Bryan W. Shaw, Ph.D., P.E., *Chairman*
Toby Baker, *Commissioner*
Jon Niermann, *Commissioner*
Richard A. Hyde, P.E., *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

February 26, 2016

MS GINA MCCARTHY
ADMINISTRATOR
US ENVIRONMENTAL PROTECTION AGENCY
HEADQUARTERS
ARIEL RIOS BLDG
1200 PENNSYLVANIA AVE NW
WASHINGTON DC 20460

Re: Executive Director's Response to EPA Order on Petition VI-2014-01
Permit Number: O31
Southwestern Electric Power Company
H.W. Pirkey Power Plant
Hallsville, Harrison County
Regulated Entity Number: RN100214287
Customer Reference Number: CN600126767
Account Number: HH-0037-F

Dear Ms. McCarthy:

On February 3, 2016, the U.S. Environmental Protection Agency (EPA) signed an order (Order) granting portions of a petition filed by Environmental Integrity Project and Sierra Club objecting to a minor revision of Federal Operating Permit Number O31 for Southwestern Electric Power Company's H.W. Pirkey Power plant that was issued on September 17, 2014.

In accordance with Title 30 Texas Administrative Code § 122.360 (30 TAC § 122.360), if the Texas Commission on Environmental Quality (TCEQ) Executive Director has issued a permit prior to receipt of an EPA objection based on a public petition, the permit remains effective and TCEQ has 90 days from receipt to resolve any objection and, if necessary, terminate or revise the permit.

The TCEQ has completed its review of and prepared a response to the Order. The attached response describes the changes that will be made to the permit records and/or supporting statement of basis during the next permit revision.

Consistent with 30 TAC § 122.360, please provide an indication of your acceptance or assessment of the responses and resolutions to the granted portions of the petition as soon as possible.

Thank you for your cooperation in this matter. If you have any other questions, please contact Janis Hudson at (512) 239-0466 or John Minter at (512) 239-0663.

Sincerely,

Michael Wilson, P.E., Director
Air Permits Division
Office of Air
Texas Commission on Environmental Quality

MPW/jmm

cc: John M. Minter, Attorney, TCEQ Environmental Law Division
Janis Hudson, Attorney, TCEQ Environmental Law Division
Michelle Baetz, Air Section Manager, TCEQ Region 5
Jeff Robinson, Air Permit Section Chief, U.S. Environmental Protection Agency, Region 6, Dallas

Enclosures: Executive Director's Response to EPA Order
Letter from Steve Hagle, TCEQ, to EPA Administrator Gina McCarthy, December 2, 2015

EXECUTIVE DIRECTOR'S RESPONSE TO EPA ORDER

The Texas Commission on Environmental Quality (TCEQ or commission) Executive Director provides this Response to a U.S. Environmental Protection Agency (EPA) Order as a result of a public petition on the H. W. Pirkey Power Plant, Federal Operating Permit (FOP) No. O31. As required by Title 30 Texas Administrative Code § 122.360 (30 TAC § 122.360) the permit remains effective and the Executive Director shall have 90 days from the receipt of an EPA objection to resolve any objection and, if necessary, terminate or revise the permit. The comments included in the public petition and EPA objections are summarized in this response.

Background

Procedural Background

The Texas Operating Permit Program requires that owners and operators of sites subject to 30 TAC Chapter 122 obtain an FOP that contains all applicable requirements in order to facilitate compliance and improve enforcement. The FOP does not authorize construction or modifications to facilities, nor does the FOP authorize emission increases. In order to construct or modify a facility, the facility must have the appropriate new source review authorization. If the site is subject to 30 TAC Chapter 122, the owner or operator must submit a timely FOP application for the site, and ultimately must obtain the FOP in order to operate.

Southwestern Electric Power Company applied to the TCEQ for an FOP minor revision to its permit for an electric services plant located in Hallsville, Harrison County on March 27, 2013. The minor revision incorporated 40 CFR Part 63, Subpart ZZZZ and 40 CFR Part 60, Subpart IIII requirements for the Diesel Fire Pump and the Emergency Generator and the amendment dated February 3, 2012 (commonly referred to as the "MSS Amendment") to New Source Review (NSR) Permit No. 6269 for planned maintenance, startup and shutdown (MSS) activities and associated emissions at this site. The public comment period began on May 14, 2013 and ended on June 14, 2013.

TCEQ sent the proposed draft permit and response to comments (RTC) to EPA on July 22, 2014. EPA did not object to the proposed draft permit which was issued by TCEQ on September 17, 2014. The 60 day petition period extended until November 4, 2014. On October 30, 2014, a public petition was submitted to EPA by the Environmental Integrity Project and Sierra Club (Petitioners). On February 3, 2016, EPA issued an order partially granting and partially denying the petition. In accordance with state and federal Title V program rules, the petition does not limit the effectiveness of the issued FOP.

TCEQ is responding to the order by sending the Executive Director's Response to the Order and will be revising the records or the statement of basis (SOB) for the permit during the next permit revision action.

Description of Site

The H.W. Pirkey Power Plant is located east of Hallsville Texas, south of Interstate 20 off Farm to Market Road 3251 in Harrison County, Texas 75650. The power plant utilizes one boiler to produce up to 721 megawatts of power. Boiler 1 (P-16) began operation in 1985 and is authorized by NSR Permit No. 6269 to burn either lignite or coal. The gases and fly ash from the boiler are directed through an electrostatic precipitator (ESP) for removal of particulate matter (PM) and subsequently through a wet limestone scrubber desulfurization system for removal of sulfur dioxide.

The emissions associated with lignite and coal handling are authorized by Permit No. 6270. The facilities associated with the lignite and coal handling include Truck Hopper A1 (P-1), Truck Hopper A2 (P-2), Transfer House (P-3), Lignite Storage Pile (P-4), Crusher House (P-5), Transfer Chutes (P-6), and Conveyors and Transfer Points (P-7).

Issues Raised by Petitioners in Claim 1

The Petitioners claim the Title V permit, which incorporates the 2012 NSR permit, "creates improper exemptions" from the 20 percent opacity limit in the approved SIP at 30 TAC § 111.111(a)(1)(B) and the 0.2 lb/MMBtu PM limit of the approved SIP at 30 TAC § 111.153(b) during planned MSS activities. Special condition 18.B of the NSR permit "purports to create an exemption" to the 20 percent opacity limit; the NSR permit authorizes the plant to emit a level of PM that exceeds the PM limit in the SIP and section condition 18.D makes it clear that Pirkey is "exempted" from the SIP opacity and PM limits during planned MSS. Petitioners further claim that these SIP limits are applicable requirements under Title V of the Federal Clean Air Act (FCAA) and the FOP, by incorporating the NSR permit, fails to assure compliance with these requirements.

The Petitioners also assert that the FCAA "forbids the state permitting agencies from issuing permits that modify SIP requirements," and that these SIP requirements apply at all times. Petitioners request that the FOP be revised to state "any condition in any incorporated NSR permit that purports to modify an applicable requirement contained in the SIP or federal rule is ineffective and does not excuse non-compliance with the requirement." The SOB must also be revised to clarify SIP requirements apply at all times regardless of what may be included in incorporated NSR permits.

EPA's Direction to TCEQ

In response, EPA grants the petition on this claim. In evaluating a petitioner's claims, the EPA states in the Order that it "considers, as appropriate, the adequacy of the permitting authority's rationale in the permitting record, including the response to comments (RTC) document." EPA also states that "the TCEQ's response in the RTC document to the public comment on issues in Claim 1 is inadequate because it fails to address the comment on the enforceability of the SIP opacity and PM limits at 30 TAC §§ 111.111(a)(1)(B) and 111.153(b) during permits of MSS as a result of the incorporation of the 2012 NSR permit." In addition, EPA asserts the permit record is unclear regarding whether the opacity and PM limits in the SIP apply during periods of MSS.

EPA directs the TCEQ to revise the Pirkey FOP to ensure that it requires that the opacity and PM limits of 30 TAC § 111.111 and § 111.153 apply during periods of planned MSS. EPA also directs TCEQ to revise the permit record accordingly. To the extent that the FOP incorporates by reference conditions from an NSR permit, such incorporation may not supersede the opacity and PM limits in the SIP, which are distinct applicable requirements. Because the SIP does not contain a source-specific exemption, the federal implementation plan must still ensure the SIP limits apply during planned MSS.

TCEQ may address EPA's objection in various ways, including but not limited to, revising only the FOP. One option for addressing this objection would be to clarify the FOP terms and conditions as described above. Another option may be to revise the NSR permit to provide the necessary clarity and, thus, avoid potentially conflicting terms and conditions in the FOP. To the extent the NSR permit continues to include alternative Best Available Control Technology (BACT) limits for MSS periods, the TCEQ should ensure that its permitting record explains how those limits reflect BACT for the operating conditions to which they apply. TCEQ should also address why it believes alternative limits are needed for planned maintenance.

In responding to this order, the TCEQ should follow the appropriate process described in its approved Title V program.

Executive Director's Response to the Issues in Claim 1 of the EPA Order

Pirkey's FOP O31 and the incorporated NSR Permit No. 6269 do not provide for an exemption from opacity and PM SIP limits as petitioners claim. There is no such exemption in the TCEQ's rules or the Texas SIP. Because the Pirkey petition concerns, in part, interpretation of Texas law, TCEQ provided EPA a letter[1] to provide the history and context of Chapter 111 SIP requirements. As TCEQ explained, the opacity and PM SIP limits in Chapter 111 do not apply during specific periods of planned MSS. Although the rules are SIP approved, which presumes EPA's understanding of their applicability, it appears EPA did not consider the TCEQ's letter in its response to the petition, choosing instead to rely on the FOP, SOB, and RTC submitted for review on July 22, 2014. That record did not provide the history and intent of Chapter 111 and the NSR permit conditions that was thoroughly presented in the letter.

As part of this response, the TCEQ is again providing the December 2, 2015 letter in order to clearly and completely explain the intent of the SIP rules, and its permit conditions as they apply to the Pirkey power plant. This letter addresses EPA's determination that the TCEQ's rationale in the "permitting record, including the RTC" was inadequate to address Petitioner's claim 1, by supplementing the "permitting record" so that EPA's record now includes TCEQ's rationale that addresses that claim.

As discussed in greater detail in the December 2, 2015 letter, the opacity and PM limits established by § 111.111 and § 111.153(b) that are referenced in the Pirkey FOP condition

1 Letter from Steve Hagle, TCEQ, to EPA Administrator Gina McCarthy, December 2, 2015 (attached)

apply to coal-fired Electric Generating Units (EGU) with ESPs only during periods of routine operation, and do not apply during periods where the operation is below a minimum temperature, such as periods of startup or shutdown. Neither the permit condition nor the rules *exempt* coal-fired EGUs with ESPs from compliance. Rather, each has their own *applicability*. As discussed below, neither § 111.111 nor § 111.153(b) were developed to apply during periods of startup or shutdown of coal-fired EGUs with ESPs. The NSR permit condition provides for certain work practices to be followed, and, for other operating periods where those requirements are not met, § 111.111 and § 111.153(b) apply.

The technical and safety limitations regarding ESPs used for coal-fired EGUs that existed at the time of the Radian study in 1971 and that formed the basis for the rules adopted in 1972 that are the predecessor to current rules § 111.111 and § 111.153(b) remain the same today. Because ESPs used for PM control at EGUs cannot effectively control startup and shutdown emissions, TCEQ's predecessor agency, the Texas Air Control Board (TACB) did not intend for the original opacity and PM limits to apply to such EGUs during any periods of startup or shutdown. Therefore, TACB's original opacity and PM limits which were premised on the exhaust gas from each coal-fired EGU controlled by an ESP, were not intended to apply and do not apply during periods that ESPs are not effective at controlling opacity or PM emissions (such as startups and shutdowns), nor could be used to control opacity or PM emissions. Because the opacity and PM limits in § 111.111 and § 111.153(b) are the same as the opacity and PM limits in the 1972 rule (which was based on the Radian report), they also do not apply during periods of startup or shutdown of a coal-fired EGU controlled by an ESP.

In accordance with Texas' Title V program rules addressing public petitions, the Executive Director has 90 days in which to resolve any objection granted by EPA, and if necessary, revise or terminate the permit (30 TAC § 122.360(h)). Based on this response and the attached letter explaining why the opacity and PM limits in § 111.111 and § 111.153 do not apply during periods of MSS of the Pirkey boiler, a revision to the FOP that the Order requests is unnecessary and inappropriate to resolve claim 1, and would be contrary to these rules. In order to provide the necessary clarification in the permit record for subsequent permit revisions, TCEQ intends to revise the SOB regarding the applicability of opacity and PM SIP limits during planned MSS at the next FOP permit revision submitted for the Pirkey plant.

Bryan W. Shaw, Ph.D., P.E., *Chairman*
Toby Baker, *Commissioner*
Jon Niermann, *Commissioner*
Richard A. Hyde, P.E., *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

December 2, 2015

Gina McCarthy
Administrator
U.S. Environmental Protection Agency
Office of the Administrator (1101A)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Re: Petitions Submitted to EPA Regarding Certain Coal-fired Power Plants in Texas

Dear Administrator McCarthy:

The U.S. Environmental Protection Agency (EPA) has received the following petitions requesting EPA action regarding certain coal-fired power plants in Texas:

- Citizen Petition for Action to Enforce the Texas State Implementation Plan and Title V of the Clean Air Act (submitted by Environmental Integrity Project and others, May 27, 2015)

- Petition Requesting that the Administrator Object to the Issuance of the Proposed Title V Operating Permit for the H. W. Pirkey Power Plant, Permit Number O31 (submitted by Environmental Integrity Project, October 30, 2014)

These petitions both concern, in part, an interpretation of Texas law, specifically two rules in the Texas State Implementation Plan (SIP), 30 Texas Administrative Code § 111.111 and § 111.153, administered by the Texas Commission on Environmental Quality (TCEQ). The history of the adoption and application of these two rules, which were approved as revisions to the Texas SIP 19 and 6 years ago, respectively, is essential to understanding the Texas SIP and for an accurate response by EPA to each of these two petitions. States are in the best position to interpret their rules, and those interpretations are entitled to great weight and deference, as EPA has acknowledged this in various SIP approval notices.

The enclosed narrative provides detailed information regarding these two TCEQ rules that are discussed in the two petitions. It is not intended as a comprehensive reply regarding either petition. TCEQ requests EPA consider the narrative as it develops any responses to these petitions.

If further information is needed, please contact attorneys for TCEQ, Janis Hudson at 512-239-0466 or John Minter 512-239-0663.

Sincerely,

Steve Hagle, P. E., Deputy Director
Office of Air
Texas Commission on Environmental Quality

SH/jbh

Enclosure

cc: Ron Curry, Regional Administrator, U.S. Environmental Protection Agency, Region 6, Dallas
Richard A. Hyde, P.E., Executive Director
Janis Hudson, Attorney, Environmental Law Division
John Minter, Attorney, Environmental Law Division

Information Regarding Rules of the Texas Commission on Environmental Quality (TCEQ) 30 Texas Administrative Code § 111.111 and § 111.153(b)[1]

The following discussion is limited to the rules regarding opacity and particulate matter (PM) emissions from coal-fired electric generating units (EGUs) that use electrostatic precipitators (ESPs).[2]

§ 111.111 and § 111.153(b) Rulemaking History

Section 111.111 establishes certain control requirements for visible emissions from stationary sources.[3] The relevant subsection for this discussion is (a). Maintenance, startup and shutdown emissions are covered by subsection (a)(1)(E). To understand the substance and applicability of this rule, the history of the regulation of opacity and PM emissions for coal-fired EGUs with ESPs in Texas must be considered.

In 1971, Radian Corporation (Radian) conducted a study and prepared a report[4] for the Texas Air Control Board (TACB)[5] to serve as the basis for TACB to develop rules to regulate emissions of PM in three areas, (1) opacity of a stack plume; (2) allowable mass emission rate; and (3) air quality surrounding the pollution source.[6] Radian specifically evaluated different types of PM and opacity control devices, including ESPs used by coal-fired EGUs.[7] As part of this study, Radian reviewed EPA's current State Implementation Plan (SIP) rules, which included EPA's proposed rules for visible emissions. EPA's rule, as characterized in the report, states that the shade or density visible emission limits must be not be equal or darker than a No. 1 on the Ringelmann chart or 20 percent opacity, although a Ringelmann No. 3 or 60 percent opacity for up to three minutes in any 60 minute period is allowed.[8, 9] And, the EPA rule also

[1] States are in the best position to interpret their rules, and those interpretations are entitled to great weight and deference, and EPA has acknowledged this in various SIP approval notices. *Florida Power & Light Co. v. Costle*, 650 F.2d 579, 588 (5th Cir. 1981); *Texas Gen. Indem. Co. v. Finance Comm'n*, 36 S.W.3d 635, 641 (Tex. App.—Austin 2000, no pet.) ("[A]n administrative agency unquestionably has the power to interpret its own rules, and . . . its interpretation is entitled to great weight and deference by a court called upon to interpret or apply such rules.").

[2] This discussion is limited to coal-fired EGUs because that is the only type of EGU common to both petitions, discussed below at p. 7-8.

[3] Attachment A.

[4] Technical Note 100-007-01, Technical Basis for Texas Air Control Board Particulate Regulations (August 20, 1971), p. 1 (Attachment B).

[5] Predecessor agency to the TCEQ.

[6] *Infra*, footnote 2.

[7] *Id.* at § 3.2 and Table 3-8.

[8] *Id.* at § 4.1. EPA also provided an exception to compliance when uncombined water is the only reason for the failure of the source to meet the limitation. The report cites as its reference material 36 *Fed. Reg.* 6680 (April 7, 1971).

provided that no source burning solid fuel may emit PM in excess of 0.10 pounds per million British Thermal Unit (lb/MMBtu).[10]

For coal-fired EGUs, Radian assumed that PM would be controlled to a PM removal efficiency of at least 99 percent,[11] and concluded that the PM control device removal efficiencies were "vital to devising reasonable" PM limits.[12] This assumption and Radian's conclusion require an understanding of how ESPs are designed to control PM emissions, and how effective they are in various periods of operation. During routine operating conditions, an ESP is designed to be effective at removing PM from the exhaust gas. However, when the exhaust gas is below a minimum temperature, as occurs during periods of startups and shutdown, an ESP cannot remove PM or reduce opacity as effectively. Operation of ESPs when the exhaust gas is below a minimum temperature will also cause safety and equipment degradation issues. During those periods, there is no technology available that will cause ESPs to remove PM from the EGU's exhaust gases, or will allow the operation of some ESPs to occur safely and without equipment degradation issues.

The Radian report excludes an evaluation of emissions from startups and shutdowns during which the emissions controls do not work effectively, and therefore it is reasonable to assume that Radian would not be asked to evaluate emissions for which the agency was regulating in a different fashion on a concurrent rulemaking schedule.[13]

In 1972, the TACB conducted rulemaking that updated its rules regarding limits for visible emissions and added limits for PM emissions using the findings in the Radian report. The new rule for visible emissions shifted the standards for evaluating opacity from antiquated smoke charts to a standard based on the percentage obstruction of the diffusion of light through ambient air.

> No person may cause, suffer, allow, or permit visible emissions from any stationary flue to exceed an opacity of 30% averaged over a five-minute period. No person may cause, suffer, allow, or permit visible emissions from any stationary flue beginning construction after January 31, 1972, to exceed an opacity of 20% averaged over a five-minute period. Visible emissions during the cleaning of a firebox or the building of a new fire, sootblowing, equipment changes, ash removal and rapping of precipitators may exceed the limits set forth in Rule 103.1 for a

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9 EPA's rule, adopted approximately four years after the TACB rules, is not as stringent.
10 Technical Note 100-007-01 at § 4.1 (Attachment B), and EPA rule published at 37 *Fed. Reg.* 10842, 10895 – 10898 (May 31, 1972).
11 *Id.* at § 4.3.1.
12 *Id.* at § 5.
13 TACB Rules 8, 12.1 and 12.2 (1972) (Attachment C). *See infra* text accompanying footnotes 17-18 and 25-34.

> period aggregating not more than five minutes in any sixty consecutive minutes, nor more than six hours in any ten-day period.[14]

For PM, this rulemaking included the following:

> Rules 105.1 and 105.2 shall not apply to solid fossil fuel fired steam generators.[15]
>
> No person may cause, suffer, allow, or permit emissions of particulate matter from any solid fossil fuel fired steam generator to exceed 0.3 lb. per million B. T. U. heat input.[16]

Because those opacity and PM limits were based on the Radian report, they were premised on the exhaust gas from each coal-fired EGU being controlled by an ESP (or similarly effective control), and were not intended to apply during periods when ESPs are not effective at controlling PM emissions or opacity, or could not be used to do so. As a result, those opacity and PM limits did not apply during periods of startups or shutdowns of coal-fired EGUs with ESPs.

The 1972 TACB rulemaking also specifically implemented a control strategy for emissions from maintenance, startup and shutdown (MSS) activities.[17] Specifically, emissions from MSS activities were subject to reporting requirements rather than being regulated by rule based on the type of air contaminant or by permit which, at the time, authorized emissions from only routine operations. These reporting rules, together with the rules for visible and PM emissions, were submitted to EPA and approved as part of the SIP.[18]

The next substantive relevant rulemaking by the TACB took place in 1989,[19] with the visible emissions rule for coal-fired EGUs designated as § 111.111.[20] Nothing in § 111.111 caused the opacity limit in that rule to begin to apply during periods of startup or shutdown of coal-fired EGUs with ESPs.

With regard to the PM limit, the original rule, § 105.3, was renumbered as § 111.153 in the same 1989 rulemaking.[21] Subsection (b) contains essentially the

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14 TACB Rule 103.1 (1972) (Attachment D).
15 TACB Rule 105.3 (1972). Rules 105.1 and 105.2 establish general limitations on PM emissions from sources and multiple sources, respectively. *See* Attachment D.
16 TACB Rule 105.31 (1972).
17 TACB Rules 8, 12.1 and 12.2 (1972) (Attachment C).
18 37 *Fed. Reg.* 10842, 10895 – 10898 (May 31, 1972).
19 During this rulemaking, the rule numbering system and structure were changed, and these are still in use today. In prior rulemakings in 1975 and 1980, the numbering system was changed for the visible emissions and PM emissions rules, as well as for the MSS reporting rules, but there were no substantive changes to these rules.
20 Attachment A.
21 14 *Tex. Reg.* 3290 (Jul. 4, 1989).

same text as was adopted in the 1972 rule.[22] Therefore, nothing in § 111.153 caused the PM limit to begin to apply during periods of startup or shutdown of coal-fired EGUs with ESPs. EPA approved this rule in 2009, noting only that the rule was one of a set of rules that were a recodification of existing SIP approved rules (some with substantive revisions).[23]

As the rule history shows, the minor changes in these rules did not change the premise on which the rules were developed, or the current applicability of the rules. Therefore, the opacity and PM limits in § 111.111 and § 111.153(b), respectively, do not apply during periods of startup or shutdown of coal-fired EGUs with ESPs.

