Application Data for Dry-Scrubbing Media in Collection Systems

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ABSTRACT

Dry-scrubbing systems have been used for many years to control odors in wastewater applications. The systems have ranged in size from larger multiple bed scrubbers for force mains and large pump station applications to smaller single bed systems and modular systems in small wet wells, motor control centers, and other areas. Two reasons for their continued use are simplicity of design, operation, and maintenance as well as the ability to remove a wide range of odorous gases

Equipment used for dry-scrubbing is inherently simple in ideology, design, and maintenance. The main purpose is to allow the dry-scrubbing media to contact the contaminant laden air stream. Various dry-scrubber systems and configurations may be applied, all of which can include a number of multi-purpose gas-phase air filtration medias. Methods of applying these systems will be included here.

Collection systems vary in the amount of odorous gases emitted depending on geographical location, time of year, population, and other factors. Data showing some of these differences have been collected and will be presented here to show what concentrations of H2S may be encountered. Two very important factors to consider here are both average concentration of the system and maximum concentrations.

Dry-scrubbing systems have been specified for many years. Some standard practices are to require Challenge Testing of the dry-scrubbing systems after installation. These are generally based on average concentrations in the collection system area and must show a certain removal efficiency of the contaminant. Such testing will be presented to show the efficiencies of these systems for the odorous gas.

INTRODUCTION

Dry-scrubbing systems have been used for many years to control odors in wastewater applications. The systems have ranged in size from larger multiple bed scrubbers for force mains and large pump station applications to smaller single bed systems and modular systems in small wet wells and other areas. Two reasons for their continued use are simplicity (of design, operation, and maintenance) and ability to remove a wide range of odorous gases (1, 2).

There are a variety of dry-scrubbing systems used in wastewater collection systems. Some are put in use in applications producing relatively low contaminant concentrations. Some are in use at sites with very high contaminant concentrations. Geographic location of these systems also effects the contaminant production rate and system requirements depending on temperature, elevation, and population. If the geography is relatively flat, there is more of a need to pump the wastewater and thus more contaminants are produced. If the climate is typically colder, then there is less volatilization of the contaminants in the waste stream. These factors lend themselves to a diverse application field.

In this light, there have been questions as to what to specify a dry-scrubber by and how to verify performance of such systems. Many times the basis for the design is a nonexistent facility, for which the production of contaminants from different areas must be estimated. Other times there are existing collection systems for which monitoring can be performed. Data for production of contaminants from various geographies would be very helpful in such situations. Historical verification protocols and testing is also needed for specifying performance.

METHODS OF APPLYING DRY-SCRUBBING MEDIA

Some knowledge of dry-scrubbing systems is needed to understand the influence application factors have on the system design. The higher the concentration and higher the flowrate, the larger the required system. The opposite of this is also true, the lower the concentration and flowrate the smaller the required system. Thus, the design can be somewhat intuitive in this respect.

Many times multiple media are used in a system to adsorb and chemisorb the different contaminants present. If only hydrogen sulfide is expected to be present, then a media fairly specific for that may be used. If ammonia is a problem contaminant, then a media targeting ammonia and ammines may be used. Typically, a mixture of hydrogen sulfide, organic sulfides, and others are expected to be present so multiple media can be used to target the hydrogen sulfide with the first media and then have a media that would react with a wide range of contaminants second. This approach does not account for ammonia, which would need to be targeted as a main contaminant if it is a problem. Table 1 gives a brief description of several different types of media and the contaminants that they would target.

