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IV B 046 A-91-61

Date: May 20, 1996

Subject: PM, CO, and CDD/CDF Average Emission Rates and Achievable Emission Levels for MWI's with Combustion Controls
EPA Contract No. 68-D1-0115, ESD Project 89/02
MRI Project No. 6503-87

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I. Introduction

This memorandum documents the emission testing program and the data analysis used to develop average emission rates and emission levels for combustion-related pollutants under varying levels of combustion control.

As described in detail in the Control Technology Performance Report, PM, CO, and CDD/CDF are the three pollutants that are most likely to be effected by combustion control.[1] These pollutants were used as the basis for evaluating the effectiveness of varying levels of combustion control. In the following sections a brief description of combustion controls will be presented, the EPA test program will be discussed, and the average emission rates for batch and nonbatch MWI's will be presented. Achievable emission levels for each level of combustion control will also be presented.

II. Description of Combustion Controls

Combustion controls are defined as any design features or operating practices that are used by MWI manufacturers and operators to reduce or limit the quantities of pollutants and to maximize the burnout of organic material in the waste.

Each MWI manufacturer has developed a package of features in its design that is aimed at controlling air emissions and ash quality. The mixture of controls varies among manufacturers, making each combustion system unique in its approach to combustion control. While each system is unique and a wide variety of specific practices are used, all of the systems comprise some combination of three general approaches: (1) controlling the rate of primary chamber chemical reactions, thereby controlling the release rate of volatile organics and the degree of ash burnout; (2) controlling waste bed turbulence, thereby limiting entrainment of particles from the waste bed; and (3) controlling secondary chamber combustion conditions, thereby promoting the complete combustion of volatile organic material.

Combustion control within an MWI is usually based on maintaining temperatures in both chambers within specified limits by controlling the combustion air rate to each chamber, the waste feed rate, and the auxiliary fuel burner operation. Limiting combustion air in the primary chamber to below stoichiometric conditions prevents rapid combustion, decreases the temperature, and allows a quiescent condition within the primary chamber that minimizes entrainment of PM. In the secondary chamber, however, high temperatures must be maintained in a turbulent condition with excess air (i.e., greater that stoichiometric levels) to ensure complete combustion of organics in the gases emitted from the primary chamber.

While each phase of the combustion control process is very important in achieving the desired conditions, secondary chamber residence time is probably the single most important. Without sufficient time to complete the combustion of organics and combustible particulates in the secondary chamber, these pollutants are emitted to the atmosphere. As regulatory concerns have become widespread, MWI manufacturers have focused on secondary chamber residence time as a key component of the redesigns of their MWI's. During the data gathering phase of the MWI project, most MWI's were found to fall into one of three groups depending on the age of the unit. The newest MWI's had secondary chambers sized to provide approximately 2 seconds of gas residence time. The MWI's that were more than about 2 or 3 years old were designed with 1 second residence time. The MWI's that were more than about 10 years old were designed with about 0.25 seconds residence time. To determine the impact on emissions reductions that could be achieved by these design changes, the EPA test program was developed with a goal of testing at least one MWI from each of the three residence time groups.

III. MWI Test Program

Table 1 presents a list of the MWI's that were tested during the EPA's MWI test program. One additional facility for which data were available (Cumberland Memorial Hospital[2]) is also included in Table 1 and in the data analysis. The goal of the test program was to fill as many gaps as possible on a matrix that was developed using MWI type, MWI design, MWI size, and APCD type. The following sections describe how the data from the test program were used to develop performance capabilities for combustion controls.

A. Averaging Time

During each of the tests conducted at the seven MWI facilities in the EPA test program, emissions were measured over three, 4-hour periods. However, additional test data has been collected to enhance the MWI test report data base. This additional data was collected using three 1-hour sampling times.

Because numerical emission levels only have meaning when coupled with an averaging time, emission data must be expressed on a common basis. Therefore, the average emission rates and emission levels have been set based on one 4-hour test run for the EPA-sponsored test data and the average of three 1-hour test runs for the additional data collected.

B. MWI Type

Continuous, intermittent, and batch MWI's are three different MWI types, differing in physical design characteristics, operating characteristics, and overall emission profiles. However, for continuous and intermittent units, there is a period in the combustion cycle when the emission profiles are similar. In continuous and intermittent units this period occurs during waste-charging. Combustion control data from these types of MWI's were combined into a nonbatch MWI data set.

