306(E) does not mean that its inclusion in the draft permit as a federally enforceable provision is appropriate. Because the “emergency” affirmative defense has been removed from Clean Air Act Title V rules at 40 C.F.R. § 70, it is no longer a requirement of these regulations and there is no requirement that it be included in any permit. Indeed, inclusion of the “Emergency Provision” affirmative defense as a federally enforceable requirement actually defies A.A.C. R18-2-306(A)(2), which requires that permits include “[e]nforceable emission limitations and standards, including operational requirements and limitations that ensure compliance with all applicable requirements[.]”. Inclusion of the “Emergency Provision” means the draft permit does not provide for compliance with all applicable requirements. The federally enforceable affirmative defense explicitly allows for noncompliance with emission limitations that are applicable requirements. Accordingly, it cannot be included in the draft permit.[3]

B. The Malfunction, Startup, and Shutdown Affirmative Defense is no Longer an Applicable Requirement and Cannot be Included in the Title V Permit

Attachment “A”, Condition XII.D of the draft permit sets forth federally enforceable affirmative defenses for violations of applicable emission limitations due to malfunctions, startups, and shutdowns. These affirmative defenses, however, are no

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[3] It is notable that ADEQ removed the “Emergencies” affirmative defense provision from a final air pollution permit issued to South32 for the construction and operation of the Hermosa Mine (Permit No. 96653), located south of where the Copper World Mine will be located.

longer applicable requirements and cannot be included in the draft permit as federally enforceable conditions.

The affirmative defenses set forth at Attachment "A", Condition XII.D specifically incorporate provisions under A.A.C. R18-2-310. However, A.A.C. R18-2-310 is not an applicable requirement. While it was previously incorporated into the Arizona SIP, EPA approved its removal from the SIP in March 2022. *See* 87 Fed. Reg. 14,802, 14,805 (March 16, 2022). This means A.A.C. R18-2-310 is not an applicable requirement as it is not a part of the Arizona SIP or otherwise an applicable requirement. Accordingly, these affirmative defenses cannot be included in the draft permit as federally enforceable requirements.[4]

Although it may be asserted that inclusion of the malfunction, startup, and shutdown affirmative defenses is acceptable so long as they are designated as "state-only enforceable" (i.e., not federally enforceable), federally enforceable permits cannot contain state-only enforceable terms that "impair the effectiveness of the permit or hinder a permitting authority's ability to implement or enforce the permit." *In the Matter of Harquahala Generating Station Project*, Order on Petition at 5 (July 2, 2003).

Here, the inclusion of the malfunction, startup, and shutdown affirmative defenses, even if they are not federally enforceable, would hinder the ability of ADEQ to enforce the terms and conditions of the permit and, as a practical matter, impair the ability of the permit to assure compliance with federally enforceable applicable requirements, including voluntary limits on potential to emit, at all times. As written, the malfunction, startup, and shutdown affirmative defenses provide an affirmative defense to enforcement of emission limits, including all applicable federally enforceable limits. Even if designated "state-only enforceable," the practical impact of the affirmative defenses would be to allow Copper World to assert an affirmative defense to state enforcement of violations of federally enforceable emission limits.[5] A "state-only" provision of a permit cannot interfere with the enforceability and effectiveness of federally enforceable emission limits in such a manner. A "state-only" affirmative defense can only apply in the context of non-federally enforceable emission limits. As the EPA has held, such "state-only" affirmative defenses are not "available in enforcement actions for alleged violations of any federally enforceable requirements[.]" 88 Fed. Reg. 47029, 47,049 (July 21, 2023).

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[4] It is notable that ADEQ removed the "Malfunction, Startups, and Shutdowns" affirmative defense provision from a final air pollution permit issued to South32 for the construction and operation of the Hermosa Mine (Permit No. 96653), located south of where the Copper World Mine will be located.

[5] Although the affirmative defenses may not apply in cases of "judicial action seeking injunctive relief," they would apply to any administrative enforcement action, including administrative enforcement action seeking injunctive relief, as well as to all enforcement actions seeking civil penalties. Thus, they would still interfere with the enforceability of federal emission limits.

IV. Specific Permit Concerns

Each permit issued by ADEQ shall include "[e]nforceable emission limitations and standards, including operational requirements and limitations that ensure compliance with all applicable requirements." A.A.C. R18-2-306(A)(2). Permits must also be "enforceable as a practical matter," particularly where voluntary limits are accepted to limit a source's potential to emit in order to avoid more stringent permitting requirements. A.A.C. R18-2-306.01(A). To be "enforceable as a practical matter" means that "specific means to assess compliance with an emissions limitation, control, or other requirement are provided for in the permit in a manner that allows compliance to be readily determined by an inspection of records and reports." *Id*. To this end, permits must include monitoring that assures compliance with applicable requirements. Where applicable requirements do not require monitoring, permits must set forth "periodic monitoring sufficient to yield reliable data from the relevant time period that are representative of the source's compliance with the permit[.]". A.A.C. R18-2-306(A)(3)(c).

Here, there is concern that numerous permit conditions are unenforceable as a practical matter due to unspecific and ambiguous language and/or due to a lack of sufficient periodic monitoring.

A. Attachment "B", Condition II

Condition II.B.2 sets forth facility-wide requirements, including emission limitations and operational limitations and requirements.

Condition II.B.2.a establishes a limit on production of 200,000 tons of material, including ore and waste rock, mined. It is not clear what the term "mined" means for purposes of assessing compliance with this limit. Does "mined" mean the moment that ore and rock is blasted or does it mean the moment that ore and rock are loaded and hauled away?

Adding to the lack of clarity is that while Conditions II.B.3.b(2)-(3) require Copper World to maintain logs containing the "total quantity of ore mined" and "total quantity of waste rock mined," it is not clear how "total quantity" of ore and waste rock mined is to actually be measured and monitored such that Copper World records reliable data representative of compliance with the applicable limit. More details are needed to ensure it is understood what the term "mined" means and how Copper World will accurately monitor mined quantities of ore and waste rock in order to assure compliance with the applicable limit.

Condition II.B.2.b(3) sets forth limits on blasting, but there is concern that the limits do not account for critical factors that influence blasting-related emissions. Emissions from blasting, in particular NO_x emissions, are dependent upon a number of factors other than tons of ANFO used, blasting area, and blasting frequency. Sopko et al. 2002 identifies a number of factors that influence the creation of NO_x emissions, including:

- Sleep time, or the time between loading and firing. Longer sleep times were associated with higher NO_x emissions.

- Wicking of oil in loads. Sopko et al. recommended using borehole liners to reduce wicking of oils and to reduce NO_x emissions.

- Ammonium nitrate dissolution with water. Moisture content of rock, as well as ambient weather conditions (e.g., rainy conditions), can lead to more water interacting with emulsion and reduce blast efficiency.

- Diameter of borehole. Sopko et al. found that detonation velocity when using emulsion was greatest at smaller borehole diameters, also reducing NO_x emissions.

Exhibit 8, Sopko, et al., "Chemical and Physical Factors that Influence NO_x Production during Blasting—Exploratory Study" (2002).[6] Despite this information in Sopko et al., Copper World's calculation of potential blasting emissions does not address sleep time, wicking, moisture content, or borehole diameter. Even the primary study relied upon by Copper World, Moetaz, et al., "NO_x Emissions from Blasting Operations in Open-Cut Coal Mining," states that, "localised conditions such as moisture in the blast hole, mineral matter or other factors) can lead to the formation of substantial amounts of the toxic gases carbon monoxide (CO) and nitric oxide (NO)."

While this all raises concerns that Copper World's potential to emit calculation for blasting is flawed, the fact that the draft permit sets no limits or requirements addressing sleep time, wicking, moisture content, or borehole diameter further underscores that the permit does not, as a practical matter, limit emissions from blasting to at or below levels estimated by Copper World in its application. This raises concerns that the ambient air quality impacts analysis has not accurately assessed impacts to the NAAQS, in particular NAAQS for nitrogen dioxide (NO_2).

Condition II.C sets forth overarching opacity monitoring requirements, but it does not appear to assure compliance with applicable quantitative opacity limits.

To begin with, Condition II.B.3.c only requires quantitative opacity monitoring if there is the "appearance" of opacity that is greater than the applicable standard. The word "appearance" is an extremely subjective term and provides no meaningful or enforceable standard for requiring quantitative opacity monitoring. It is not clear who or what is "observing," whether that person (or thing, as the case may be) is qualified to "observe," from what location, or what specific qualitative parameters are actually being observed such that the "appearance" of opacity can be accurately gauged. Emissions could "appear" to exceed the applicable standard for one observer, yet the same emissions could "appear" not to exceed the applicable standard for another observer.

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[6] This study has been relied upon by other mining companies in Arizona to assess blasting emissions, most recently by the company South32 in support of its Hermosa Mining Project in Santa Cruz County.

While the draft permit cannot rely on qualitative monitoring to demonstrate compliance with the applicable quantitative opacity limit, in this case the permit allows Copper World to completely forego quantitative monitoring of opacity on the basis of qualitative observations of the "appearance" of opacity. This is not sufficient periodic monitoring.

Further, to the extent that quantitative monitoring may occur, it must be conducted by an "EPA Reference Method 9 certified observer," but the Title V Permit at Condition II.C.2 does not require a certified observer to be on site, only "on call." This clearly suggests that certified observers are likely to not be on site in the event of visible emissions requiring Method 9 observations, meaning it is likely not possible to conduct the "immediate" observation required by Condition II.B.3.c. Given that compliance with applicable opacity limits relies entirely on observations by certified Method 9 observers, the draft permit cannot rely on "on call" observers who are not on-site to conduct the required "immediate" observations to determine compliance.

B. Attachment "B", Condition III.A

Condition III.A.3.e requires "weekly surveys of visible emissions" in accordance with Condition II.C to assure compliance with the applicable 20% limit set forth at Condition II.B.1.b, as well as requires monitoring to assure compliance with more stringent opacity limits set forth at Condition III.B and III.C. Condition II.C does not set forth sufficient periodic monitoring, however. As discussed above, Condition II.C does not require quantitative monitoring of opacity to assure compliance and does not assure that there are qualified people present to conduct opacity monitoring when necessary.

Conditions III.A.2.b and III.A.2.c require Copper World to "install, operate, and maintain a water suppression fogging system" to control emissions from oxide and sulfide ore feed bins, rock breakers, and feed bin to primary crusher transfer points. It is not clear what a "water suppression fogging system" is and how these systems will be installed and configured such that they will effectively control particulate matter at all times. The permit must provide more detail so that it is understood what particular equipment must be installed, operated, and maintained in order to assure compliance with these Conditions.

Adding to our concerns it that there are no applicable quantitative limits set forth in the permit governing the operation of the water suppression fogging systems, meaning it is not possible to assess whether the fogging systems are actually performing as intended. This is concerning as Copper World's application indicates that potential particulate matter emissions from these emission units could be very high (more than 170 tons/year of PM if not controlled) and that the fogging systems will achieve a 93% control efficiency to effectively limit potential emissions. To assure the fogging systems achieve at least this level of control efficiency, there must be quantitative limits and/or standards set forth in the permit, either emission limits or a standard that requires compliance with the 93% control efficiency assumptions. Although Condition III.A.3.d requires weekly inspections of the fogging systems to ensure water is flowing to discharge spray nozzles, there is no indication that simply ensuring water is flowing to discharge spray nozzles assures compliance with the 93% control efficiency assumption or effectively ensures particulate matter emissions are effectively limited consistent with the assumptions in Copper World's application.

C. The Draft Permit Does not Assure Monitoring of "Uncombined Water"

Conditions III.C.2.c, III.D.2.c, and IV.B.1.d all provide that if the presence of uncombined water is the only reason for an opacity exceedance, the exceedance shall not constitute a violation of the applicable opacity limit. However, the draft permit sets forth no monitoring of "uncombined water" that would assure compliance with the exemptions set forth in these Conditions. In order for this exemption to be legitimately applied in accordance with the Arizona SIP and Pima County Code, the permit must set forth sufficient monitoring of "uncombined water" in order to verify the presence of "uncombined water" and its contribution to any exceedance of the 20% opacity limit. Without monitoring, this exemption is not enforceable and does not assure compliance with applicable opacity limits.

D. The Draft Permit Fails to Set Forth Applicable Particulate Matter Limits

Several provisions of the draft permit require compliance with applicable particulate matter limits, yet the permit does not actually set forth what these particulate matter limits are for purposes of ensuring compliance.

Conditions III.C.2.a, III.D.2.a, and IV.B.1.b all require compliance with applicable particulate matter limits set forth in Pima County Code, but these Conditions do not actually set forth the applicable limits. Instead, these Conditions simply incorporate language in the Pima County Code requiring applicable sources to establish maximum allowable hourly particulate matter emission limits using specific equations. For example, Condition III.C.2.a purports to establish "maximum allowable emissions," yet the Condition only sets forth equations for determining "maximum allowable emissions." Conditions III.D.2.a and IV.B.1.b similarly just set forth equations. This does not assure compliance with applicable requirements.

ADEQ was required to identify which sources are subject to the applicable equations and do the math to establish applicable particulate matter limits in the draft permit. It was not sufficient to simply reprint equations set forth in regulatory text without explaining how the regulations specifically apply. A permit cannot just refer to equations required to be utilized to establish enforceable limitations and standards.

This is especially true given that it is not clear how the equations would actually apply to any piece of equipment or activity subject to Conditions III.C.2.a, III.D.2.a, and IV.B.1.b.

The equations set forth in these Conditions are based on a source's "process weight rate." For example, Condition III.D.2.a(1) explains that for sources having a "process weight rate of 60,000 pounds per hour (30 tons per hour) or less, the maximum allowable emissions shall be determined by the following equation: $E = 3.59P^{0.62}$," where E = the maximum particulate limit and P = the process weight rate. Process weight rate, however, is a unique, emission unit-specific factor and it is unclear based on the draft permit what the "process weight rates" are for purposes of establish and assuring compliance with applicable particulate matter limits.

Pima County Code 17.16.130(F) explains that "process weight rate" is determined as follows:

> For continuous or long run, steady-state process sources, the process weight rate is the total process weight for the entire period of continuous operation, or for a typical portion of that period, divided by the number of hours of the period, or portion of hours of that period.
>
> For cyclical or batch process sources, the process weight rate is the total process weight for a period which covers a complete operation or an integral number of cycles, divided by the hours of actual process operation during the period.

P.C.C. 17-16-130(F)(1) and (2). Here, applicable requirements make clear that the "process weight rate" is not a constant, but rather a carefully calculated variable that depends on whether a source is "steady-state" or "cyclical" and on total process weight during appropriate activities and time periods. The draft permit does not even acknowledge P.C.C. 17-16-130(F) or attempt to establish any definition that is functionally equivalent.

Given that the correct definition of "process weight rate" under applicable requirements is source-specific, the permit must define and set forth "process weight rate" by emission unit to ensure the enforceability of Conditions III.C.2.a, III.D.2.a, and IV.B.1.b. Furthermore, in establishing specific maximum allowable particulate matter limits, any permit must assure sufficient periodic monitoring to ensure compliance with these limits.