Permit Condition that References § 111.111 and §111.153

In 2011, owners and operators of coal-fired EGUs in Texas that control PM emissions with ESPs applied for New Source Review (NSR) authorization of their planned startup, shutdown and maintenance activities[24] from boilers and turbines, as well as from auxiliary equipment. Those permit actions were the final phase of a regulatory regime that had been in place for almost 40 years following EPA's 1972 approval of the original Texas SIP.[25]

Under that regulatory regime, and up until planned MSS emissions began to be authorized by permit, SIP-approved regulation of MSS activities generally involved (1) notification of an MSS activity to TCEQ (or its predecessor agency); and (2) a determination by TCEQ whether the emissions occurring during the MSS activities were exempted from complying with any applicable emissions limits.[26] The "exemption" terminology continued in use when TCEQ re-promulgated the current Chapter 111 limits in 1989,[27] and again when EPA SIP-approved those limits in 1996.[28]

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[22] TACB Rules 8, 12.1 and 12.2 (1972) (Attachment C), and 14 *Tex. Reg.* 3290 (Jul. 4, 1989).
[23] 74 *Fed. Reg.* 19144 (Apr. 28, 2009). The notice states that EPA proposed approval on Oct. 28, 1999 (64 *Fed. Reg.* 57983).
[24] TCEQ rules do not define "planned MSS activity," but define "unplanned MSS activity" in 30 Tex. Admin. Code § 101.1(109); "planned" generally means "authorized" emissions. It should be noted that "planned" is not the equivalent of "scheduled." The use of the term "scheduled MSS activities" is related to the TCEQ reporting requirements for unauthorized emissions, as required by the Texas Clean Air Act, Tex. Health & Safety Code § 382.0215, and 30 Tex. Admin. Code § 101.1(91) and § 101.221.
[25] *See* 37 *Fed. Reg.* 10,842, 10,895 (May 31, 1972).
[26] *See* TACB Rules 8, 12.1 and 12.2 (1972) (approved by EPA at 37 *Fed. Reg.* 10842 (May 31, 1972) (Attachment C); amended § 101.6 and §101.7 (16 Tex. Reg. 2007 (April 2, 1991)); and repealed § 101.6 and §101.7, new § 101.6 and §101.7, and amended § 101.11 (22 *Tex. Reg.* 7040 and 7057 (July 29, 1997)). These last two amendments were not approved as SIP revisions.
[27] 14 *Tex. Reg.* 3290 (Jul. 4, 1989).
[28] 61 *Fed. Reg.* 20,732 (May 8, 1996).

Over the years, the regulation of MSS activities, both planned and unplanned, and associated emissions became more stringent and prescriptive.

In 2000, TCEQ[29] amended its rules, in response to EPA's review of rule amendments made in 1991 and 1997, to add criteria that an owner or operator was required to satisfy before the agency's executive director would determine that the exemption applied to emissions from MSS activities.[30] EPA approved the exemption language that included the more stringent criteria as part of the Texas SIP.[31] Because the criteria must be satisfied before the exemption would apply to emissions from MSS activities, the exemption was not automatic, and, instead, it was effectively an affirmative defense.[32]

In 2003, in response to a subsequent EPA request, TCEQ amended language in its rules to replace "exempt from compliance" with applicable limits to "subject to an 'affirmative defense'" to enforcement penalties for planned MSS activities.[33] This affirmative defense for emissions from planned MSS activities was temporary. In 2005, TCEQ adopted a schedule for phasing out the use of that affirmative defense as an incentive for owners and operators to obtain permit authorization for their planned MSS activities.[34]

In response to those rules, owners and operators of coal-fired EGUs with ESPs in Texas applied for and obtained authorization for their planned MSS activities. For each of these permit actions, the TCEQ included a permit condition for control of opacity during planned MSS activities that requires certain work practices, monitoring and recordkeeping, as well as compliance with § 111.111 and § 111.153. The condition in the permit for the Pirkey Power Plant that is the subject of a Title V Petition reads as follows:

> 18. Opacity greater than 20 percent from the boiler is authorized when the permit holder complies with the planned MSS duration limitations in Special Condition No. 14[35] and the applicable work practices identified below.

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[29] Action taken by Texas Natural Resource Conservation Commission, the previous name for TCEQ.
[30] 25 *Tex. Reg.* 6750-52 (Jul. 14, 2000).
[31] 65 *Fed. Reg.* 70729 (Nov. 28, 2000).
[32] 25 *Tex. Reg.* 6750-52 (Jul. 14, 2000).
[33] 28 *Tex. Reg.* 118 (Jan. 2, 2004).
[34] 30 Tex. Admin. Code § 101.222(h)(1); 30 *Tex. Reg.* 8956 (Dec. 30, 2005).
[35] Permit Special Condition No. 14 is the permit condition concerning planned startup and shutdown activities. The permit contains other conditions that require the owner or operator to minimize emissions during planned MSS. Examples include a permit condition that limits the time the EGU can operate in planned startup and planned shutdown mode, and a permit condition that imposes stringent work practices that apply during each planned startup and planned shutdown.

A. Opacity during planned startup and shutdown activities shall be minimized by employing the following work practices: During planned startup and shutdown activities, the permit holder shall comply with the parts of the boiler and ESP manufacturer's operating procedures or the procedures in the permittee's written Standard Operating Procedures manual that impact opacity, and shall operate the boiler and ESP in a manner consistent with those procedures to minimize opacity by placing the ESP into service as soon as practical during planned startups or removing the ESP from service as late as possible during planned shutdowns. The boiler and ESP manufacturer's operating procedures or written Standard Operating Procedure manual shall be located on-site and available to the TCEQ regional investigator.

B. Periods of opacity greater than 20 percent from planned online and offline maintenance activities identified in Attachment A or B are authorized for no more than 600 minutes in a calendar year.

C. The permit holder shall keep records to identify periods of planned MSS, the opacity measured by the continuous opacity monitoring system (COMS) for the duration of the planned startups and shutdowns, and the planned maintenance activities identified in Attachments A or B, and the work practices in Special Condition No. 18A followed during the planned MSS activities for the purpose of demonstrating compliance with this permit special condition.

D. For periods of MSS other than those subject to Paragraphs A - C of this condition, 30 TAC § 111.111, 111.153, and Chapter 101, Subchapter F apply.

This permit condition was not created as an exemption from requirements, but to clarify that § 111.111 and § 111.153 are not applicable for certain defined activities for specific durations. Sections 111.111 and 111.153 are applicable at all other times. More importantly, because this permit condition does not provide an exemption from § 111.111 or § 111.153, TCEQ did not circumvent the requirements of the federal Clean Air Act nor its SIP by use of this permit condition in permits for any of the coal-fired EGUs with ESPs.

Response to Misrepresentations Regarding § 111.111 and §111.153 In Two Petitions Submitted to EPA[36]

[36] This document is not intended to be a comprehensive response to either of these petitions.

Neither the Pirkey Petition [37] nor the Citizen Petition,[38] accurately states the applicability of the rules or the permit condition at issue. The TCEQ provides the responses below to address the misstatements and inaccurate comprehension in the two petitions.

<u>Pirkey Petition</u>

In this Title V Petition, the Petitioners allege NSR permit condition 18 "purports to create an exemption" to the opacity and PM SIP limits established by TCEQ rule.[39] Petitioners acknowledge that neither paragraph B of the condition nor the maximum allowable emission rate table (MAERT) in the permit expressly state that the alleged new opacity or PM exemption and increased PM limit are meant to relax applicable SIP limits, but that paragraph D makes clear the intent to do so. The Petitioners state that the SIP limits [in § 111.111 and § 111.153(b)] apply at all times, including planned MSS activities for three reasons. The TCEQ responds below to each of these:

1. The rules establishing the limits do not provide for any exception for planned MSS events.

The commission agrees that these rules do not provide any exception for MSS activities, but the rules are not applicable to MSS activities because the Pirkey EGU is a coal-fired EGU with an ESP. No exemption can be provided if the rules do not apply.

2. These limits are SIP limits and SIP limits are not subject to exemptions during MSS and malfunction activities [citing to the Federal Register notice that approved TCEQ rules for reporting of unauthorized emissions from MSS activities].

The commission agrees that these rules do not provide exemptions from compliance during MSS activities, but the rules are not applicable activities because the Pirkey EGU is a coal-fired EGU with an ESP. No exemption can be provided if the rules do not apply. Malfunctions are unauthorized emissions and are not raised in the Pirkey petition.

3. EPA has spent the better part of the last decade working with the TCEQ to end the historic (and illegal) practice of allowing blanket exemptions from compliance with SIP limits.

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[37] Petition Requesting that the Administrator Object to the Issuance of the Proposed Title V Operating Permit for the H. W. Pirkey Power Plant, Permit No. O31 (Oct. 30, 2014).
[38] Petition for EPA Action Addressing Startup, Shutdown, and Maintenance Exemptions in Revised Permits for Texas Coal-fired Power Plants to Administrator McCarthy (May 27, 2015).
[39] Pirkey Petition at p. 5.

As discussed above, TCEQ notes that the term "exemption" was removed from certain TCEQ rules in 2002, which EPA approved as a SIP revision in 2003. And, as discussed above, the "exemption" for the planned MSS in question was removed and the coal-fired EGUs obtained permit authorization of their planned MSS activities, as EPA requested. Moreover, the word "exemption" was not (and is not) included in § 111.111 or § 111.153(b).

Citizen Petition

In the Citizen Petition, Petitioners make the following arguments in support of request for specific relief from EPA with regard to application and interpretation of § 111.111 or § 111.153(b).[40] The TCEQ responds below to each of these:

1. At least 19 coal-fired units are exempted from a Texas SIP emission limit in § 111.111 and § 111.153(b) without the required SIP review and approval.

Petitioners' reading of the rules is erroneous because it ignores the history and the factual basis of the rules' applicability (as discussed above) which demonstrates that § 111.111 and § 111.153(b) do not apply during periods of startup or shutdown of coal-fired EGUs with ESPs. Without that information, no SIP revision or EPA approval was required, and the allegation is unfounded.

2. TCEQ violated specific requirements for changing SIP opacity limits.

As discussed above, TCEQ did not change any SIP opacity limits and therefore was not subject to additional procedural requirements that are necessary for SIP revisions, which TCEQ discusses below.

3. Exemptions apply to an unlimited number of startups and shutdowns.

As discussed above, the permit condition does not exempt compliance with § 111.111 or § 111.153 because those rules are not applicable during periods of startup and shutdown of coal-fired EGUs with ESPs. Further, the TCEQ does not interpret the terms "planned startup" and "planned shutdown" as applicable to all startup or shutdown activities.

SIP Revision Requirements

Texas is required by the federal Clean Air Act to submit a SIP revision, or a site-specific SIP revision, to EPA if there is a desire to regulate an individual or

[40] *Supra*, footnote 38, at p. 4 and Section III at p. 12-15.

group of stationary sources or facilities in a way that is not compliant with the SIP. Such a revision will require adequate justification and public notice.[41]

This procedure was not required for issuance of a permit with a condition like Pirkey's permit condition number 18, paragraph (D), because it does not include an exemption from SIP compliance, nor was there any failure by the TCEQ to comply with its SIP in issuing permits with this permit condition. Non-applicability is not the same as exemption.

As discussed above, the opacity and PM limits established by § 111.111 and § 111.153(b) that are referenced in that permit condition apply to coal-fired EGUs with ESPs only during periods of routine operation, and do not apply during periods where the operation is below a minimum temperature, such as periods of startup or shutdown. Neither the permit condition nor the rules *exempt* coal-fired EGUs with ESPs from compliance. Rather, each has their own *applicability*. Neither § 111.111 nor § 111.153(b) were developed to apply during periods of startup or shutdown of coal-fired EGUs with ESPs.[42] The permit condition provides for certain work practices to be followed, and, for other operating periods where those requirements are not met, § 111.111 and § 111.153(b) apply. Therefore, no SIP revision was required.

Summary

The technical and safety limitations regarding ESPs used for coal-fired EGUs that existed at the time of the Radian study in 1971 and that formed the basis for the rules adopted in 1972 that are the predecessor to current rules § 111.111 and § 111.153(b) remain the same today.[43] Because ESPs used for PM control at EGUs cannot effectively control startup and shutdown emissions, the TACB did not intend for the original opacity and PM limits to apply to such EGUs during any periods of startup or shutdown. Therefore, TACB's original opacity and PM limits which were premised on the exhaust gas from each coal-fired EGU controlled by an ESP, were not intended to apply and do not apply during periods that ESPs are not effective at controlling opacity or PM emissions (like startups and shutdowns), nor could be used to control opacity or PM emissions. Because the opacity and PM limits in § 111.111 and § 111.153(b) are the same as the opacity and PM limits in the 1972 rule (which was based on the Radian report), they also do not apply during periods of startup or shutdown of a coal-fired EGU controlled by an ESP.

[41] 42 U.S.C. § 7410.
[42] *See supra*, text accompanying footnotes 14-17.
[43] Section 111.111 was also amended in 1993, but that change is not relevant to this discussion.

ATTACHMENT A

Texas Commission on Environmental Quality
Excerpts from Chapter 111 - Control of Air Pollution From Visible Emissions and Particulate Matter

§111.111. Requirements for Specified Sources.

(a) Visible emissions. No person may cause, suffer, allow, or permit visible emissions from any source, except as follows:

(1) Stationary vents. Visible emissions from any vent shall not exceed the following opacities and must meet the following requirements:

(A) Opacity shall not exceed 30% averaged over a six-minute period.

(B) Opacity shall not exceed 20% averaged over a six-minute period for any source on which construction was begun after January 31, 1972.

(C) Opacity shall not exceed 15% averaged over a six-minute period for any source having a total flow rate greater than or equal to 100,000 actual cubic feet per minute, unless an optical instrument capable of measuring the opacity of emissions is installed in the vent in accordance with subparagraph (D) of this paragraph. Facilities utilizing such instruments shall meet opacity limits outlined in subparagraph (A) or (B) of this paragraph as applicable. Records of all such measurements shall be retained as provided for in §101.8 of this title (relating to Sampling).

(D) Any opacity monitoring system installed as provided for in subparagraph (C) of this paragraph must satisfy the New Source Performance Standards requirement for opacity continuous emissions monitoring systems (CEMS) as contained in 40 Code of Federal Regulations (CFR) Part 60, Appendix B, Performance Specification 1. In order to demonstrate compliance with Performance Specification 1, the system shall undergo performance specification testing as outlined in 40 CFR 60.13. The facility will maintain records of all such testing for a period of not less than two years which shall be available for inspection by federal, state, and local air pollution control agencies. Compliance with this provision shall be accomplished within one year of the effective date of this rule, except as specified in paragraph (2) of this subsection.

(E) Visible emissions during the cleaning of a firebox or the building of a new fire, soot blowing, equipment changes, ash removal, and rapping of precipitators may exceed the limits set forth in this section for a period aggregating not more than six minutes in any 60 consecutive minutes, nor more than six hours in any ten-day period. This exemption shall not apply to the emissions mass rate standard, as outlined in §111.151(a) of this title (relating to Allowable Emissions Limits).

(F) Compliance with subparagraphs (A) - (C) of this paragraph shall be determined by applying the following test methods, as appropriate. The highest reading obtained shall determine compliance with the appropriate visible emission limit:

(i) CEMS as described in subparagraph (D) of this paragraph;

(ii) Test Method 9 (40 CFR 60, Appendix A);

(iii) Alternate Method 1 to Method 9, Light Detection and Ranging (40 CFR 60, Appendix A); or

(iv) equivalent test method approved by the executive director of the Texas Air Control Board (TACB) and the United States Environmental Protection Agency (EPA).

(G) Current certification of opacity readers for determining opacities under 40 CFR 60, Appendix A, Method 9, shall be accomplished by the successful completion of a TACB visible emissions evaluator's course by opacity readers no more than 180 days before the opacity reading.

(2) Sources requiring continuous emissions monitoring. Beginning March 1, 1994, all stationary vents located at the sources specified in this paragraph shall be equipped with a calibrated and properly operating CEMS for opacity. The system shall be calibrated, installed, operated, and maintained as specified in 40 CFR 51, Appendix P, hereby incorporated by reference:

(A) steam generators fired by solid fossil fuel with an annual average capacity factor of greater than 30%, as reported to the Federal Power Commission for calendar year 1974, and with a heat input of greater than 250 million British thermal units per hour;

(B) steam generators that burn oil or a mixture of oil and gas and are not able to comply with the applicable particulate matter and opacity regulations without the use of particulate matter collection equipment, and have been found to be in violation of any visible emission standard contained in a state implementation plan;

(C) catalyst regenerators for fluid bed catalytic cracking units of greater than 20,000 barrels per day of total feed capacity.

(3) Exemptions from continuous emissions monitoring requirements. Opacity monitors shall not be installed or used to determine opacity from any gas stream or portion of a gas stream containing condensed water vapor which could interfere with proper instrument operation, as determined by the executive director. Opacity monitoring techniques as listed in paragraph (1)(F) of this subsection may be substituted with the approval of the executive director and EPA, the highest reading of which will be used to determine compliance with the appropriate opacity standard. If opacity is determined through 40 CFR 60, Appendix A, Method 9, readings shall be made daily, unless weather or other conditions prevent visual observation.

(4) Gas flares.

(A) Visible emissions from a process gas flare shall not be permitted for more than five minutes in any two-hour period, except as provided in §101.11(a) of this title (relating to Exemptions from Rules and Regulations). Process gas flares are those used in routine or scheduled facility operations. Acid gas flares, as defined in §101.1 of this title (relating to Definitions), are subject only to the provisions of paragraph (1) of this subsection. Beginning September 1, 1993, compliance with this subparagraph for process gas flares shall be determined:

(i) any time there is an operational change in the flare that requires a permit amendment under TACB Regulation VI. Compliance shall be determined using Reference Method 22 (40 CFR 60, Appendix A), Reference Method 9 (40 CFR 60, Appendix A), or an alternative test method approved by the executive director and the United States Environmental Protection Agency (EPA). The observation period for this compliance demonstration shall be no less than two hours unless noncompliance is determined in a shorter time period or operational changes are made to the flare that stop any observed smoking; and

(ii) by a daily notation in the flare operation log that the flare was observed including the time of day and whether or not the flare was smoking. For flares operated less frequently than daily, the observation will be made for each operation. The flare operator shall record at least 98% of these required observations. If smoking is detected, compliance with the emission limits of this paragraph shall be determined using Reference Method 22, Reference Method 9, or an alternative test method approved by the executive director and EPA. The observation period for this compliance determination shall be no less than two hours unless noncompliance is determined in a shorter time period or operational changes are made to the flare that stop the smoking. A Method 22 or Method 9 observation will be waived provided the operator reports the flare to be in an upset condition under the requirements of §101.6 of this title (relating to Notification Requirements for Major Upset).

(B) Flares used only during emergency or upset conditions are exempt from the compliance monitoring requirements of subparagraph (A)(i) and (A)(ii) of this paragraph.

(5) Motor vehicles. Motor vehicles shall not have visible exhaust emissions for more than ten consecutive seconds. Compliance shall be determined as specified in 40 CFR 60, Appendix A, Method 22.

(6) Railroad locomotives or ships.

(A) Visible emissions shall not be permitted from any railroad locomotive, ship, or any other vessel to exceed an opacity of 30% for any five-minute period, except during reasonable periods of engine start-up.

(B) Compliance with subparagraph (A) of this paragraph shall be determined by applying the following test methods, as appropriate:

(i) Test Method 9, (40 CFR 60, Appendix A); or

(ii) equivalent test method approved by the executive director and EPA.

(7) Structures.

(A) Visible emissions shall not be permitted to exceed an opacity of 30% for any six-minute period from any building, enclosed facility, or other structure.

(B) Compliance with subparagraph (A) of this paragraph shall be determined by applying the following test methods, as appropriate:

(i) Test Method 9 (40 CFR 60, Appendix A); or

(ii) equivalent test method approved by the executive director and EPA.

(8) Other Sources.

(A) Visible emissions shall not be permitted to exceed an opacity of 30% for any six-minute period from all other sources not specified in §111.111 of this title (relating to Requirements for Specified Sources).

(B) Compliance with subparagraph (A) of this paragraph shall be determined by applying the following test methods, as appropriate:

(i) Test Method 9 (40 CFR 60, Appendix A), or

(ii) equivalent test method approved by the executive director and EPA.

(b) Compliance determination exclusions. Contributions from uncombined water shall not be included in determining compliance with this section. The burden of proof which establishes the applicability of this subsection shall be upon the person seeking to come within its provisions.

(c) Solid fuel heating devices.

(1) Operating restrictions. In the City of El Paso, including the Fort Bliss Military Reservation, no person shall operate a solid fuel heating device during a period when National Weather Service data indicates that an atmospheric stagnation condition exists or is predicted to exist. For the purposes of this section, a solid fuel heating device shall be defined as any fireplace, wood heater, wood stove, wood-fired boiler, coal-fired furnace, or similar device burning any solid fuel which is used for aesthetic, cooking (excluding commercial cooking), or heating purposes, and located inside a building.

(2) Exemptions. An exemption from the requirements of this section may be granted by the executive director of the Texas Air Control Board if one or more of the following conditions are met:

(A) the solid fuel heating device is in a period of burn down; that is, a period of time not to exceed three hours for the cessation of combustion within the device;

(B) the solid fuel heating device is the sole source of heat for the building in which it is situated; or

(C) the solid fuel heating device becomes the sole source of heat within the building because of a temporary power loss.

Adopted June 18, 1993 Effective July 23, 1993

§111.153. Emissions Limits for Steam Generators.

(a) Section 111.151 of this title (relating to Allowable Emissions Limits) shall not apply to any oil or gas fuel-fired steam generator with a heat input greater than 2,500 million British thermal units (Btu) per hour or any solid fossil fuel-fired steam generator.

(b) No person may cause, suffer, allow, or permit emissions of particulate matter from any solid fossil fuel-fired steam generator to exceed 0.3 pound of total suspended particulate per million Btu heat input, averaged over a two-hour period.