The emission profiles for PM and CDD/CDF from a batch MWI vary significantly from those for continuous and intermittent units as demonstrated by the data from the EPA test program. Combustion control performance for batch MWI's, therefore, is based only on the data from Facility J and the Cumberland Memorial Hospital.[2] The operating cycle of a batch MWI is comprised of three distinct phases. During the first phase, the low-air or "burn" phase, the MWI slowly comes up to the normal operating conditions. During the high-air or "burndown" phase, combustion air flow to the primary chamber is increased and combustion of the waste progresses more rapidly. It is during this burndown phase that operating temperatures peak and most of the actual destruction of waste occurs. Because of the difference in operating conditions between these two phases, tests were conducted during each phase. The achievable emission levels were developed from data obtained during the burndown phase because that is when most of the combustion of waste occurs. For the typical performance levels, data from both phases were used because this more closely represents the entire operating cycle.

C. MWI Design

The scope of the EPA test program was designed to obtain data covering a broad range of MWI's, APCD's, and operating parameters. As a result, not all of the test sites were considered to be appropriate for characterizing emissions for every pollutant. The following paragraphs identify those test sites/test runs from which data were not used in determining emission rates from combustion control.

Facility B was selected for testing because it was part of a co-funded program being performed by a State. It is a large continuous MWI with a venturi scrubber/packed bed APCD. Data on the performance of the APCD and on the emission rates of waste-related pollutants is believed to be useful in our data analysis. However, the design of the MWI is unique to one manufacturer and is not believed to be representative of other MWI's relative to combustion controls. The primary chamber on this unit is suspended from a surrounding frame by cables and is jarred or "pulsed" at regular intervals to move the ash bed toward the discharge end. The movement of the primary chamber is believed to cause disruptions in the air flow through the system and the increased agitation within the ash bed is believed to result in higher PM entrainment. Because this unit is considered by the project team to be atypical of most MWI's, the combustion control performance determinations did not include data from this facility.

Facility M is a large rotary-kiln type MWI. As with Facility B, it is not a typical design in the MWI industry. Facility M was tested largely because the APCD at this unit is a spray-dryer/FF. Because of the increased PM entrainment characteristic of a rotary hearth, PM data from Facility M like that from the moving hearth MWI at Facility B was not included in the data analysis.

During the parametric testing conducted at Facilities K and W, tests were conducted to examine the effects of overcharging waste to the MWI. Test runs K3 and W3, therefore, were not included in the determination of achievable emission levels. They were, however, used in calculating the average value for the typical performance.

Test runs S1 and S2 were not included in the analysis of combustion control because they were conducted while the MWI was burning only pathological waste. Test run S3, performed while burning mixed medical waste, is included.

D. Data Variability

In establishing typical performance for combustion control, all data except that described above was used. The numerical averages of the data gathered for each combustion control condition were used to represent typical emission levels for the given condition.

In establishing the achievable emission levels for all pollutants, the amount of data available and variation in that data were taken into consideration. The emission levels were set as 1.1 times the highest value in a given set of data (i.e., 10 percent higher) rounded up to the nearest appropriate round number.

IV. Emission Rates and Achievable Emission Levels

Table 2 presents the typical measured emission rates (performance) and the achievable emission levels for PM, CDD/CDF, and CO for each of the three combustion control levels when applied to continuous and intermittent (nonbatch) MWI's. Figures 1-4 present each of the data points (graphically) that were used to calculate the emission levels presented in Table 2.

In the initial analysis of the CDD/CDF data from batch MWI's there appeared to be a significant difference in the emission levels between batch and nonbatch MWI's. The data from Facility J showed wide variations in the burndown test runs (see Figure 5). While there were no apparent difference in operation between run J-2-6 and the other test runs, runs J-2-2 and J-2-4 seem to indicate that combustion control on batch units can be as effective as combustion control on nonbatch units. The vendor who installed the Facility J expressed concerns that the unit was not allowed to "cure" before testing was done and that this may have contributed to the high CDD/CDF levels.[3] In light of these concerns EPA tested an additional batch MWI (Weeks Hospital[4]) to determine if there is a significant difference in CDD/CDF emission levels between batch and nonbatch MWI's. The results of the CDD/CDF testing produced significantly lower emissions (8 to 16 ng/dscm). Therefore, because of the concerns expressed by the vendor and the new test data the project team concluded that the average CDD/CDF emission rates and achievable emission levels of batch units are the same as nonbatch levels (presented in Table 2).

The PM emission levels from the batch MWI's were significantly lower than those from nonbatch units (see Figure 6). This can be explained by the waste charging differences between batch and nonbatch MWI's. Nonbatch MWI's are loaded periodically, resulting in agitation of the waste bed and increased entrainment of PM. However, in a batch MWI all of the waste to be burned during a complete cycle is loaded into the primary chamber before the unit begins operation. Once the unit is filled with waste and the burning cycle begins, the charging door is not opened again until the cycle is complete and the unit is cool. This difference in waste charging is believed to result in significantly lower PM emission levels. Data from the Cumberland Memorial Hospital and Weeks Hospital tests confirms the difference in PM emission levels. For batch units the only test data came from MWI's that have the 2-sec combustion control level. The performance levels and achievable emission levels for 1-sec combustion were calculated using the ratios observed in nonbatch units. The nonbatch ratios were applied to the 2-sec batch data to predict the 1-sec emission levels. Table 3 presents the performance and achievable PM emission levels for combustion controls on batch MWI's.