TABLE 1 – ENGINEERED MEDIAS

Principle Target Gases	Media Composition
Hydrogen sulfide (H_2S), chlorine (Cl_2), sulfur dioxide (SO_2), acid gases	Activated alumina, activated carbon, potassium hydroxide (KOH)
H_2S, SO_2, nitric oxide (NO), low molecular weight organics	Activated alumina, potassium permanganate ($KMnO_4$)
Ammonia (NH_3), amines	Activated carbon, phosphoric acid (H_3PO_4)
Chlorine	Activated alumina, activated carbon, sodium thiosulfate ($Na_2S_2O_3$)

Multiple systems have been designed in the following manner. A certain concentration of hydrogen sulfide is targeted for a certain time period and then an additional amount of media is added to polish the remaining contaminants. Here is an example of life estimates for one system at different airflows. This will give the reader an idea of what varying factors can do to system design. The standard design for a non-occupied wet well is to pull a slight negative on the area and channel all contaminants through the system. This approach keeps odors from escaping, but maximizes the life of the system by pulling a minimum airflow.

TABLE 2 – SMALLEST SINGLE BED UNIT WITH 5 CUBIC FEET OF MEDIA (TARGETING H_2S + OTHERS)

Contaminant Design	Airflow (cfm)	H_2S Conc. (ppm)	Lifetime Estimate (months)
H_2S & others	20	5	>36
H_2S & others	20	20	17-18
H_2S & others	20	100	3-4
H_2S & others	100	5	14-15
H_2S & others	100	20	3-4
H_2S & others	100	100	<1

As can be seen, the airflow and contaminant concentration both can have a large effect on the type of system that would be chosen. For some concentrations shown above, such as the 100 cfm and 100 ppm case, a larger unit would be recommended to provide removal for more than one month. The data shown above is not intended to show the limit of dry-scrubbing systems, but allow the reader to understand how factors can affect the life and design of one system.

DATA ON HYDROGEN SULFIDE CONCENTRATIONS THROUGHOUT THE U.S.

Several sites have been sampled throughout the U.S. for concentration of H_2S evolving from them. Table 3 summarizes the time of the year, location, and concentrations that were detected. The full data can be seen in Appendix A – H_2S Concentration Data in a graphical format as a function of time. Even in what would typically be considered the colder months, Florida had a much higher production rate of hydrogen sulfide than any others. This can be expected since Florida is known for its warmer climate and flat terrain. Both of those factors can cause the amounts of contaminant production to increase.

This type of data can be very helpful in sizing systems for the appropriate challenge. The longer the monitoring period the better the design will be. Two of these locations (PA and KS) look to be in the range for which the small single bed system described above would be a very good solution. Even if the system works at 100 cfm, the average concentrations of 2 to 5 ppm should give a reasonable life of more than one year. The Indiana data contains a 9.4 ppm average with a 251 ppm maximum. This may be a low average and indicate that a longer monitoring period is needed. The Florida pump station would require a system design to pull a slight negative (using least amount of air) and have a large quantity of media compared the system described in the previous section.

Further data is being collected and will be presented in following papers to keep gathering an overview of contaminant levels in various parts of the U.S.

TABLE 3 – H2S CONCENTRATION DATA FOR SEVERAL COLLECTION SYSTEMS IN THE U.S.

Date	LOCATION	Collection System Placement	Max Conc. (ppm)	Min Conc. (ppm)	Avg Conc. (ppm)
2002.10.17-23	PA (New Castle)	Pump Station	10	0	2.0
2002.10.25-28	KS (Manhattan)	Manhole	12	0	4.6
2003.01.15-18	IN (Lawrenceberg)	Force Main	251	0	9.4
2003.02.17-19	FL (Navarre)	Pump Station	253	25	120

SYSTEM VERIFICATION DATA FOR DRY-SCRUBBING MEDIA

In order to verify system performance for end users, customers, etc., a number of tests have been performed in the past. The simplest one consists of challenging the odor control system with a specified concentration of hydrogen sulfide and monitoring the discharge concentration. This has been specified by a number of engineers. It allows the operating efficiency and the potential outlet concentration of the system to be viewed.