(c) No person may cause, suffer, allow or permit emissions of particulate matter from any oil or gas fuel-fired steam generator with a heat input greater than 2,500 million Btu per hour to exceed 0.1 pound of total suspended particulate per million Btu input averaged over a two-hour period.

Adopted June 16, 1989 Effective July 18, 1989

ATTACHMENT B

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TECHNICAL NOTE 100-007-01

TECHNICAL BASIS FOR TEXAS AIR CONTROL BOARD PARTICULATE REGULATIONS

20 August 1971

Prepared by:
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1.0 INTRODUCTION

The Texas Air Control Board plans to issue new regulations governing the control of particulates in the very near future. For stack emissions, these regulations will be concerned with control in three areas: (1) opacity of the stack plume, (2) allowable mass emission rate, and (3) air quality surrounding the pollution source. The purpose of this technical note is to provide the TACB staff with the technical basis for developing "equivalent" particulate regulations in these three areas.

The State would like to use three types of regulations for controlling particulate emissions to reasonable level (see Figure 1-1). As stated by Rule 102 in TACB Staff Proposal, November 4, 1970, the State would like to control the visible emissions so that the opacity does not exceed 20% averaged over a five-minute period. Secondly, the State would like to control air quality surrounding a pollution source so as not to exceed a ground-level concentration of 250 $\mu g/m^3$ for any 60-minute sampling period. This regulation corresponds to the proposed Rule 103B with only the 60-minute sampling time criterion being retained. The third type of regulation involves limiting the particulate emissions rate (pounds per hour) as a function of the volumetric flow rate (cubic feet per minute) of exhaust gases.

Radian's task has been to provide the TACB staff with the information required for setting particulate regulations of this type which are "equivalent" to one another. Here "equivalent" is a key word since it will not be possible to make each regulation represent the same degree of control for the wide variety of particulate sources. Radian's responsibility has

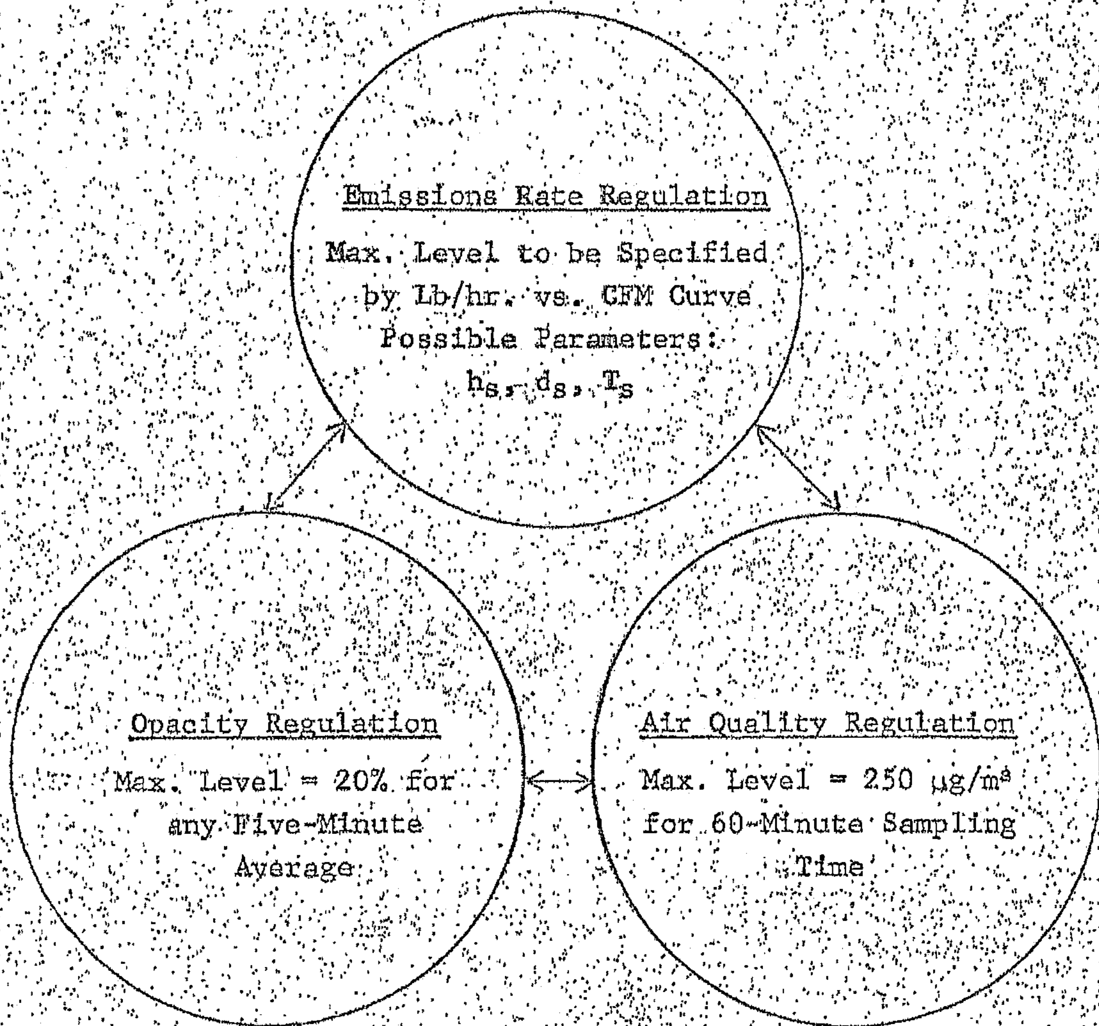

Figure 1-1

SCHEMATIC OF PROPOSED REGULATIONS FOR PARTICULATE EMISSIONS been to provide the TACB staff with relationships and computational results which will allow the TACB staff to determine the appropriate "equivalence."

The relationships between opacity, emissions rate, and air quality are presented in Section 2.0. A discussion of the characteristics of stationary sources and particulate control techniques follows this section. Section 4.0 suggests possible particulate regulations and gives typical control requirements for several processes.

2.0 TECHNICAL RELATIONSHIPS

The technical relationships which provide the basis for developing "equivalent" opacity, emissions rate, and air quality regulations are presented in this section. The relationship between opacity of the stack plume and the mass concentration of particulates in the stack effluent (most frequently expressed as "grain loading") will be discussed first. This provides the basis for relating opacity to emissions rate. Then, grain loading will be related to air quality.

2.1 Relationship of Opacity to Grain Loading

The opacity of the effluent from a smoke stack is an indication of the amount of particulate matter being put through the stack and it is possible to control the emission of particulates by controlling the opacity of smoke stacks. In the following paragraphs the relationship of an opacity regulation to an emission regulation is investigated.

The opacity of a smoke stack will be defined to be one minus the transmittance of the smoke stack. The transmittance in turn is defined to be the fraction of the light energy incident on a stack plume which is transmitted through the plume and which can be measured with appropriate instruments on the opposite side of the plume. The transmittance depends on the amount of light which is absorbed or scattered relative to the amount which finds its way through the plume unhindered. As it happens the amount of light absorbed or scattered by a small layer of the plume is proportional to the amount incident on the small layer and proportional to the thickness of the layer. This behavior produces an exponential decay of light intensity with distance into the plume. If T is the transmittance, and F and F_o are the transmitted and incident light intensities respectively, then (CO-007)

$$T = F/F_o = \exp(-naQD_s) \quad (2\text{-}1)$$

where n is the particle density, a is the projected area of a particle, D_s is the diameter of the stack, i.e., the longest path length light must travel to reach the other side of the plume, and Q is the extinction coefficient of the particle.

In general the particulates emitted by a stack will not be monodisperse; there will be particles of many different sizes, shapes and compositions. In such cases the particle parameters must be replaced by appropriate average parameters, $\bar{a}$ and $\bar{Q}$ such that

$$T = \exp(-n\bar{a}\,\bar{Q}\,D_s) \quad (2\text{-}2)$$

gives the appropriate transmittance of the plume.

The theory of scattering and absorption of light by spherically shaped particles has been developed for some time (JA-020). In the long wavelength limit (when the particle diameter is small in comparison to the wavelength of the incident light) the well-known result for the scattering cross section σ for a conducting particle is

$$\sigma = 10\pi/3\ d_p^6\ k^4 \quad (2\text{-}3)$$

where d_p is the particle diameter and k is $2\pi/\lambda$, where λ is the wavelength. Since a is proportional to d_p^2, this expression says that the extinction coefficient will be proportional to d_p^4 when $d_p << \lambda$. This means that when particles are much smaller than the wavelength of light their effect upon the extinction of that light decreases rapidly with particle size. In scattering theory this long wavelength region is known as the Rayliegh region.

The wavelength of visible light is in the range of 0.3 to 0.7 microns. This means that particles which are much smaller than this will not affect the opacity of a plume. As the particles become 0.5 micron size or larger the scattering cross section tends to become proportional to the square of the diameter of the particle. This means that the extinction coefficient tends to be independent of diameter since Q is proportional to σ divided by a.

In summary, the extinction coefficient of a particle decreases rapidly with particle diameter for diameters which are small compared to ½ micron. Above this size the extinction coefficient tends to a constant (with the numerical value 2). The behavior in the intermediate region depends on the optical properties of the particle (the relative amount of scattering and absorption being proportional to the real and imaginary parts of the dielectric constant of the material at optical frequencies). Examples of the dependence of extinction coefficients on particle diameter and index of refraction (which is proportional to the square root of the dielectric constant) are given in Figure 20 of reference CO-007.

The behavior of the cross section, or the extinction coefficient, with particle size for nonspherical particles is very similar to the behavior for spherical particles. In general, the scattering of a nonspherical particle is very similar in magnitude to the scattering of an equivalent spherical particle whose diameter is approximately equal to the largest dimension of the nonspherical particle. For this reason it is not a bad approximation to perform calculations based on spherical particles (unless the deviation from sphericity is extreme).

If Cm is the mass concentration of particulates and if spherical particles are assumed, the transmittance can be written

$$I/I_0 = e^{-\frac{3}{2}\frac{Q C_m D_s}{\rho d_p}}$$

$$T = \exp(-3 C_m Q D_s / 2 \rho d_p) \qquad (2\text{-}4)$$

where ρ is the mass density of the particulate material. Since the opacity is one minus the transmittance it becomes evident that the relationship between opacity and mass density out of a smoke stack is dependent on a number of particle parameters.

In order to compare an opacity regulation with a grain loading regulation it is necessary to assume certain particle and stack parameters and also to consider the ranges over which these parameters may, in fact, vary over the state of Texas.

For particles with density $\rho = 2 g/cm^3$ and for 5 feet diameter stacks with exit temperatures of 300°F, the opacity depends on the areal average particle diameter as shown in Figure 2-1. The particle diameters are given in microns and the mass concentrations in grains/scf. The opacity is seen to fall off rapidly for particles smaller than 0.1 microns.

A fairly stringent standard suggested by the federal government for grain loading is .05 gr/scf. From Figure 2-1 it is noted that if the particulates are large enough that the areal average is greater than 5 microns or so, an opacity requirement of 20% is not strict compared to a reasonable grain loading requirement like .15 gr/scf. If the average particle diameter is ½ micron or so (as may happen when particles of larger size have been removed by utilization of a control device), the opacity requirement would be more strict.

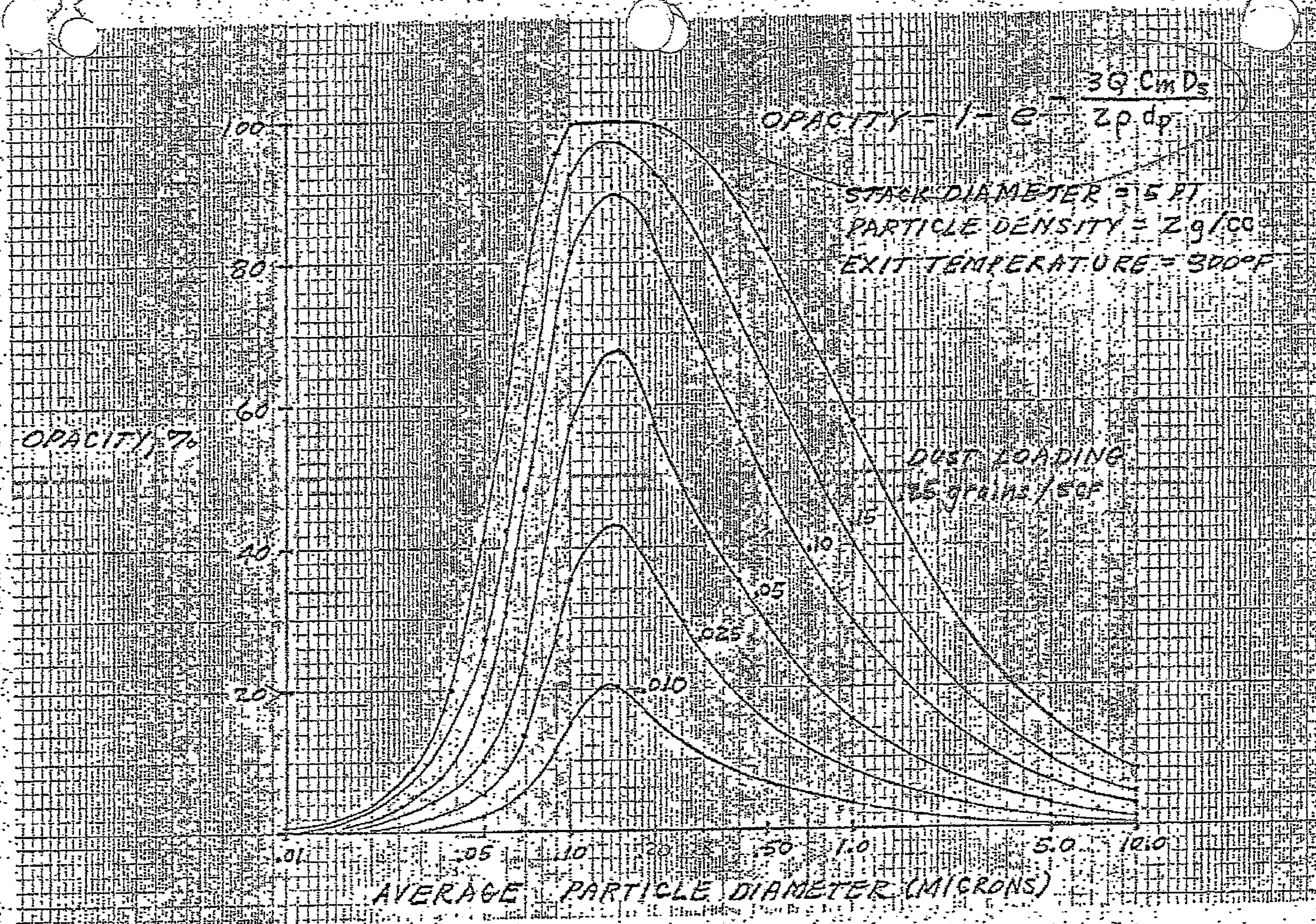

Figure 2-1

Plume Opacity As A Function of Particle Diameter and Dust Loading

OPACITY

$$\%\,OPACITY = \left(1 - e^{-\left[\frac{3 Q C_M D_s}{2 \rho d_p}\right]}\right) \times 100$$

WHERE $Q = 2$ FOR $d_p \geq .14$

$Q = 5206\,(d_p)^4$ FOR $d_p < .14$

C_M = DUST LOADING IN GRAINS/CU.FT. AT EXIT TEMPERATURE.

D_s = STACK DIAMETER IN FEET.

ρ = PARTICLE DENSITY IN GRAINS/CU.FT.

d_p = PARTICLE DIAMETER IN FEET.

1 GRAM/CC ≡ 437,053.4 GRAINS/CU.FT.

1 μMETER ≡ $\frac{10^{-6}}{.3048}$ FEET

$$\therefore \frac{3\,Q\,C_M\,D_s\;10^{6}\,(.3048)}{2\,\rho\,(437{,}053.4)\,d_p\left(\frac{10^{-6}}{.3048}\right)} = \frac{1.046\,Q\,C_M\,D_s}{\rho\,d_p}$$

WHERE C_M = GRAINS/CU.FT. AT EXIT TEMP.

D_s = FEET

ρ = GRAMS/CC

d_p = MICRONS.

$$\frac{\%\ OPACITY}{100} = 1 - e^{-\left[\frac{1.046\, Q\, C_M\, D_s}{\rho\, d_P}\right]}$$

(3) (1) (2)

C_M = DUST LOADING, GRAINS / CU. FT. AT EXIT TEMPERATURE.

$Q = 2$ FOR $d_p \geq .14$

$Q = 5206\,(d_p)^{4}$ FOR $d_p < 0.14$

D_s = STACK DIAMETER IN FEET

ρ = PARTICLE DENSITY IN GRAMS / C.C.

d_p = PARTICLE DIAMETER IN 10^{-6} METERS.

$$e^{-[\,]} = \left[1 - \frac{\%\ OPACITY}{100}\right]$$

$$+[\,]\log e = -\frac{\log\left[1 - \frac{\%\ OPACITY}{100}\right]}{\log e}$$

$$\frac{1.046\, Q\, C_M\, D_s}{\rho\, d_p} = -\left[\frac{\log\left(1 - \frac{\%\ OPACITY}{100}\right)}{\log e}\right] \frac{\rho}{(1.046)\, Q\, D_s}$$

$$C_M = d_p \left[-\frac{\log\left(1 - \frac{\%\ OPACITY}{100}\right)}{\log e}\right]\left[\frac{\rho}{(1.046)(Q)(D_s)}\right]$$

Assume:

1. % opacity = 20% ✓
2. $d_p > .1$, ∴ $Q = 2$
3. $\rho = 2.0$ ✓
4. $D_s = 5.0$ FT. ✓

$C_{M_{20}} = d_p (0.1067) \frac{\rho}{D_s}$ OPACITY = 20%

$C_{M_{30}} = d_p (0.1705) \frac{\rho}{D_s}$ OPACITY = 30%

$C_{M_{40}} = d_p (.2442) \frac{\rho}{D_s}$ OPACITY = 40%

$C_{M_{50}} = d_p (.3313) \frac{\rho}{D_s}$ OPACITY = 50%

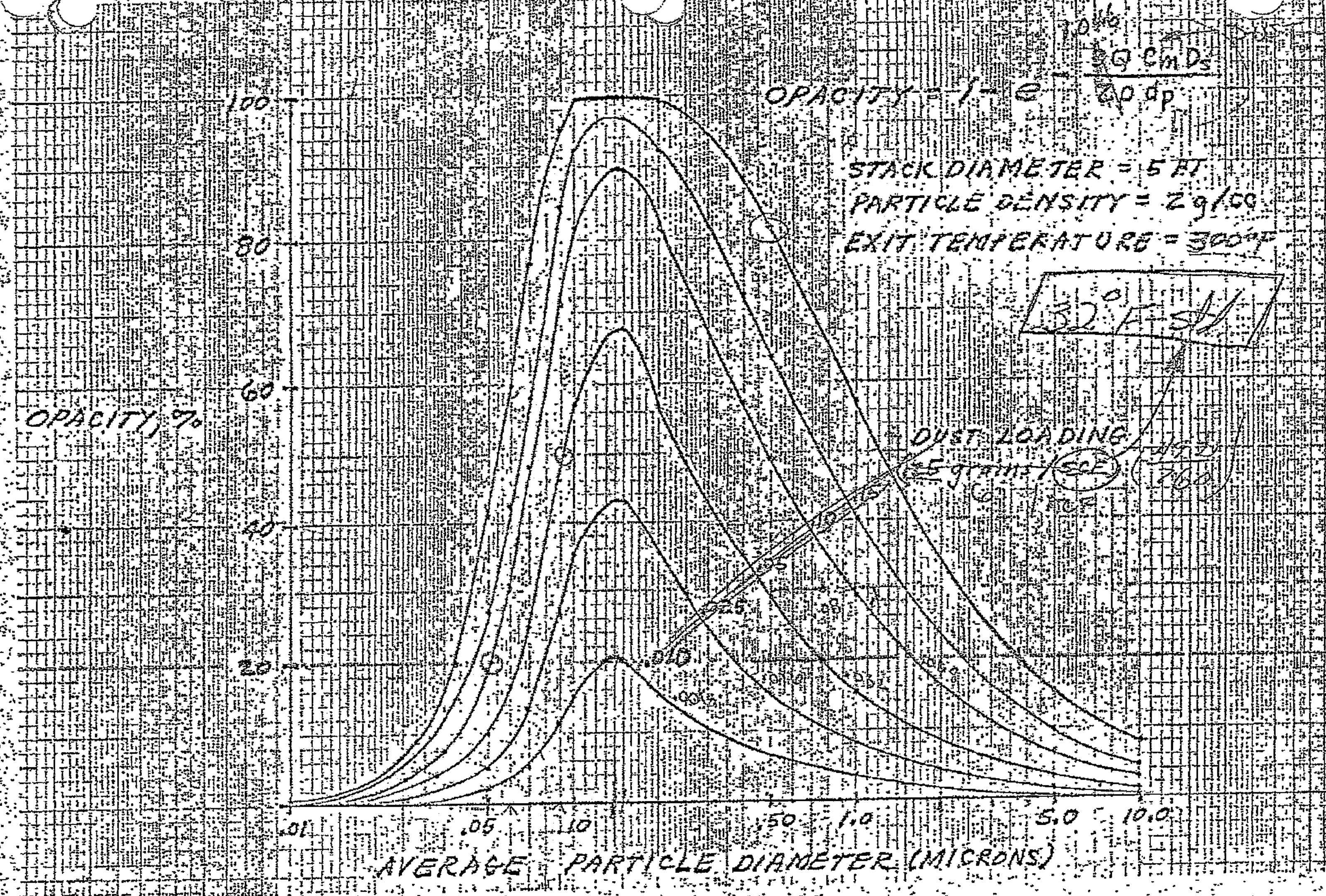

Figure 2-1

Plume Opacity As A Function of Particle Diameter and Dust Loading

C_m = Dust Loading

$Q = k d^4$

$2 = k(.14)^4$

$k = 5206$

$Q = 2$ for $d_p \geq .14$

$Q = 5206\, d_p^4$ for $d_p \leq .14$

It is noticed that the opacity is affected most by particles in the range 0.05 to 0.5 microns. This is the range of particles which are deleterious to health. It would seem reasonable then to adopt a grain loading regulation and an opacity regulation which are compatible in the particle size range to be expected from reasonable control devices and which strongly influence the opacity. This means making the regulations compatible in the 0.5 to 1.0 micron region.