In the analysis of the data there was no significant difference between the batch and nonbatch data for CO. Therefore, the average emission rates and achievable emission levels for batch MWI's are the same as nonbatch MWI's (presented in Table 2).

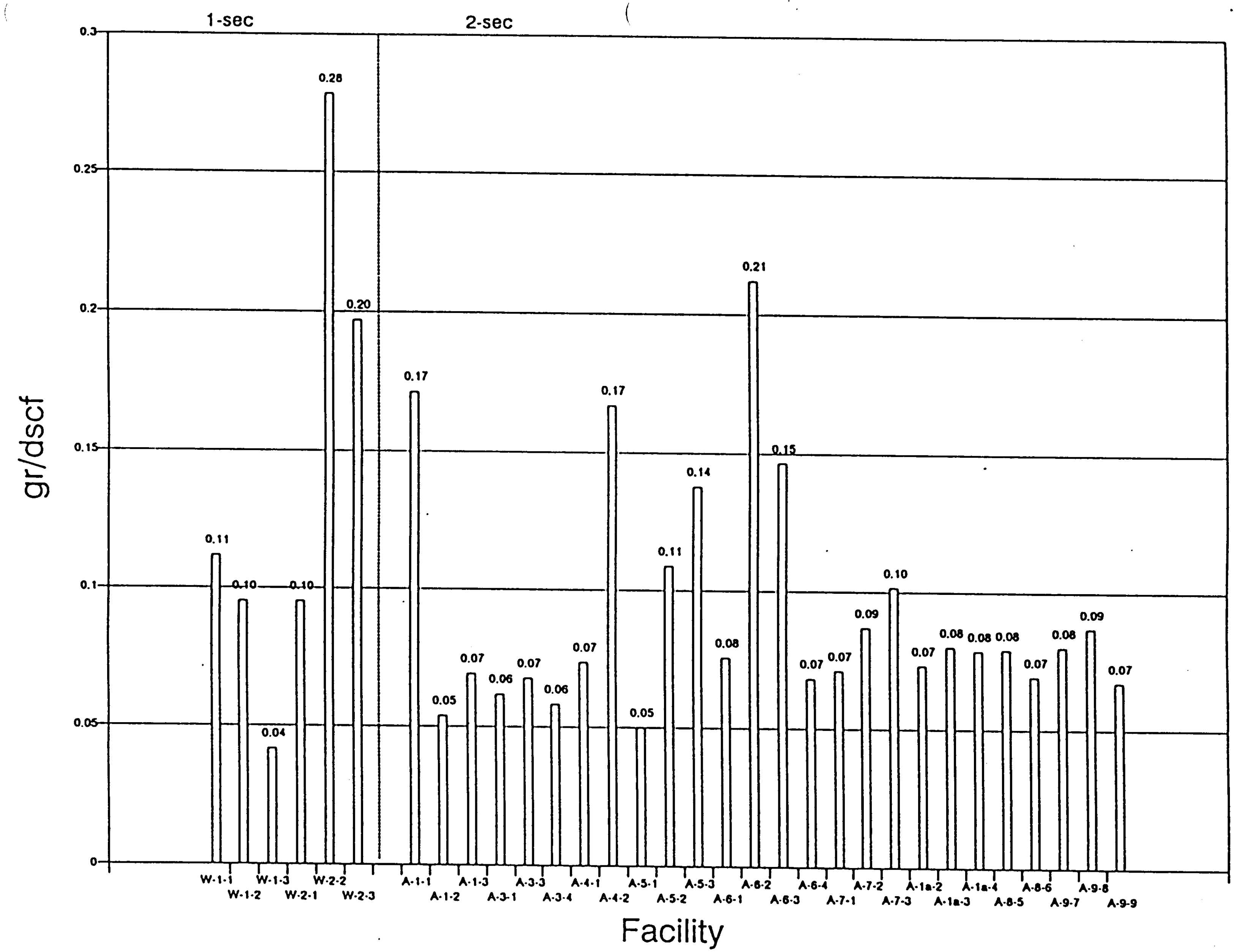

Figure 1. PM emissions for setting emission limits for good combustion systems (corrected to 7% O_2).