EXHIBIT 1

February 10, 1999

<u>MEMORANDUM</u>

SUBJECT: Interpretation of the Definition of Fugitive Emissions
in Parts 70 and 71

FROM: Thomas C. Curran, Director /s/
Information Transfer and Program
Integration Division (MD-12)

TO: Judith M. Katz, Director
Air Protection Division, Region III (3AT00)

This is in response to your memorandum of August 8, 1997 and subsequent discussions regarding the definition of "fugitive emissions." Specifically, you asked how this definition applies to the emissions of volatile organic compounds (VOC) from the printing industry, whiskey warehouses, paint manufacturing facilities, and other similar sources for purposes of title V. The delay in getting back to you was principally due to extensive consultation as needed among the various Headquarters and Regional Offices and has resulted in more technically and legally supportable policy.

When counting emissions to determine if a source exceeds the major source thresholds under title V (parts 70 and 71), nonfugitive VOC emissions are always counted. Fugitive VOC emissions, however, are counted only in certain circumstances. Because of this, the determination of whether emissions are fugitive or nonfugitive can be critically important for major source determinations under title V.

The EPA defines "fugitive emissions" in the regulations promulgated under title V as "those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening" (see title 40 of the <u>Code of Federal Regulations</u>, sections 70.2 and 71.2). This definition is identical to the definition of "fugitive emissions" adopted by EPA in the regulations implementing the new source review (NSR) program. Given this, the precedents established in the NSR program should be relied on in interpreting the definition of “fugitive emissions” for purposes of title V.

In 1987 and again in 1994, EPA issued guidance regarding the classification of emissions from landfills for NSR applicability purposes.[1] In these guidance memorandums, EPA made clear that emissions which *are actually collected* are not fugitive emissions. Thus, for example, when a source is subject to a national standard requiring collection of emissions, these emissions cannot be considered fugitive. Whether or not a source is subject to such a national standard, emissions which pass through a stack, chimney, vent, or other functionally-equivalent opening are not fugitive.

Where emissions are not actually collected at a particular site, the question of whether the emissions are fugitive or nonfugitive should be based on a factual, case-by-case determination made by the permitting authority. As noted in EPA’s 1994 guidance,

> In determining whether emissions could reasonably be collected (or if any emissions source could reasonably pass through a stack, etc.), “reasonableness” should be construed broadly. The existence of collection technology in use by other sources in a source category creates a presumption that collection is reasonable. Furthermore, in certain circumstances, the collection of emissions from a specific pollutant emitting activity can create a presumption that collection is reasonable for a similar pollutant-emitting activity, even if that activity is located within a different source category.

Based on the above principles, EPA believes it appropriate to presume that VOC emissions from the printing industry and paint manufacturers could reasonably be collected and thus are

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[1] See memorandums entitled “Classification of Emissions from Landfills for NSR Applicability Purposes” from John S. Seitz, Office of Air Quality Planning and Standards, to Air Division Directors, Regions I-X, dated October 21, 1994, and “Emissions from Landfills” from Gerald A. Emison, Director, Office of Air Quality Planning and Standards, to David P. Howekamp, Director, Air Management Division, Region IX, dated October 6, 1987.

not fugitive. In addition, unless this presumption is rebutted by the source, such emissions should be counted in major source determinations.

We have reached this conclusion for printers and paint manufacturers because certain printers are subject to national standards and State implementation plan (SIP) requirements (e.g., reasonably achievable control technology, best available control technology, or lowest achievable emissions rate) requiring collection. Moreover, sources in both of these source categories commonly employ collection devices. The common use of collection technology by other printing and paint manufacturing sources creates a presumption that collection of emissions is reasonable at other similar sources.

In the case of whiskey warehouses, the presumption that emissions could reasonably be collected is less compelling and may warrant further consideration by States in consultation with the EPA Regional Offices. For example, we are not aware of any national standards or SIP requirements for the collection of VOC emissions from whiskey warehouses, and we believe it is uncommon for them to have voluntarily installed collection devices. On the other hand, EPA is aware of warehouses in other source categories that collect emissions and thus a presumption is created that whiskey warehouse emissions could reasonably be collected. In addition, in a factual determination for a whiskey warehouse in the State of Indiana, EPA Region V found, after careful review, that the emissions of the warehouse were not fugitive.

In addition, you ask whether costs should be a factor used to determine if emissions can be reasonably collected. Obviously, when emissions are actually collected, cost considerations are irrelevant to determine whether emissions are fugitive. On the other hand, when a source does not actually collect its emissions, but there is a presumption that collection would be reasonable, a permitting authority could consider costs in determining whether this presumption is correct. However, when analyzing whether collection is reasonable for a particular source, the permitting authority should not focus solely on cost factors, nor should cost factors be given any more weight than other factors. Instead, the permitting authority should focus on determining whether a particular source is truly similar to the "similar sources" used to create the presumption. This determination can be made by looking at whether there are substantial differences in the technical or engineering characteristics of the sources. In this stage of the analysis, a comparison of the costs of collecting emissions could be relevant where it illustrates the underlying technical or engineering differences. Moreover, keep in mind that title V does not impose any requirements on subject sources to collect (or control) their emissions and that collection is only assumed for the purpose of determining title V applicability. Thus, no source will ever be required to incur the costs of installing, operating, or maintaining collection devices (or control devices) because of a presumption that its emissions are not fugitive or subsequently because it is found to be subject to title V.

The approach for interpreting the definition of fugitive emissions outlined in this memorandum is consistent with the approach used historically by Headquarters, as well as the majority of EPA Regions and States. We believe, therefore, that the impact of this memorandum will be limited, both in the number of sources for which reclassification of emissions from fugitive to nonfugitive may be required, and to a greater extent, in the number of sources subject to reclassification from minor to major source.

We recognize that this interpretation may present enforcement issues for an unknown (but presumably small) number of sources whose initial title V applicability determinations were overly broad with respect to which emissions they have interpreted as being fugitive. Therefore, EPA recommends that the following steps be taken. If the policies of an EPA Region or State for interpreting the definition of fugitive emissions are consistent with the policies described in this memorandum, then the EPA Region or State should continue to enforce its policies as it has in the past. However, if the policies of an EPA Region or State have not been as inclusive as the policies described in this memorandum, then major sources that have not applied for operating permits on the basis of these less-inclusive policies should be instructed to immediately notify the State and EPA Region in writing of their obligation to obtain a title V permit. Such sources should be instructed to prepare and submit permit applications to the appropriate permitting authority as expeditiously as possible.

The EPA will use its enforcement discretion in deciding whether or not to seek an enforcement action against sources for failure to obtain an operating permit. However, factors that may be considered in deciding whether to seek enforcement action against sources may include whether the sources relied on less inclusive policies of a State or EPA Region and whether the sources expeditiously submit permit applications after they become aware of the national policy described in this memorandum.

If you have any questions, please contact Steve Hitte at 919-541-0886 or Jeff Herring at 919-541-3195 of the Operating Permits Group.

cc: Director, Office of Ecosystem Protection, Region I
Director, Division of Environmental Planning and Protection, Region II
Director, Air, Pesticides, and Toxics Management Division, Region IV
Director, Air and Radiation Division, Region V
Director, Multimedia Planning and Permitting Division, Region VI
Director, Air, RCRA, and Toxics Division, Region VII
Assistant Regional Administrator, Office of Partnership and Regulatory Assistance, Region VIII
Director, Air Division, Region IX
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OAQPS/ITPID/OGC/JHerring:pfinch:MD-12:541-5281:12/4/98
Herring\katz-fug.def

EXHIBIT 2

October 21, 1994

MEMORANDUM

SUBJECT: Classification of Emissions from Landfills for
NSR Applicability Purposes

FROM: John S. Seitz, Director
Office of Air Quality Planning and Standards (MD-10)

TO: Director, Air, Pesticides and Toxics
Management Division, Regions I and IV
Director, Air and Waste Management Division,
Region II
Director, Air, Radiation and Toxics Division,
Region III
Director, Air and Radiation Division,
Region V
Director, Air, Pesticides and Toxics Division,
Region VI
Director, Air and Toxics Division,
Regions VII, VIII, IX and X

The EPA has recently received several inquiries regarding the treatment of emissions from landfills for purposes of major NSR applicability. The specific issue raised is whether the Agency still considers landfill gas emissions which are not collected to be fugitive for NSR applicability purposes.

The EPA's NSR regulations define "fugitive emissions" to mean "those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening" (40 CFR 51.165(a)(1)(x)). In general, where a facility is not subject to national standards requiring collection, the technical question of whether the emissions at a particular site could "reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening" is a factual determination to be made by the permitting authority, on a case-by-case basis.

In determining whether emissions could reasonably be collected (or if any emissions source could reasonably pass through a stack, etc.), "reasonableness" should be construed broadly. The existence of collection technology in use by other sources in the source category creates a presumption that collection is reasonable. Furthermore, in certain circumstances, the collection of emissions from a specific pollutant emitting activity can create a presumption that collection is reasonable for a similar pollutant-emitting activity, even if that activity is located within a different source category.

In 1987, EPA addressed whether landfill gas emissions should be considered as fugitive.[1] The Agency explained that for landfills constructed or proposed to be constructed with gas collection systems, the collected landfill gas would not qualify as fugitive. Also, the Agency understood at the time that, with some exceptions, landfills were not constructed with such gas collection systems. The EPA explained that "[t]he preamble to the 1980 NSR regulations characterizes nonfugitive emissions as emissions which would ordinarily be collected and discharged through stacks or other functionally equivalent openings'" (see 45 FR 52693, Aug. 7, 1980).[2] Based on the "understanding that landfills are not ordinarily constructed with gas collection systems," the Agency concluded that "emissions from existing or proposed landfills without gas collection systems are to be considered fugitive emissions." The Agency also made clear, however, that the applicant's decision on whether to collect emissions is not the deciding factor. Rather, it is the reviewing authority that makes the decision regarding which emissions can reasonably be collected and therefore not considered fugitive.

The EPA believes its 1987 interpretation of the 1980 preamble may have been misunderstood, and in any case that its factual conclusions at that time are now outdated. Continued misunderstanding or application of this outdated view could discourage those constructing new landfills from utilizing otherwise environmentally- or economically-desirable gas collection and mitigation measures in order to avoid major NSR applicability.

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[1] See memorandum entitled "Emissions from Landfills," from Gerald A. Emison, Director, Office of Air Quality Planning and Standards, to David P. Howekamp, Director, Air Management Division, Region IX, dated October 6, 1987 (attached). It is important to note that the interpretation contained in this memorandum was only applicable to landfills.

[2] In fact, the 1980 preamble language recognized the concern that sources could avoid NSR by calling emissions fugitives, even if the source could capture those emissions. The EPA's originally-proposed definition of fugitive emissions was changed in the final 1980 regulations to "ensure that sources will not discharge as fugitive emissions those emissions which would ordinarily be collected and discharged through stacks or other functionally equivalent openings, and will eliminate disincentives for the construction of ductwork and stacks for the collection of emissions." Id.

Specifically with regard to landfill gas emissions, gas collection and mitigation technologies have evolved significantly since 1987, and use of these systems has become much more common. Increasingly, landfills are constructed or retrofitted with gas collection systems for purposes of energy recovery and in order to comply with State and Federal regulatory requirements designed to address public health and welfare concerns. In addition, EPA has proposed performance standards for new landfills under section 111(b) of the Clean Air Act and has proposed guidelines for existing landfills under section 111(d) that, when promulgated, will require gas collection systems for existing and new landfills that are above a certain size and gas production level (see 56 FR 24468, May 30, 1991). Under these requirements, EPA estimates that between 500 and 700 medium and large landfills will have to collect and control landfill gas. The EPA believes this proposal created a presumption at that time that the proposed gas collection systems, at a minimum, are reasonable for landfills that would be subject to such control under the proposal.

Thus, EPA believes it is no longer appropriate to conclude generally that landfill gas could not reasonably be collected at a proposed landfill project that does not include a gas collection system. The fact that a proposed landfill project does not include a collection system in its proposed design is not determinative of whether emissions from a landfill are fugitive. To quantify the amount of landfill gas which could otherwise be collected at a proposed landfill for NSR applicability purposes, the air pollution control authority should assume the use of a collection system which has been designed to maximize, to the greatest extent possible, the capture of air pollutants from the landfill.

In summary, the use of collection technology by other landfill sources, whether or not subject to EPA's proposed requirements or to State implementation plan or permit requirements, creates a presumption that collection of the emissions is reasonable at other similar sources. If such a system can reasonably be designed to collect the landfill's gas emissions, then the emissions are not fugitive and should be considered in determining whether a major NSR permit is required.

Today's guidance is applicable to the construction of a new landfill or the expansion of an existing landfill beyond its currently-permitted capacity. To avoid any confusion regarding the applicability of major NSR to existing landfills, EPA does not plan to reconsider or recommend that States reconsider the major NSR status of any existing landfill based on the issues discussed in this memorandum. Also, nothing in this guidance voids or creates an exclusion from any otherwise applicable requirement under the Clean Air Act and the State implementation plan, including minor source review.

The Regional Offices should send this memorandum, including the attachment, to States within their jurisdiction. Questions concerning specific issues and cases should be directed to the appropriate Regional Office. Regional Office staff may contact Mr. David Solomon, Chief, New Source Review Section, at (919) 541-5375, if they have any questions.

Attachment

cc: Air Branch Chief, Regions I-X
NSR Contacts, Regions I-X and Headquarters

bcc: L. Wegman
S. Shaver
S. Hitte
E. Lillis
D. Solomon
Cindy Jacobs, OAP
Mark Najarian, MD-13
Susan Thorneloe, MD-63
Julie Domike, OECA

EXHIBIT 3

BULK STORAGE

Mineral Ores

Mining companies face the toughest environmental and permitting challenges. Geometrica helps meet both with elegant, versatile domes.

Ore stockpiles house immense volumes and produce dust. They sit on sloping terrain at inaccessible locations. They are irregular in shape. And, often, they are already in operation.

Geometrica domes can be built to meet every one of these challenges. Dust is controlled and your property becomes attractive to clients, investors, regulators and neighbors alike.

A Geometrica dome solves your stockpile dust problem.

Geometrica domes can be built without stopping production.

Below we see the Herradura twin domes built over operating stockpiles.

BULK STORAGE

Coal and Pet-coke

The largest fuel stockpiles can now be covered.

More than a third of the world's energy is produced from solid fuel. Coal and pet-coke are stored in huge stockpiles near plants that consume them. These piles used to be open-air, but current environmental consciousness demands that they are covered. As an example, above are Enel’s Bocamina coal yards in Chile. Over 300,000t of fuel were previously stored in the open. Now, two Freedomes cover all that fuel and 46,000m2.

COMBUSTIBILITY MAKES COAL STORAGE A SPECIAL CASE THAT DESERVES CAREFUL TREATMENT.

The National Fire Protection Association (standards NFPA 120 and 850) identifies the hazards associated with storage and handling of coal, and gives the following recommendations for protection and safety.

- Storage structures are made of non-combustible materials
- The surface area upon which dust can settle is minimized or, even more desirable, cladding is installed underneath a building's structural elements
- Coal should be kept as dry as possible (sprinklers are not recommended)
- A sufficient ventilation system should be provided to reduce the chance of methane (and, in case of fire, smoke) build-up and for explosion venting requirements. Ventilation should be provided at the apex to take advantage of the chimney effect.

COAL STORAGE MEETS ENVIRONMENTAL RESPONSIBILITY.