2.2 Relationship Between Grain Loading and Air Quality

The dispersal of particulate matter from a smoke stack is an example of turbulent diffusion which was first investigated by G. I. Taylor in the early twenties. The study of atmospheric turbulent diffusion was originated by Sutton (SU-004) who formulated what has become known as Sutton's equation. If $\bar{u}_1$ is the mean wind speed at a reference height above ground level, z_1, and if the mean wind speed is assumed to increase with height according to

$$\bar{u} = \bar{u}_1 (z/z_1)^{n/(2-n)} \quad (2\text{-}5)$$

then the concentration is a distance x downwind of a point source, such as a smoke stack, is given by (SU-004).

$$C(x,y,z) = \frac{E}{\pi C_z C_y \bar{u}_1 x^{2-n}} \exp\left[-\frac{1}{x^{2-n}}\left(\frac{y^2}{C_y^2} + \frac{z^2}{C_z^2}\right)\right] \quad (2\text{-}6)$$

where E is the emission rate in mass per unit time and C_z and C_y are coefficients which determine the diffusion in the vertical and cross wind directions respectively.

When the atmosphere is stable (adiabatic lapse conditions) the value of n is near zero. This means that the mean wind speed is nearly a constant. Under very unstable conditions n is about equal to one.

The difficulty with applying Sutton's equation is the lack of knowledge of the coefficients C_y and C_z and the fact that measurements have shown that these coefficients are not constants. This difficulty can be circumvented by using the Pasquill-Gifford modification of the equation. This modification is

$$C(x,y,z) = \frac{E}{2\pi\sigma_y\sigma_z u} \exp\left[-\tfrac{1}{2}\left(\frac{z^2}{\sigma_z^2} + \frac{y^2}{\sigma_y^2}\right)\right] \quad (2-7)$$

where σ_y and σ_z replace $C_y\left(\frac{x^{2-n}}{2}\right)^{\frac{1}{2}}$ and $C_z\left(\frac{x^{2-n}}{2}\right)^{\frac{1}{2}}$ in Sutton's formulation.

The advantage of this approach is that the measurements of atmospheric diffusion can be used to obtain the proper functional dependence of the numbers σ_y and σ_z for the various stability classes. This has in fact been done by Pasquill and Gifford. The results are used in the Air Quality Display Model (AQDM) which relates emissions to air quality (TR-001). A good reference on the Pasquill-Gifford plume model is the workbook by Turner (TU-001).

The use of the AQDM to determine the maximum arithmetic mean ground level concentration as a function of stack height results in the data presented in Figure 2-2. The concentration is proportional to the stack emission rate, E, and inversely proportional to the mean wind speed, u, so that what is actually plotted is $C_{max}u/E$.

With a knowledge of the maximum arithmetic mean concentration, the expected yearly maximum concentration for

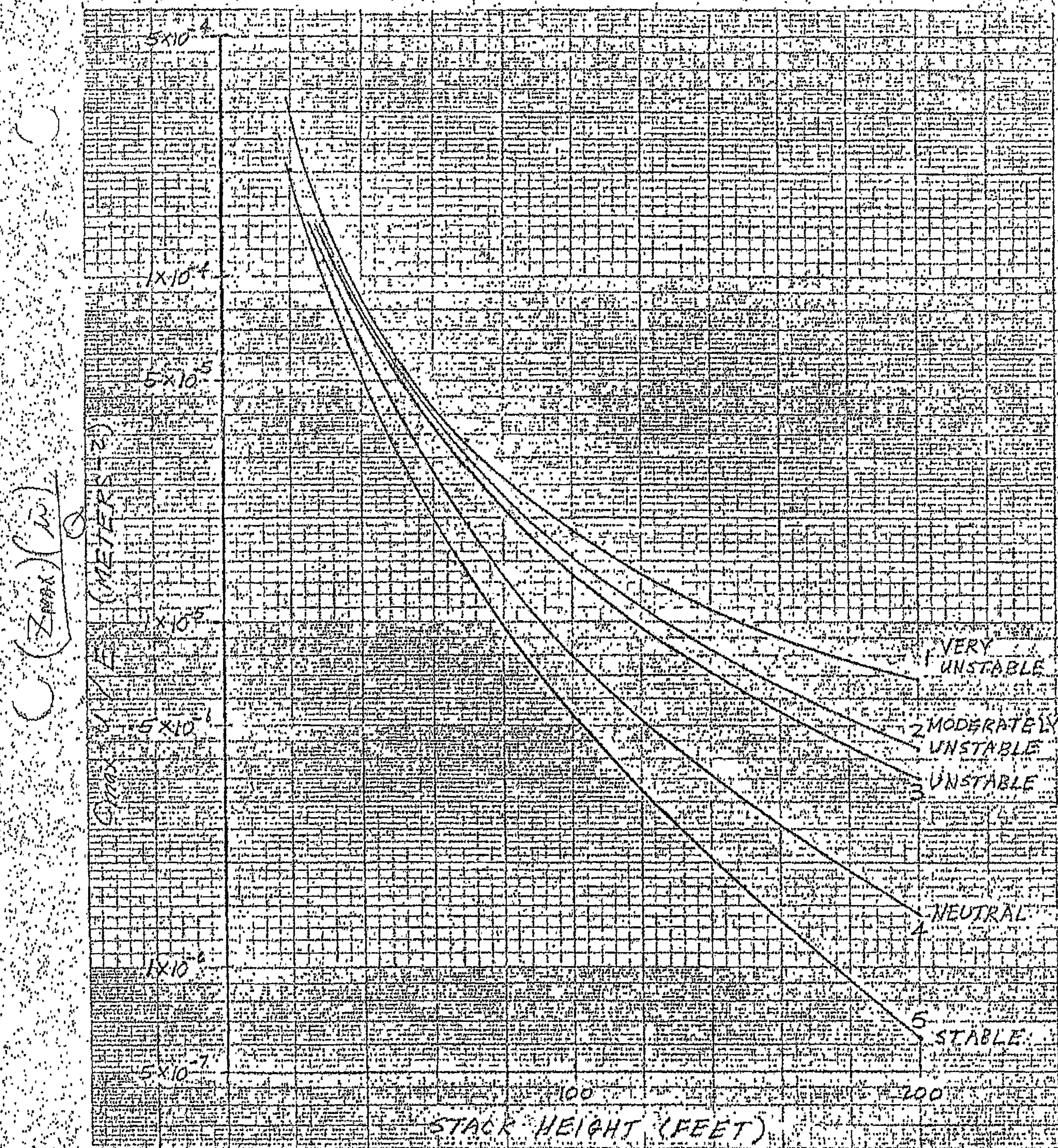

Figure 2-2

Maximum Arithmetic Mean Concentration As A Function of Stack Height and Stability Conditions various averaging times can be found if it is assumed that the concentrations are distributed in a lognormal fashion. In general, this has been found to be the case in large urban areas where the total air pollution concentration is due to many sources. However, the use of such an assumption to predict the maximum from a single source is open to some question but is most likely not too far wrong.

The result of using a lognormal distribution to determine the expected yearly maximum is presented in Figure 2-3. This is the maximum based on a 1-hour averaging period. The results were computed using the arithmetic means in Figure 2-2. The requirement that the 2-hour maximum be less than 250 $\mu gm/m^3$ can be compared to emission rates as follows. Assume parameters for a standard stack. Let the stack diameter be 5 feet, the stack exit velocity be 30 fps and let the mean wind velocity be 8 mph. Then the horizontal dashed lines in Figure 2-3 represent the 250 $\mu gm/m^3$ requirement of the various grain loadings indicated in grains/scf.

According to Sutton's equation, the maximum ground-level concentration is inversely proportional to the square of the stack height. The two dashed curves plotted in Figure 2-3 represent this dependence. It is noticed that the $1/H^2$ dependence is better for unstable conditions than for neutral or stable conditions. While the neutral or stable conditions are more probable in Texas, the maximum 60-minute averaged value is most likely to occur in unstable conditions. The upper dashed curve is more appropriate for this reason.

If a $1/H^2$ credit is given for taller stacks, it is noticed that a stack approximately 50 feet high would require a stack grain loading less than or equal to .05 gr/scf to satisfy the ground-level regulation. However, a source with the "standard conditions" chosen above and at a 100 foot stack height could could satisfy the regulation with a 0.20 gr/scf grain loading.

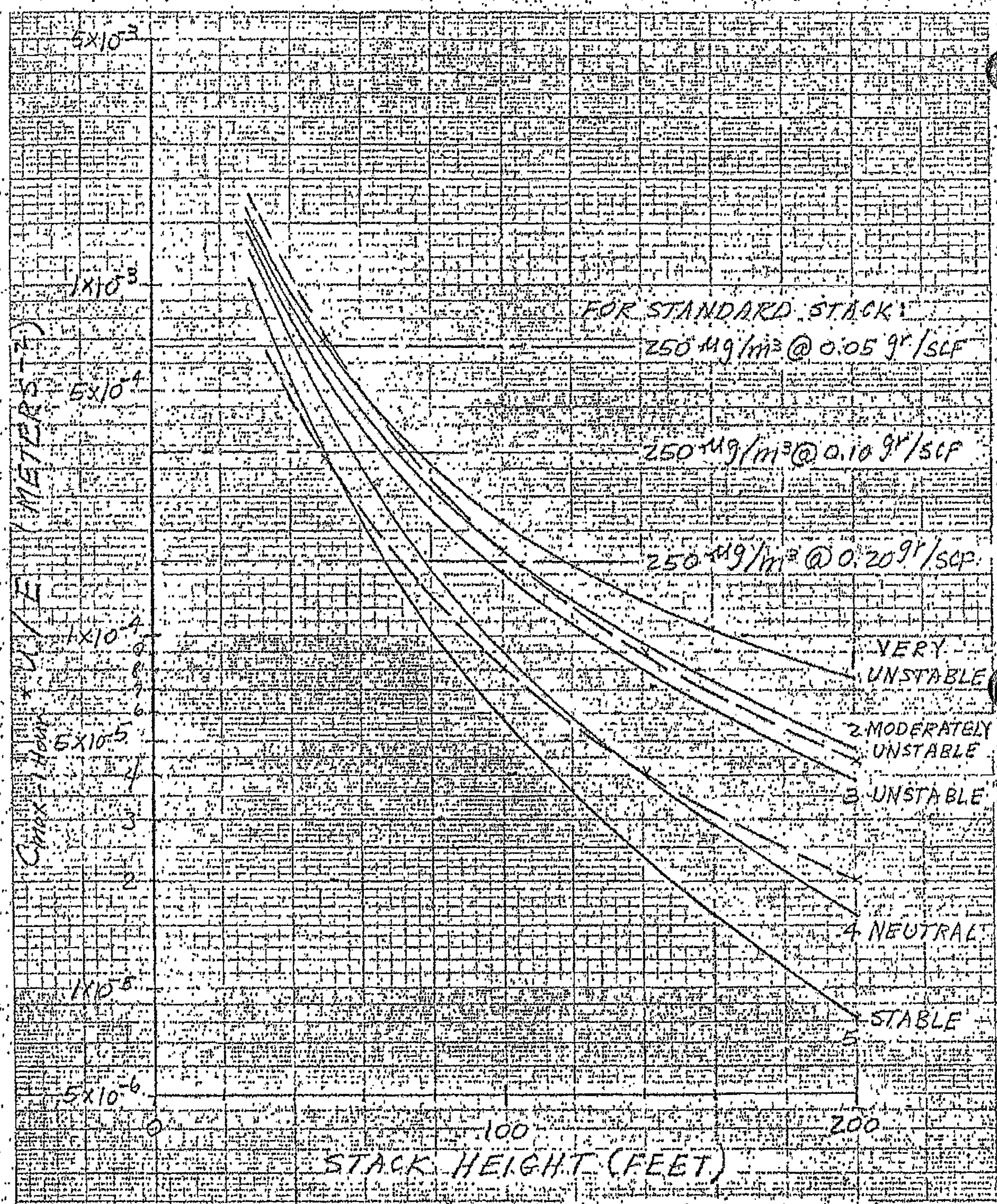

Figure 2-3

Maximum 1 Hour-Averaged Concentration As A Function of Stack Height and Stability Conditions

To determine the air quality for a wind speed of 4 mph, one must remember that the concentration is inversely proportional to wind speed and proportional to emission rate E (for a constant effective stack height). Thus a 0.20 grain/scf grain loading at 8 mph is equivalent to a 0.10 grain/scf level at 4 mph. This means that (from Figure 2-3) a 0.10 grain/scf requirement in 4 mph weather requires a 100 ft. stack.

In a similar manner other parameters may be investigated. The standard stack diameter for the purpose of the calculation was five feet. The emission rate, E, is proportional to the diameter squared for a given velocity. Thus, the stack height required for a 5 ft. diameter stack emitting 0.20 gr/scf is the same as that required for a 10 diameter stack emitting 0.05 gr/scf and so forth.

The conclusions to be drawn from the relationships presented in this section are as follows:

(1) a 250 $\mu gm/m^3$ sixty minute maximum concentration regulation is consistent with a reasonable grain loading regulation (0.1 to 0.3 grains/scf) for reasonable stack heights.

(2) The maximum ground-level concentration is inversely proportional to the square of the stack height for the more critical stability classes.

In these calculations the effective stack height is the physical stack height plus Δh where

$$\Delta H = \frac{v_s D_s}{u}\left[1.5 + 2.68 \times 10^{-3} P\left(\frac{T_s - T_a}{T_s}\right) D_s\right] \qquad (2\text{-}8)$$

where v_s is the stack velocity, P is the atmospheric pressure, and T_a and T_s are the atmospheric and stack exit temperatures, respectively.

3.0 PARTICULATE EMISSIONS IN TEXAS

The equivalence of three types of particulate regulations is dependent upon several characteristics of the emission source. The relationship between opacity and particulate concentration of the stack effluent involves: (1) the diameter and density of the particles being emitted and (2) the stack diameter. The emissions rate (E) is the product of the mass concentration (C_m) and the volumetric flow rate (q), i.e.,

$$E = C_m \times q \qquad (3\text{-}1)$$

Thus, the relationship between opacity and emissions rate also depends upon the volumetric flow rate. The relationship between emissions rate and air quality (maximum ground-level concentration of particulates surrounding the pollution source) is dependent also upon the above parameters. In addition, the relationship depends upon the physical stack height, the exit gas temperature, the prevailing wind speed, and the atmospheric stability class.

The characteristics of the pollution sources and atmospheric conditions for the State of Texas will now be discussed briefly since they do play a significant role in determining "regulation equivalence." This discussion will be followed by a summary of particulate control techniques.

3.1 Characteristics of Pollution Sources

The stationary sources of particulate emissions can be divided (MC-032) into the following categories: (1) stationary combustion sources, (2) chemical process industries, (3) food and agriculture industries, (4) metallurgical industries, (5) mineral products industries, (6) petroleum refining, and (7) wood processing industries. A significant number of each of these types of pollution sources operate within the State of Texas.

3.1.1 Particle Size

Particle size distributions for selected pollution sources <u>without</u> control equipment are given in Table 3-1. The effect of control equipment, of course, is to reduce the average particle size. Table 3-2 presents average collection efficiencies for various particulate sizes and types of control equipment. These data indicate that most of the particulates being emitted from sources with reasonable control equipment have a particle diameter less than 5 microns. Figure 3-1 shows the range of particle sizes that can be expected from various types of pollution sources. These data indicate that most of the air-borne particulates are above 0.01 microns in size. Actually, the data are suspect on the small size portion of the spectrum. Both measurement and collection of these particles are difficult.

In summary, the average particle diameter of particulates emitted from Texas industries (equipped with reasonable control devices) can be expected to be in the 0.05 to 5.0 micron range, with average diameters in the 0.2 to 2.0 micron range the more probable. Of course, the areal average particle diameter (which is used to characterize plume opacity) will be smaller than the mass average diameter (which characterizes the mass concentration of the stack effluent).

3.1.2 Particle Density

The particle density of particulate emissions can also vary widely depending upon the type of material being emitted. The specific gravities for various industrial dusts and combustion

TABLE 3-1

Source: MC-032

PARTICLE SIZE DISTRIBUTION FROM SELECTED SOURCES WITHOUT CONTROL EQUIPMENT

Type Source	Percent less than 5 microns	Percent 5-10 microns	Percent 10-20 microns	Percent 20-44 microns	Percent greater than 44 microns
Stationary Combustion					
Bituminous Coal					
Pulverized	15	17	20	23	25
Cyclone	65	10	8	7	10
Stoker	4	6	11	18	61
Anthracite Coal	35	5	8	7	45
Fuel Oil	50	NA	NA	NA	0
Natural Gas	100	--	--	--	--
Solid Waste Disposal					
Refuse Incineration	12	10	15	18	45
Mobile Combustion					
Gasoline-Powered Motor Vehicles	100	--	--	--	--
Diesel-Powered Motor Vehicles	63	NA	NA	0	0
Aircraft	100	--	--	--	--
Chemical Process					
Phosphoric Acid	100	--	--	--	--
Soap and Detergents	3	15	46	20	18
Sulfuric Acid	100	--	--	--	--
Food and Agriculture					
Alfalfa Dehydrating	Average size 2-10 microns				
Cotton Ginning	NA	NA	NA	NA	40
Feed and Grain	5	15	20	45	15
Fish Meal	1	1	3	8	87
Phosphate Fertilizer	6	6	10	8	70
Metallurgical					
Primary Aluminum	13	12	17	13	58
Primary Zinc	14	17	40	NA	NA
Iron and Steel					
Sintering	0	0	15	15	85
Blast Furnace	NA	NA	NA	NA	70
Open Hearth	46	22	17	20	5
	64	8	8	14	14
Basic Oxygen	99.5	0.5	0	0	0
Bessemer Converter	--	--	--	100	--
Secondary Aluminum	34	30	23	10	3
Brass & Bronze	100	--	--	--	--
Gray Iron Foundry	18	8	12	14	48
Secondary Lead	95	3	2	0	0
Secondary Steel	60	14	11	9	6
Secondary Zinc	100	--	--	--	--
Mineral Products					
Asphalt Batching	35	25	17	20	3
Asphalt Roofing	100	--	--	--	--
Ceramic Clay	36	NA	NA	40	6
Castable Refractories	100	--	--	--	--
Cement	22	25	25	20	8
Concrete	13	21	27	25	14
Frit	45	33	15	17	10
Glass	26	NA	NA	NA	0
Gypsum	95% smaller than 10 microns				
Lime	2	8	24	38	28
Mineral Wool	0.5	2.5	10	27	60
Perlite	37	10	10	13	35
Phosphate Rock	80	15	5	0	0
Stone Quarrying & Processing					
Crushing	5	5	5	10	75
Conveying & Screening	30	20	20	18	12
Petroleum Refinery					
Catalyst Regenerator	50	15	NA	NA	NA
Wood Processing					
Fiberboard	NA	NA	NA	NA	25

NA = No further breakdown of particle distribution available.

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TABLE 3-2

AVERAGE COLLECTION EFFICIENCIES FOR VARIOUS PARTICLE SIZES AND VARIOUS PARTICULATE CONTROL EQUIPMENT[a,b]

Source: MC-032

Type Collector	Overall	Efficiency, %, in micron range: 0-5	5-10	10-20	20-44	>44
Baffled Settling Chamber	58.6	7.5	22	43	80	90
Simple Cyclone	65.3	12	33	57	82	91
Long-cone Cyclone	84.2	40	79	92	95	97
Multiple Cyclone (12 in. diameter)	74.2	25	54	74	95	98
Multiple Cyclone (6 in. diameter)	93.8	63	95	98	99.5	100
Irrigated Long-cone Cyclone	91.0	63	93	96	98.5	100
Electrostatic Precipitator	97.0	72	94.5	97	99.5	100
Irrigated Electrostatic Precipitator	99.0	97	99	99.5	100	100
Spray Tower	94.5	90	96	98	100	100
Self-induced Spray Scrubber	93.6	85	96	98	100	100
Disintegrator Scrubber	98.5	93	98	99	100	100
Venturi Scrubber	99.5	99	99.5	100	100	100
Wet Impingement Scrubber	97.9	96	98.5	99	100	100
Baghouse	99.7	99.5	100	100	100	100

a - References 366,367

b - Data based on standard silica dust with the following particle distribution:

Particle Size Range Microns	Percent by Weight
0-5	20
5-10	10
10-20	15
20-44	20
>44	35

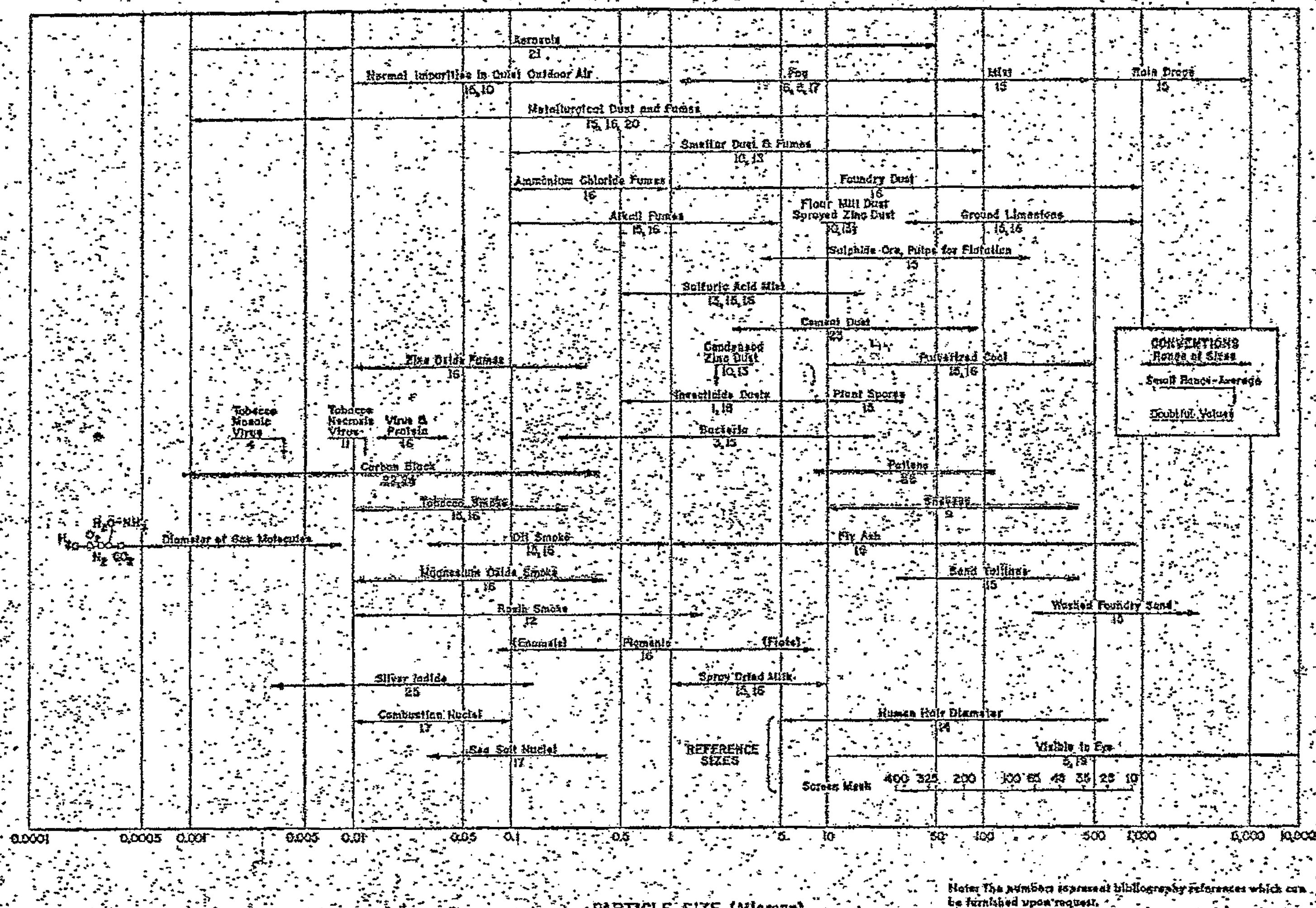

Figure 3-1

Sizes of Air-Borne Particulates (M.S.A.)