Two such challenge tests will be described here. One at the lower end of the concentration spectrum and one at the upper end of the concentration spectrum. Both tests were performed on deep bed dry-scrubbing media systems on the end user's site. The introduction of hydrogen sulfide gas was performed using a 22 lb cylinder of liquefied hydrogen sulfide gas and a one-stage regulator operating against a variable restrictor to allow a 20 to 40 psi back pressure. The gas was introduced upstream of the Odor Control System either in the ductwork piping or in the inlet fan section. The length of the tests were 2 hours for which the outlet concentration was monitored continuously and the inlet was monitored continuously and non-continuously (3, 4).

CHALLENGE TESTING AT 5 PPM (3)

The setup for this test was as is shown in Table 4 below. The criteria for the test was to show 99.5% efficiency over the length of the test when challenged with a 5 ppm inlet concentration of hydrogen sulfide. A diagram of such a system is shown in Figure 1 below. The system is filled with bulk media so that there was approximately 31 inches in the path of airflow. The residence time of the gases through the entire media bed was 2.04 seconds.

TABLE 4 - 5 PPM CHALLENGE TEST DETAILS

Challenge Conc. (H_2S):	5 ppm
System Airflow:	500 cfm
Total Volume of Media:	17 ft^3
Mass of H_2S Media:	585 lb
Mass of Polishing Media:	160 lb
Bed Depth:	31 in
Residence Time:	2.04 sec
Length of Test:	2 hrs

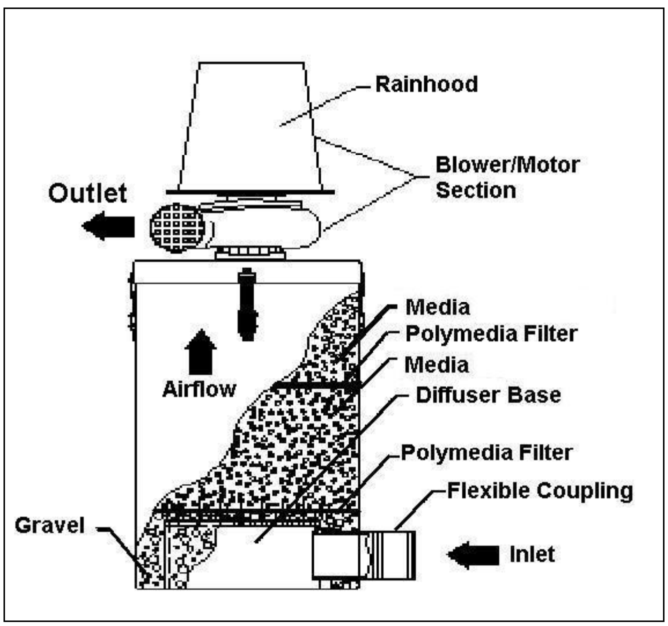

FIGURE 1 – DRY-SCRUBBING MEDIA SYSTEM HOLDING 17 FT^3 OF MEDIA WITH A FLOWRATE OF 500 CFM

The results of this testing are shown in Table 5. The test criteria of 99.5% efficiency was surpassed with an efficiency of greater than 99.98%. The average inlet concentration was 6.2 ppm and the outlet concentration was less than 1 ppb for the 2 hour duration.

TABLE 5 – RESULTS OF 5 PPM CHALLENGE TESTING

Criteria:	>99.5% efficiency
Avg H_2S inlet:	6.2 ppm
Avg H_2S discharge:	<1 ppb
Efficiency:	>99.98%

CHALLENGE TESTING AT 100 PPM (4)

The setup for this test was as is shown in Table 6 below. The criteria for the test was to show an outlet discharging less than 2 ppm over the length of the test when challenged with a 100 ppm inlet concentration of hydrogen sulfide. A diagram of such a system is shown in Figure 2 below. Typically the air is pulled through the media bed for odor control, instead of pushed through as shown here. The system is filled with bulk media so that there was approximately 36 inches in the path of airflow. The residence time of the gases through the entire media bed was 2.52 seconds.