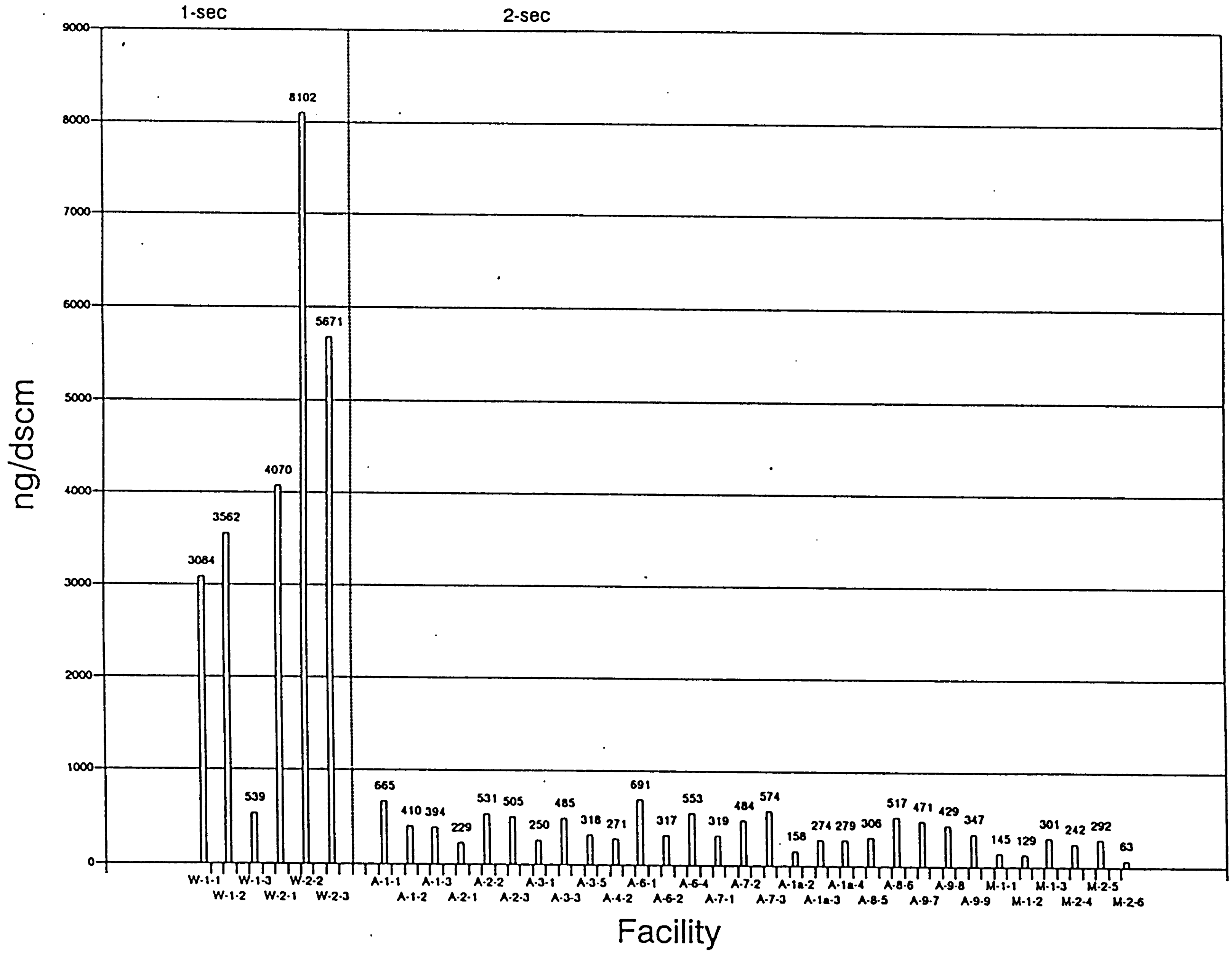

Figure 2. CDD/CDF emissions for setting emission limits for good combustion systems (corrected to 7% O_2).