Pupuk-Kaltim’s coal-boiler project produces the steam required to help the company deliver its annual 3 million tons of urea to its customers in Indonesia and beyond. As Indonesia’s largest fertilizer producer, Pupuk-Kaltim has won numerous awards for its green practices and outstanding engineering. And the shiny Geometrica dome at Bontang keeps the coal, and the company's track record, spotless.

Geometrica coal storage domes protect the environment around the world.

BULK STORAGE

Limestone and Clinker

In cement manufacture, Geometrica domes store raw materials and finished products.

Cement plants need large, column free buildings for limestone blending, fuel and additives storage, clinker storage and palletizing areas. Geometrica provides cost effective

Clinker storage silos contain the material with concrete walls. The Geometrica dome sits atop the wall to cover the stockpile. Being hygroscopic, clinker domes typically feature both buildings for all these needs with quick construction and low labor requirements. Limestone blending beds typically go from under 70m to over 120m. Longitudinal additives and fuel stockpiles and stacking equipment require buildings that span from 50m to over 100m. Geometrica has supplied domes in the whole range.

internal and external cladding. This prevents the material from accumulating on the structure in humid conditions.

Circular or longitudinal blending is best done under a Geometrica dome.

Gallery: Cement Manufacture Domes

BULK STORAGE

Hazardous Materials

Fire, corrosion or explosion hazards are inherent to certain bulk materials.

Geometrica domes can help control the associated risk.

COMBUSTIBLE MATERIALS STORAGE

Coal, pet-coke and sulphur are combustible. Their dust presents fire and explosion hazards. Geometrica domes have round structural members that minimize potential dust accumulation, and may be clad internally to completely prevent dust from accumulating on the inside of the structure.

CORROSIVE MATERIAL STORAGE

Urea, sulfur, salt, and other materials can present corrosion challenges. Structure and cladding material selection is very important.

Geometrica provides structures in galvanized steel, aluminum and even stainless steel. Paint may be applied over these structural materials for added protection. Cladding may also be made from these different materials, or from plastic. And the structures may be clad internally, externally or both.

COMPARISON OF DOME CLADDING SYSTEMS

Hazardous materials must often be kept away from structural components to prevent corrosion or explosion hazards. This is not easy in conventional structures because dust accumulates on ledges and niches in the structural members. Geometrica structures, built with circular hollow sections, naturally shed most dust. And for even more protection, cladding can be fixed to the underside of the structure.

BULK STORAGE

Ring

Stockpiles

A Geometrica dome on your stockyard will improve your plant's runoff and air quality measures.

Geometrica is the industry leader in domes for automated ring piles, having provided the majority and the largest domes in the world for this application.

A slewing stacker at the center stacks the material and creates the pile, while a bridge or a portal rake reclaims the material from a face of the pile. Limestone, clay, marl, coal, wood chips, fertilizers, sulfur and many other materials are stored in automated ring piles.

Geometrica geodesic domes have been built over piles of over 140m in diameter, and it is feasible to span up to 300m.

Typically, a dome for this application will need to cover an additional 3m to 6m width area around the base circumference of the pile for reclaimer clearance and circulation of maintenance personnel or small vehicles. Thus, the diameter

Geodesic domes for ring piles also need to clear the reclaimer at its highest point near the perimeter of the stockpile, as well as provide a minimum height for the vehicles in the free area around the material. Instead of using an of a dome for this application is usually 6 to 12m more than the pile's diameter. The dome's height is normally set at about 1/3 of the diameter for efficiency, but may be substantially lower or higher if desired.

expensive vertical wall to achieve this, Geometrica can supply domes with elliptical or compound parabolic profiles that have a steep slope near the perimeter.

BULK STORAGE

Conical Piles

Ores, grains, salts and many other commodities are stored in conical stockpiles. Geometrica provides covers for all these materials.

Conical stockpiles are formed from the free-fall of bulk material off the end of a static conveyor. In open-air conical piles, the drop of material through windy air creates blinding plumes of dust. Geometrica domes block the wind and contain this dust, helping your plant meet its environmental goals.

Domes may be designed to enclose the drop-off point, or to support the tip of the conveyor and load through an apex chute. Clearance should

In conical piles, fines naturally accumulate around the perimeter, at the base of the pile. Because the dust is aerated when settling, fines have a very small angle of repose and the stockpile grows over time. Geometrica recommends placing the dome on a wall, or leaving a gap around the pile where equipment may circulate to remove accumulated dust. Geometrica also offers replaceable panels for the dome's bottom ring to prevent damage in case of accidental lateral overloading.

be provided to allow mobile equipment to circulate around and on the stockpile. A concrete wall support can increase storage capacity.

Whether mining, agriculture, concrete or other industries, a Geometrica dome protects your inventory and the environment from each other.

Maximizing Efficiency, Eliminating Downtime

Geometrica domes are custom-designed to for your projects specific site conditions. Local labor can install the domes using a variety of construction methods and following the strictest health and safety standards.

The Caserones dome in Chile. An engineering feet in a tough terrain, with snow and slopes, yet beautifully displaying Geometrica's system.

CLICK BELOW TO WATCH VIDEO

BULK STORAGE

Freeform Piles

Existing bulk material stockyards are often unruly. Tame them with a Freedome®.

A pile of raw material is usually formed in the proximity of the area where it is needed. These piles are not always conveniently shaped, especially when located on rough slopes close to the quarry. Some are continuously recreated with moveable conveyor or truck drops and reshaped with earthmovers. They may be encroached by equipment and buildings. Many became operational before a cover was ever deemed necessary.

Geometrica developed and trademarked the Freedome®, a freestyle geodesic dome that can enclose stockpiles of any size and shape on any terrain without internal columns. And this can be done even while the stockyard is in operation. Freedome® removes the constraints of traditional domes, and helps you and your property achieve its emissions goals.

Geometrica free-form domes achieve the world's longest spans.

The Freedomes at Enel’s Bocamina II power plant in Chile may be the world’s largest domes of irregular plan. They cover more than 45,000 m2, following the original border of the uncovered fuel yards. Below is a lighthearted video (duration 01:44) about how we delivered the first of these domes, from concept to completion.

CLICK THE IMAGE BELOW TO PLAY VIDEO.

BULK STORAGE

Longitudinal Piles

Geometrica offers efficient longitudinal structures in cross sections that suit the project's conditions.

Perhaps the most common way to store large volume bulk materials is by stacking them in long, prismatic piles. The material is loaded with a side stacker, or with a tripper car from above.

For Carthage Cement in Tunisia as seen above, Geometrica built three bulk-storage structures for the greenfield plant.

- 200m Additives longitudinal dome

Reclaiming is done with a bridge or side scrapper reclaimer or with front end loaders.

- 300m Coal longitudinal dome
- 90m Limestone circular dome

Custom Longitudinal Geometries

The different Geometrica geometries are shown in the figures below. Parabolic or acute geometries are best for large crest loads, such as tripper cars, which these domes can easily support. Circular cross sections are ideal for large wind loading sites. Bents start vertically to minimize the footprint of the building. The ends of any enclosure may be left open, or closed with semi-domes or flat space frame walls.

Geometrica longitudinal structures are particularly suited for highly corrosive environments. The structural tubes may be galvanized steel or aluminum, and either of these materials may be finished with a highly resistant thermoset epoxy or polyester coating. Cladding may be steel, aluminum, fiber-reinforced plastic, polycarbonate, or a combination of these. For aggressive interior environments, FRP cladding may be applied internal to the structure.

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CIRCULAR

PROFILE

ACUTE PROFILE

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EXHIBIT 4

Mining & Mineral Processing

Helping You Navigate the Complex World of Dust Collection

Overview

Large volumes of hard and abrasive dust particles are typical in most mining and mineral processing related applications. This dust type rapidly wears out filter media, leading to frequent maintenance or worse: filter leaks. Without effective dust emission control, equipment, process, employees and the environment may be at risk and production could be halted.

Cement manufacturing offers particularly difficult challenges to dust collectors. Based on data from installations, it's been estimated that as much as 1% of mining throughput can be lost to the surrounding environment. For a 700 TPH quarry, that's about seven tons per hour lost from conveyors, crushers and screens, and that does not include losses from stockpiles.

As your single filtration source for mining and minerals, Donaldson helps you navigate the complex world of dust collection specifically for the cement industry in the most efficient and environmentally-friendly way.

Applications

Dust Control in Specific Areas

The following is a list of some of the typical areas at mines and quarries generating dust that can be controlled by dust collection equipment:

Rail or truck dumps
Crushers
Screens
Conveyor belt transfer points
Silos or bin filling
Rail, barge or truck loading

Guidelines to Practical Dust Collection

Years of experience in mining and quarry dust control has highlighted a number of significant points:

Good Design and Equipment Selection Is Essential

Anything marginal in either design or selection results in immediate or short term inadequacies in collector performance. The difference in selections between an effective and ineffective dust collector is often much narrower than in many other industries.

Everywhere That Material Is Supposed to Drop Through Air, Dust Is Generated

The most obvious dust generation points may seem to be conveyor transfer points and feed points from screens and crushers. But often, oversized feed-outs from screens or transfer of large product into bins will generate significant dust.

Budgetary constraints are important, so it is generally better to do some parts right than a lot of parts wrong.

Dust Collectors Philosophy: Source or Central

Two basic strategies exist for applying dust control to mines and quarries; source collection (putting the dust collector at the source of the dust emission so collected dust can be deposited directly back into the process stream) or centralized collection (putting the collector in a central location where dusty air is ducted to the collector and discharged as a separate process stream).

Source Collection Operational Advantages Include:

Lower capital costs as less ducts, and fewer hoppers, screw conveyors or rotary valves are typically required.

Fewer maintenance problems as fewer ducts or hoppers are being used that can block or bridge. In addition, since there are fewer hoppers, there are fewer hopper discharge devices that need to be maintained.

A shutdown of one unit may result in temporary increased emissions in a single area, but will be unlikely to necessitate a complete plant shutdown.

Dust Collection Considerations

The following points need to be considered in the selection of central dust collectors for mining and quarrying applications:

Mine and quarry dust is often abrasive and particle impact against filter media needs to be considered to avoid possible filter damage. This requires consideration of incoming air velocity, dust distribution, and air patterns within the collector.

Dust removal and disposal requires careful consideration to avoid blockages, equipment abrasion, secondary dust emissions, and higher costs for maintenance and materials handling.

Source collection systems may be easier to deal with since hoppers and ducting are often not used. But when using source collection, the following should be considered:

Since collectors are often much closer to the source of dust generation, be aware of any water or oil in the dust as this could create problems with filter medias.

Filter abrasion typically is not an issue, however, if the source collector is being used as a bin vent, place the collector as far from the inlet as possible to avoid abrasion and/or unnecessarily high dust loading.

Collectors In Use

	Model	Product Family	Use
	RFs (Four 376RFW10 Units & One 484RFW12 Unit)	Baghouse Dust Collector	Limestone Crushing
	81MBT8(s)	Baghouse Dust Collector	Bin Venting Diatomaceous Earth
	Dalamatic Insertable 20/10	Baghouse Dust Collector	Coal Conveyor Transfer Point
	PowerCore	PowerCore Dust	Cement

	CPC 3	Collector	
	DLMC 4/8/15	Baghouse Dust Collector	Rock Crushing

We can help you get the optimal solution for your application.

Contact Us

Videos

Donaldson Filters for the Mining Industry

Articles

Technical Article

Seven Things to Consider When Purchasing a Dust Collector

Do you have plans to purchase or upgrade a dust collector for your facility? If so, we advise the following seven considerations to ensure you get exactly what you need.

Case Study

Torit PowerCore® Helps Anchor Block Operate Smarter

The Torit PowerCore® collector at Anchor Block is ducted to a 5,000-lb. concrete mixer that mixes very fine and abrasive sand, fly ash, aggregates and cement.

See All Technical Articles See All Case Studies

Products

Cartridge

Downflo® Evolution

The Donaldson Torit® Downflo® Evolution (DFE) cartridge dust collector is capable of reducing equipment size and the number of required filters by up to 40%.

PowerCore®

CP Series

Donaldson Torit® PowerCore® CP Series cartridge dust collectors use smaller, more efficient filters compared to baghouse models with a footprint up to 50% smaller.

Baghouse

Rugged Pleat

The Donaldson Rugged Pleat (RP) Baghouse sets a new standard for baghouse dust collector performance, combining advanced collector design with superior filtration technology in our most maintenance-friendly design ever.

Dalamatic®

The Dalamatic® baghouse dust collector uses Dura-Life™ envelope-shaped bag filters, providing greater movement to dislodge dust cakes during pulsing.

Modular Baghouse

Donaldson Torit® Modular Baghouse dust collectors deliver reliable, efficient, continuous-duty, pulse jet operation in a compact design with easy maintenance.

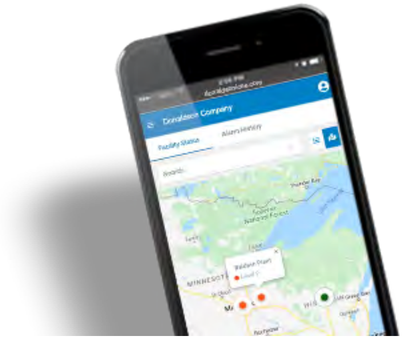

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EXHIBIT 5

Dust Collection for Mining and Mineral Processing

INTRODUCTION TO DUST AND FUME CONTROL FOR MINING AND MINERAL PROCESSING

The mining industry includes not only excavation sites (e.g., surface mining, open-pit mining, quarrying, mega-mining, open-cast mining and open-cut mining) but also all of the infrastructure for processing mined materials and ores and turning them into usable raw materials.

Mined materials include sand and gravel, stone, coal, metals (e.g., iron, lead, copper, gold, silver, platinum, aluminum, zinc, lithium, nickel, molybdenum, manganese, cadmium, beryllium, chromium, tin, tungsten), nonmetals (e.g., phosphate, gypsum, talc, feldspar, pumice and gemstones) and rare-earth minerals (e.g., neodymium, dysprosium, yttrium, europium, terbium). In North America, the most common mine types by far are sand, gravel and stone, followed by coal. Copper and iron are the most common metal mines. Heavy, abrasive dust is produced at a number of points in the mining industry. These include:

- Excavation sites (e.g., quarries and open-pit/surface mines)
- Conveyors, belt transfer points and weigh-belt feeders
- Ore storage bins and silos
- Crushers and grinders
- Hammer mills and ball mills
- Screeners
- Blenders

SOLUTIONS FOR MINING AND MINERAL PROCESSING

RELATED RESOURCES

Abrasion-Resistant Intake

RoboVent offers robust dust control solutions for the mining and mineral processing industry. A RoboVent solutions engineer can design an effective dust control system for your mining and mineral processing application that fully meets ACGIH and NIOSH recommendations. We can help you:

- Evaluate the hazard level and combustion risk

of your mining dust
- Design and install a dust control solution tailored to your application
- Maintain your dust collection system for maximum longevity and efficiency
- Ensure compliance with regulations including EPA air quality standards for PM10 and PM2.5 and OSHA, MSHA and NFPA requirements.

RoboVent Senturion is a heavy-duty, versatile dust collector suitable for mining and mineral processing applications. Senturion features:

- A modular design that can be scaled up for heavy-duty dust control and outfitted with abrasion-resistant options for mining applications.
- An advanced filtration system for the smallest footprint per CFM in the industry.
- Heavy-duty cabinet construction, powder-coated inside and out, with optional UHMW lining.