TABLE 6 - 100 PPM CHALLENGE TEST DETAILS

Challenge Conc. (H_2S):	100 ppm
System Airflow:	500 cfm
Total Volume of Media:	21 ft^3
Mass of H_2S Media:	630 lb
Mass of Polishing Media:	330 lb
Bed Depth:	36 in
Residence Time:	2.52 sec
Length of Test:	2 hrs

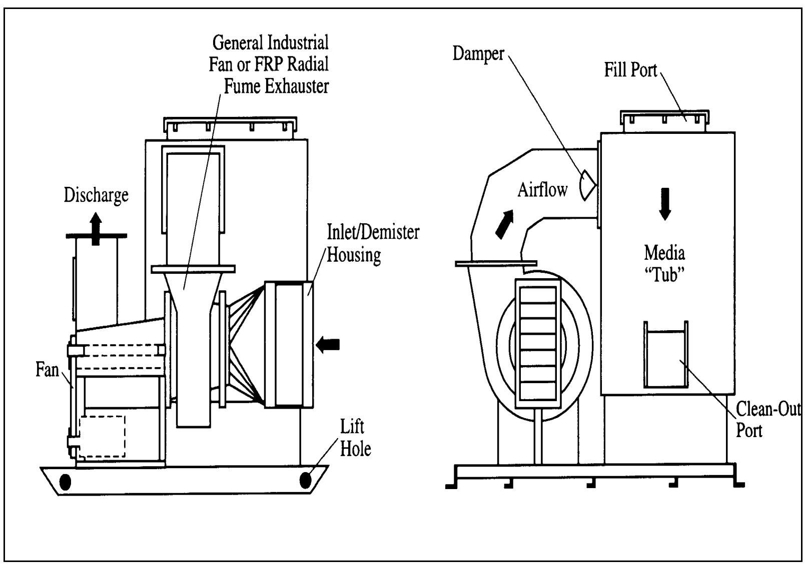

FIGURE 2 - DRY-SCRUBBING MEDIA SYSTEM HOLDING 21 FT^3 OF MEDIA WITH A FLOWRATE OF 500 CFM

The results of this testing are shown in Table 7. The test criteria of less than 2 ppm was surpassed with a discharge concentration less than 1 ppb. This equates to an efficiency of greater than 99.999%. The average inlet concentration was 103 ppm and the outlet concentration was less than 1 ppb for the 2 hour duration.

TABLE 7 – RESULTS OF 100 PPM CHALLENGE TESTING

Criteria:	< 2 ppm discharge
Avg H_2S inlet:	103 ppm
Avg H_2S discharge:	<1 ppb
Efficiency:	>99.999%

SUMMARY

Dry-scrubbing systems have been employed for many years to obtain highly efficient removal of odorous contaminants. The simplicity of these systems in their design, operation, and maintenance, have contributed to this degree of use.

The production of odorous contaminants from various geographic locations can fluctuate greatly. Shown in this paper were differences of colder climate areas versus areas of warmer climates. The warmer climate, particularly Florida, had much higher hydrogen sulfide concentrations than the colder climates (Pennsylvania, Indiana, and Kansas). This plays into the type of system that can be used to remove odors. The higher the concentration of contaminants and higher the airflow, the more media that is required. As more data is collected in collection systems across the U.S., engineers will be able to better estimate what their potential systems may produce.

System verification data in the form of challenge testing results has presented the fact that dry-scrubbing systems can operate with high removal efficiencies (>99.5%). The tests shown here are becoming standard recommendations for dry-scrubbing systems, to verify system performance on site. These tests can also give engineers insight into what can be specified for the performance of systems.