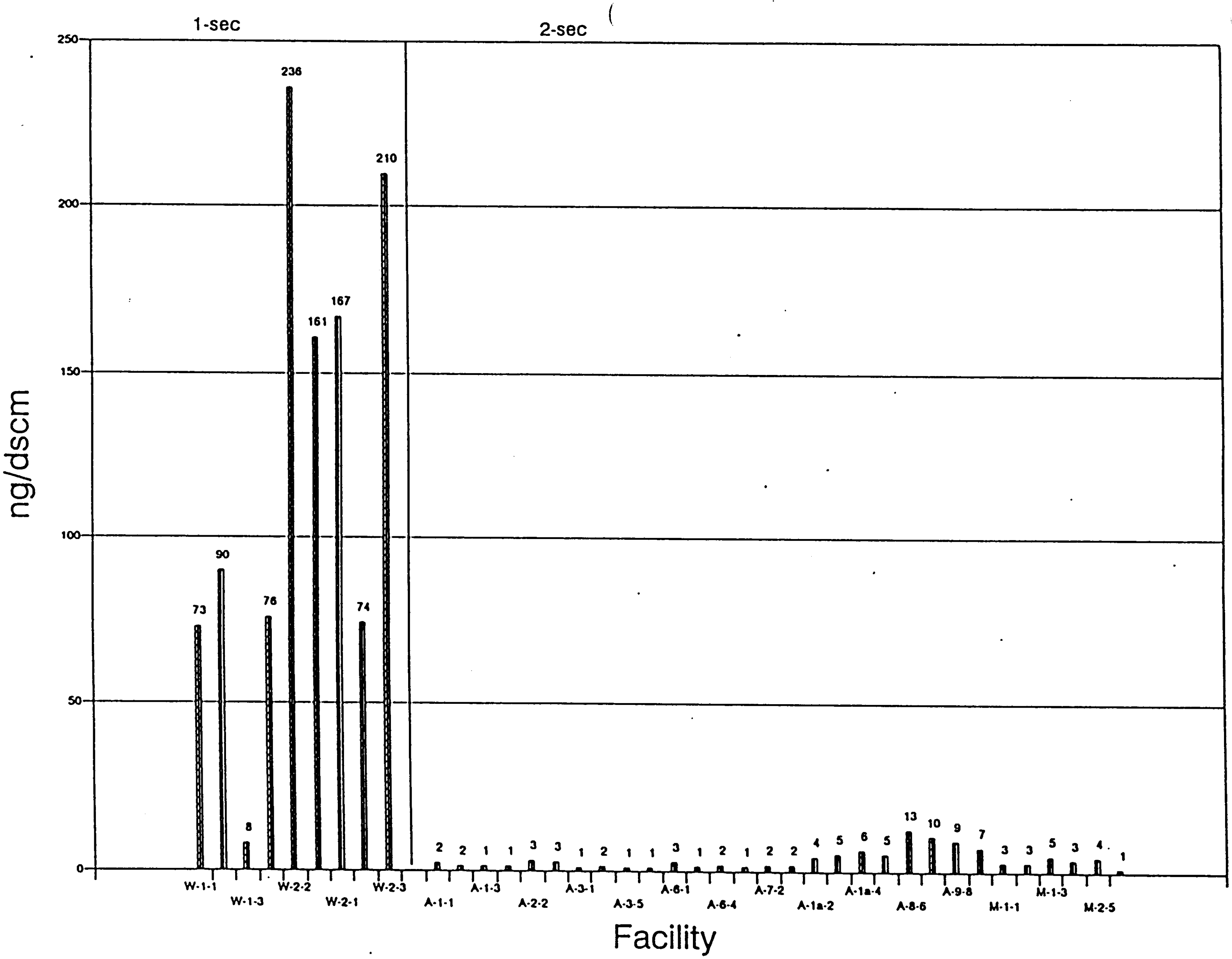

Figure 3. TEQ CDD/CDF emissions for setting emission limits for good combustion systems (corrected to 7% O_2).