DUST CONTROL

CHALLENGES FOR MINING AND MINERAL PROCESSING

Dust control for mining and mineral processing has a number of challenges due to the volume, abrasiveness and toxicity of mining dust. While the specific challenges vary by mineral or ore type and process, there are some general challenges common to all mining applications.

READ MORE

HEALTH RISKS OF MINING AND MINERAL PROCESSING DUST

Mining and mineral or ore

processing produce heavy, abrasive dust that is irritating to the eyes, skin and tissues of the nose, throat and lungs. Dust produced by mining operations may be heavy enough to create visibility challenges or slip-and-fall hazards. Mining dust may also contain elements that are toxic when inhaled.

Fine dust produced when crushing, grinding and transporting minerals and ores can be inhaled deeply into the lungs, where it becomes embedded in lung tissue.

READ MORE

REGULATIONS FOR MINING AND MINERAL PROCESSING

The mining industry is highly regulated. In the U.S., companies involved in mineral extraction and processing must follow regulations related to dust control from multiple industries, including the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA) and the Mine Safety and Health Administration (MSHA)

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CONSIDERATIONS IN DUST CONTROL FOR

MINING AND MINERAL PROCESSING

Because of the diversity of dust types and processes represented across the mining and mineral processing industry, there is no "one size fits all" solution for dust control in mining. The National Institute of Occupational Health and Safety (NIOSH) has created the Dust Control Handbook for Industrial Minerals and Mining as an overview of basic principles. Companies should also follow ACGIH general guidelines for industrial ventilation and filtration when designing a dust control solution.

⊕ READ MORE

RELATED SOLUTIONS

Senturion

Senturion Modular Dust Collector ONE TOUGH DUST COLLECTOR. COUNTLESS APPLICATIONS. Senturion i...

DUST TYPES

CONTACT US

Contact one of our industrial dust experts to gain the advantage against dust-generating processes and applications.

First name

Last name

Company name*

Job title

Your role in the company

Phone number*

Email*

Country/Region*

Please Select

What's the nature of your inquiry?*

Please Select

Do you currently have any RoboVent equipment in your facility?

Please Select

What application is generating dust?

What dust types need to be controlled?

Tell us a bit about your application or project*

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EXHIBIT 6

Comments on Revised AERMOD Modeling Report for Copper World. Prepared by Trinity Consultants, July 2024

Meteorological Input

1. Instead of using meteorological data from the National Weather Service in Tucson (including upper air data) Trinity Consultants has decided to use a newly established meteorological site at Copper World by Hudbay. The site location, instrumentation and QA/QC are described in "Meteorological Quality Assurance Plan for Hudbay Minerals Inc., Copper World, Inc., Trinity Consultants, June 2024." However, none of the meteorological data has been provided and so it is impossible to check for accuracy and completeness.
2. Meteorological observations are critically important for dispersion modeling because pollutants are dispersed through the atmosphere by the winds. Without accurate observations the results of any air dispersion model are questionable.
3. The new meteorological data acquired by Hudbay covers just one year, not the 3-5 years that the EPA prefers for input for AERMET and AERMOD, although the EPA will accept a 1-year record of on-site observations under certain circumstances.
4. The new data covers the period May 2023 to April 2024, a time frame that is inconsistent with the Background PM10 record from Corona de Tucson (three years from January 2019 to December 2021), the PM10 record from the Rosemont monitor on the east side of the mountain (June 2006 to June 2009), and the meteorological record from Rosemont (also June 2006 to June 2009).
5. For regulatory purposes, AERMOD and AERMET should include upper air observations. These are normally obtained from a NWS radiosonde balloon record (Tucson in this case). Without upper air data it is impossible to accurately assess dispersion, turbulence, and boundary layer mixing of pollutants in the atmosphere, i.e., the dispersion model calculations are undermined. Trinity may in fact have used the Tucson upper air data, or they may have used the 10-meter tower observations made at the Hudbay Copper World site, but they never state which meteorological data were used at which altitudes and for which time periods in the model and so it is impossible to assess the validity of the modeled air flow patterns and dispersion of pollutants.
6. Although their chosen meteorological station has changed from Tucson to Copper World, Trinity does not provide any sensitivity analysis as ADEQ required for the

Tucson data. The July 2024 report therefore appears to be incomplete in this respect.

Removal of PM10 Background Observational Data from Corona de Tucson Record

Trinity Consultants state that: "Upon detailed review of the maximum monthly PM10 concentrations, it was determined that the data included concentrations that were influenced by natural high wind dust events that were eligible for removal using the guidelines included in the Technical Criteria Documents for Determination of Natural and Exceptional Events published on May 31, 2000, February 10, 2005 and December 12, 2005 (Section 4.1.1)." I do not agree that they should have removed the data from the record for the following reasons.

1. None of the PM10 data they removed from consideration represented an exceedance of the NAAQS (150 µg/m^3). The data they removed did not even come close to an exceedance, ranging from 52 to 64 µg/m^3 (their Table 4-1). They simply removed data that corresponded to seven windy days. In the natural desert environment, background PM10 concentrations of about 10-50 µg/m^3 are to be expected. Windy days are also to be expected and so Trinity should include these observations in order to be conservative in their PM10 estimates. The data Trinity removed are completely normal and should remain in the record.
2. Trinity suggests that they followed EPA's guidelines for Exceptional Events. However, exceptional events are those that a) exceed NAAQS standards, and b) have been previously flagged by the state in the official EPA Air Quality System (AQS) database, neither of which is true in this case.

Concerning Exceptional Events, which are often caused by natural events, I have extracted some relevant language from the Title 40 Code of Federal Regulations below. I believe that an exceptional event can only be claimed after there is a flagged NAAQS exceedance. I do not believe there is any EPA guidance that permits a non-exceeding natural event to be removed from the data set.

> ***Exceptional event*** *means an event(s) and its resulting emissions that affect air quality in such a way that there exists a clear causal relationship between the specific event(s) and the monitored exceedance(s) or violation(s), is not reasonably controllable or preventable, is an event(s) caused by human activity that is unlikely to recur at a particular location or a natural event(s), and is determined by the Administrator in accordance with 40 CFR 50.14 to be an exceptional event. It does not include air pollution relating to source noncompliance. .... However, conditions involving high temperatures or lack*

> *of precipitation may promote occurrences of particular types of exceptional events, such as wildfires or high wind events, which do directly cause emissions.*
>
> *(k)* ***Natural event*** *means an event and its resulting emissions, which may recur at the same location, in which human activity plays little or no direct causal role. For purposes of the definition of a natural event, anthropogenic sources that are reasonably controlled shall be considered to not play a direct role in causing emissions.*
>
> *(l)* ***Exceedance with respect to a national ambient air quality standard*** *means one occurrence of a measured or modeled concentration that exceeds the specified concentration level of such standard for the averaging period specified by the standard.* *https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-50*
>
> *"In the case of exceptional events, States place the initial flag on the data in the AQS database. Following an evaluation of the supporting documentation, EPA will decide whether to concur with the flag; concurrence will be marked by the placement of a second flag in the AQS database by EPA. Once EPA has concurred on the flag, the data will be excluded from regulatory decisions such as determinations of attainment or nonattainment."* *https://www.federalregister.gov/documents/2007/03/22/E7-5156/treatment-of-data-influenced-by-exceptional-events*

Trinity's arbitrary decision to remove seven high PM10 observations ranging from 52-64 μg/m^3 from the official record significantly lowers the predicted PM10 results given in Table 8-1, 8-3 and 8-5 (described below) where some of the predicted PM10 concentrations come close to the 150 μg/m^3 NAAQS. I have attempted to calculate the effect of *including* the seven high PM10 observations but I cannot be sure my work can be directly compared to Trinity's because their AERMOD modeling report is so obscure as to make it impossible to be certain (more below). I lack the necessary information, which was supposed to be provided in Section 4, Appendix B, Section 8, Appendix F and elsewhere in the Air Quality Permit application.

PM10 Background Observations

PM10 in Section 4.1.1 (West Side of Mountains) and Appendix B

Section 4 includes ambient background PM10 observations taken from the Corona de Tucson site, an EPA Air Quality System (AQS) site. This site records only PM10, not any other NAAQS pollutants and not meteorological observations. In pg. 4-1 Trinity justifies the removal of seven data points, and they state that the calculation of the resulting corrected monthly background PM10 and a “detailed analysis of the natural event removal” is “included in Appendix B”. This is not correct. Appendix B does not contain a detailed analysis.

1. In Appendix B, Step 1 is annotated: “Determine highest five 24-hour concentrations from three-year data set and remove from consideration.” Yet in this table Trinity lists *six* observations. By contrast, in the modeling report (section 4.1.1) Trinity made the case to remove *seven* observations. Consequently, I cannot be certain if Trinity removed 5, 6, or 7 data points from the Background observations. To add to my confusion, in ADEQ’s Technical Review and Evaluation of Application for Air Quality Permit No. 96659 (pg. 38), ADEQ states that *four* data points were excluded. This is important because the Background concentration plays a critical role in determining the NAAQS compliance claimed in Tables 8-1 to 8-5.
2. In Appendix B, Step 2, Column 5, Trinity creates a monthly maximum concentration for any of the three years by replacing an offending high value with the highest for that month in the other two years. I believe that this is the “Monthly” data point that is given in Tables 8-3 to 8-5, Column 6, but I cannot be certain because nowhere in the report is this clearly stated. It is critically important to know how the Background PM10 is incorporated into the model because otherwise it is impossible to add the Background PM10 to the AERMOD-computed mining emissions (called Modeled Concentration in Tables 8) and thereby check for possible NAAQS violations.
3. In Appendix B, Step 3, Trinity computes the *seasonal* maximum PM10 background observation. First, why do they even calculate a seasonal value? Is it the *seasonal* Background value that is added to the Modeled Concentration value in Tables 8? In which case why do Tables 8-3 to 8-5 include *monthly* data and not seasonal data?
4. Appendix B, Step 3 calculations contain two minor errors. Dec-Feb should be 40 μg/m^3, not 17 μg/m^3, and Sep-Nov should be 53 μg/m^3, not 58 μg/m^3 according to their Step 2 data.
5. I am troubled by the fact that ADEQ has performed computer modeling on behalf of Trinity/Hudbay.   On pg. 38 of their Technical Review and Evaluation of Application for Air Quality Permit No. 96659, they state that they “re-ran the model for PM10 in year 8…” Since when does a State agency perform computer modeling on behalf of an applicant, and what results are reported in Table 8-3 in Trinity’s air dispersion modeling report – Trinity’s or ADEQ’s?

PM10 in Section 4.1.1.1 (East Side of Mountains) and Appendix B

In this section, Trinity changes the discussion of PM10 monitors from Corona de Tucson to an unnamed monitor located somewhere "east of the Santa Rita Mountain." No further description is provided. The monitoring equipment is not described, maintenance and calibration records are not provided and nor is the raw data provided. I suspect they used the PM10 observations made at the Rosemont monitor that operated from June 2006 to June 2009 in anticipation of Augusta's air quality permit application.

1. The change in monitors from Corona de Tucson, north of the mountain, to Rosemont, east of the mountain was not adequately justified.
2. Trinity suggests that ADEQ has previously approved the use of these data for regulatory purposes, but I could not find any supporting documentation on the ADEQ website. The fact that ADEQ approved the use of these observations for Rosemont (a different mine) in a different time period (2006-2007), under different wind patterns (east side) should not necessarily imply approval for Copper World in 2019-2021 on the west side. Although this is not an EPA AQS quality site, the data might still ultimately become accepted because EPA does recognize on-site measurements under certain circumstances. However, Trinity has not made the case for the use of this historic Rosemont data for Copper World operations.
3. The observational dates (June 2006 – June 2009) do not coincide with the Corona de Tucson PM10 dates (2019-2021). No justification or discussion of possible bias or errors introduced by this inconsistency is provided.
4. Inspecting Table 4-2, Trinity appears to have used the highest 24-h PM10 concentration observed *annually*, not *monthly,* which is inconsistent with how they modeled the west side. So, the results summarized in Tables 8-2 and 8-4 demonstrating NAAQS compliance, are not calculated on the same basis as the results in Tables 8-1, 8-3 and 8-5, also supposedly demonstrating NAAQS compliance. This is a profoundly serious problem as it gets to the very heart of the air dispersion modeling report.
5. The highest and second highest recorded PM10 observations are provided in Table 4-2 but the raw data supporting this selection from the three-year record are not provided and so cannot be checked.
6. Trinity goes to the trouble of performing a statistical analysis to demonstrate (to their satisfaction) that the highest observation (71.3 $\mu g/m^3$) is a statistical anomaly compared to the second highest value (27.0 $\mu g/m^3$), yet they promptly discard their statistical argument and retain the highest value in their calculation. I cannot fathom this. Why even write about the so-called anomaly when it makes no difference to the background concentration they finally chose to use, and, more

damningly, why did they not choose to use the highest values recorded at Corona de Tucson instead of making the questionable "Exceptional Events" argument to ignore the highest observations for the west side? The seven high values removed from the Corona de Tucson record (52-64 μg/m^3) are in fact lower than the high value retained in the east side record. This inconsistency is not discussed.

7. Appendix B, titled "PM10 Summary and Natural Events Documentation" is mute on how the *eastside* Background PM10 observations were actually selected and incorporated into AERMOD so it is impossible to check their conclusions with certainty.

Section 8. Evaluation of Dispersion Modeling Results for PM10

This is the most important section of the entire report where Trinity makes the case that the proposed mining operations will not lead to any NAAQS violations, yet I cannot confidently evaluate Section 8 results because of missing information.

The Trinity AERMOD Modeling Report (July 2024), refers the reader to "Appendix F. Emissions Workbook and Model Files" for the supporting raw data but although the report states that "All files [were] provided in original electronic format" (pg. F-1), the ADEQ website provides links to only the emissions inventory (which are AERMOD-calculated *fluxes* of NAAQS pollutants) not to modeled *concentrations* that can be compared to the NAAQS concentrations. Nor does the ADEQ link to Appendix F provide other crucial model data such as Corona de Tucson PM10 observations for the modeled years, the "east side" PM10 observations nor the associated and QA/QC documentation, new on-site meteorological data, nor topographical data, to name a few glaring omissions, despite Trinity's acknowledgment that this is the very purpose of their modeling (Section 8.1):

> *"The purpose of the dispersion modeling outlined in this report is to demonstrate that emissions from the Copper World Project will not cause exceedances of applicable National Ambient Air Quality Standards (NAAQS)."*

Even without having access to the necessary raw data, I believe that Trinity Consultants have made significant errors in Table 8-1, Table 8-3, and Table 8-5, copied below.

1. In Tables 8, the "Modeled Concentration" (column 3) is added to the observed "Background Concentration" (column 6) to yield the "Maximum Ambient Concentration" (column 7) for comparison to the NAAQS (column 8). At least I think this is the case, but the term "Maximum Ambient Concentration" is ambiguous and is not defined.