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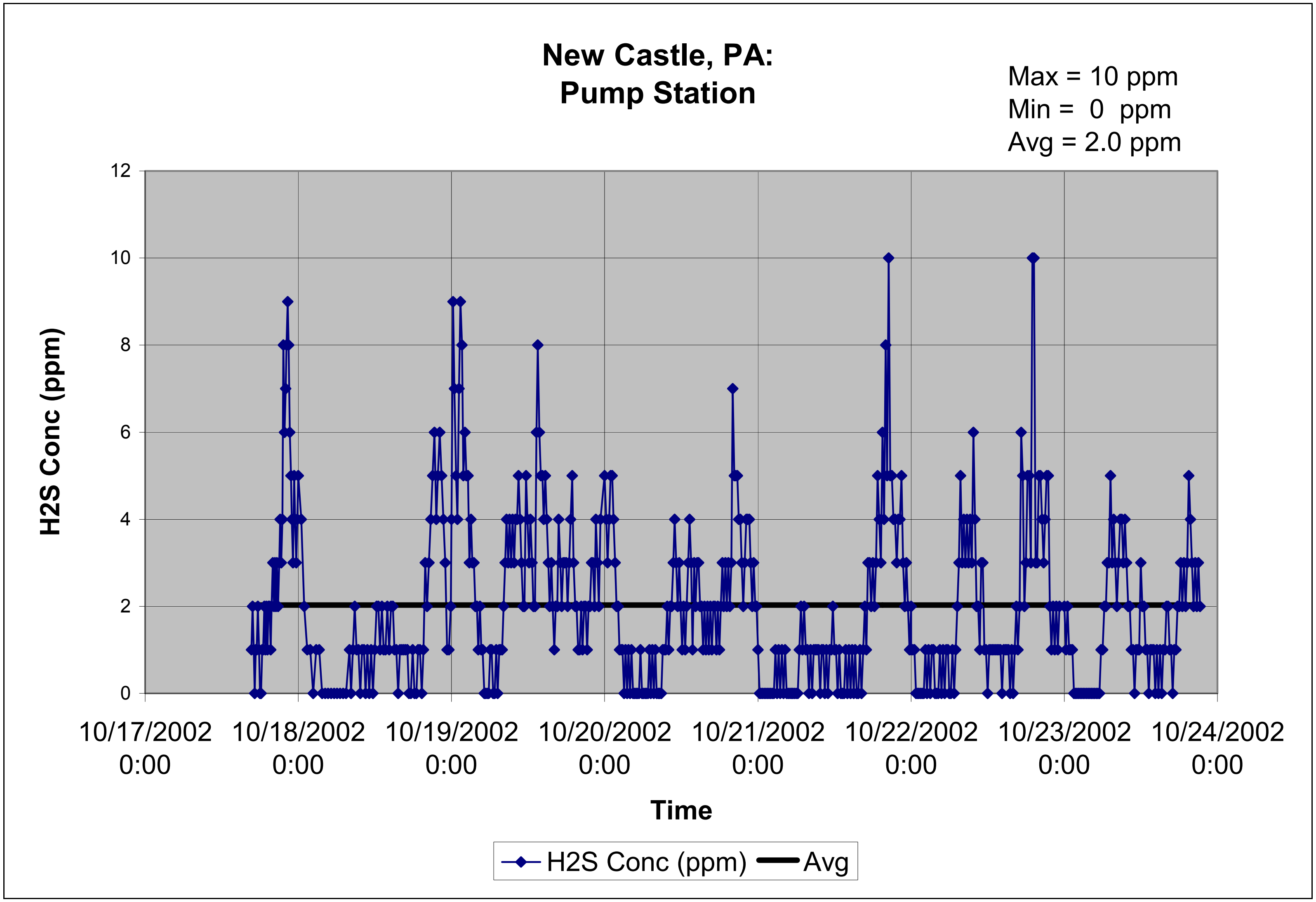