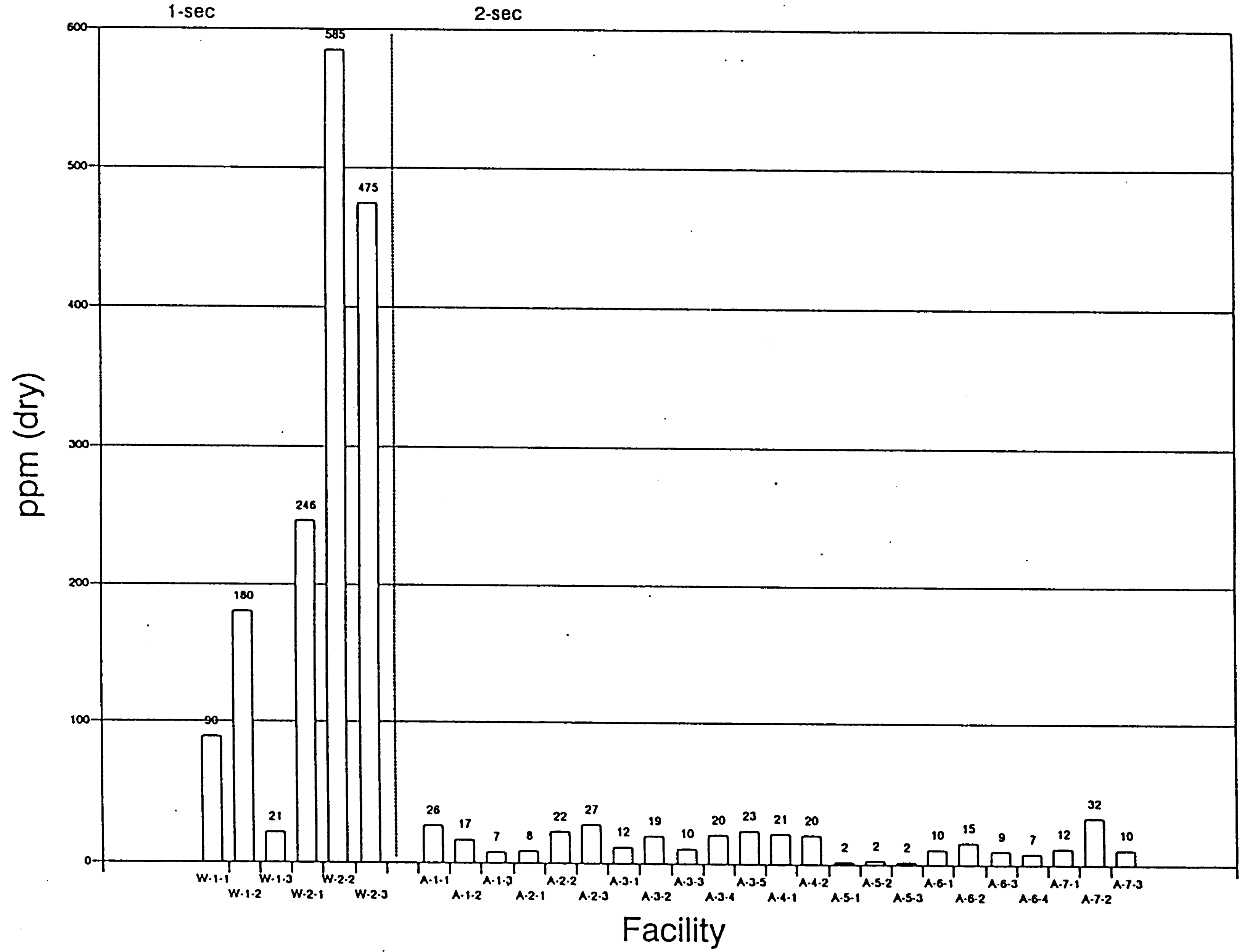

Figure 4. CO emissions for setting emission limits for good combustion systems (corrected to 7% O_2).