Source: -004

products are given in Table 3-3. The specific gravities for most grains are in the range of 0.7 to 1.0.

These data would indicate that particle densities for particulate emissions in Texas should be in the range of 0.8 to 5.0 grams per cubic centimeter, with 2.0 g/cc a reasonable average.

3.1.3 Stack Characteristics

As one would expect, the stack characteristics for pollution sources in Texas vary over a wide range of values.

Review of the 1970 emissions inventory data for Texas shows that most stack heights are within the range of 15 to 200 feet, with 50 feet an approximate average value. Several stacks of 300 feet and higher do exist. Although tall stacks do tend to allow dispersion of particulates over a wide area, they do not have the more desirable effect of removing particulates from the atmosphere. For this reason, there would appear to be an upper limit to the credits for building tall stacks. A second reason exists due to the economics of constructing and operating an exhaust system with a tall stack. Figure 3-2 shows how the investment cost of power plant stacks increases rapidly above 500 feet. Of course, the operating cost of the exhaust fan also increases with stack height.

According to emissions inventory data, stack diameters vary from 0.5 to 15 feet, with an approximate "mass-average" value of 5 feet. Stack velocities are normally in the range of 5 to 100 feet per second, with a typical value of 30 ft/sec. Exit gas temperatures normally vary from 70 to 1000°F, with 300°F a typical value.

TABLE 3-3

SPECIFIC GRAVITIES OF WIND EROSION PRODUCTS, INDUSTRIAL DUSTS AND COMBUSTION PRODUCTS

Source: SH-004

Specific gravity	Wind erosion products	Industrial dusts	Combustion products
0-1		sawdust	cenospheres incinerator ash
1-1.6	most fibers, biological materials: starches, etc.	plastics, gums, resins, most organic compounds, many hydrated salts like $Na_2SO_4 \cdot 12H_2O$, $Na_2CO_3 \cdot CaCO_3 \cdot 5H_2O$ (Carnallite)	most smoke
1.6-2.6	sand	glass wool, KCl, $NaNO_3$, sand, paint spray, borax, clays, alums, sylvite, phosphates	public utilities, paint, flyash
2.6-3.3	calcite, feldspars, micas, dolomite	talc, micas, cryolite, fluorite	
> 3.3	barite, aragonite, cinnabar, periclase, pyrolusite, realgar, rutile, siderite, sphalerite	asbestos, metal powders, corundum, lime, galena, garnets, barium, strontium, hematite, lead salts, etc., magnetite, marcasite, pyrite, willemite, zincite	

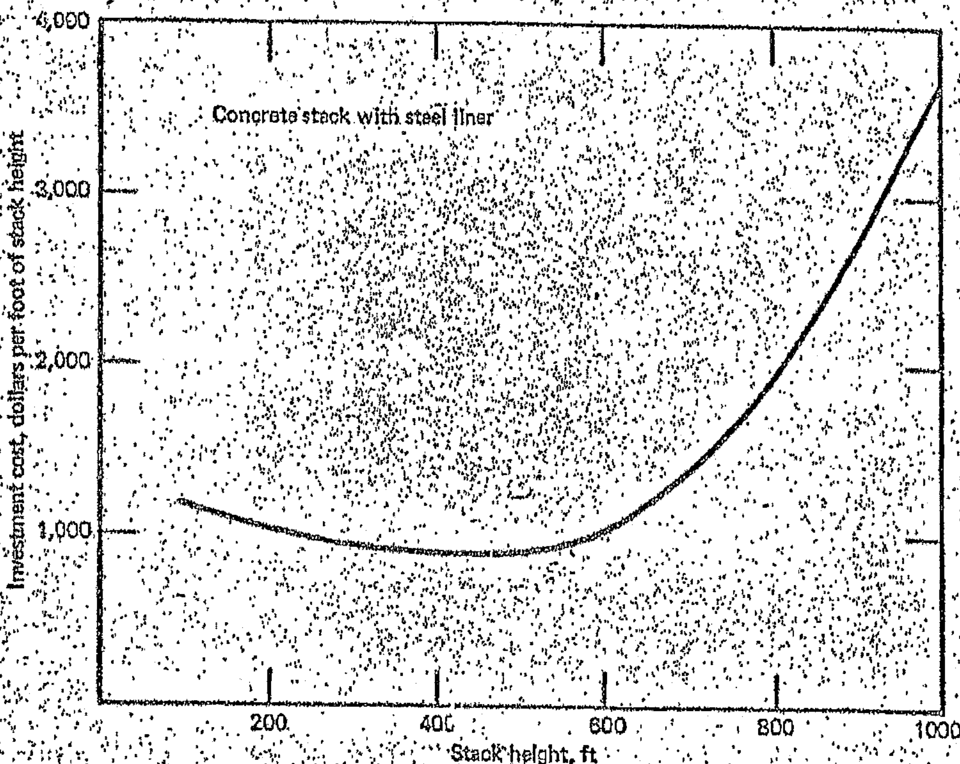

Figure 3-2
Cost of Power Plant Stacks
Source: TE-001

3.1.4 Atmospheric Conditions

The average atmospheric conditions for a pollution source must be considered in relating particulate emission rates to ground-level concentration. Meteorological data for Houston, Dallas-Fort Worth, and San Antonio have been reviewed to determine the atmospheric conditions prevailing in various locations. The average wind speed and the "fastest mile" speed for several Texas cities are listed in Table 3-4. The "fastest mile" speed is the fastest wind speed observed for a 1-minute interval. Meteorological data for the State would indicate that 9 mph is a representative average wind speed and that 2 to 20 mph represent a reasonable range of wind speed values.

Table 3-5 lists the frequency of occurrence of the five stability classes for the Houston, Dallas-Fort Worth, and San Antonio areas. These data indicate that the neutral and stable classes are the most frequently occurring conditions. As indicated by Figure 2-3, less credit should be given to building tall stacks when the atmospheric conditions tend to be unstable.

3.1.5 Source and Atmospheric Parameters

A summary of the characteristic values for source and atmospheric parameters is given in Table 3-6.

TABLE 3-4

WIND SPEEDS FOR SELECTED TEXAS CITIES (1969)

City	Wind Speed, mph Average	Wind Speed, mph Fastest Mile
Houston	7.9	46
Dallas-Ft. Worth	10.2	36
San Antonio	9.1	37

TABLE 3-5

STABILITY CLASSES FOR SELECTED TEXAS CITIES*

	Frequency of Occurrence for Stability Class				
	1	2	3	4	5
Houston	0.01	0.05	0.09	0.50	0.35
Dallas-Ft. Worth	0.02	0.09	0.11	0.37	0.41
San Antonio	0.06	0.06	0.10	0.52	0.26

*Houston and San Antonio data are for the five year period 1965-69. Dallas-Ft. Worth data are for 1969 only.

TABLE 3-6

SOURCE AND ATMOSPHERIC PARAMETERS

	Characteristic Value		
	Low	Average	High
Stack Height, h_s (ft)	15	50	200
Stack Diameter, D_s (ft)	0.5	5	15
Stack Exit Velocity, v_s (ft/sec)	5	30	100
Exit Temperature, T_s (°F)	70	300	1000
Average Particle Diameter, d_p (μ)	0.05	0.5	5
Particle Density, ρ (g/cc)	0.8	2	5
Wind Speed, u (mph)	1	8	20
Stability Class*	1	4	5

*Choice of low and high designation was arbitrary. Stability class 1 represents the most unstable atmospheric condition, stability class 5 is the most stable.

3.2 Control Techniques

The purpose of this section is not to present a comprehensive review of particulate control equipment. Numerous reviews (NA-029, BR-016, DA-004, WA-011, SO-002) of this nature are available in the literature. Only a brief summary of (1) the types of particulate control equipment used by industry, (2) the relative advantages and disadvantages, and (3) typical removal efficiencies will be presented.

Table 3-7 lists the methods of particulate control devices used by selected industries. Table 3-8 summarizes the advantages and disadvantages of various collection devices. These devices range from the low-cost, low-efficiency gravitational separators to the more expensive electrostatic precipitators, fabric filters, and afterburners. Table 3-2 shows average collection efficiencies for various control devices as a function of particle size.

Table 3-9 lists typical performance data for electrostatic precipitators for various industrial applications.

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TABLE 3-7

TYPES OF CONTROL EQUIPMENT USED BY SELECTED INDUSTRIES

Source: NA-029

Industry or process	Source of emissions	Particulate matter	Method of control
Iron and steel mills	Blast furnaces, steel making furnaces, sintering machines.	Iron oxide, dust, smoke	Cyclones, baghouses, electrostatic precipitators, wet collectors.
Gray iron foundries	Cupolas, shake out systems, core making.	Iron oxide, dust, smoke, oil, grease, metal fumes.	Scrubbers, dry centrifugal collectors.
Metallurgical (non-ferrous)	Smelters and furnaces	Smoke, metal fumes, oil, grease.	Electrostatic precipitators, fabric filters.
Petroleum refineries	Catalyst regenerators, sludge incinerators.	Catalyst dust, ash from sludge.	High-efficiency cyclones, electrostatic precipitators, scrubbing towers, baghouses.
Portland cement	Kilns, dryers, material handling systems.	Alkali and process dusts	Fabric filters, electrostatic precipitator, mechanical collectors.
Kraft paper mills	Chemical recovery furnaces, smelt tanks, lime kilns.	Chemical dusts	Electrostatic precipitators, venturi scrubbers.
Acid manufacture-phosphoric, sulfuric.	Thermal processes, phosphate rock acidulating, grinding and handling systems.	Acid mist, dust	Electrostatic precipitators, mesh mist eliminators.
Coke manufacturing	Charging and discharging oven cells, quenching, materials handling.	Coal and coke dusts, coal tars.	Meticulous design, operation, and maintenance.
Glass and glass fiber	Raw materials handling, glass furnaces, fiberglass forming and curing.	Sulfuric acid mist, raw materials dusts, alkaline oxides, resin aerosols.	Glass fabric filters, afterburners.
Coffee processing	Roasters, spray dryers, waste heat boilers, coolers, conveying equipment.	Chaff, oil aerosols, ash from chaff burning, dehydrated coffee dusts.	Cyclones, afterburners, fabric filters.

TABLE 3-8

ADVANTAGES AND DISADVANTAGES OF COLLECTION DEVICES

Source: NA-029

Collector	Advantages	Disadvantages
Gravitational	Low pressure loss, simplicity of design and maintainance.	Much space required. Low collection efficiency.
Cyclone	Simplicity of design and maintainance.	Much head room required.
	Little floor space required	Low collection efficiency of small particles.
	Dry continuous disposal of collected dusts.	Sensitive to variable dust loadings and flow rates.
	Low to moderate pressure loss.	
	Handles large particles.	
	Handles high dust loadings.	
	Temperature independent.	
Wet collectors	Simultaneous gas absorption and particle removal.	Corrosion, erosion problems.
		Added cost of wastewater treatment and reclamation.
	Ability to cool and clean high-temperature, moisture-laden gases.	Low efficiency on submicron particles.
	Corrosive gases and mists can be recovered and neutralized.	Contamination of effluent stream by liquid entrainment.
	Reduced dust explosion risk	Freezing problems in cold weather.
	Efficiency can be varied	Reduction in buoyancy and plume rise.
		Water vapor contributes to visible plume under some atmospheric conditions.
Electrostatic precipitator.	99+ percent efficiency obtainable	Relatively high initial cost.
	Very small particles can be collected	Precipitators are sensitive to variable dust loadings or flow rates.
	Particles may be collected wet or dry	Resistivity causes some material to be economically uncollectable.
	Pressure drops and power requirements are small compared to other high-efficiency collectors.	Precautions are required to safeguard personnel from high voltage.
	Maintenance is nominal unless corrosive or adhesive materials are handled.	Collection efficiencies can deteriorate gradually and imperceptibly.
	Few moving parts	
	Can be operated at high temperatures (550° to 850° F.).	
Fabric filtration	Dry collection possible	Sensitivity to filtering velocity.
	Decrease of performance is noticeable	High-temperature gases must be cooled to 200° to 550° F.
	Collection of small particles possible	Affected by relative humidity (condensation).
	High efficiencies possible	Susceptibility of fabric to chemical attack.
Afterburner, direct flame.	High removal efficiency of submicron odor-causing particulate matter.	High operational cost. Fire hazard.
	Simultaneous disposal of combustible gaseous and particulate matter.	Removes only combustibles.
	Direct disposal of non-toxic gases and wastes to the atmosphere after combustion.	
	Possible heat recovery	
	Relatively small space requirement	
	Simple construction	
	Low maintenance	
Afterburner, catalytic.	Same as direct flame afterburner	High initial cost.
	Compared to direct flame: reduced fuel requirements, reduced temperature, insulation requirements, and fire hazard.	Catalysts subject to poisoning.
		Catalysts require reactivation.

TABLE 3-9

TYPICAL PERFORMANCE DATA FOR ELECTROSTATIC PRECIPITATORS

Source: ST-001

Type of plant	Gas flow ft³/min at temperature	Dust concentrations gr/ft³ at operating temp.		Collecting efficiency %
		inlet	outlet	
1. Power Stations:				
Pulverized fuel fired boilers	161,850	5·72	0·071	98·67
Pulverized fuel fired boilers	144,231	4·76	0·027	99·43
Refuse burning boilers	50,000	7·3	0·252	96·6
Lignite stoker fired boilers	235,300	0·7–0·874	0·00743–0·01616	98·15
Lignite pulverized fuel fired boiler (hammer mills)	942,000	2·015	0·0698	96·5
2. Coal Industry:				
Lignite rotary type steam dryer	17,050	15·32	0·1225	99·25
Lignite rotary type steam dryer	15,300	7·96	0·0394	99·40
Lignite plate type steam dryer	14,700	3·42	0·0272	99·20
Combustion gas lignite dryer	24,700	6·25	0·0481	99·50
Lignite mill dryer	23,580	10·93	0·1445	98·67
Lignite conveying system de-dusting	12,050	23·8	0·121	99·40
Bituminous coal tube type steam dryer	25,300	7·09	0·0355	99·50
Bituminous coal conveying system de-dusting	6,480	9·75	0·0656	99·30
Bituminous coal–coke grinding plant	2,825	6·02	0·0245	99·59
3. Coal Gas Industry:				
Peat gas producer	2,650	2·32	0·00351	99·85
Cracking plant for natural gas	5,120	0·0976	0·000875	99·20
Producer gas from lignite briquettes	7·650	16·4	0·0875	99·47
Producer gas from semi-bituminous lignite	28,250	12·47	0·0437	99·7
Shale-gas cleaning plant	20,000	17·4	0·0026	99·9
Coke oven town gas cleaning	1,825	10·5	0·00437	99·9
Coke oven town gas cleaning	1,350	7·35	0·00131	99·9
Coke oven gas cleaning	8,230	12·17	0·0342	99·8
Oil carburetted water gas cleaning	7,360	2·06	0·0171	99·2
Tar carburetted water gas cleaning	2,358	4·37	0·0219	99·5
4. Paper Industry:				
Pyrites roaster 25 ton/day	5,570	1·398	0·0205	98·5
Pyrites roaster 36 ton/day	8,230	1·79	0·0157	99·1
Acid mist from sulphur burning furnace 7·5 ton/day	1,470	2·99	0·0179	99·4
Sulphuric acid mist following cooler tower	2,530	5·33	0·0267	99·5
Sulphuric acid mist following cooler tower	2,940	3·29	0·0306	99·1
Black liquor burning plant	78,000	1·234	0·058	95·3
5. Cement Industry:				
Rotary kiln dry process 520 ton/day	80,000	9·0	0·084	99·06
Lepol rotary kiln dry process 470 ton/day	74,750	2·75	0·032	98·85
Rotary kiln wet process 350 ton/day	85,400	9·26	0·029	99·68
Rotary kiln with calciner, wet process 350 ton/day	85,400	4·82	0·105	98·2
Vertical kiln	73,600	0·78	0·021	97·3
Raw material dryer	21,200	21·3	0·052	99·75
Cement mill	14,100	22·3	0·037	99·8
Packing machine	8·840	16·4	0·048	99·7
6. Chemical Industry:				
Pyrites roaster 29 ton/day	6,480	0·95	0·0162	98·3
Pyrites roaster 35 ton/day	7,660	0·525	0·00157	99·7
Blende roaster	9,140	2·23	0·0328	98·5
Arsenic and sulphuric acid mist removal	8,250	1·18	0·0000022	99·99
Tail gas for sulphuric acid concentration	12,380	5·[illegible]		
Elemental sulphur fume from hydrogen sulphide combustion plant	2,530	11·2		
7. Mineral Earths and Salts Processing:				
Bauxite dryer 180 ton/day	11,800	6·		
Bauxite calcining and processing kiln 220 ton/day	25,900	2·		
Alumina calciner with multicyclone pre-cleaner 45 ton/day	8,950	129·		
Potassium chloride dryer	17,100	3·		
Fullers earth dryer	17,650 *	1·		
8. Non-Ferrous Metallurgical Industry:				
Vertical blast furnace: lead ore	5,880	5		
Vertical blast furnace: lead ore	9,410	2		
Rotary kiln processing: zinc ores	4,710	17		
Rotary kiln processing: zinc ores	7,360	[illegible]		
Vertical blast furnace tin ores	5,700	[illegible]		
Vertical blast furnace: tin ores	2,120	[illegible]		
Vertical blast furnace: antimony ores	3,650			
Copper converters	18,530			
Rotary kiln for nickel bearing iron ores	26,500	1		

* Lineal velocity through the precipitator: data from R. L. Cotham, Paper No. 29 *Clean Air Conference*, Sydney, 1962.

† Lineal [illegible] through precipitator: data from G. Funke, *Zement, Kalk, Gips*. 12, 189 (1959).

4.0 FORMULATION OF REGULATIONS

Guidelines for developing "equivalent" opacity, air quality, and emissions rate regulations will be presented in this section. First, particulate regulations used or suggested by other governmental agencies will be reviewed briefly. Next, possible particulate regulations will be presented. Then the control requirements imposed on selected industries by these regulations will be discussed.

4.1 Other Regulations

The Environmental Protection Agency (EPA) has recently issued guidelines for states' preparation of implementation plans (EN-017). This document includes an example set of regulations for particulate emissions. These regulations are divided into the following categories: (1) visible emissions, (2) fugitive dust, (3) incineration, (4) fuel burning equipment, and (5) process industries.

The regulation on visible emissions states that stationary sources may not emit any air contaminant which yields a density equal to or greater than a Ringelmann No. 1 or 20 percent opacity. The regulation does allow (1) a Ringelmann No. 3 or 60 percent opacity for up to 3 minutes in any 60 minute period and (2) an exception to the visibility regulation where uncombined water is the only reason for failure of a source to meet this requirement.

The regulation on fuel burning equipment states that no source burning solid fuel may emit particulate matter in excess of 0.10 pounds per million Btu. (For a typical coal-fired unit, this corresponds to a 0.056 gr/scf grain loading. For a typical lignite-fired unit, this corresponds to a 0.049 gr/scf grain loading.)

Oil-fired fuel burning equipment rated equal to or greater than 250 million Btu per hour may not emit particulates in excess of 0.025 pounds per million Btu per hour. For a coal-fired unit using 10 percent ash coal, the regulation for solid fuel corresponds to 99 percent particulate removal. For combustion of a high-ash residual fuel-oil, the fuel-oil regulation corresponds to 80 percent particulate removal.

The regulation on process industries uses an emissions rate vs. process weight curve to define allowable emissions. This curve is represented by the equation

$$E = 4.10 * P^{0.67} \quad (4\text{-}1)$$

for process weight rates up to 60,000 lbs/hr. Here E is the rate of emissions in pounds per hour and P is the process weight rate in tons per hour. This regulation is essentially the one put forth by the Los Angeles County Air Pollution Control District (LACAPCD). Above a process weight rate of 60,000 lbs/hr., the LACAPCD regulation becomes more stringent and is represented by the equation

$$E = 55 * P^{0.11} - 40 \quad (4\text{-}2)$$

The regulation utilizing Equations (4-1) and (4-2) is the one proposed by the TACB staff in November 1970. In the EPA example regulation, a 0.03 gr/scf graining loading restriction is also imposed upon the process industries. That is, the regulation does not allow emissions in excess of (1) 0.03 gr/scf of exhaust gas <u>or</u> (2) the emissions rate specified by the process weight curve, whichever is less.