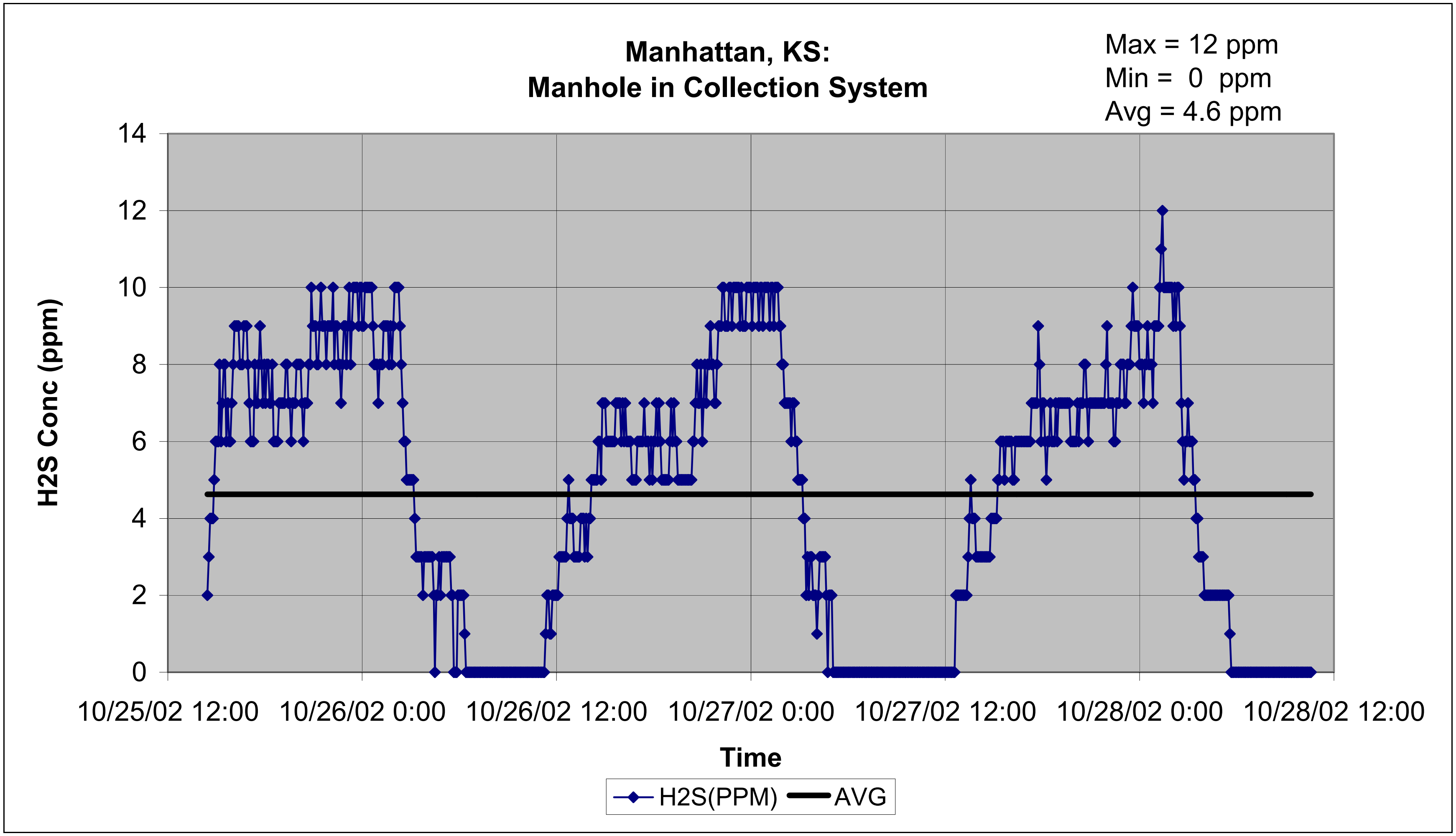
Appendix A – H_2S Concentration Data