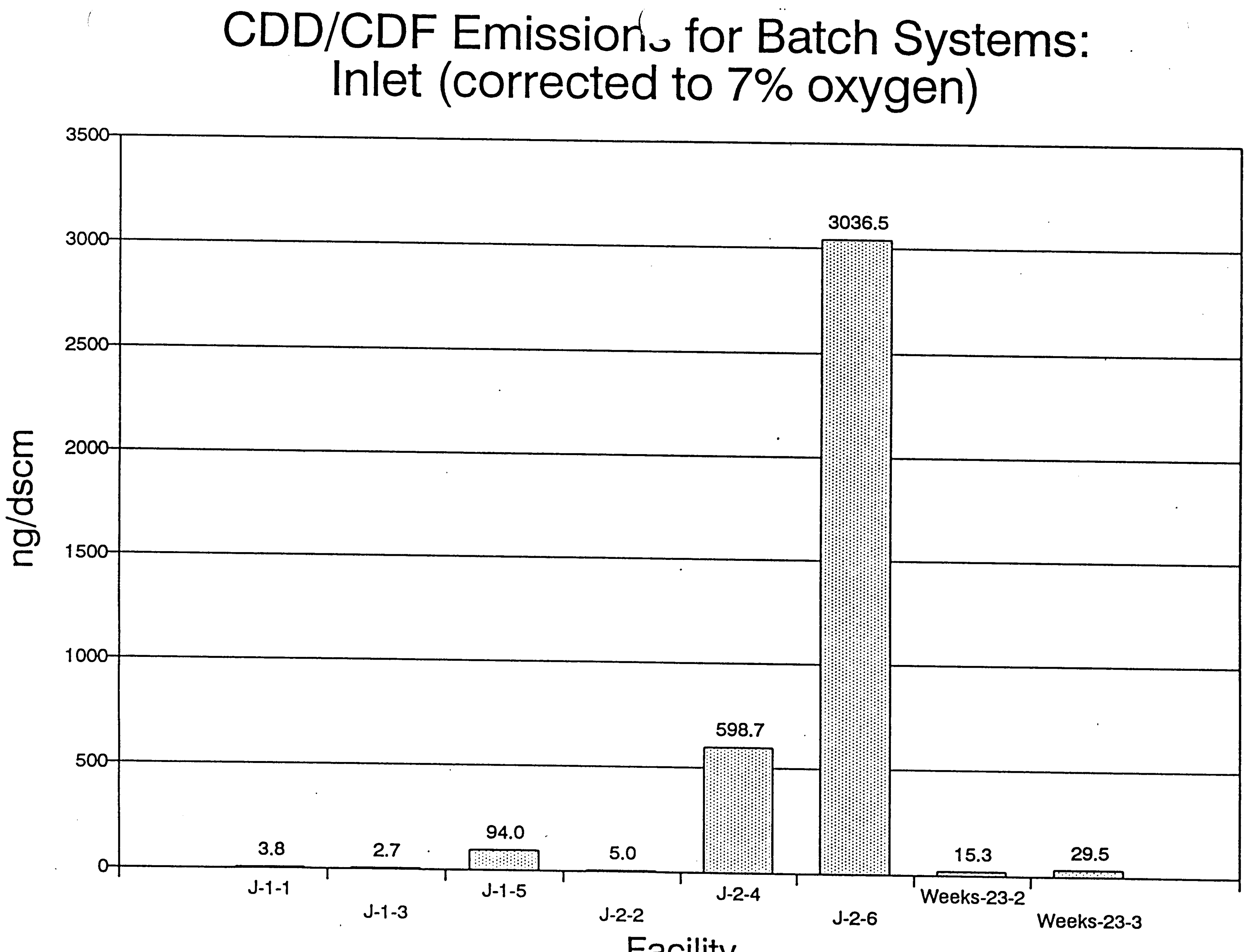

Figure 5. CDD/CDF emissions from batch systems (corrected to 7% O_2).