2. The “Background Concentration” entry in Tables 8-1, 8-3 and 8-5 (column 6) is given as “Monthly”, instead of as a numerical concentration (µg/m^3). The text, “Monthly,” cannot be added to a number and therefore their spreadsheet might have assumed a value of zero for the “Monthly” text entry thereby resulting in an erroneously low NAAQS concentration estimate. I suspect that is what happened in Tables 8-1, 8-3 and 8-5 because the Modeled Concentration is identical to the Maximum Ambient Concentration, i.e., the Background Concentration was wrongly taken to be zero. The result might be crucial since in Table 8-3 the Maximum Ambient Concentration (148.1 µg/m^3) is 99% of the NAAQS.
3. I have “corrected” Tables 8-1, 8-3, and 8-5 by adding the Background from Table 4-1, column 5, month by month to the Modeled Concentration and checking for an exceedance but I cannot be sure of my correction because their methodology (and overall questionable approach) is so obscure:

   Table 8-1: four exceedances: 150.7 µg/m^3 (for February), 150.7 µg/m^3 (for April), 150.7 µg/m^3 (for June), and 163.7 µg/m^3 (for September).

   Table 8-3: exceedances for every month of the year ranging from 167.1 µg/m^3 (for January) to 201.1 µg/m^3 (for September).

   Table 8-5: one exceedance: 160.4 µg/m^3 (for September).

4. The exceedances would be even worse if the original uncorrected Corona de Tucson data had been used, as I believe they should have.

The Trinity report does not include the crucial background concentration data in Appendix F, and nor does the ADEQ website provide it, therefore I cannot confidently evaluate the PM10 results. Most importantly, even in Appendix B, Trinity does not clearly describe how they calculated the “monthly” background PM10 observations in Tables 8-1, 8-3 and 8-5. For example, did they select the highest 24-h observation for each month and average each month over 3-years, or did they calculate the mean of all the 24-h observations every month for three years?

Moreover, lacking the raw input/output data Trinity used to calculate the other expected NAAQS pollutant concentrations, it is difficult to evaluate any of the other NAAQS results in these Tables.

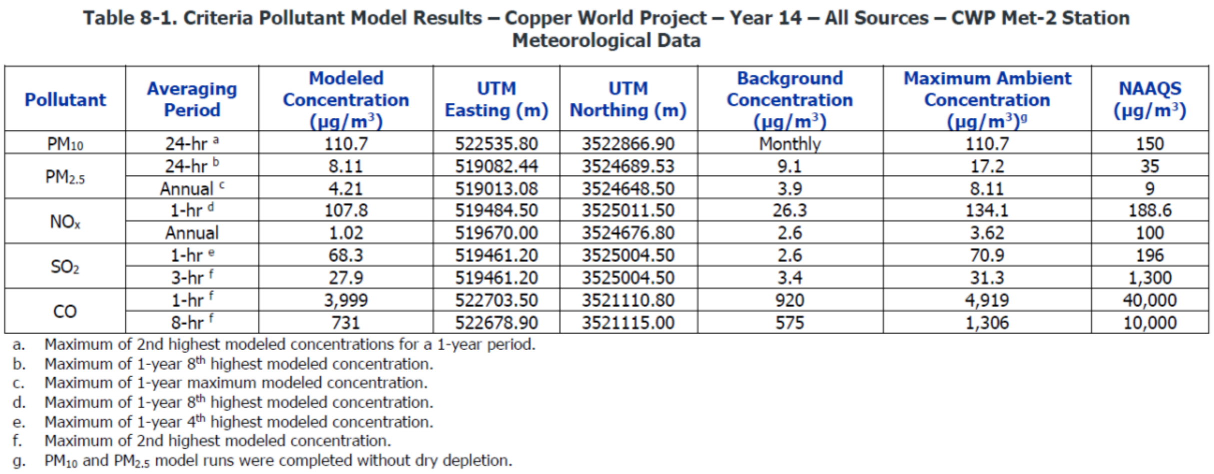

Table 8-1. Criteria Pollutant Model Results – Copper World Project – Year 14 – All Sources – CWP Met-2 Station Meteorological Data

Pollutant	Averaging Period	Modeled Concentration (μg/m^3)	UTM Easting (m)	UTM Northing (m)	Background Concentration (μg/m^3)	Maximum Ambient Concentration (μg/m^3)[g]	NAAQS (μg/m^3)
PM$_{10}$	24-hr [a]	110.7	522535.80	3522866.90	Monthly	110.7	150
PM$_{2.5}$	24-hr [b]	8.11	519082.44	3524689.53	9.1	17.2	35
	Annual [c]	4.21	519013.08	3524648.50	3.9	8.11	9
NO$_x$	1-hr [d]	107.8	519484.50	3525011.50	26.3	134.1	188.6
	Annual	1.02	519670.00	3524676.80	2.6	3.62	100
SO$_2$	1-hr [e]	68.3	519461.20	3525004.50	2.6	70.9	196
	3-hr [f]	27.9	519461.20	3525004.50	3.4	31.3	1,300
CO	1-hr [f]	3,999	522703.50	3521110.80	920	4,919	40,000
	8-hr [f]	731	522678.90	3521115.00	575	1,306	10,000

a. Maximum of 2nd highest modeled concentrations for a 1-year period.
b. Maximum of 1-year 8th highest modeled concentration.
c. Maximum of 1-year maximum modeled concentration.
d. Maximum of 1-year 8th highest modeled concentration.
e. Maximum of 1-year 4th highest modeled concentration.
f. Maximum of 2nd highest modeled concentration.
g. PM$_{10}$ and PM$_{2.5}$ model runs were completed without dry depletion.

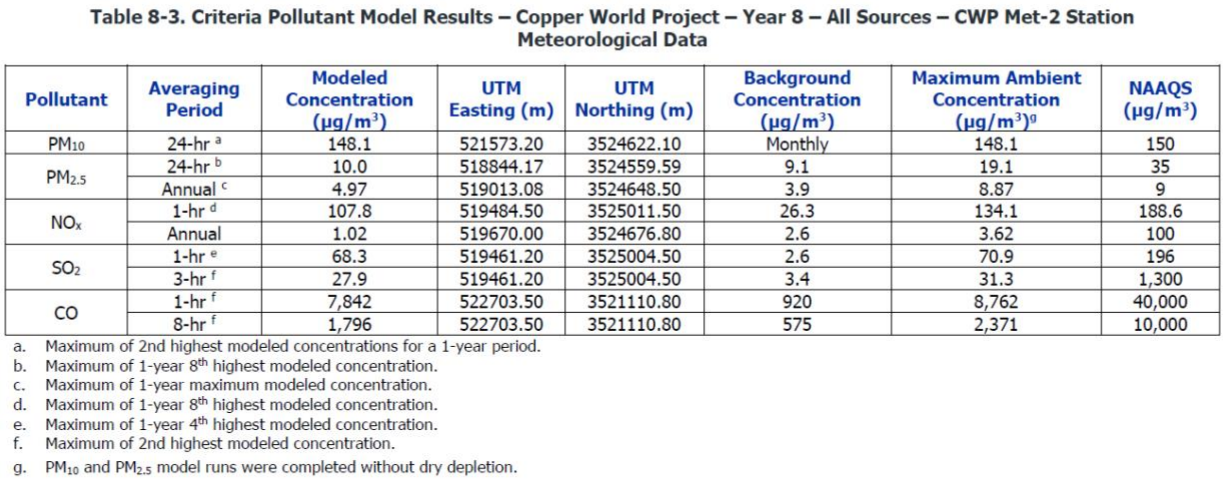

Table 8-3. Criteria Pollutant Model Results – Copper World Project – Year 8 – All Sources – CWP Met-2 Station Meteorological Data

Pollutant	Averaging Period	Modeled Concentration (μg/m^3)	UTM Easting (m)	UTM Northing (m)	Background Concentration (μg/m^3)	Maximum Ambient Concentration (μg/m^3)[g]	NAAQS (μg/m^3)
PM$_{10}$	24-hr [a]	148.1	521573.20	3524622.10	Monthly	148.1	150
PM$_{2.5}$	24-hr [b]	10.0	518844.17	3524559.59	9.1	19.1	35
	Annual [c]	4.97	519013.08	3524648.50	3.9	8.87	9
NO$_x$	1-hr [d]	107.8	519484.50	3525011.50	26.3	134.1	188.6
	Annual	1.02	519670.00	3524676.80	2.6	3.62	100
SO$_2$	1-hr [e]	68.3	519461.20	3525004.50	2.6	70.9	196
	3-hr [f]	27.9	519461.20	3525004.50	3.4	31.3	1,300
CO	1-hr [f]	7,842	522703.50	3521110.80	920	8,762	40,000
	8-hr [f]	1,796	522703.50	3521110.80	575	2,371	10,000

a. Maximum of 2nd highest modeled concentrations for a 1-year period.
b. Maximum of 1-year 8th highest modeled concentration.
c. Maximum of 1-year maximum modeled concentration.
d. Maximum of 1-year 8th highest modeled concentration.
e. Maximum of 1-year 4th highest modeled concentration.
f. Maximum of 2nd highest modeled concentration.
g. PM$_{10}$ and PM$_{2.5}$ model runs were completed without dry depletion.

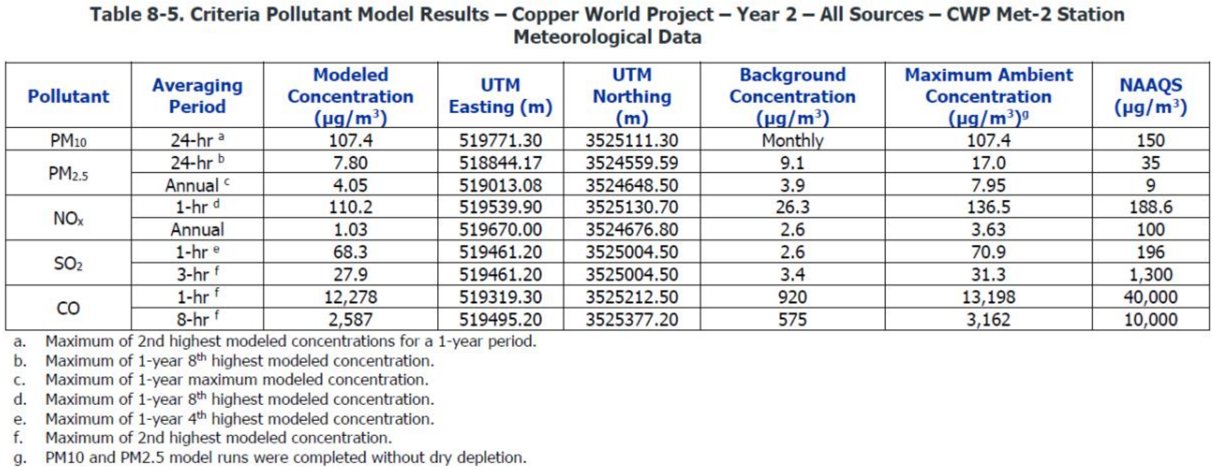

Table 8-5. Criteria Pollutant Model Results – Copper World Project – Year 2 – All Sources – CWP Met-2 Station Meteorological Data

Pollutant	Averaging Period	Modeled Concentration (μg/m^3)	UTM Easting (m)	UTM Northing (m)	Background Concentration (μg/m^3)	Maximum Ambient Concentration (μg/m^3)[g]	NAAQS (μg/m^3)
PM$_{10}$	24-hr [a]	107.4	519771.30	3525111.30	Monthly	107.4	150
PM$_{2.5}$	24-hr [b]	7.80	518844.17	3524559.59	9.1	17.0	35
	Annual [c]	4.05	519013.08	3524648.50	3.9	7.95	9
NO$_x$	1-hr [d]	110.2	519539.90	3525130.70	26.3	136.5	188.6
	Annual	1.03	519670.00	3524676.80	2.6	3.63	100
SO$_2$	1-hr [e]	68.3	519461.20	3525004.50	2.6	70.9	196
	3-hr [f]	27.9	519461.20	3525004.50	3.4	31.3	1,300
CO	1-hr [f]	12,278	519319.30	3525212.50	920	13,198	40,000
	8-hr [f]	2,587	519495.20	3525377.20	575	3,162	10,000

a. Maximum of 2nd highest modeled concentrations for a 1-year period.
b. Maximum of 1-year 8th highest modeled concentration.
c. Maximum of 1-year maximum modeled concentration.
d. Maximum of 1-year 8th highest modeled concentration.
e. Maximum of 1-year 4th highest modeled concentration.
f. Maximum of 2nd highest modeled concentration.
g. PM10 and PM2.5 model runs were completed without dry depletion.

Eastside Background PM10

By contrast, Table 8-2 and Table 8-4 indeed have a numerical entry for the observed Background Concentration (47.7 µg/m^3) supposedly valid for sources east of the Santa Rita mountains, not the Corona de Tucson monitor. Trinity appears to have used PM10 observations acquired by Rosemont's own PM10 monitor but the raw data supporting the eastern PM10 observations (Table 4-2) were not provided in the report or appendices so I cannot rigorously evaluate the background concentrations reported in Tables 8-2 and 8-4.

However, one can glean some insight from the data Trinity provides in Table 4-2. Instead of calculating the 24-h average for *each month's* high over a period of three years as they apparently did with Corona de Tucson, Trinity now calculates an average for *each year's* high over a (different) period of three years to yield a single Background value of 47.7 µg/m^3 which they use in both Table 8-2 (year 14 east side sources) and Table 8-4 (year 8 east side sources). The inconsistent use of two different averaging schemes (monthly vs. annual) for west side vs. east side is never addressed. The NAAQS PM10 standard is defined for an averaging period of 24-h but it is not apparent that Trinity used 24-h observations for the east side monitor.

I am suspicious of the predicted Year 14 Maximum Ambient Concentration of 149.1 µg/m^3 which is less than1 µg/m^3 below the NAAQS of 150 µg/m^3. A minor error in calculating the PM10 Background Concentration for the east monitor could easily push the result above the standard. Or if Trinity had followed EPA guidance to be as conservative as possible and used the *highest* background observed at the east side site (71.3 µg/m^3, Table 4-2) then they would have predicted a NAAQS PM10 exceedance: 172.6 µg/m^3.

I am also suspicious of the Year 8 east side value (Table 8-4) which is within 9.8 µg/m^3 of the standard. Being conservative and adding the highest background observed at the east side site (71.3 µg/m^3, Table 4-2) would also have caused a predicted exceedance: 163.3 µg/m^3.