The example regulation displayed by EPA does not allow a credit for tall stacks. A number of other proposed regulations do allow this credit. One proposal (CR-013) suggests that their grain loading regulation be increased by $(H/100)^2$ for stack heights greater than 100 feet. This credit applies only to less than 10 micron particulates. Of course, the reasoning behind this proposal is that fine particulates discharged aloft from tall stacks will be widely dispersed before fall-out. Whether this proposal would in fact be suitable would depend on prevailing wind current, the amount of thickly-populated area downwind, and the amount of particulate pollution already existing downwind. This would be a suitable regulation in a coastal area where wind currents would normally blow the particulates out to sea. The particulate regulation adopted by the State of New Jersey in 1964 (CR-013) is a variation of the process weight concept which gives consideration to the height of the stack, the distance from the stack to the plant property line, the particle size of the particulates, and their hazardous nature.

Numerous other regulations are reported in the literature (CR-013, DA-004, ST-001). However, air pollution control legislation is constantly changing, with the trend towards tighter control. Thus, the regulations reported in the literature tend to be less restrictive than the regulations which are currently being proposed.

4.2 Possible Regulations

The bases for developing particulate regulations have been presented. Although it is not the purpose of this note to design particulate regulations, it would appear appropriate to outline possible regulations which could be utilized by the TACB.

4.2.1 Opacity and Grain Loading

First of all, let us consider a means by which "equivalent" opacity and grain loading regulations can be set. Figure 2-1 gives the relationship between opacity and grain loading for different particle diameters. This figure shows that opacity is strongly dependent upon particle diameter. Particulate emissions with an areal average particle diameter of 0.15 microns produce a very opaque plume. For a 5-foot diameter stack with an exit gas temperature of 300°F and a particle density of 2 g/cm³, the grain loading would need to be below 0.01 gr/scf to satisfy a 20% opacity regulation if the areal average particle diameter were 0.15 microns. This means that a 20% opacity regulation would be very severe for such a source.

The above situation represents the most restrictive case for the 20% opacity regulation. This pollution source could attain compliance by installing several stacks with smaller diameters. For example, if several one foot diameter stacks were used, a 0.05 gr/scf grain loading would just about satisfy the 20% opacity regulation. The above statement can be easily verified by observing in the opacity equation that decreasing the stack diameter D_s has the same effect as decreasing the grain loading C_m.

In a similar fashion, Figure 2-1 and the opacity equation shown on this figure can be used to generate opacity values corresponding to given grain loadings for various source (D_s, d_p, ρ, and T_s) parameters. Selected values are shown in Table 4-1. The effect of exit gas temperature is to modify the volumetric flow rate of exit gas. The grain loadings shown in Figure 2-1 are based upon an exit temperature of 300°F, the grain loading shown on Figure 2-1 should be modified by multiplying them by the factor (T + 460)/(760).

These data indicate that the opacity reading is strongly dependent upon the stack parameters. Two alternatives could be

TABLE 4-1

SELECTED OPACITY VALUES FOR VARIOUS SOURCE PARAMETERS

Grain Loading (gr/scf)	Stack Diameter (ft)	Particle Density (g/cc)	Particle Diameter (microns)	Opacity (%)
0.050	5	2	0.76	20
0.100	5	4	0.76	20
0.025	5	1	0.76	20
0.050	2.5	2	0.38	20
0.100	2.5	4	0.38	20
0.025	2.5	1	0.38	20
0.050	1.0	2	0.15	20
0.100	1.0	4	0.15	20
0.025	1.0	1	0.15	20
0.050	5	4	0.76	11
0.050	5	1	0.76	36

be considered for equilibrating opacity and grain loading regulations. One approach would be to include all of these parameters in the equilibration step. This approach would appear to be too cumbersome and result in regulations which are difficult to enforce. The particle size distribution and density of the stack emissions would have to be measured.

The second approach would be to equilibrate the opacity and grain loading at one key point. For the "standard" source plotted on Figure 2-1, a possible point for this equilibration is at 0.05 gr/scf grain loading for an areal average particle diameter of 0.076 microns. For "standard" sources with an average particle diameter above 0.76 microns, the opacity regulation will be less stringent than a 0.05 gr/scf grain loading regulation, whereas for particles with an average diameter smaller than 0.76 microns the reverse is true.

For sources with "non-standard" parameters, similar reasoning can be applied to determine which regulation will be the most stringent. For example, if a source with $D_s = 5$ feet and $T_s = 300°F$ emits particles with an areal average diameter of 0.76 microns and a density of 1.0 g/cc, the opacity regulation will be more stringent than a 0.05 gr/scf grain loading regulation. If a pollution source were confronted with this type of situation, it could (1) build a stack with a smaller diameter, (2) dilute the exit gas, or (3) heat the exit gas to avoid the more stringent opacity regulation.

As noted in various particulate regulations covering visible emissions, the opacity regulation should not be applied to a stack which is opaque due to the presence of uncombined water. Some provision in the regulations could except sources from the opacity criterion when the opacity is due to uncombined moisture.

4.2.2 Emissions Rate

Next let us consider what type of emissions rate regulation is desirable. The example particulate regulation displayed by EPA (EN-017) in the Federal Register has one rule for fuel combustion sources and one for industrial process sources. The "example" rule for solid-fuels combustion sources corresponds to a grain loading of 0.056 gr/scf for typical coal-fired units and 0.049 gr/scf for typical lignite-fired units. The "example" rule for industrial process sources uses an emissions rate vs. process weight curve and a 0.03 gr/scf grain loading regulation. The process source must satisfy the minimum emissions indicated by these two criteria. The TACB staff would prefer to devise an emissions rate regulation which is based upon a "grain loading" concept for all sources rather than use the process weight rate concept. The process weight rate concept suffers the disadvantages of not being able to accurately define or determine the process weight rate for all pollution sources.

Thus, let us consider a "grain loading" type of regulation. That is, let us construct a curve for allowable emissions rate (E) which is a function of the volumetric flow rate (q) of exit gas.

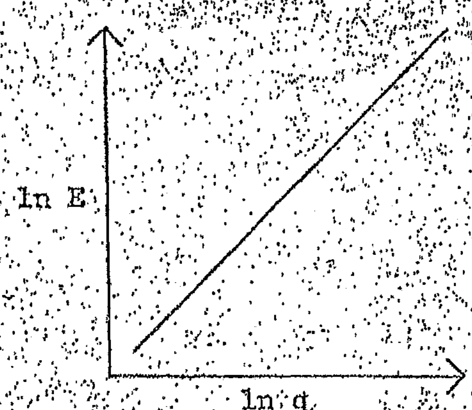

Figure 4-1
Emissions Rate Curve

This curve is represented by the equations

$$\ln E = b \ln q + \ln a \qquad (4\text{-}3a)$$

$$E = aq^b \qquad (4\text{-}3b)$$

$$\text{where} \quad E = q\,C_m \qquad (4\text{-}4)$$

Combination of Equations (4-3) and (4-4) indicates that a curve of C_m versus q specifies a E versus q curve.

The next question to be answered is should all sources be allowed to emit particulates at the same concentration (C_m) regardless of the source size. Many agencies have adopted the philosophy that large sources will be contaminating the environment more than small sources so the large sources should be required to control to lower grain loadings. The sketch below indicates two types of regulations:

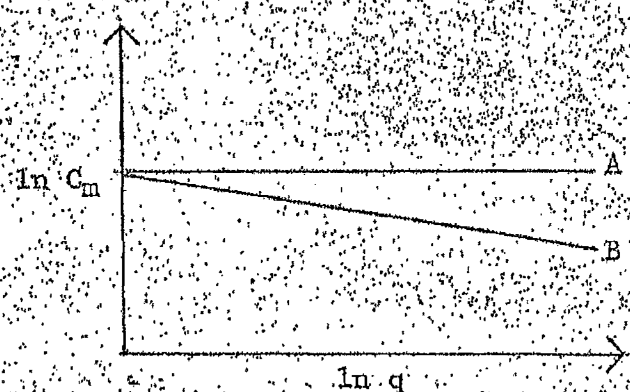

Figure 4-2
Grain Loading Curve

The A curve represents a constant grain loading regulation, whereas the B curve represents a decreasing grain loading restriction for increasing size. Using the notation given in Equations (4-3) and (4-4), the equation

$$C_m = a\ q^{b-1} \qquad (4\text{-}5)$$

would represent (1) the A curve provided b is equal to one and (2) the B curve provided b-1 is negative.

One way of achieving the goal of placing a more restrictive grain loading on large sources and at the same time maintaining a good "tie" between the opacity and emissions rate regulations would be to let the product C_m times D_s be a constant for all gas flow rates, i.e.,

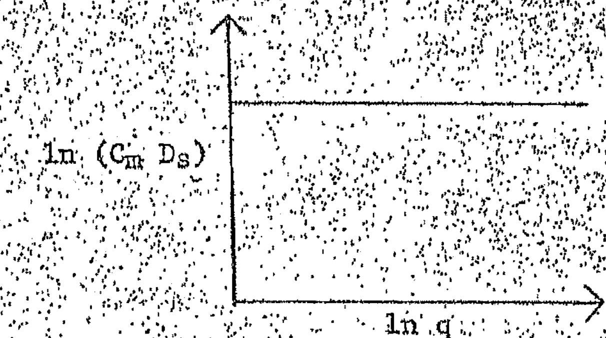

Figure 4-3
$C_m D_s$ Product Curve

$$C_m D_s = (C_m D_s)_{Std},\ \text{a constant} \qquad (4\text{-}6)$$

Use of Equation (4-6) implies that the opacity is also a constant (for the same particulates and stack temperature).

For the emissions rate expressed in lbs/hr (E), the mass concentration expressed in gr/scf (C_{ms}) and the volumetric flow rate expressed in scf/minute (q_s),

$$E = 8.57 \times 10^{-3}\ C_{ms}\ q_s \qquad (4\text{-}7)$$

The volumetric flow rate (q_s) is related to the stack velocity v_s (in ft/sec) and the stack diameter D_s (feet) by the relation

$$q_s = 47.1\ D_s^2\ v_s (492)/(T_s + 460) \qquad (4\text{-}8)$$

For a standard stack with $v_s = 30$ ft/sec and $T_s = 300°F$,

$$q_s = 913\ D_s^2 \qquad (4\text{-}9)$$

If a 0.05 gr/scf grain loading is selected as the basis for the "standard" stack with $D_s = 5$ feet, the $C_{ms}\ D_s$ product can be set by

$$C_{ms}\ D_s = 0.25 \qquad (4\text{-}10)$$

Combining Equations (4-9) and (4-10),

$$C_{ms} = 7.56\ (q_s)^{-\frac{1}{2}} \qquad (4\text{-}11)$$

which is the equation for the grain loading curve. Combining Equations (4-7) and (4-11),

$$E = 6.48 \times 10^{-2}\ (q_s)^{\frac{1}{2}} \qquad (4\text{-}12)$$

This is the emissions rate curve that corresponds to $C_m\ D_s$ = 0.25 gr-ft/scf. It should be emphasized that this expression was developed based upon holding $C_m\ D_s$ constant and for the "standard" stack parameters ($D_s = 5$ feet and $v_s = 30$ ft/sec). The criterion of holding $C_m\ D_s$ constant places a stringent grain loading restriction on large diameter stacks. This may force pollution sources into building multiple stacks when the benefit for doing so is not that great. However, the opacity regulation has the same effect.

Of course, numerous other emissions rate curves could be constructed based upon $C_m D_s$ being held constant. If the less stringent criterion of $C_m D_s = 0.50$ gr-ft/scf is used as a basis, the corresponding emissions rate curve is defined by

$$E = 1.30 \times 10^{-1} (q_s)^{\frac{1}{2}} \qquad (4\text{-}13)$$

Figure 4-4 displays Equations (4-12) and (4-13) graphically. Equations (4-12) and (4-13) are designed as the B_1 and B_2 curves, respectively.

A constant grain loading regulation could be adopted. This would not force the larger sources to comply with a more stringent grain loading regulation. If 0.05 gr/scf is chosen as the regulation basis,

$$E = 4.28 \times 10^{-4} (q_s) \qquad (4\text{-}14)$$

The A curve in Figure 4-4 represents this equation displayed graphically. Of course, other grain loadings could be chosen as the basis.

Another possibility is to compromise between the constant $C_m D_s$ (opacity) and constant grain loading concepts. One such compromise would be to have the emissions rate dependent upon the 3/4th power of the volumetric flow rate, i.e.,

$$E = 5.26 \times 10^{-3} (q_s)^{3/4} \qquad (4\text{-}15)$$

Equation (4-15) is based upon a 0.05 gr/scf grain loading at the stack parameters of $D_s = 5$ feet, $v_s = 30$ ft/sec and $T_s = 300°F$.

4.2.3 Emissions Rate and Air Quality

The relationship between stack emissions rate and air quality was presented in Section 2.2. Figure 2-3 displays the maximum ground-level concentration averaged over 60 minutes as a function of effective stack height and atmospheric stability class. The horizontal dashed lines correspond to ordinate values for grain loadings of a "standard" source (D_s = 5 feet, v_s = 30 ft/sec, T_s = 300 F, and u = 8 mph).

This figure shows that a stack approximately 50 feet high emitting particulates at 0.05 gr/scf would result in a maximum ground-level concentration of 250 μg/m³. If the stack height is increased, the allowable grain loading for this standard source decreases. For the moderately unstable (Class 2) and slightly unstable (Class 3) atmospheric conditions, the ground-level concentration dependence is closely approximated by a $1/H^2$ dependence (dashed lines on Figure 2-3). As the atmospheric conditions become more stable, a higher order dependence is observed (note that the lower dashed line does not parallel the lines for Stability Classes 4 and 5).

The dependence of ground-level concentration on effective stack height shown in Figure 2-3 would indicate that a credit proportional to H^2 could be applied to the allowable emissions rate. This credit would correspond to the dependence for the most critical atmospheric conditions (stability Classes 2 and 3). The maximum 60-minute concentration is much more likely to occur for these conditions than for the neutral or stable atmospheric conditions.

If a more conservative credit for stack height is desired, a credit proportional to H could be applied. This type of credit would discourage the use of tall stacks as a pollution control technique.

The adjustment to allowable emissions rate for various stack heights should be bounded. The particulate regulation should probably include a minimum physical stack height, say, around 15 feet above nearby structures. The credit for taller stacks should probably be limited to physical stack heights of about 200 feet.

The effective stack height to be used in any crediting for taller stacks should be the physical stack height H* plus the plume rise Δh, i.e.,

$$H = H^* + \Delta h \qquad (4\text{-}16)$$

The plume rise formula used in the AQDM (TR-001) is given by Equation (2-8). It is suggested that a modified form of this formula be used in the TACB particulate regulation. Standard values for (1) the mean wind speed, (2) atmospheric pressure, and (3) ambient air temperature should be substituted into Equation (2-8). Substituting u = 8 mph, P = 1013 millibars, and T_a = 70°F (average values for Houston) into Equation (2-8) and converting the units

$$\Delta h = 0.128\ v_s\ D_s\ [1.00 + 0.550\ D_s (T_s - 70)/(T_s + 460)] \qquad (4\text{-}17)$$

where v_s is expressed in ft/sec, D_s in ft, and T_s in °F.

4.3 Typical Control Requirements

In this section, the impact of the particulate lations outlined in Section 4.2 upon several pollution s will be discussed. The purpose of this section is to de whether or not these regulations are reasonable.

4.3.1 Solid-Fuel Combustion Sources

As examples of large pollution sources which c to the particulate pollution problem, coal and lignite f power plants will be discussed. First, let us consider burning power plant to illustrate how the regulations ou here correspond to the example regulation displayed by E the Federal Register. This regulation restricts particu emissions from solid-fuel combustion sources to 0.10 lbs As mentioned earlier in this note, this correspond to a gr/scf grain loading for a typical coal-fired unit. A 5 power station will produce about 1.1×10^6 scf per minut 4.64×10^4 lbs of fly ash (based upon 10% fly ash from c per hour. If the power station were to remove 99% of th particulates, the power station would be emitting 0.049 and thus be in compliance with the EPA example regulatic

Now let us consider applying the regulations in the previous section to this pollution source. For station this large, several stacks would be utilized. 10 foot diameter stacks could accommodate the gas flow exit gas velocity of 60 ft/sec and temperature of 300°F $D_s = 10$ ft and $C_m = 0.049$ gr/scf, it can be seen from F that the 20% opacity regulation could be met if the are particle diameter is 1.5 microns or larger. This seems for fly ash.

Compliance with the emissions rate curves in Figure 4-4 depends upon the manner in which these curves are applied. If the flow rates from each of the six stacks are summed to yield a total flow rate from this particular pollution source and the total allowable emissions rate is determined based upon this gas flow rate, most of the regulations on Figure 4-4 will be very stringent for this type of source. On the other hand, if the emissions rate curve is applied to each stack separately and thus the total allowable emissions rate is computed, compliance would more likely be attainable.

The allowable emissions rate indicated by each of the curves on Figure 4-4 are summarized in Table 4-2. Only the constant grain-loading type regulation (Curve A) could be satisfied by 99% particulate removal with this 6 stack network. If the emissions rate curve were applied to each stack separately, the use of multiple stacks would be encouraged. To achieve compliance with a B_1, B_2, or C curve regulation, this pollution source would need to attain higher removal efficiencies or build more stacks.

Application of an air quality regulation must also consider the question of how it should be applied to multiple stacks. If the network of six stacks is considered to be one source, the (C_{max} - 1 hour * μ)/E value based upon an 8 mph wind velocity would be $1.53 \times 10^{-5} m^{-2}$. As can be seen from Figure 2-3 ($1.53 \times 10^{-5} m^{-2}$ does not intersect upper dashed line), the pollution source could not attain compliance with 99% removal and a 200 foot high stack. To attain compliance with this type of regulation, this pollution source would need to attain 99.67% removal efficiencies and build a 200 foot stack. The 99.67% removal figure corresponds to 140 lbs/hr of particulate emissions.

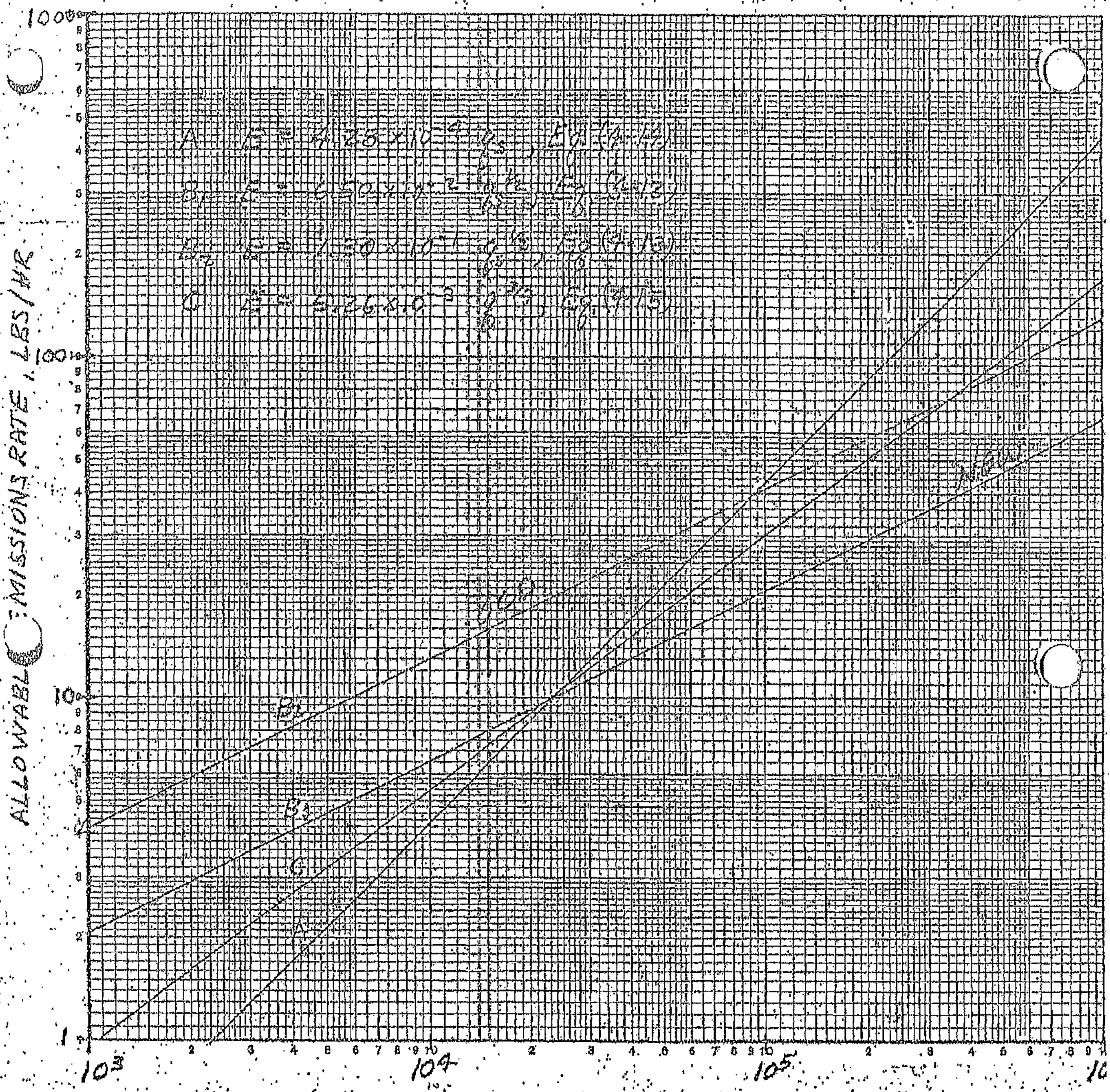

Figure 4-4
Allowable Emissions Rate Curves

TABLE 4-2

ALLOWABLE EMISSIONS FOR A TYPICAL COAL-FIRED POWER STATION

	Total Allowable Emissions (lbs/hr)	
Regulation	Based on Total Flow Rate	Based on Stack Flow Rate
Curve A	470	470
Curve B_1	68.2	167
Curve B_2	136.4	334
Curve C	179	280

Emissions corresponding to 99% particulate removal - 464 lbs/hr.

On the other hand, if each of the stacks is considered separately, the (C_{max} - 1 hour * u)/E value would be $9.14 \times 10^{-5} m^{-2}$. This pollution source could be within compliance of the air quality regulation by building a 140 ft high stack and removing 99% of the particulates.

Lignite-fired power stations will produce more particulates per unit of heat generated than coal-fired plants. A typical lignite-fired plant will produce 16.9 lbs of fly ash per 10^6 Btu of heat, whereas a typical coal unit produces about 8.7 lbs/10^6 Btu. A typical 500 mw lignite-fired plant will produce approximately 1.15×10^6 scfm of flue gas and 9.55×10^4 lbs/hr fly ash. For 99% removal of particulates, the grain loading of the exit gas would be 0.083 gr/scf (compared to 0.049 gr/scf for the coal unit). This means that a lignite-fired power station must devise a control scheme (or stack arrangement) which corresponds to twice the removal efficiencies of the coal-fired system.