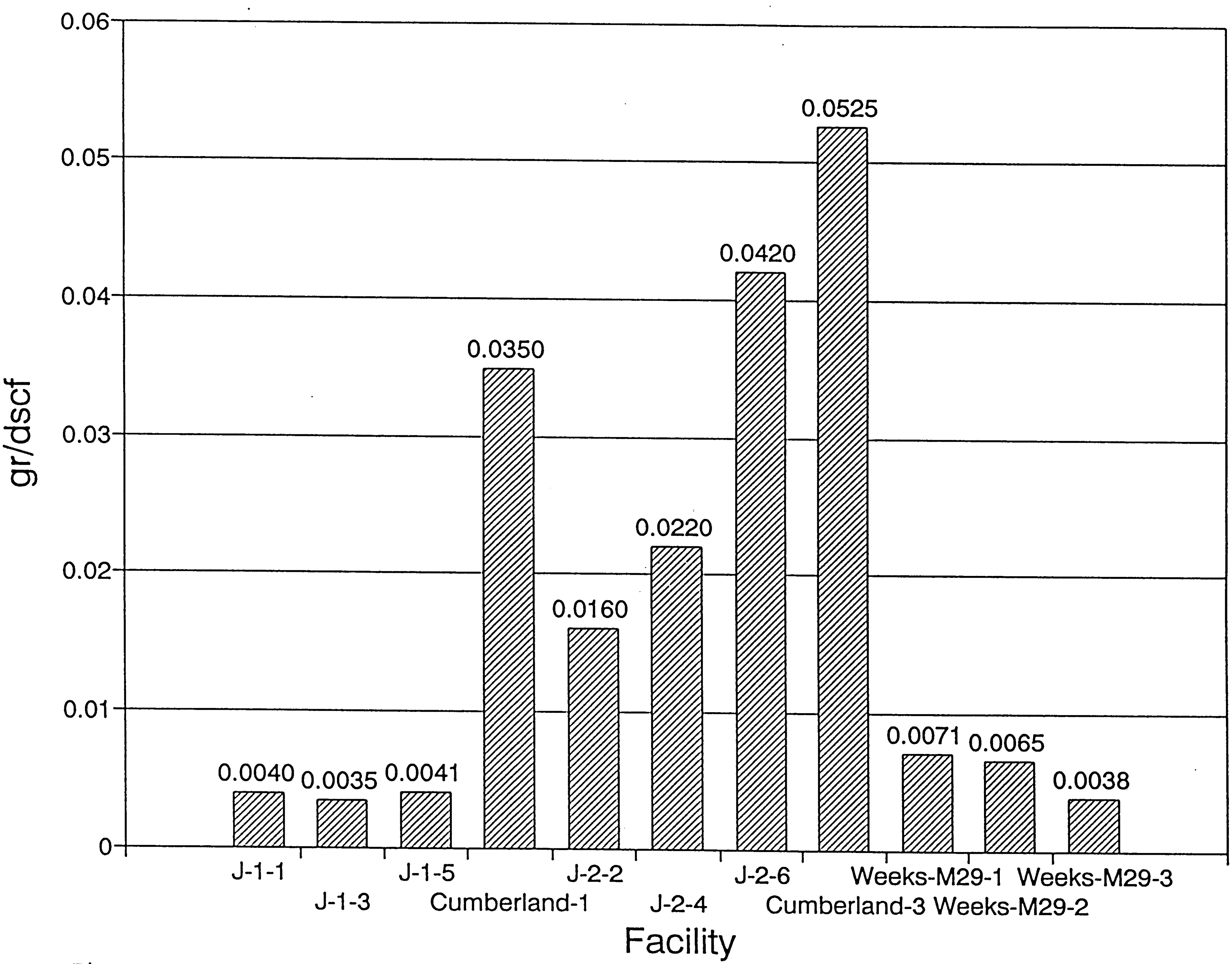

Figure 6. PM emissions for setting emission limits for batch systems (corrected to 7% O_2).

TABLE 1. TESTED MWI FACILITIES

Facility	Description
A	650 lb/hr, intermittent, ram-fed; 2-sec residence time in secondary chamber; dry injection/fabric filter (DI/FF) system tested with and without activated carbon injection
B	1,500 lb/hr, continuous, ram-fed; 2-sec residence time in secondary chamber; venturi scrubber/packed bed (VS/PB) system
J	750 lb/batch, batch, manually fed; 1.75-sec residence time in secondary chamber; fabric filter/packed bed (FF/PB) system
K	300 lb/hr, intermittent, manually fed; 0.33-sec residence time in secondary chamber
M	800 lb/hr, continuous, ram-fed; rotary-kiln; 2-sec residence time in secondary chamber; spray dryer/fabric filter (SD/FF) system tested with and without activated carbon injection
S	250 lb/hr, intermittent, manually fed; 0.2-sec residence time in secondary chamber; conditions 1 and 2 = pathological waste, condition 3 = mixed medical waste
W	300 lb/hr, intermittent, ram-fed; 1-sec residence time in secondary chamber
Cumberland Memorial Hospital	600 lb/batch, batch, manually fed; 2-sec residence time in secondary chamber
Weeks Memorial Hospital	560 lb/batch, batch, manually fed; 2-sec residence time in secondary chamber

TABLE 2. ACHIEVABLE EMISSION LEVELS AND TYPICAL PERFORMANCE FOR CONTINUOUS AND INTERMITTENT MWI'S

Control option	Achievable emission levels (rounded)	Typical performance
PM emissions (gr/dscf)		
Combustion:		
0.25-sec		0.30
1-sec	(0.35)	0.16
2-sec	(0.25)	0.10
CDD/CDF emissions (ng/dscm)		
Combustion:		
0.25-sec		19,425
1-sec	(9,000)	4,458
2-sec	(800)	365
TEQ CDD/CDF emissions (ng/dscm)		
Combustion:		
0.25-sec		644.6
1-sec	(275)	121.5
2-sec	(15)	3.6
CO emission limits (ppm)		
Combustion:		
0.25-sec		696.8
1-sec	(700)	297.2
2-sec	(40)	13.04

TABLE 3. EMISSION LEVELS AND TYPICAL PERFORMANCE FOR BATCH MWI'S

Control option	Achievable emission levels (rounded)	Typical performance
PM emissions, gr/dscf		
Combustion:		
0.25-sec	NA	
burn		0.035
burndown/cooldown		0.0994
1-sec	(0.08)	
burn		0.0186
burndown/cooldown		0.053
2-sec	(0.06)	
burn		0.01165
burndown/cooldown		0.03313

V. References

1. Medical Waste Incinerators - Background Information for Proposed Standards and Guidelines: Control Technology Performance Report for New and Existing Facilities. U. S. Environmental Protection Agency. Research Triangle Park, North Carolina. Publication No. EPA-453/R-94-044a. July 1994. 191 pp.

2. Source Emissions Test at Cumberland Memorial Hospital Cumberland, Maryland. Medical Waste Incinerator Stack Test Report. Prepared by Technical Services for Pollution Control. October 8, 1992.

3. J. Presley, Simonds Manufacturing corporation, to R. Copland, U. S. Environmental Protection Agency. May 31, 1996. Comments on EPA testing at Jordan Hospital, Plymouth, Massachusetts.

4. Medical Waste Incinerator Draft Emission Test Report, Weeks Memorial Hospital, Lancaster, New Hampshire. Pacific Environmental Services, Inc. Prepared for the U. S. Environmental Protection Agency, Research Triangle Park, North Carolina. May 1996.