FIGURE 3 – H_2S MONITORING DATA FOR A PUMP STATION IN NEW CASTLE, PA



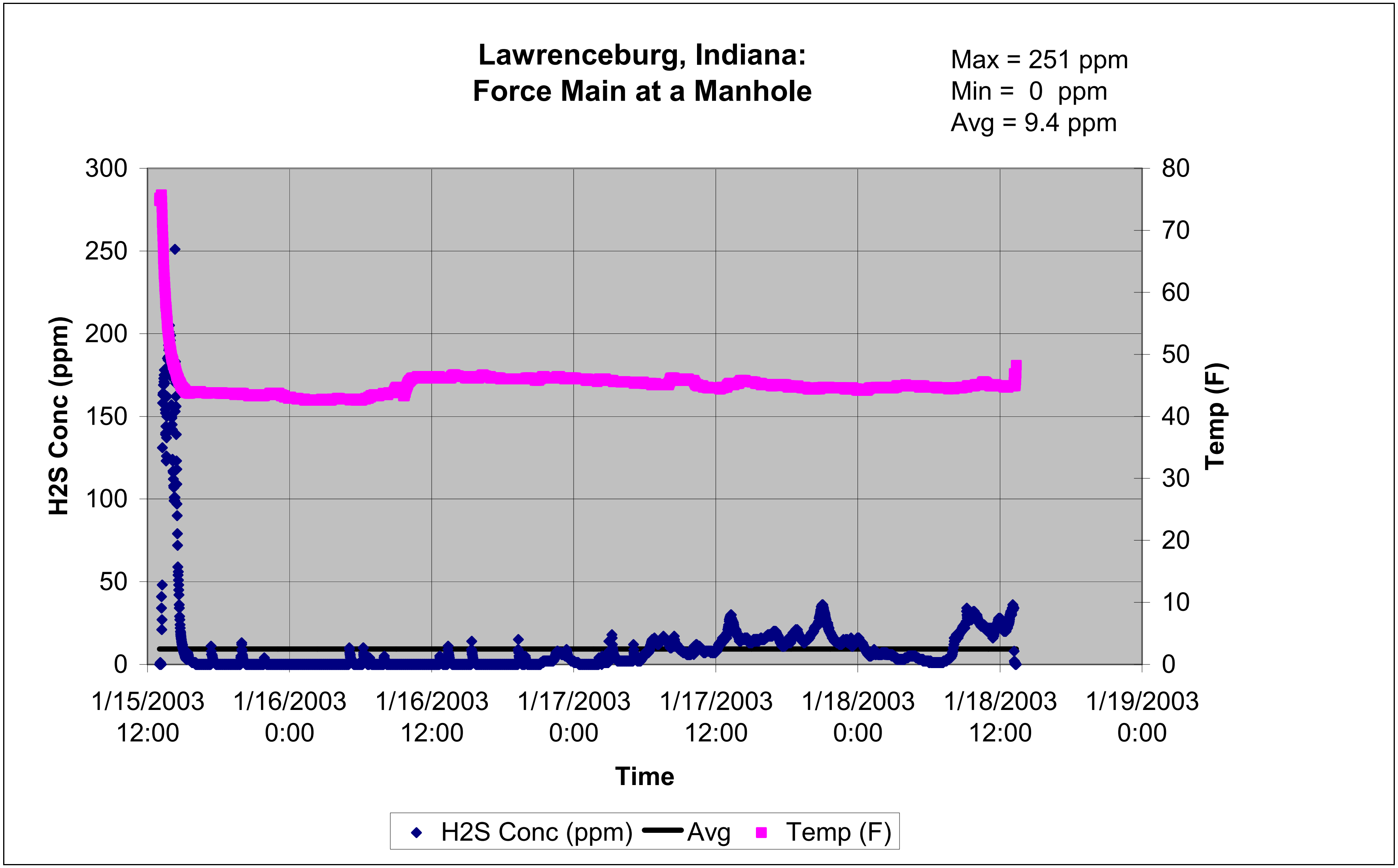
Appendix A – H_2S Concentration Data

FIGURE 4 - H_2S MONITORING DATA FOR A MANHOLE IN MANHATTAN, KS



Appendix A – H_2S Concentration Data

FIGURE 5 - H_2S MONITORING DATA FOR A FORCE MAIN IN LAWRENCEBURG, IN



Appendix A – H_2S Concentration Data

FIGURE 6 - H_2S MONITORING DATA FOR A PUMP STATION IN NAVARRE, FL