4.3.2 Asphalt Batching Plants

Hot asphalt batching plants are potential sources of heavy dust emissions. Asphalt batching involves the mixing of hot dry sand, aggregate, and mineral dust with hot asphalt. The major source of dust is the direct-fired dryer. Exit gases range from 250° to 350°F at volumetric flow rates of 15,000 to 60,000 scfm (NA-029). Most dryers use simple cyclone separators to collect about 70 to 90% of the dust. Scrubbers can be used following the primary cyclones to achieve 99% overall dust removal efficiencies (FR-021). To achieve higher efficiencies, fabric filters have been used with success.

Consider a small asphalt batching plant exiting 8,200 scfm of gas through a 3 foot diameter stack at 300°F. Friedrich (FR-021) estimates an average dust loading of 75 gr/scf for a kiln dryer. A primary cyclone followed by a wet scrubber could reduce effluent dust loadings to approximately 0.1 to 0.2 gr/scf (this corresponds to 99.73% removal). For $D_s = 3$ ft; $\rho = 3$ g/cc, and $C_m = 0.2$ gr/scf, the 20% opacity regulation could be met if the average particle diameter is 1.2 microns or larger. Based upon the data presented by Friedrich, the average particle diameter of the effluent stream could be smaller than 1.2 microns. If this is the case, effluent dust loadings of 0.1 gr/scf may be required to satisfy the opacity regulation (for $C_m = 0.1$ gr/scf, d_p must be equal to or greater than 0.67 microns).

If a 0.10 gr/scf effluent dust loading is achieved, the emissions rate for a 8,200 scfm unit would be 7.0 lbs/hr. The maximum allowable emissions rate for the regulatory curves shown in Figure 4-4 are listed below:

Regulatory Curve	Max. Allowable Emissions Rate (lbs/hr)
A	3.6
B_1	5.8
B_2	11.7
C	4.7

Thus, a 0.10 gr/scf dust loading would only satisfy the B_2 regulation. If any of the curves A, B_1, or C were adopted, this source would probably be forced to use fabric filters.

Now let us determine whether or not the air quality criterion can be satisfied by this source. For an 8 mph wind speed and an emissions rate of 7.0 lbs/hr, $(C_{max\text{ - }1\text{ hour}} * u)/D = 7.5 \times 10^{-4} m^{-2}$. This means this source could comply with a 250 μg/m³ concentration by having a 50 foot high stack.

5.0 SUMMARY

A basis for developing reasonable particulate emissions regulations is given in this note. Technical relationships between plume opacity, emissions rate, and air quality have been discussed. Plume opacity can be related to grain loading by means of the expression

$$\text{Opacity} = 1 - \exp\left(-\frac{3}{2}\frac{Q\,C_m D_s}{\rho\, d_p}\right)$$

Q = Extinction coefficient

The parameters d_p, ρ, D_s, and T_s have a strong influence on opacity (see Figure 2-1). The grain loading (and thus emissions rate) can be related to air quality by means of (1) stack parameters (d_s, v_s, T_s, and h_s) and (2) atmospheric conditions (u and stability class). For the more critical stability classes, the maximum ground-level concentration is inversely proportional to the square of the stack height (see Figure 2-3).

The characteristics of particulate emission sources in Texas were summarized. Typical source parameters and atmospheric conditions were tabulated (see Table 3-6). The removal efficiencies of various control devices and previously used or suggested control regulations were presented. This information is vital to devising reasonable control regulations.

Several possible control regulations were suggested. Curves for the maximum allowable emissions rate as a function of gas flow rate were constructed. The curves presented (see Figure 4-4) are based upon controlling particulate emissions by (1) holding the effluent grain loading (C_m) constant as the gas flow rate increases, (2) holding the product $C_m D_s$ constant, and (3) a compromise between the two concepts above. The effect of various "possible" regulations upon two particulate emissions sources was discussed.

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ATTACHMENT C

GENERAL RULES

Rule 1. Definitions

In addition to the terms which are defined by Article 4477-5, V.T.C.S., the following terms shall have the meanings given herein:

1.01 Act. The Texas Clean Air Act, codified as Article 4477-5.

1.02 Ambient Air. That portion of the atmosphere, external to buildings, to which the general public has access.

1.03 Article. When followed by a number, "article" refers to provisions of the law as codified in Vernon's Revised Civil Statutes of Texas, 1925, as amended.

1.04 Background. Background concentration is defined as that level of air contaminants that cannot be reduced by controlling emissions from man-made sources. It is determined by measuring levels in non-urban areas.

1.05 Combustion Unit. Any boiler plant, furnace, incinerator, flare, engine, or other device or system used to oxidize solid, liquid, or gaseous fuels, but excluding motors and engines used in propelling land, water, and air vehicles.

1.06 Commercial Incinerators. An incinerator used to dispose of waste material from retail and wholesale trade establishments.

1.07 Domestic Wastes. The garbage and rubbish normally resulting from the functions of life within a residence.

1.08 Downwind Level. The concentration of air contaminants from a source or sources on a property as measured at or beyond the property boundary.

1.09 Exhaust Emission. Air contaminants emitted to the atmosphere from an opening downstream from the exhaust ports of a motor vehicle engine.

1.10 Federal Motor Vehicle Regulation. The Motor Vehicle Air Pollution Standards, Title 45, Subtitle A, Part 85, Code of Federal Regulations.

1.11 Flue. Any duct, stack, chimney, or conduit used to conduct air contaminants into the open air.

1.12 Forage. Any vegetation which may be consumed by animals.

1.13 Garbage. Solid waste consisting of putrescible animal and vegetable waste materials resulting from the handling, preparation, cooking, and consumption of food, including waste materials from markets, storage facilities, handling and sale of produce and other food products.

1.14 Hydrocarbons. Compounds which contain carbon and hydrogen.

1.15 Incinerator. An enclosed combustion apparatus and appurtenances thereto which is used in the process of burning wastes for the primary purpose of reducing its volume and weight by removing the combustibles of the waste, and which is equipped with a flue for conducting products of combustion to the atmosphere. An open trench type (with closed ends) combustion unit may be considered an incinerator when approved by the Executive Secretary.

1.16 Inorganic Fluoride Compounds. All inorganic chemicals having an atom or atoms of fluorine in their chemical structure.

1.17 Major Upset. An unscheduled occurrence or excursion of a process or operation that results in an emission of air contaminants that contravenes the Texas Air Control Board Regulations and/or the intent of the Texas Clean Air Act and is beyond immediate control, or a release that is initiated to protect life in the immediate or adjacent areas.

1.18 Motor Vehicle. A self-propelled vehicle designed for transporting persons or property on a street or highway.

1.19 Net Ground-Level Concentration. The upwind level subtracted from the downwind level.

1.20 New Source. Any stationary source, the construction or modification of which is commenced after the date of adoption of these Regulations.

1.21 Non-Methane Hydrocarbons. The total hydrocarbon content of the sample minus the methane content of the sample.

1.22 Opacity. The degree to which an emission of air contaminants obstructs the transmission of light expressed as the percentage to which the light is obstructed as measured by an optical instrument or trained observer.

1.23 Outdoor Burning. Any fire or smoke-producing process which is not conducted in a combustion unit.

1.24 Particulate Matter. Any material, except uncombined water, that exists as a solid or liquid in the atmosphere or in a gas stream at standard conditions.

1.25 Process or Processes. Any action, operation, or treatment embracing chemical, commercial, industrial, or manufacturing factors such as combustion units, kilns, stills, dryers, roasters, and equipment used in connection therewith, and all other methods or forms of manufacturing or processing that may emit smoke, particulate matter, gaseous matter, or visible emissions.

1.26 Process Weight Per Hour. "Process Weight" is the total weight of all materials introduced or recirculated into any specific process which process may cause any discharge into the atmosphere. Solid fuels charged into the process will be considered as part of the process weight, but liquid and gaseous fuels and combustion air will not. The "Process Weight Per Hour" will be derived by dividing the total process weight by the number of hours in one complete operation from the beginning of any given process to the completion thereof, excluding any time during which the equipment used to conduct the process is idle. For continuous operation, the "Process Weight Per Hour" will be derived by dividing the process weight for a 24-hour period by twenty-four.

1.27 Property. All land under common control or ownership on which any source or combination of sources is located, coupled with all improvements on such land, and all fixed or movable objects on such land, or any vessel on the waters of this State which may constitute a source.

1.28 Rubbish. Nonputrescible solid waste, consisting of both combustible and noncombustible waste materials; combustible rubbish includes paper, rags, cartons, wood, excelsior, furniture, rubber, plastics, yard trimmings, leaves, and similar materials; noncombustible rubbish includes glass, crockery, tin cans, aluminum cans, metal furniture, and like materials which will not burn at ordinary incinerator temperatures ($1600^{o}F$ to $1800^{o}F$).

1.29 Smoke. Small gas-borne particles resulting from incomplete combustion consisting predominantly of carbon and other combustible material and present in sufficient quantity to be visible.

1.30 Sour Gas. Any natural gas containing more than one and one-half (1½) grains of hydrogen sulfide per one hundred (100) cubic feet, or more than thirty (30) grains of total sulfur per one hundred (100) cubic feet.

1.31 Sour Crude. A crude oil which will emit a sour gas when in equilibrium at atmospheric pressure.

1.32 Source. A point of origin of air contaminants, whether privately or publicly owned or operated. Upon request of a source owner the Executive Secretary shall determine whether multiple processes emitting air contaminants from a single point of emission will be treated as a single source or as multiple sources.

1.33 Standard Conditions. A condition at a temperature of 70°F and a pressure of 14.7 pounds per square inch absolute. Pollutant concentrations from an incinerator will be corrected to a condition of 50% excess air if the incinerator is operating at greater than 50% excess air.

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1.34 Standard Metropolitan Statistical Area. An area consisting of a county or one or more contiguous counties which is officially so designated by the U. S. Bureau of the Budget.

1.35 Submerged Fill Pipe. Any fill pipe the discharge opening of which is entirely submerged when the liquid level is six inches above the bottom of the tank or is always submerged during filling operations; or when applied to a tank which is loaded from the side, shall mean any fill pipe the discharge opening of which is entirely submerged when the liquid level is two times the fill pipe diameter in inches above the bottom of the tank.

1.36 Sulfur Compounds. All inorganic or organic chemicals having an atom or atoms of sulfur in their chemical structure.

1.37 Sweet Crude Oil and Gas. Those crude petroleum hydrocarbons that are not "sour" as defined.

1.38 System or Device. Any article, chemical, machine, equipment, or other contrivance, the use of which may eliminate, reduce, or control the emissions of air contaminants to the atmosphere.

1.39 Upwind Level. The representative concentration of air contaminants flowing onto or across a property as measured at any point.

1.40 <u>Visible Emissions</u>. Particulate or gaseous matter which can be detected by the human eye. The radiant energy from an open flame shall not be considered a visible emission under this definition.

1.41 <u>Volatile Organic Compounds</u>. Any compound containing carbon and hydrogen or containing carbon and hydrogen in combination with any other element which has a vapor pressure of 1.5 pounds per square inch absolute or greater under actual condition of storage or use.

1.42 <u>Volatile Organic Compound - Effluent Water Separation</u>. Any tank, box, sump, or other container in which any volatile organic compound thereof, floating on or entrained or contained in water entering such tank, box, sump, or other container, is physically separated and removed from such water prior to outfall, drainage, or recovery of such water.

Rule 2. Other Definitions.

Unless specifically defined in the Act or in the Rules of the Board, the terms used by the Board have the meanings commonly ascribed to them in the field of air pollution control.

Rule 3. Multiple Air Contaminant Sources or Properties.

3.1 In an area where an additive effect occurs from the accumulation of air contaminants from two or more sources on a single property or from two or more properties, such that the level of air contaminants exceeds the ambient air quality standards established by the Texas Air Control Board, and each source or each property is emitting no more than the allowed limit for an air contaminant for a single source or from a single property, further reduction of emissions from each source or property shal be made as determined by the Board.

3.2 Two or more property holders in a county having a population of less than 50,000 as determined by the most recent federal census may petition the Board to have their properties designated a single property for purposes of controlling emissions therefrom, if the properties are contiguous except for intervening roads, railroads, rights-of-way, canals and watercourses, which are considered a part of the area for purposes of this provision. The petition shall describe generally the manner in which control of emissions from the combined properties will be administered and shall name the party or parties accepting responsibility thereof. The petition shall be accompanied by an executed copy of a written agreement between the property holders who consent to having their properties so designated and shall also be accompanied by a detailed map of the vicinity showing geographical features such as roads, watercourses, and well-known landmarks; the boundaries of the petitioner's properties; the area to be included in the single property designation; and present land uses in the areas surrounding the area to be included. The Board may place such conditions on the approval of the petition as it may deem appropriate.

Rule 4. Circumvention.

No person shall use any plan, activity, device or contrivance which the Executive Secretary determines will, without resulting in an actual reduction of air contaminants, conceal or appear to minimize the effects of an emission which would otherwise constitute a violation of the Act or Regulations. Air introduced for dilution purposes only is considered a circumvention of the Regulations.

Rule 5 Nuisance.

No person shall discharge from any source whatsoever one or more air contaminants or combinations thereof, in such concentration and of such duration as are or may tend to be injurious to or to adversely affect human health or welfare, animal life, vegetation or property, or as to interfere with the normal use and enjoyment of animal life, vegetation or property.

Rule 6. Traffic Hazard.

No person shall discharge from any source whatsoever such quantities of air contaminants, uncombined water, or other materials which cause or have a tendency to cause a traffic hazard or an interference with normal road use.

Rule 7. Notification Requirements for Major Upset.

The Executive Secretary and the appropriate local air pollution control agency shall be notified as soon as possible of any major upset condition which causes or may cause an excessive emission that contravenes the intent of the Texas Clean Air Act and/or the Regulations of the Board. A list of persons to contact may be obtained from the Executive Secretary upon request.

Rule 8. Notification Requirements for Maintenance.

The Executive Secretary and the appropriate local air pollution control agency shall be notified in writing at least ten (10) days prior to any planned maintenance, start-up, or shut-down which will or may cause an excessive emission that contravenes the intent of the Texas Clean Air Act and/or the Regulations of the Board. If ten (10) days notice cannot be given due to an unplanned occurrence, notice shall be given as soon as practical prior to the shut-down.

Rule 9. Monitoring.

Any person affected by any Rule or Regulation of the Texas Air Control Board shall conduct sampling of the appropriate emissions. The sampling must reflect the pattern of emissions with reasonable accuracy. During periods of officially designated air pollution episode conditions, those persons affected by Rule 803 shall monitor their emissions. The Executive Secretary may prescribe methods and frequency of monitoring under this rule and may exempt persons from the application of this rule. The results of all monitoring shall be recorded and retained for at least five years and shall be made available to the Board or any members, employees, or agents of the Board and local air pollution control agencies upon request.

Rule 10. Sampling Ports.

Any person, at the request of the Board shall provide in connection with each flue a power source near the point of testing in addition to such sampling and testing facilities and sampling ports, including safe and easy access thereto, exclusive of instruments and sensing devices, as may be necessary for the Board to determine the nature and quality of emissions which are or may be discharged as a result of source operations. Evidence and data based on these samples and calculations may be used to substantiate violations of the Act, Rules and Regulations. Agents of the Board shall be permitted to sample the stacks during operating hours.

Rule 11. Filing of Emissions Data.

Upon request by the Board or the Executive Secretary, any person affected by any Rule or Regulation of the Texas Air

Control Board shall file emissions data with the Board on forms supplied by the Board.

Rule 12. Exemptions from Rules and Regulations.

12.1 Emissions occurring during major upsets may not be required to meet the allowable emission levels set by the Rules and Regulations upon proper notification as set forth in Rule 7 of these General Rules, if a determination is made by the Executive Secretary after consultation with appropriate local agencies and with appropriate officials of the subject source that the upset conditions were unavoidable and that a shut-down or other corrective actions were taken as soon as practicable.

12.2 Emissions occurring during start-up or shut-down of processes or during periods of maintenance may not be required to meet the allowable emission levels set by the Rules and Regulations if so determined by the Executive Secretary upon proper notification as set forth in Rule 8 of these General Rules. The Executive Secretary may specify the amount, time, and duration of emissions that will be allowed during start-up and shut-down and during periods of maintenance.

12.3 Smoke generators and other devices used for training inspectors in the evaluation of visible emissions at a training school approved by the Board are not required to meet the allowable emission levels set by the Rules and Regulations, but must be located and operated such that a nuisance is not created at any time.

12.4 Equipment, machines, devices, flues, contrivances built or installed to be used at a domestic residence for domestic use are not required to meet the allowable emission levels set by the Rules and Regulations unless specifically required by a particular Regulation.

12.5 Sources emitting air contaminants which cannot be controlled or reduced due to a lack of technological knowledge may be exempt from the applicable Rules and Regulations when so determined and ordered by the Texas Air Control Board. The Board may specify limitation and conditions as to the operation of such exempt sources.

12.6 No nuisance conditions shall be permitted to occur under these exemptions.

Rule 13. Board Seal.

The seal of the Board shall bear the words "Texas Air Control Board," the star, and the oak and olive branches common to other official State seals.

Rule 14. Use and Effect of Rules.

These rules may be used by the Board as guides in the exercise of discretion, where discretion is vested. They shall not be construed as a limitation or restriction on the exercise of discretion, where it exists, nor shall they be construed to deprive the Board of the exercise of any power, duties and jurisdiction conferred by law, or to limit or restrict the amount and character of data or information which may be required for the proper administration of the law.

Rule 15. Sampling Procedures and Terminology.

Where not otherwise specified in the Rules, Regulations, determinations and orders of the Board, the procedures used for sampling air and measuring air contaminants, and the methods of expressing the findings shall be those commonly accepted and used in the field of air pollution control.

Rule 16. Invoking Jurisdiction of the Board.

Any person may petition the Board through the Executive Secretary for such consideration and action related to air pollution control as he may desire. The Board will review and act on the petition in such manner as the Board may prescribe.

Rule 17. Petition for Variance.

Any person seeking a variance, amendment of a variance, or extension of a variance issued to that person shall file a petition on a form prepared by the Board. The form shall be furnished by the Board without charge upon request. In order to obtain a variance past the date by which compliance is to be achieved, a person must have demonstrated continuous and substantial progress toward compliance before the date of petition.

Rule 18. Effect of Acceptance of Variance or Permit.

Acceptance of a variance or a permit constitutes an acknowledgement and agreement that the holder thereof will comply with its terms and with the Rules, Regulations, and orders of the Board adopted pursuant to the Act.

Rule 19. Initiation of Review.

The Board may initiate proceedings to revoke or amend a variance or a permit on its own motion, on recommendation of the Executive Secretary, or upon request of an interested person who presents reasonable justifiable grounds therefor.

Rule 20. Transfers.

A variance or a permit is granted in personam, and does not attach to the realty to which it relates. A variance cannot be transferred without prior notification to the Board. If a transfer of ownership of a source covered by a variance is contemplated by the holder of the variance, and the source and characteristics of the emissions will remain unchanged, upon notification, the Executive Secretary shall issue an endorsement to the variance reflecting the name of the new owner. Continuation of emissions by the new owner without prior notification to the Board makes the variance subject to forfeiture.

Rule 21. Remedies Cumulative.

The administrative and judicial procedures available to the Board to prevent, correct or remedy air pollution conditions or violations are cumulative. Within the limits of the authority set forth in the Act and these Rules, the Board or the Executive Secretary may act under any one or more of these procedures, as applicable to the facts of a particular air pollution condition or claimed violation.

Rule 22. Severability.

If any provision of any of the Regulations of the Board or the application of that provision to any person, situation or circumstance is for any reason adjudged invalid, the adjudication does not affect any other provision of the Regulations or the application of the adjudicated provision to any other person, situation, or circumstance. The Board declares that it would have adopted the valid portions and applications of the Regulations without the invalid part and to this end the provisions of the Regulations are declared to be severable.

Rule 23. It is the intention of the Texas Air Control Board to utilize and enforce the Ambient Air Quality Standards and emission limitations promulgated pursuant to the Federal Clean Air Act, 42 U.S.C., 1857 et seq., as amended.

Rule 24. The National Primary and Secondary Ambient Air Quality Standards as published in the Federal Register, 36 Fed. Reg. 818F (April 30, 1971), are to be applied throughout all parts of Texas. The Primary Standards are to be achieved no later than three (3) years after the Implementation Plan is approved by the Environmental Protection Agency, and the Secondary Standards are to be achieved within a reasonable time thereafter as so determined by the Texas Air Control Board.

Rule 25. The general rules contained herein shall be in force immediately and shall supersede all previous General Provisions and Procedural Rules of the Texas Air Control Board.

Date Adopted: January 26, 1972

Date Filed with the Secretary of State: February 4, 1972

Date Effective: March 5, 1972

ATTACHMENT D

REGULATION I

CONTROL OF AIR POLLUTION FROM SMOKE, VISIBLE EMISSIONS, AND PARTICULATE MATTER

Rule 101. Outdoor Burning

101.1 No person may cause, suffer, allow or permit any outdoor burning within the State of Texas, except as provided by Rule 101.2.

101.2 Outdoor burning is authorized in the following instances if no nuisance is or will be created:

101.21 Outdoor burning when conducted pursuant to a written grant of authority by the Texas Air Control Board or Executive Secretary.

101.22 Outdoor burning for the purpose of training fire-fighting personnel when requested by certified mail and when authorized in writing by the local air pollution control agency or local health unit. If notice of denial from the local air pollution control agency or local health unit is not received within ten (10) days of the request, the burning is authorized. Authorization to conduct outdoor burning under this provision may be revoked by the Texas Air Control Board if it is found that this provision is used to circumvent Rule 101.

101.23 Outdoor burning of domestic waste at and from a property designed for and used exclusively as a private residence, housing not more than three families when collection of the domestic waste is not provided by the local governmental entity having jurisdiction.

101.24 Outdoor burning consisting of campfires and fires used solely for recreational or ceremonial purposes, or in the non-commercial preparation of food.

101.25 Outdoor burning in a rural area of trees, brush, grass, and other dry vegetable matter from such area in land-clearing, right-of-way maintenance operations, forest management purposes, and range land management purposes, if all the following conditions are met:

101.251 The burning must be outside the corporate limits of a city or town except when it is necessary to eliminate a naturally occurring fire hazard.