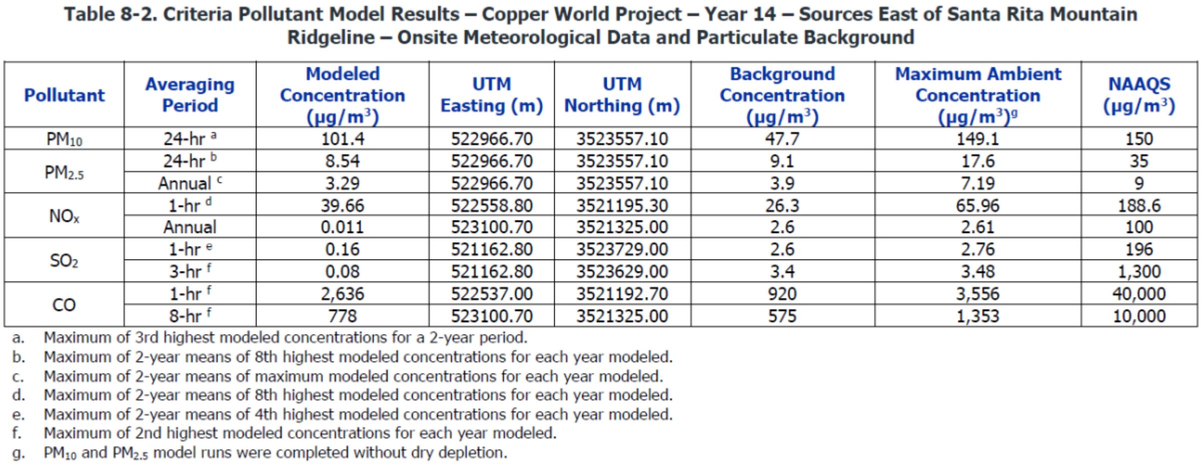

Table 8-2. Criteria Pollutant Model Results – Copper World Project – Year 14 – Sources East of Santa Rita Mountain Ridgeline – Onsite Meteorological Data and Particulate Background

Pollutant	Averaging Period	Modeled Concentration (μg/m³)	UTM Easting (m)	UTM Northing (m)	Background Concentration (μg/m³)	Maximum Ambient Concentration (μg/m³)[g]	NAAQS (μg/m³)
PM_{10}	24-hr [a]	101.4	522966.70	3523557.10	47.7	149.1	150
$PM_{2.5}$	24-hr [b]	8.54	522966.70	3523557.10	9.1	17.6	35
	Annual [c]	3.29	522966.70	3523557.10	3.9	7.19	9
NO_x	1-hr [d]	39.66	522558.80	3521195.30	26.3	65.96	188.6
	Annual	0.011	523100.70	3521325.00	2.6	2.61	100
SO_2	1-hr [e]	0.16	521162.80	3523729.00	2.6	2.76	196
	3-hr [f]	0.08	521162.80	3523629.00	3.4	3.48	1,300
CO	1-hr [f]	2,636	522537.00	3521192.70	920	3,556	40,000
	8-hr [f]	778	523100.70	3521325.00	575	1,353	10,000

a. Maximum of 3rd highest modeled concentrations for a 2-year period.
b. Maximum of 2-year means of 8th highest modeled concentrations for each year modeled.
c. Maximum of 2-year means of maximum modeled concentrations for each year modeled.
d. Maximum of 2-year means of 8th highest modeled concentrations for each year modeled.
e. Maximum of 2-year means of 4th highest modeled concentrations for each year modeled.
f. Maximum of 2nd highest modeled concentrations for each year modeled.
g. PM_{10} and $PM_{2.5}$ model runs were completed without dry depletion.

EXHIBIT 7

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Eric A Betterton

Professor Emeritus

Contact

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Bio	**Interests**	**Courses**	**Scholarly Contributions**

Biography

I am a Distinguished Professor Emeritus of Hydrology and Atmospheric Sciences. I retired in May 2021. I also held courtesy appointments in the Department of Chemical and Environmental Engineering, and in the Division of Community, Environment and Policy, Zuckerman College of Public Health.

Born and raised in Zimbabwe, I studied chemistry in South Africa, and environmental science at Caltech. Along the way, I worked in the platinum mining industry, and in cement and lime manufacturing. I joined the University of Arizona in 1988.

My research in the laboratory and in the field has been focused on environmental pollutants, especially those found in the air and water that might affect people. For example, I studied toxic metals in airborne dust, the chemistry of rain and snow, and the environmental fate of sodium azide, the propellant used in certain automobile airbags.

I have taught large introductory course in weather and climate, and smaller, more advanced courses in atmospheric physics, atmospheric chemistry, and atmospheric aerosols (suspended particulate matter).

Degrees

- Ph.D. Chemistry
    - University of the Witwatersrand, Johannesburg, South Africa
    - Studies in the Properties and Reactions of Vitamin B12 Complexes
- B.S. Chemistry (Honors)
    - University of Natal, Durban, South Africa
- B.S. Chemistry and Applied Chemistry
    - University of Natal, Durban, South Africa

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Work Experience

- Department of Hydrology and Atmospheric Sciences (1998 - 2020)
- Department of Chemistry, California State University (1987 - 1988)
- California Institute of Technology, Pasadena, California (1985 - 1987)
- Anglo-Alpha Cement Ltd (1984 - 1985)
- Anglo-Alpha Technical Services (1982 - 1984)
- Impala Platinum Limited (1976 - 1979)

Awards

- University of Arizona Distinguished Professorship
    - Fall 2013
- Professor Leon and Pauline Blitzer Award for Excellence in the Teaching of Physics and Related Sciences
    - Blitzer family foundation, Spring 2012
- UA at the Leading Edge Recognition
    - University of Arizona, Spring 2012

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EXHIBIT 8

CHEMICAL AND PHYSICAL FACTORS THAT INFLUENCE NO_x PRODUCTION DURING BLASTING - EXPLORATORY STUDY

by Michael Sapko, James Rowland, Richard Mainiero, and Isaac Zlochower

ABSTRACT

The National Institute for Occupational Safety and Health (NIOSH) carried out exploratory laboratory-scale studies to identify factors that may contribute to nitrogen oxides (NO_x) production associated with non-ideal detonation of blasting agents. Explosive admixture with drill cuttings, loss of fuel oil in ammonium nitrate and fuel oil (ANFO) from wicking, ammonium nitrate dissolution with water, degree of explosive confinement, ANFO density, and critical diameter were identified as contributing factors to increased NO_x production under the laboratory test conditions. Experiments were also conducted to examine the effectiveness of various additives in reducing the NO_x production from ANFO, emulsion, and ANFO/emulsion blends. Aluminum powder, coal dust, urea, and excess fuel oil in ANFO formulations were tested and were found to reduce both the nitric oxide (NO) and nitrogen dioxide (NO_2) production. Fumes measurements were obtained in the NIOSH underground closed chamber from the detonation of 4.5-kg (10 lbs) charges in schedule 80 seamless steel pipe and from detonations in light weight galvanized steel stove pipe. Some exploratory tests were also conducted with 0.8-kg (1.8 lbs) charges of pulverized ANFO initiated with 0.08-kg (0.18 lbs), 50/50 (Pentolite) boosters (in the NIOSH 12-ft (3.7-m) diameter steel sphere) to measure the degree of fumes production associated with post-detonation oxidation. Ammonium nitrate, emulsion and Pentolite boosters were also detonated in an oxygen-poor environment.

INTRODUCTION

The generation of orange post-blast NO_2 clouds, more commonly referred to as yellow or orange smoke, is not uncommon in the commercial explosives' industry. The occurrence of such post-detonation fumes has historically been associated with wet conditions and has generally not been viewed with alarm due to the rapid dispersion of the gas into the air. Current cast-blasting in some surface coal mining operations have resulted in the use of millions of pounds of ANFO and ANFO/emulsion agents in a single blast. While NO_2 dissipation into the atmosphere from relatively small shots is generally achieved in a matter of seconds, comparable NO_2 dissipation from huge casting operations may take minutes. Faced with the noticeable levels of NO_2 in the form of orange/red clouds which may drift off the mine property, the mining industry has requested assistance from NIOSH to identify potential causes for generation of these orange clouds, and to recommend ways to minimize their occurrence.

The orange/red coloration is caused by the presence of NO_2 which is a direct product of the detonation process, and is also produced in the after burning reactions and by the secondary oxidation of NO to NO_2 as the cloud mixes with air. Both NO and NO_2 are toxic gases, as indicated by the NIOSH recommended exposure limits (REL) for a 10-hour work day of 25 ppm and 2 ppm respectively[1]. The cloud due to NO_2 is both more noticeable and potentially more toxic.

Several factors have been identified as contributing to the non-ideal detonation behavior observed in some large cast blasts: A weak overburden, which significantly reduces the necessary explosive confinement; significant water infiltration during long intervals between loading and firing, which changes the explosive composition; long explosive columns, which produce bottom hole hydrostatic pressures that decrease the probability of successful detonation propagation; and explosive pre-compression caused by hole-to-hole shock propagation due to wet overburden and clay veins. Research has shown that the degree of confinement of an explosive charge and the material being blasted both have a significant impact on fumes production[1,4,5]. As a result, measurements of fumes produced by blasts in one mine tells us little about the fumes that would be produced for a different blast pattern in different material at another mine. Tests on a smaller scale, with better control over the variables are therefore required in order to delineate causal factors and to indicate means of minimizing this problem.

Over the years, extensive explosive testing research has been done on the toxic fumes generated by the detonation of high explosives, and many countries have test procedures and formal requirements in place as to the maximum permitted fumes production in the mandated tests [2,3]. Typically, 100 grams or so of high explosives are detonated in a chamber and the fumes collected for analysis. Measuring the fumes produced by the detonation of blasting agents is much more difficult. Any test to measure the fumes produced by blasting agents must take into account the fact that most blasting agents require boosters, larger charge sizes, and heavy confinement to detonate well and to simulate the conditions used in actual practice. In addressing this issue, NIOSH developed tests that report fumes production under a well defined set of conditions[6,7,8] in a large mine room and in a large steel sphere.

It must be understood, however, that it is not generally possible to extrapolate quantitative toxic fumes data to mine site conditions. First, it is difficult to achieve consistent detonations of ANFO in small diameter pipes without pulverizing the prills and thereby introducing a grain-size variable. Second, the degree of confinement plays an important role in determining the detonation conditions and the composition of the expanded detonation products. The actual degree of explosive confinement in the field can not be duplicated in the laboratory. Laboratory studies, however, provide a useful, inexpensive approach for comparing the relative effectiveness of various techniques for reducing the production of toxic fumes.

This paper describes results from the series of detonation tests with blasting agents conducted in the mine chamber and in a smaller scale 12-ft (3.7-m) diameter sphere to identify factors contributing to fumes production, and to evaluate the potential of various additives or stemming techniques to reduce the formation of NO_2 when blasting under non-ideal conditions primarily caused by low confinement. Most blasting agents are formulated to be near stoichiometrically balanced in fuel vs oxygen content to maximize energy output while minimizing carbon monoxide (CO), NO, and NO_2 production when properly boosted, shot in large diameters, and shot under heavy borehole confinement. In many blasting operations, the ground conditions do not provide good confinement, resulting in non-ideal detonations. This study focuses on the potential use of inexpensive additives to blasting agents to reduce the formation of NO and NO_2 generated under these non-ideal conditions. Various stemming materials were also evaluated to determine their potential to reduce the NO_2 concentration through absorption by water and/or alkaline materials. ANFO additives included, aluminum, coal dust, urea, and diesel fuel. Stemming materials included water, $NaHCO_3$, Na_2CO_3, coal dust, trona, and wet drill cuttings. The most important consideration is safety when considering modification to any explosive formulation through the incorporation of additives. Any non-proven modifications to explosive formulation should be approached with extreme caution and only by qualified explosive manufacturers. Preliminary results will be presented, but further full-scale field research under controlled field conditions must be conducted to evaluate the validity of these potential remedial measures.

EXPERIMENTAL APPROACH

Underground Chamber

A facility for detonating large, confined charges in a controlled volume has been constructed at the Pittsburgh Research Laboratory=s Experimental Mine and has been used for measuring fumes production as a function of various additives in 4.5-kg (10 lbs) explosive charges[8]. Tests are conducted in thin-wall 4-in (10-cm) diameter galvanized pipe to simulate light confinement, and in nominal 4-in (10-cm) schedule 80 seamless steel pipe to simulate heavier confinement. The facility, illustrated in Figure 1, consists of a portion of mine entry enclosed between two explosion proof bulkheads. Total volume of the chamber is 9,667 ft (274 m3). The chamber is equipped with an air circulating system and is vented by opening the vent ports to the mine's airflow. Up to 4.5-kg (10 lbs) charges can be detonated in the chamber using a variety of confinements. For a typical test, the blasting agent is confined in a 4-in (10-cm) schedule 80 seamless steel pipe and is initiated by a 2-in (5.1-cm) diameter, 2-in (5.1-cm) thick Pentolite booster. This combination of confinement and initiation yields a detonation velocity of about 4,000 m/s for a 26-in (66-cm) column of ANFO prills. Twenty-four 2-in (5.1-cm) thick steel plates are suspended around the pipe, which is itself suspended vertically above a heavy steel plate on the mine floor, to form a cage which stops shrapnel that would otherwise seriously damage the chamber. Following detonation of an explosive in the chamber, a circulating fan is run for about 10 minutes to uniformly mix the chamber atmosphere. Fumes samples are taken out of the chamber through 0.25-in (6-mm) Teflon tubes via sampling pumps for analysis. Vacutainer gas samples are taken and sent to our analytical laboratory for gas chromatographic analysis. The latter technique is appropriate for components that are stable in the Vacutainer, namely hydrogen (H_2), carbon monoxide (CO), and carbon dioxide (CO_2), nitrogen (N_2), oxygen (O_2), and methane (CH_4). NO and NO_2 are measured with an on-line chemiluminescence analyzer and ammonia (NH_3) is measured with a MSA Chilguard* analyzer[8]. A minimum of 2 and a maximum of 6 experiments were conducted with each explosive mixture and the average concentration reported. The reproducibility for most tests was within10% with the largest difference being 20%.

12-ft (3.7-m) Diameter Sphere

Smaller scale studies were conducted in NIOSH=s 12-ft (3.7-m) diameter sphere shown in Figure 2. The preparation of ANFO mixtures involves blending of No. 2 diesel fuel (with red dye) with pulverized ammonium nitrate (AN). The AN had passed through a 60-mesh screen, corresponding to AN particles that are less than 250 microns. For a typical test, the pulverized ANFO mixture is placed in a glass tube with a 1.75-in (4.45-cm) inner diameter, 0.06-in (0.15-cm) wall thickness and 24-in (61-cm) long. Glass was chosen because it is inert and would not contribute to the fumes production. A cast Pentolite booster that is 1-in (2.5-cm) thick (about 80 grams) was taped with masking tape to one end of the tube. Prior to loading the pipe with explosive, a continuous velocity probe of the type described by Lon Santis[9] is taped to the inner surface of the pipe along its length. The glass tube filled with ANFO is suspended vertically in the geometric center of the 12-ft (3.7-m) sphere and initiated with a No. 8 copper blasting cap.

Ten minutes after detonation, gas samples are withdrawn at about 1.2 L/min through an MSA* Ultra-Filter with Type H cartridge via Teflon tubing and introduced into the flow controlled electrochemical cells in a Testo 350 analyzer*. The Testo provides an on-line readout of NO, NO_2, and CO concentrations. The Testo 350 has a time constant of about 2 minutes and was calibrated before each test with calibration quality mixtures of each of the sensed gases (CO, NO, and NO_2) in nitrogen. Vacutainer samples were also taken at 5, 10, 30, and 60 minutes after the detonation for subsequent GC analysis for H_2, CO_2 and the hydrocarbons (C_1-C_5). Overpressure in the sphere following the detonation was less than 3 kPa (20 torr). Continuous and batch sampling results showed a relatively constant concentration of CO from 5 minutes to 60 minutes after detonation. Some detonation tests were also conducted in mostly argon atmospheres containing less than 1% oxygen.

RESULTS AND DISCUSSION

ANFO Particle Size

Several chamber tests were conducted to compare the fumes production from the detonation of prilled and pulverized ANFO. 10 lbs (4.5 kg) of prilled and pulverized ANFO was loaded and shot in 4-in (10-cm) galvanized steel pipe. The bulk loading density of the prills was 0.86 g/cc and the bulk (non tamped) loading density of the pulverized ANFO (< 200 microns) averaged 0.82 g/cc. The average measured detonation velocity (VOD) was 3927 m/s for the pulverized ANFO and 2738 m/s for prilled ANFO. The resulting fumes from the detonations were collected and measured. With the same degree of light confinement, the NO_2 production from pulverized AN was a factor of 4 lower than that produced from standard prills. Both CO and H_2 from the detonation of pulverized AN were

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*Reference to specific products does not imply endorsement by NIOSH.

about factor of 2 lower, and the NO was 30% lower than with pills. No significant difference in CO_2 production was detected between the pulverized and prilled AN. With pulverized AN, the ammonium nitrate is presumably more intimately mixed with the fuel than in the case of the prills. The more intimate contact between the ammonium nitrate and fuel may cause a more complete reaction to take place. With prills, the decomposition reactions in the grains of nitrate may take place further behind the detonation front to yield more NO. Studies continue in the mine chamber and in the 12-ft (3.7-m) sphere in argon to better understand the causes for the NO_x reduction with decreasing AN particle size.

ANFO Prills vs Emulsion and Confinement

It has been proposed that the reduced confinement provided by a soft overburden present at some surface mines may promote the generation of NO from the explosive composition within the borehole due to thermal reaction of the nitrates (and fuel) contained in the explosives. As the NO is released from the muck pile following the detonation of the blast pattern, the gas is further oxidized in air to form the colorful after-blast fumes of $NO_{2.}$ NIOSH's underground chamber was used to examine the relative NO_x production as a function of simulated levels of explosive confinement. Three explosive compositions with different detonation velocities were examined. Compositions of ANFO, a 50/50 blend of emulsion with ANFO, and straight emulsion were detonated in both schedule 80 steel pipe and in light weight galvanized pipe. The emulsified explosive used in this study was the Apex 1220 emulsion donated by Energetic Solutions Inc*, and the AN prills were from the Seneca* plant in Pennsylvania. Post-detonation products were analyzed and the results are presented in Figures 3 and 4.

The oxidation of NO to NO_2 in air depends on the initial NO concentration and time. Concentrations of both NO and NO_2 are added and the sum is given as NO_x concentration. The NO_x concentration shows significant increases with decreasing confinement for all three explosives. Furthermore, the ANFO and 50/50 ANFO/emulsion blend produced much more NO_x than the emulsion. Grain size of the explosive is probably most important in this connection, too. Explosives like ANFO contain rather large grains of AN which tend to decompose and yield NO_x. In emulsion explosives, the nitrate is mainly found in solution and more intimately in contact with the emulsified fuel droplets. As a result the NO_x produced from the thermal decomposition of AN will tend to react with hydrocarbons to yield nitrogen and water rather than remaining as NO after the detonation.

Critical Diameter of the Emulsified Explosive

To determine the critical diameter, the emulsion was detonated in various diameter schedule 40 steel pipe from nominally 1 to 4-in (2.5 to10-cm) diameters. The length of the pipe was 2-ft (61- cm). The velocity of detonation (VOD) was measured and the degree of pipe fragmentation was noted. The VOD results shown in Table 1 indicate that the emulsion detonated about 6600 m/s in 4-in (10-cm) pipe to slightly over 5300 m/s in 1 in pipe (inside diameter of 1.05-in or 2.67-cm). The critical diameter for this emulsion appears to be less than 1-in (2.5-cm) and the detonations using heavy confinement are relatively ideal, thus producing much less $_{Nox}$.

Table 1.- VOD as a function of pipe diameter.

Nominal Size Schedule 40 Pipe	VOD (m/s)
4-inch[1]	6604
3-inch	6634
1.5-inch	5862
1-inch	5346
[1]Nominal size Schedule 80 steel pipe	

ANFO Additives

The generation of post-blast NO_2 is hypothesized to be the result of thermal reactions (in addition to the ideal products of detonation), which result in the enhanced formation of NO_x. The NO component readily oxidizes to the visual orangish cloud characteristic of NO_2 when introduced into the atmosphere. Modification of the explosives' composition was considered as a remedial method for reducing the probability of forming NO_x in the reaction zone following the detonation front. Detonation tests with blasting agents were conducted in the mine chamber and in the 12-ft (3.7-m) diameter sphere to evaluate the potential for various additive or stemming techniques to reduce the formation of NO_2 when blasting under low confinement. Coal dust, urea, excess diesel fuel, WR Conditioner 260* additive, and aluminum were mixed in various proportions with the emulsion, ANFO, and blends, followed by detonation in light weight 4-in (10-cm) galvanized steel pipe. These additives had been alleged to reduce NO_x in blasting operations. The WR Conditioner also forms a gel in contact with water to provide protection against AN dissolution. Figure 5 compares the NO and NO_2 produced from ANFO with that produced using various additives. Excess diesel fuel (8%), reduces the NO_2 production by a factor of 3 with only a slight reduction in NO. The addition of 3% Pittsburgh Pulverized Coal (PPC) dust to the 6% fuel oil (FO) was just as effective. The 3% FO plus 3% PPC produced less NO_2 than 6% FO, with an increase in NO. Making the explosives fuel rich thus leads to a reduction of NO_x, but at the expense of an increase in CO. The benefit of any additive with low confinement will be lost if some of the explosive column is compromised during the long interval between borehole loading and firing from water influx dissolving the AN or to the loss of fuel oil due to wicking action of the borehole walls. In such cases the explosive column composition would have to be protected against water influx and against oil absorption by the surrounding overburden material. This is the intended function of the WR additive.

50/50-ANFO/Emulsion Blends with Additives

Figure 6 compares the NO and NO_2 production for 50/50 blends of emulsion with ANFO shot in galvanized steel pipe with and without additives. The additive is mixed with ANFO and then mixed with the emulsion. Pittsburgh Pulverized Coal (PPC) (mean particle size 74 microns) had little effect on the NO and NO_2 production. Even 5% PPC produced only a slight reduction in NO_2. Addition of 3% urea also had little effect on NO_2 production. When 3% aluminum was added to the 6% FO - 91% AN the NO_2 decreased by a factor of 2.5. Added aluminum powder was expected to increase the temperature, reaction rate and the completeness of the thermal reaction of the fuels and the oxidizer. Studies continue with blends to evaluate the effectiveness of higher aluminum concentrations.

Stemming Materials

In addition to the additives, stemming with water was considered a potential mitigation technique to reduce NO_2 production by dissolution of the soluble acidic gas in water augmented by a basic material such as sodium carbonate (Na_2CO_3). One liter of water mixed with 10 grams of Na_2CO_3 reduced the detectable NO_2 by 48% with little reduction in NO. Practical stemming with water may, however, be somewhat difficult to accomplish in the field. One would need to ensure that water does not leak into a lower explosive column during the long period between loading and firing. Adding a gelling agent to the bagged water could minimize such concerns. Wetting down the blast area prior to firing was considered as a way to help absorb the NO_2 on damp dust dispersed during the blast.

Oil Wicking and AN Dissolution

A common explanation for post-detonation NO_2 fumes from ANFO is that the mix was under-fueled (positive oxygen balance) or the boreholes were wet. If under-fueling occurred, the production of oxides of nitrogen may be expected due to incomplete reduction of the nitrates to nitrogen. The possibility exists that a balanced ANFO formulation could become fuel-poor if fuel oil is lost to the borehole wall by wicking. Several experiments were conducted to assess the amount of fuel oil loss due to wicking of the fuel oil in ANFO. AN prills were mixed with No. 2 diesel fuel and set for 24 hours. They were then placed in simulated boreholes consisting of cylindrical holes in porous cement blocks. The cement was made with 12 parts sand and 1 part cement, plus enough water to yield a workable mix and set in 1-gal metal paint cans. The ‘boreholes’ were 1, 2, and 2.5- in (2.5, 5, and 6-cm) in diameter. Larger, 4.5-in (11-cm) diameter boreholes were fabricated in 6-gal sealable plastic cans. All of the cement blocks were dried in an oven at 110°C for 7 days before loading. The ANFO was weighed, placed in a hole, sealed, and kept at 55°C during testing. The ANFO was removed from the boreholes and weighed at 1, 2, 6, 8, 9, and 13 day intervals. The mass loss was found to be relatively constant at 0.0048 $g/in^2/day$. Using this average loss rate, the fuel oil content as a function of borehole diameter for 7, 14, and 30 days was calculated and is shown in Figure 7. For 3-in (7.6-cm) diameter boreholes, after 30 days the average fuel oil concentration in the mixture decreases from 6% to 4.5%. Such a loss of fuel oil would result in under-fueled explosives in blasting situations, leading to an increase in NO and NO_2 production.

Similar tests were conducted as above except that 8% moisture was added to the dried cementitious borehole. Eight percent was chosen since the drill cuttings from a mine in Wyoming that had experienced red cloud formation after blasting, contained from 7% to 8% water. The drill cuttings, with 8% bound moisture, seemed dry to the touch. The can with the added water set for about 24 hours while the moisture was drawn into the walls of the simulated cementitious borehole. ANFO was weighed and added to the empty 2-in (5-cm) diameter borehole and sealed. In these tests, the hygroscopic AN, drew the water from the cement, which dissolved some AN, and the column height decreased as the AN solution was drawn into the cementitious walls. The height of the column was recorded and the mass loss was calculated from the change in prill height and initial density. Shown in figure 8 is AN loss as a function of time. Note that in 10 days about 50% (½ the column height) was lost to the cementitious borehole. Similar tests were also conducted with the borehole cased with 12 parts drill cuttings and 1 part cement. There was no significant difference in loss rate between the sand/cement borehole and the one fabricated with drill cuttings of similar particle size. Without borehole liners, there can be a significant loss of AN. Even with holes that appear dry to the touch, a significant loss of AN can result with time.

Thickening Agents

Two additives were evaluated, one added to the fuel oil and one to the AN, to help reduce the fuel oil and AN loss. Two percent Cabosil* (fumed silica) was added to the fuel oil component and rapidly mixed with the AN prills. The mixture was then placed in the pre-dried 2-in (5.1 cm) diameter boreholes and the oil loss measured. The Cabosil prevented the wicking away of the fuel oil from the prills. However, under these conditions the Cabosil may have also prevented the oil from effectively migrating into the prill pores. Adding the Cabosil to the prills first, then mixing in the red-dyed fuel oil, appeared to restrict the oil absorption by the prills and prevented uniform distribution of the oil on the outside of the prills. Work continues to identify other liquid gelling agents that permit oil distribution throughout the prills before gelling occurs. The thickened fuel oil significantly reduced the loss of oil wicking but did not reduce the AN loss when placed in the simulated borehole containing 8% water.

WR Conditioner 260, an ANFO gelling agent, was also evaluated. The conditioner was added to the ANFO and placed in a simulated 2-in (5.1-cm) diameter cement-sand borehole containing 8% moisture. When compared with results from straight ANFO, the conditioner delayed the AN loss as shown in figure 9. As the AN draws water from the walls of the borehole, the WR Conditioner gels the water near the wall of the borehole, thereby reducing the rate of AN dissolution. The performance of WR Conditioner, under damp conditions, is expected to improve with an increase in borehole diameter. As the gelled water boundary layer between the explosive column and the borehole wall thickens, the better the center explosive core is protected from further erosion. These observations were based on a 2-in (5.1 cm) diameter simulated borehole and would have to be evaluated in the field in larger and deeper holes where hydrostatic effects may become important.

Emulsion Admixture with Drill Cuttings

Cast blasting is used extensively in large surface coal mines. Angled holes, 12.25 in (31 cm) in diameter, 170-ft (53 m) long are commonly used to cast overburden into the pit, thereby reducing drag line time and providing a more stable highwall. As the drill is withdrawn from the hole, the weak overburden from the walls of the hole falls down and accumulates at the bottom of the hole, as illustrated in figure 10. When drilling in soft overburden, the angled drill holes often become elliptical in cross-section. In some cases the angle holes are slightly sub-drilled into the coal, and backfilled with drill cuttings. Loading emulsion explosives on top of drill cuttings will tend to produce a mix of emulsion and drill cuttings near the bottom of the boreholes. The hydrostatic head produced by the emulsion will tend to force it into the interstitial void within the drill cuttings. Some mixing of drill cuttings and emulsion will also occur at the top of the column when drill cuttings are piled on top for stemming.

NIOSH conducted a series of tests to examine the potential impact of emulsion admixture by Wyoming drill cuttings on the toxic fumes production. Shown in figure 11 is a 4-in (10 cm) diameter glass pipe with drill cuttings placed on top of the emulsion column and dead weight loaded at 10 psi (69 KPa) to simulate a 20-ft (6.1 m) high column of stemming. The drill cuttings sink into the emulsion filling the interstitial spaces. To measure the relative production of toxic fumes associated with this type of emulsion dilution, 5 lbs (2.3 Kg) of drill cuttings were mixed with 5 lbs (2.3 Kg) of emulsion and this mixture was shot atop of 5 lbs (2.3 Kg) of straight emulsion in a galvanized pipe in the mine fumes chamber. The explosive was initiated at the emulsion end and the detonation propagated into and through the mixture. VOD probes, along with a schedule 80 seamless steel witness pipe, were placed outside and parallel to the galvanized pipe. Shown in figure 12, is the NO and NO_x produced from the 50/50 blend of emulsion and drill cuttings. The average VOD measured through the emulsion was 6000 m/s while the average VOD through the drill cutting/emulsion mix was 3500 m/s. The witness pipe was completely collapsed near the straight emulsion and about 75% collapsed over the section containing the 50/50 emulsion/drill cuttings. The NO and NO_2 produced was about 6 to 8 times greater than with the straight emulsion. A mixture of 25% emulsion and 75% drill cuttings was also tested. The emulsion detonated but the 25/75 mixture failed to propagate the detonation. Consequently, there was little increase in NO_x production. Tests were also conducted using 1/8 in (0.32 cm) coal chips from a surface coal mine in place of the overburden drill cuttings. The fumes production with coal chips was about the same as with the inert drill cuttings, indicating little chemical reaction. Additionally, both drill cuttings and coal seem to serve as a thermal sink in cooling the reaction front. These results indicate that inadvertent admixture of solids in a emulsified explosive may be a significant contributing factor to NO_x production.

Argon Atmosphere in 12-ft (3.7-m) Sphere

Exploratory tests were conducted in the 12-ft (3.7-m) sphere in which the air was displaced with argon in order to minimize the influence of air on post-detonation reactions. The 80 g Pentolite boosters (2-in (5.1-cm) diameter by 1-in (2.5-cm) thick) when detonated in argon produced an average of 257 L/kg of CO, 2.5 L/kg of NO, 250 L/kg of CO_2, and no NO_2, as compared to 35 L/kg of CO, 8 L/kg of NO, 680 L/kg of CO_2 and no NO_2, when detonated in air. This indicates significant post-detonation air oxidation reactions even with the high-explosive fuel rich booster. A significant amount of carbon was deposited on the absolute filter in the sampling line in for the argon detonations. Figure 13 compares the NO and NO_2 production from the detonation of 750 g of finely pulverized ANFO (AN particles < 250 microns, density-0.75 g/cm^3) in air and in argon with a max oxygen concentration of 0.4%.   Detonated in air, 6.8 L/kg of NO and 3.7 L/kg of NO_2 were measured. When detonated in argon, 23.2 L/kg of NO and zero NO_2 was produced. The CO production in air was 25.8 L/kg and decreased to 15.3 L/kg when detonated in argon. The results for ANFO in air and argon are obtained once the corresponding CO and NO contribution from the booster is removed from the data (Also in figures 13 and 14).   Figure 14 compares the production of NO, NO_2 and CO from the detonation of 1.65 lbs (750 g) of emulsion detonated in air with that produced when detonated in argon. In the presence of air, 2.8 L/kg of NO and 18.2 L/kg of CO are produced. In argon, the detonation produced an average of 6.8 L/kg of NO and 8.5 L/kg of CO with no NO_2 detected in either the air or argon atmosphere. These results indicate significant post-detonation reactions, particularly for the booster explosive and ANFO. Studies continue in argon atmospheres to better understand the mechanism of fumes formation and results will be reported at a later date.