101.252 The wind direction at the time of starting the burning must be away from any nearby city, town, residence, recreational, commercial, or industrial area.

101.253 The burning must be at least one thousand feet from any residence, recreational, commercial, or industrial area except those located on the property where the burning is to take place, except when it is necessary to eliminate a naturally occurring fire hazard.

101.254 Heavy oils, asphaltic materials, items containing natural or synthetic rubber or any material other than dry plant growth which may produce unreasonable amounts of smoke must not be burned.

101.255 If the burning will cause smoke to blow onto or across a highway, it is the responsibility of the person initiating the burning to post flagmen on affected roads in accordance with the requirements of the Department of Public Safety.

101.256 The initial burning for land clearing and right-of-way maintenance purposes may be commenced after 9:00 a.m. Material which will not be completely consumed before 5:00 p.m. shall not be added to the fire.

101.257 Burning within an area should be staggered so that total atmospheric loads of smoke are reduced.

101.258 Burning shall not be conducted when meteorological forecasts predict wind movement of less than three (3) miles per hour or greater than fifteen (15) miles per hour or when a significant shift in wind direction is predicted which could produce adverse effects to personnel, animals, or property during the burning period.

101.259 Burning shall not be conducted during periods of actual or predicted persistent (12 hours or more) low-level (below 1600 feet) atmospheric inversions or in areas covered by a current air stagnation advisory.

101.26 Outdoor burning of the garbage and rubbish generated by a city or town having a population of less than 5,000, as determined by the most recent federal census, or by any unincorporated area serving less than 5,000, as determined by the most recent federal census, may be conducted if the following conditions are met:

101.261 The city or unincorporated area and the location of the burning must be outside a defined Standard Metropolitan Statistical Area.

101.262 Cities in newly designated Standard Metropolitan Statistical Areas shall have eighteen (18) months after the designation of the Standard Metropolitan Statistical Area to comply with Rule 101.

101.263 The location of the burning must not be within a city or town; must be at least one mile from any residential, recreational, commercial, or industrial area; and must be at least 300 yards from any public road.

101.264 The initial burning may be commenced only between the hours of 9:00 a.m. and 1:00 p.m. Combustible material must not be added to the fire between 1:00 p.m. of one day and 9:00 a.m. of the following day.

101.265 The exceptions provided by Rule 101.26 will not apply after December 31, 1973, to cities with a population over 3,000, as determined by the most recent federal census.

101.27 Outdoor burning of hydrocarbons from pipeline breaks and oil spills may be allowed upon proper notification as set forth in Rule 7 of the General Rules, if the Executive Secretary determines that the burning is necessary to protect the public welfare.

101.3 No disposal or deposit outdoors of any material capable of igniting spontaneously is allowed except where the disposal or deposit is made pursuant to a specific grant of authority by the Texas Air Control Board or the Executive Secretary.

101.4 The authority to conduct outdoor burning under this Regulation does not exempt or excuse the person responsible from the consequences, damages, or injuries resulting from the burning and does not exempt or excuse anyone from complying with all other applicable laws or ordinances, Regulations and orders of governmental entities having jurisdiction even though the burning is otherwise conducted in compliance with the Regulation.

Rule 102. Incineration

102.1 No person may cause, suffer, allow, or permit the burning of garbage or rubbish in a single-chamber residential or commercial incinerator unless the Executive Secretary approves an incinerator demonstrated to provide equivalent performance to multiple chamber incinerators.

102.2 No person may cause, suffer or permit the burning of garbage or rubbish in a single-chamber incinerator constructed after April 1, 1972, unless the Executive Secretary approves an incinerator demonstrated to provide equivalent performance to multiple-chamber incinerators.

Rule 103. Visible Emissions.

103.1 No person may cause, suffer, allow, or permit visible emissions from any stationary flue to exceed an opacity of 30% averaged over a 5-minute period. No person may cause, suffer, allow, or permit visible emissions from any stationary flue beginning construction after January 31, 1972, to exceed an opacity of 20% averaged over a 5-minute period. Visible emissions during the cleaning of a firebox or the building of a new fire, sootblowing, equipment changes, ash removal and rapping of precipitators may exceed the limits set forth in Rule 103.1 for a period aggregating not more than five minutes in any sixty consecutive minutes, nor more than six hours in any ten-day period.

103.2 No person may cause, suffer, allow, or permit visible emissions from a waste gas flare for more than five minutes in any 2-hour period except as provided in Rule 12.1 of the General Rules.

103.3 No person may cause, suffer, allow, or permit excessive visible emissions from any building or enclosed facility.

103.4 No person may cause, suffer, allow, or permit excessive visible emissions from motor vehicles for more than ten consecutive seconds .

103.5 No person may cause, suffer, allow, or permit excessive visible emissions from any railroad locomotive, ship or any other vessel, except during reasonable periods of of engine start-up.

103.6 No person may cause, suffer, allow, or permit visible emissions from any stationary flue having a total flow rate of 100,000 acfm or more to exceed an opacity of 15% averaged over a 5-minute period unless an optical instrument capable of measuring the opacity of emissions is installed in the flue. Records of all such measurements shall be retained as provided for in Rule 9 of the General Rules. The provision shall not apply to flues having gas streams containing moisture which interferes with proper instrument operation, if so determined by the Executive Secretary.

103.7 Contributions from uncombined water shall not be included in determining compliance with Rule 103. The burden of proof which establishes the applicability of Rule 103.7 shall be upon the person seeking to come within its provisions.

Rule 104. Particulate Matter From Materials Handling, Construction, and Roads.

104.1 Rule 104 shall apply only in Standard Metropolitan Statistical Areas where the federal air quality standards for particulate matter are exceeded.

104.2 No person may cause, suffer, allow, or permit any fine material to be handled, transported, or stored without taking at least the following precautions to prevent particulate matter from becoming airborne:

104.21 Application of water or suitable chemicals or some other covering on materials stockpiles, and other surfaces which can create airborne dusts under normal conditions;

104.22 Installation and use of hoods, fans and filters to enclose, collect, and clean the emissions of dusty materials;

104.23 Covering or wetting at all times when in motion, of open-bodied trucks, trailers, or railroad cars transporting materials in areas where the general public has access which can create airborne particulate matter.

104.3 No person may cause, suffer, allow or permit a building structure to be used, constructed, altered, repaired or demolished without taking at least the following precautions to prevent particulate matter from becoming airborne:

104.31 Use of water or chemicals where feasible for control of dust in the demolition of buildings or structures, in construction operations, or in the clearing of land;

104.32 Use of adequate methods to prevent airborne particulate matter during sandblasting of buildings or other similar operations.

104.4 No person may cause, suffer, allow, or permit a road to be used, constructed, altered, or repaired without taking at least the following precautions to prevent particulate matter from becoming airborne:

104.41 Application of asphalt, oil, water or suitable chemicals on heavily traveled dirt streets as necessary.

104.42 Paving of public or commercial parking surfaces having more than five parking spaces.

104.43 Removal as necessary from paved street and parking surfaces of earth or other material which have a tendency to become airborne.

104.5 Alternate means of control may be approved by the Executive Secretary of the Texas Air Control Board.

Rule 105. Particulate Matter

105.1 No person may cause, suffer, allow, or permit emissions of particulate matter from any source to exceed the allowable rates specified in Table 1 and/or Figure 1.

105.11 If a source has an effective stack height less than the standard effective stack height as determined from Table 2 and/or Figure 2, the allowable emission level must be reduced by multiplying it by

$$\left(\frac{\text{Effective Stack Height}}{\text{Standard Effective Stack Height}}\right)$$

105.12 Effective stack height shall be calculated by the following equation:

$$he = h + 0.083 v_e D_e \left[1.5 + 082 \left(\frac{T_e - 550}{Te}\right) D_e\right]$$

Where:

he = Effective stack height in feet (ft)

h = Physical stack height above ground level in feet (ft)

v_e = Stack exit velocity in feet per section (ft/sec)

D_e = Stack exit inside diameter in feet (ft)

T_e = Stack exit temperature in degrees Rankin ($^{\circ}R$)

105.2 No person may cause, suffer, allow or permit emissions of particulate matter from a source or sources operated on a property or from multiple sources operated on contiguous properties to exceed any of the following net ground level concentrations.

105.21 One hundred (100) micrograms per cubic meter ($\mu g/m^3$) of air sample, averaged over any five (5) consecutive hours.

105.22 Two hundred (200) micrograms per cubic meter ($\mu g/m^3$) of air sampled, averaged over any three (3) consecutive hours.

105.23 Four hundred (400) micrograms per cubic meter ($\mu g/m^3$) of air sampled, averaged over any one (1) hour period.

105.3 Rules 105.1 and 105.2 shall not apply to solid fossil fuel fired steam generators.

105.31 No person may cause, suffer, allow, or permit emissions of particulate matter from any solid fossil fuel fired steam generator to exceed 0.3 lb. per million B.T.U. heat input.

Rule 106. Transient Operations.

106.1 Rules 103 and 105 shall not apply to portable hot-mix asphaltic concrete plants, portable rock-crusher, and other transient operations engaged in public works projects which are not operated at the same premise for more than six months if all the following conditions are met:

106.11 The plant is located at least one mile outside the nearest corporate limits of any city or town.

106.12 The plant is located at least one mile from any occupied facility or recreational area other than that located on the same property as the plant.

106.13 The plant is equipped with cyclones, or wet scrubbers, or water sprays at the material transfer points open to the atmosphere, or other equipment or systems approved by the Executive Secretary, properly installed, in good working order and in operation.

106.2 The time requirement for Rule 106.1 may be extended by the Executive Secretary upon written request.

106.3 All emissions from sources operating under provisions of Rule 106 shall be controlled so as not to permit or create a nuisance.

106.4 Rule 106 shall not apply in Dallas or Harris Counties.

106.5 Rule 106 shall not apply to portable hot-mix asphaltic concrete plants after December 31, 1974.

Rule 107. Agricultural Process.

107.1 Rules 103, 104, 105 and 108 shall not apply to any person affected by Section 3.10 (3) of the Texas Clean Air Act.

107.2 No person affected by Section 3.10 (3) of the Texas Clean Air Act may cause, suffer, allow, or permit emissions of particulate matter from any or all sources associated with a specific process to exceed the allowable levels specified in Table 3 and/or Figure 3, except as provided by Rule 107.3.

107.3 Any person affected by Section 3.10 (3) of the Texas Clean Air Act who does not wish to be controlled by the process weight method, established by Rule 107.2, may select an alternate method of control which the Executive Secretary finds will provide emission control efficiency and measurement to achieve the same goals as Rule 107.2.

107.4 Any person affected by Section 3.10 (e) of the Texas Clean Air Act who does not select an alternate method and notify the Executive Secretary, in writing, prior to any plant investigation by the staff of the Texas Air Control Board, shall be controlled by the process weight method established by Rule 107.2, unless the Executive Secretary, at his discretion, chooses to accept proposals for an alternate method at that time.

107.5 Nothing herein is intended to affect the limitations on burning set out in Rule 101.

107.6 Persons affected by Rule 107 shall be in compliance with the provisions set forth herein by February 15, 1973.

Rule 108. Persons affected by this Regulation shall be in compliance with the provisions contained herein no later than December 31, 1973. Not later than six months after the effective date of this Regulation, any person affected by his Regulation shall submit to the Texas Air Control Board a written report on his compliance status, including but not limited to, the minimum time required to design, procure, install and test abatement equipment or procedures. Progress reports shall be submitted to the Board every four months commencing in July of 1972 until compliance is achieved.

All persons shall continue to be governed by the provisions of Regulation I, which became effective on March 16, 1967, and amended on January 23, 1968, September 12, 1969, and May 18, 1971, and Regulation II, which became effective February 22, 1968, and amended on September 12, 1969, until December 31, 1973, at which time this Regulation shall supersede the previous Regulation I and II.

Date Adopted: January 26, 1972

Date Filed with Secretary of State: February 4, 1972

Date Effective: March 5, 1972

TABLE 1

ALLOWABLE PARTICULATE EMISSION RATES

FOR SPECIFIC FLOW RATES

Effluent Flow Rate acfm	Rate of Emission lb/hr
1,000	3.5
2,000	5.3
4,000	8.2
6,000	10.6
8,000	12.6
10,000	14.5
20,000	22.3
40,000	34.2
60,000	44.0
80,000	52.6
100,000	60.4
200,000	92.9
400,000	143.0
600,000	184.0
800,000	219.4
1,000,000	252.0

Interpolation and extrapolation of the data in this table shall be accomplished by the use of the equation $E=0.048\ q^{0.62}$ where E is the allowable emission rate in lb/hr and q is the stack effluent flow rate in acfm.

FIGURE 1

ALLOWABLE PARTICULATE EMISSION RATES

FOR SPECIFIC FLOW RATES

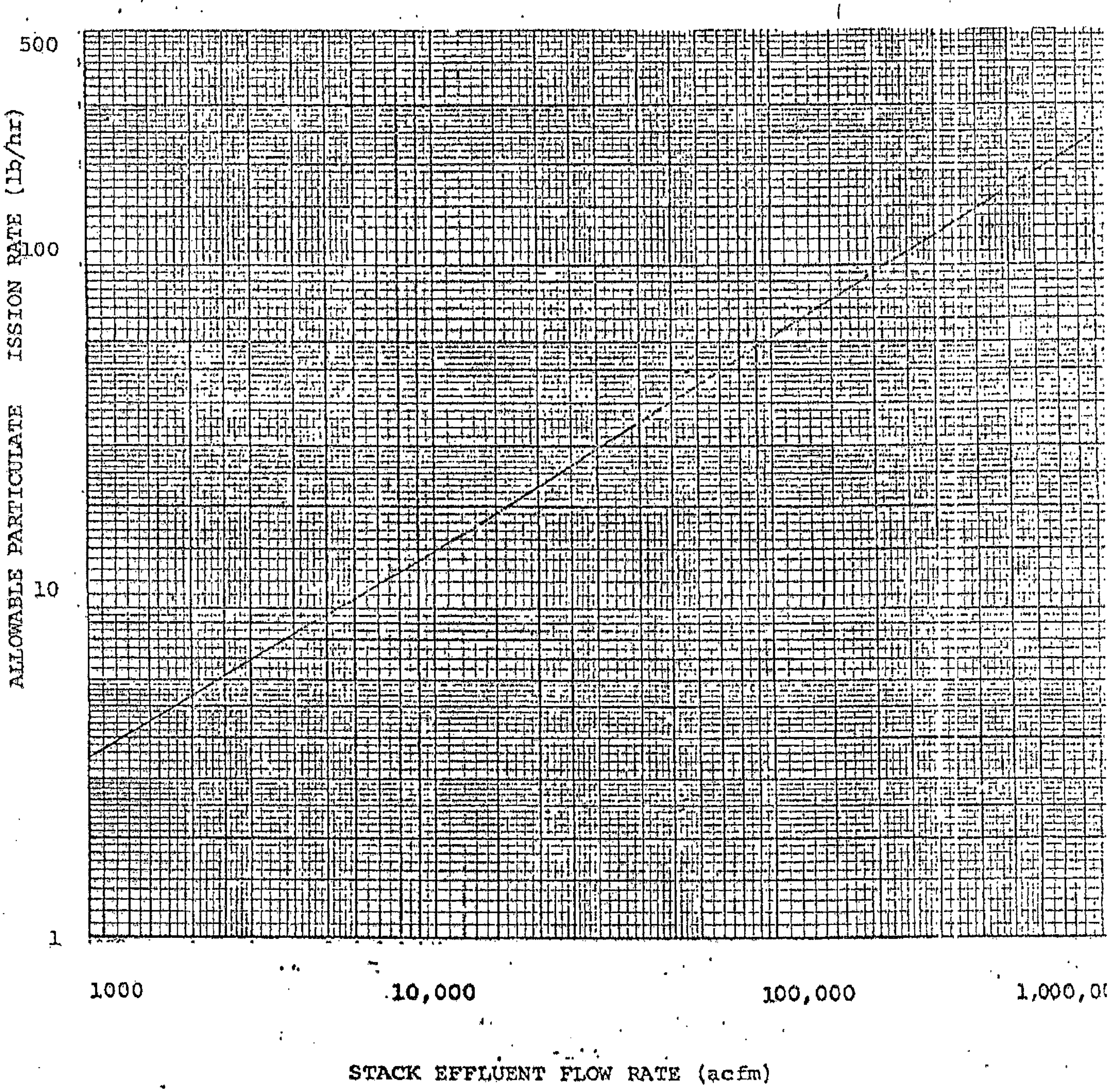

TABLE 2

STANDARD EFFECTIVE STACK HEIGHT
BASED ON SPECIFIED FLOW RATES

Effluent Flow Rate acfm	Standard Effective Stack Height ft
1,000	12
2,000	15
4,000	19
6,000	22
8,000	24
10,000	26
20,000	34
40,000	43
60,000	49
80,000	55
100,000	59
200,000	75
400,000	96
600,000	110
800,000	122
1,000,000	132

Interpolation and extrapolation of the data in this Table shall be accomplished by the use of the equation $H_e = 1.05\, q^{0.35}$ where H_e is the standard effective stack height in feet and q is the stack effluent flow rate in acfm.

FIGURE 2

STANDARD EFFECTIVE STACK HEIGHT

BASED ON SPECIFIC FLOW RATES

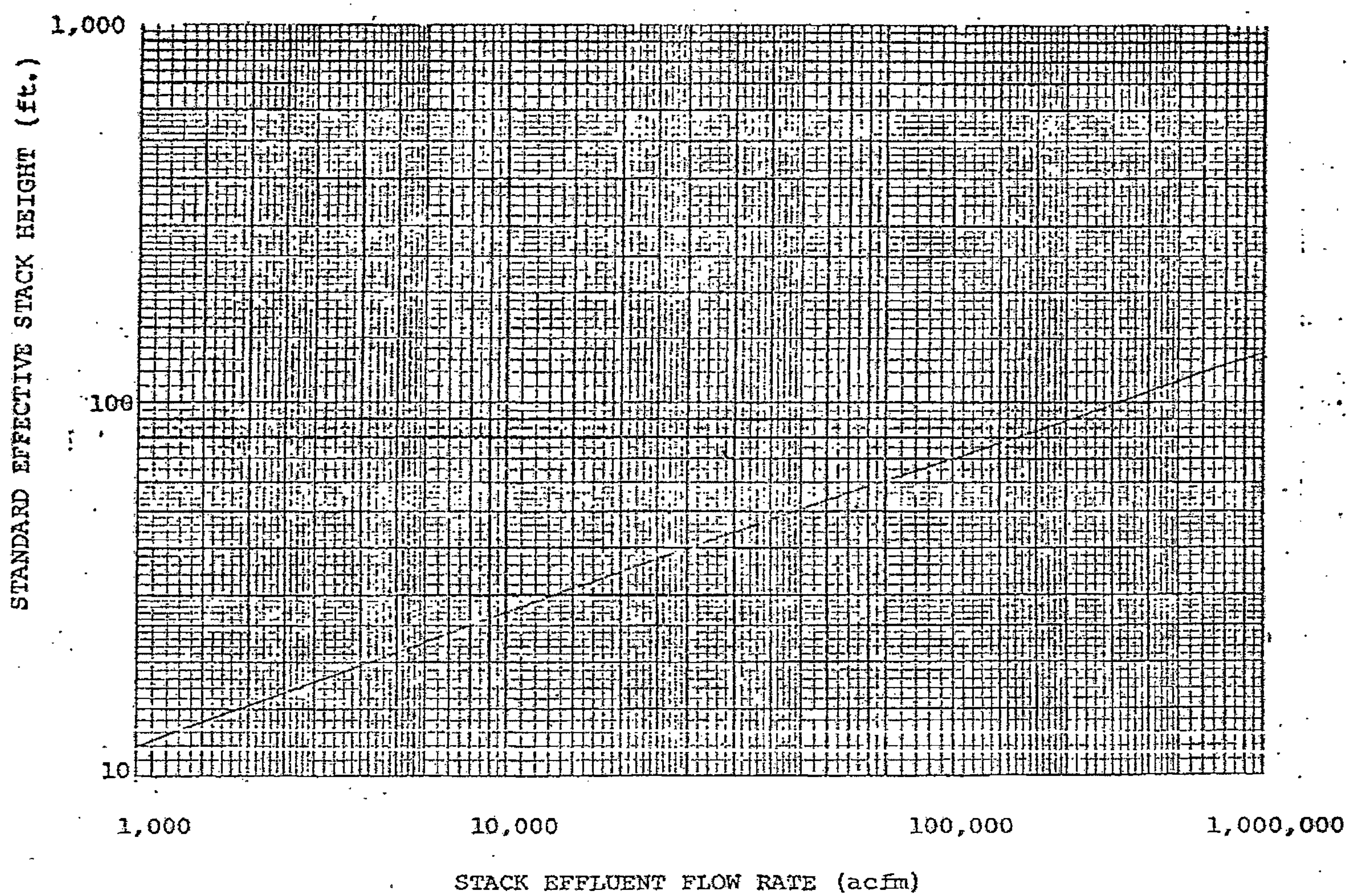

TABLE 3

ALLOWABLE RATE OF EMISSION BASED ON PROCESS WEIGHT RATE

PROCESS WEIGHT RATE lb/hr	RATE OF EMISSION lb/hr	PROCESS WEIGHT RATE lb/hr	RATE OF EMISSION lb/hr
1,000	1.6	16,000	24.2
1,500	2.4	18,000	27.2
2,000	3.1	20,000	30.1
2,500	3.9	30,000	44.9
3,000	4.7	40,000	59.7
3,500	5.4	50,000	64.0
4,000	6.2	60,000	67.4
5,000	7.7	70,000	70.5
6,000	9.2	80,000	73.2
7,000	10.7	90,000	75.7
8,000	12.2	100,000	78.1
9,000	13.7	150,000	87.7
10,000	15.2	200,000	95.2
12,000	18.2	250,000	101.5
14,000	21.2	500,000	123.9

* Interpolation of the data in this table for process weights up to 40,000 lb/hr shall be accomplished by the use of the equation $E = 3.12 (p^{0.985})$, and interpolation and extrapolation of the data for process weight rates in excess of 40,000 lb/hr shall be accomplished by use of the equation $E = 25.4(p^{0.287})$ where E = rate of emission in pounds per hour and p = process weight rate in tons per hour.

FIGURE 3

ALLOWABLE PARTICULATE EMISSION LEVELS BASED ON PROCESS WEIGHT RATE