SUMMARY

Generally, the heavier the explosive confinement the more ideal the detonation and the lower the NO and NO_2 production for all blasting agents tested. NO and NO_2 production from the emulsion explosive is less sensitive to degree of confinement when compared to ANFO and to a 50/50 blend of the emulsion and ANFO. At the same confinement, the NO production was about the same for ANFO and the 50/50 blend with both about 3 times higher than that of the more ideal emulsion.

Additives like coal dust and excess fuel oil when mixed with ANFO slightly reduced the NO production whereas urea and WR Conditioner 260 showed a slight increase over that of 6% ANFO. All ANFO additives tested reduced the NO_2 production. These small scale laboratory tests indicate that excess fuel (8%) in AN reduces NO_2 formation as much as any other additive including coal dust. The same additives when mixed with the ANFO component of the 50/50 blend showed little to no benefit in reducing NO or NO_2.

The NO production, from the detonation of pulverized 6% FO/94% AN in argon, was about 3.4 times higher than in air. The NO_2 decreased from about 3.7 l/kg in air to zero when detonated in argon. Studies continue in the 12-ft (3.7-m) sphere in the presence of argon to better understand the formation of NO and NO_2 and the role of post-detonation fumes production.

Lab results indicate that dry, soft, and porous overburden may wick away significant amount of fuel oil from ANFO during long intervals between explosive loading and firing ("sleep times"). The degree of wicking was more pronounced with smaller diameter holes. In addition, ANFO in the presence of overburden containing only 8% bound moisture will cause significant AN dissolution over time. If practical for field use, borehole liners should reduce the wicking of fuel oil and AN dissolution during long sleep times.

Lab studies show that inadvertent emulsion admixture with drill cuttings can be a significant contributing factor to NO_x production. The NO production from the detonation of emulsion equally mixed (by mass) with drill cuttings increased by a factor of 2.7 over that of emulsion alone. The corresponding NO_2 production increased by a factor of 9 while propagating a steady VOD at 3500 m/s. Placing stemming plugs at the bottom of the hole and loading emulsion from the bottom up through flexible tubing, may help reduce borehole erosion caused by cascading emulsion falling through slanted holes; further study is warranted. Also, placing a stemming device at the top of the emulsion column should help reduce explosive admixture from drill cuttings.

ACKNOWLEDGMENTS

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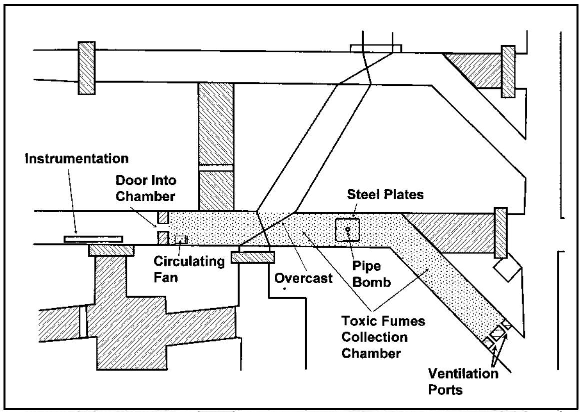

Figure 1. Chamber in the underground mine at the NIOSH Pittsburgh Research Lab in which the gaseous products of a 10-lb explosive detonation are confined and analyzed.

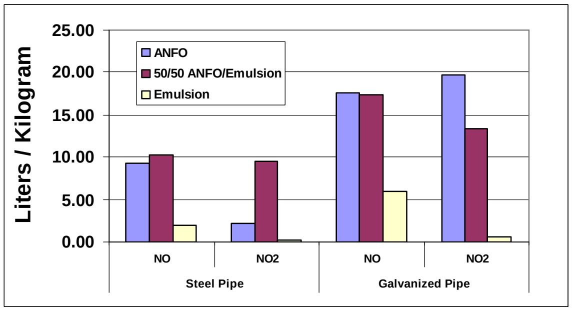

Figure 3. The effect of relative confinement on the NO and NO_2 production from the detonation of ANFO, Emulsion, and 50/50 blend.

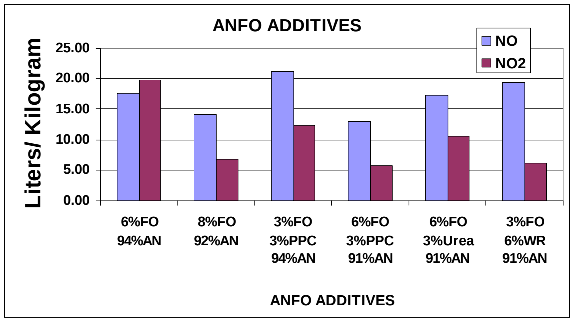

Figure 5. The effect of ANFO additives on the production of NO and NO_2.

Figure 2. Twelve-foot sphere in which the gaseous products of 2-lb explosive charges are confined for analysis.

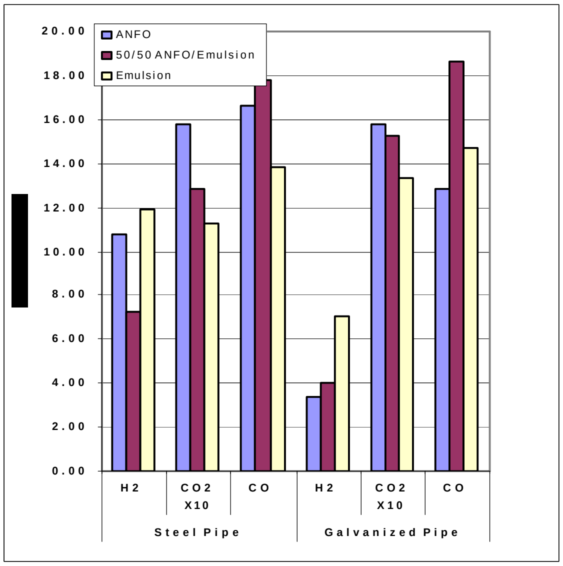

Figure 4. The effect of relative confinement on the CO, CO_2, and H_2 production from detonation of ANFO, Emulsion, and 50/50 blend.

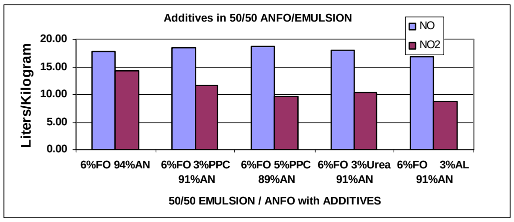

Figure 6. The effect of ANFO additives with a 50/50 blend of Emulsion/ANFO on the production of NO and NO_2.

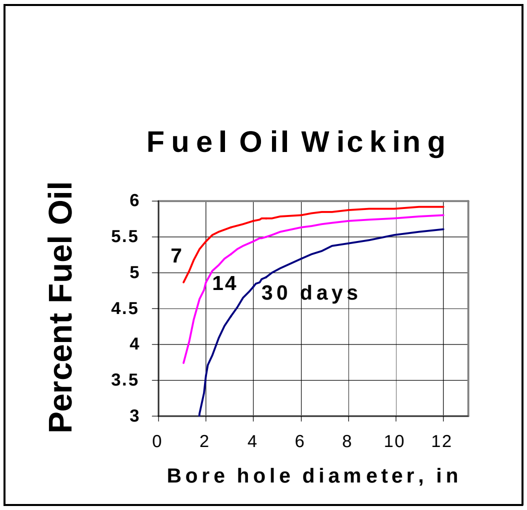

Figure 7. Calculated loss of fuel oil, due to wicking, from 6 % FO-94%AN mixture as a function of borehole diameter.

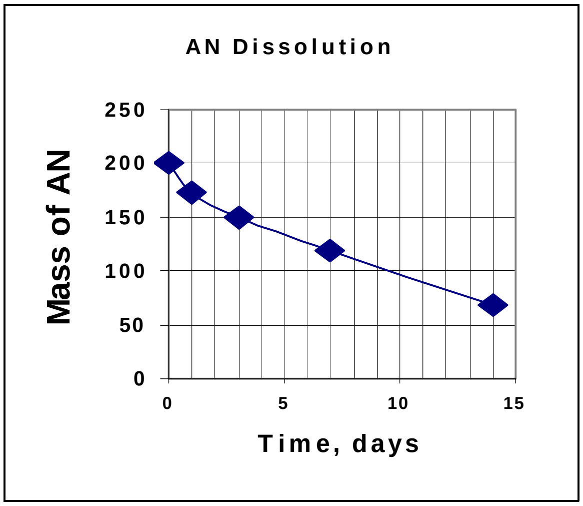

Figure 8. The dissolution of ammonium nitrate as a function of time when exposed to 8 % moisture in a simulated cementitious borehole.

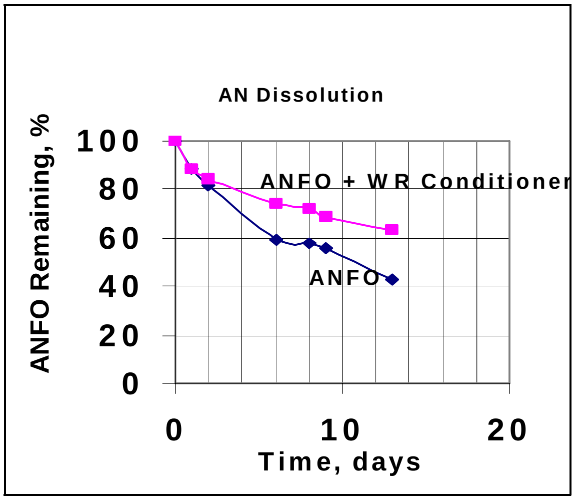

Figure 9. Comparison of ANFO dissolution with and without WR 260 Conditioner in 2-inch diameter cementitious borehole.

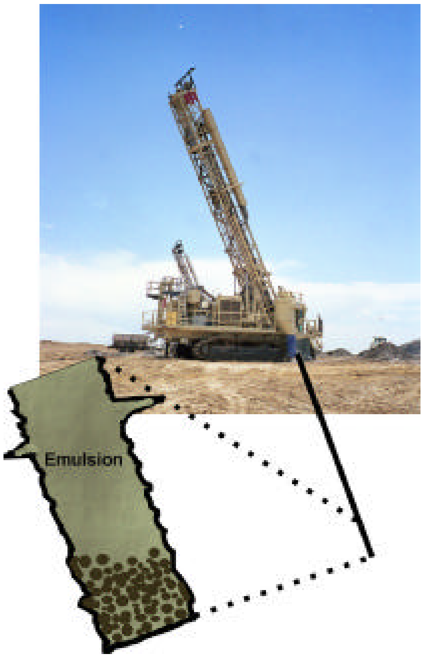

Figure 10. Schematic showing potential emulsion dilution with drill cuttings.

Figure 11. Photo showing the emulsion permeating the interstitial spaces of drill cuttings when loaded at 10 psi.

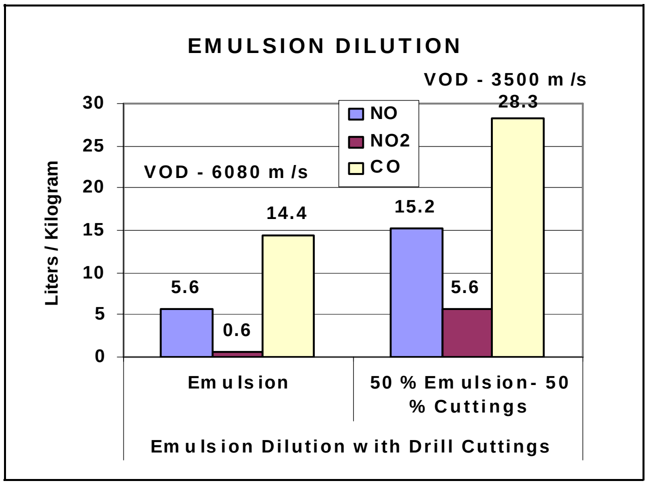

Figure 12. Comparison of NO, NO_2, and CO formed from the detonation of emulsion and a 50/50 blend of emulsion and drill cuttings.

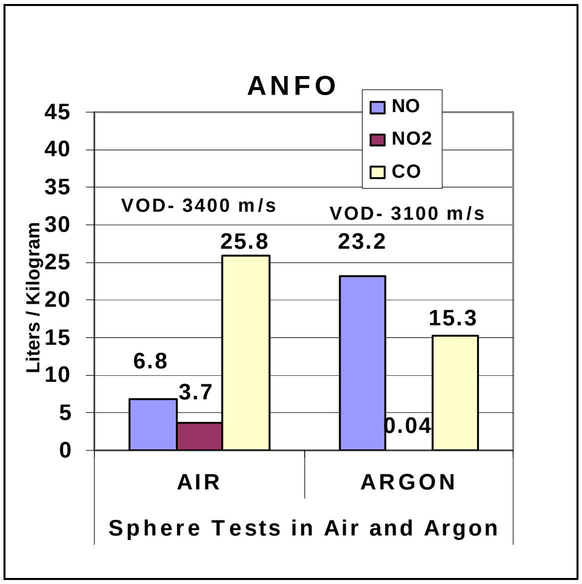

Figure 13. Comparison of NO, NO_2, and CO formed from the detonation of pulverized ANFO in air and in argon.

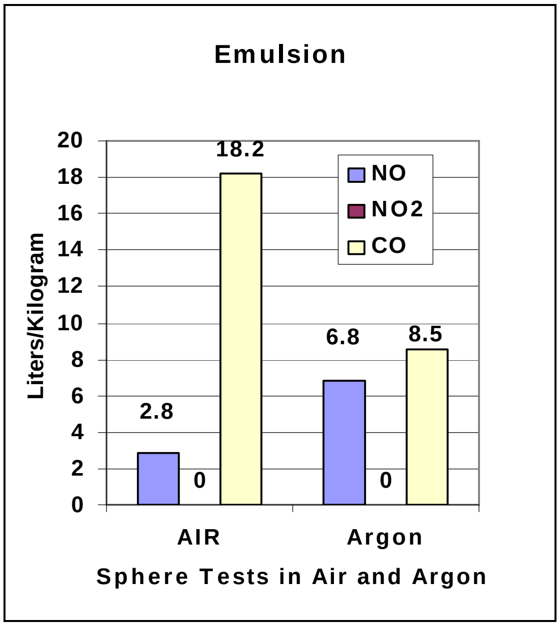

Figure 14. Comparison of NO, NO_2, and CO formed from the detonation of emulsion in air and in argon.