0031547

APR 09 1993

ENGINEERING DATA TRANSMITTAL

1. EDT № 141095

Sta. 7

2. To: (Receiving Organization) T-Plant Operation	3. From: (Originating Organization) Instrumentation & Data Acquisition Engineering	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: T-Plant / 340	6. Cog. Engr.: 4/8/93 MA ~~Lopez~~ ORTEGA	7. Purchase Order No.: N/A
8. Originator Remarks: Please sign for release supporting document WHC-SD-WM-ER-192. This document addressed the possible solutions and recommendations for Radioactive Airborne Emissions Monitoring Program at T-Plant.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 221T/T-Plant
11. Receiver Remarks:		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: March 31, 1993

OCT 1993 RECEIVED EDMC

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	~~WHC-SD-WM-ER-1992~~ JPT 4/9/93 WHC-SD-WM-ER-192		0	221T- T-PLANT EFFLUENT MONITORING / AUDIT RESPONSE	3E	1,2	1	

16. KEY

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 (see MRP 5.43)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Impact Level for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
1	1	Cog.Eng. H.G. Doolittle	HG Doolittle	3-25-93	T1-29	GV DeLisle	GV DeLisle	3/24/93		1	1
1	1	Cog. Mgr. RJ Bottenus	RJ Bottenus	3/25/93	T3-28	JP Tran	JP Tran	3/22/93	L7-05	1	1
1	1	Env. R.J. Boom	RJ Boom	4/8/93		WE Willingham, Jr.	WE Willingham Jr	3/24/93	L7-05	1	1
		Safety									

18.	19.	20.	21. DOE APPROVAL (if required)
JP Tran 3/22/93 Signature of EDT Originator / Date	Authorized Representative for Receiving Organization / Date	RJ Bottenus 3/25/93 Cog. Plant/Project Engineer's Manager / Date	Ltr. No. [] Approved [] Approved w/comments [] Comments

Response to #6

BD-7400-172-2 (07/91) GEF097

SUPPORTING DOCUMENT

1. Total Pages 26

2. Title	3. Number	4. Rev No.
221T - PLANT EFFLUENT MONITORING / AUDIT RESPONSE	WHC-SD-WM-ER-192	0

5. Key Words	6. Author
221T, T-PLANT, EFFLUENT, MONITORING, 291-T-1, 296-T-13	Name: JP Tran Signature Organization/Charge Code W23850 I&DAE/A3W4L

7. Abstract

This supporting document addressed the possible solutions and recommendations for finding numbers EFA-F01, EFA-F02, EFA-F03 and Observation no. EFA-OB06 in the Appraisal of Radioactive Airborne Emissions Monitoring Program at T-Plant, EFA-91-014

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9. Impact Level 3E

10. RELEASE STAMP

APPROVED FOR PUBLIC RELEASE
CW 5-14-93

OFFICIAL RELEASE BY WHC (14)
DATE APR 09 1993
Sta. 7

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1.0 INTRODUCTION

T-Plant was constructed as a reactor fuel processing plant in the mid-1940s. Plant operations were discontinued in 1956 after PUREX was started. T-Plant was then renovated and placed in service in 1957 for decontamination and repair of contaminated equipment. The main canyon exhaust system for T-Plant has evolved from an unfiltered system to a sand filtered system to a high efficiency particulate air (HEPA) filtered system. A temporary HEPA filter system was installed in 1983 but the system had several operational and environmental problems that precluded its use on a permanent basis. Therefore, an exhaust system that was more reliable and environmentally safe was installed under Project B-459 and is now in use.

Recently T-Plant was audited with the results reported in appraisal EFA-91-014, "Radioactive Airborne Emissions Monitoring Program at T-Plant", dated July 1991. The appraisal resulted in four findings and seven observations. The findings were related to the measurement of air flow in the stacks, record keeping and flow rates above filter design capacity.

Instrumentation and Data Acquisition Engineering (I&DAE), of Central Engineering was requested to identify some solutions to the findings and observations that apply to codes and regulations governing effluent monitoring in T-Plant.

2.0 SCOPE

The scope of this document shall be to discuss the status of the 221-T exhaust ventilation systems and to recommend solutions to meet the current regulations governing the effluent of nuclear air treatment systems.

3.0 DEFINITIONS

Anisokinetic: A condition which prevails when the velocity of air entering a sampling probe or the collector when held in the airstream is different from the velocity of the airstream being sampled at that point.

DOP: Dioctyl phthalate (an oily, clear, noncorrosive liquid) that forms an aerosol of repeatable dimensions under given parameters of temperature, pressure and flow.

HEPA filter: A High Efficiency Particulate Air (HEPA) filter having a fibrous medium with a particle removal efficiency of at least 99.97% for 0.3 micron particles of dioctyl phthalate.

Isokinetic: A condition which prevails when the velocity of air entering a sampling probe or the collector when held in the airstream is identical to the velocity of the airstream being sampled at that point.

Manifold: A device to uniformly disperse or collect a test agent mixed with air over a defined area from or into a single pipe or tube.

Super-isokinetic: A condition which prevails when the velocity of air entering a sampling probe or the collector when held in the airstream is greater than the velocity of the airstream being sampled at that point.

4.0 FINDINGS AND RECOMMENDATIONS

The following sections are divided into Finding, Discussion, Response, and Recommendation. The Finding and Discussion sections are complete quotes from EFA-91-014 and are presented in italics. The Response and Recommendation sections were developed by Instrumentation and Data Acquisition Engineering.

4.1 EFA-F01

Finding: *"The 291-T-1 stack is operated above the indicated design capacity, contrary to DOE 5480.4 and ANSI/ASME N509."*

Discussion: *"The design capacities were determined from the design name plates on the units. Most current measurements of flow rates indicate that the flow through 3 of the 4 HEPA filters is above the design limit for the HEPA filters, 10,000 cfm. Based on review of air flow capacity tests, the 291-T-1 stack appears to be operated above the stated design capacity of 10,000 cfm per HEPA filter train, and the prefilter stage design capacity of 1000 cfm. Review of surveillances which were performed in February and August of 1991 ("Airflow Capacity and Distribution Tests," Maintenance Procedure 7-GN-56) indicate that the 291-T-1 stack for the 221 Canyon is operated at flow rates of 9522 to 11,862 cfm (48.6-60.5 m/s) for each individual train of HEPA filters. There are four filter trains of one prefilter and two HEPA filter banks each. Each train is marked with a data nameplate which states the rated design capacity of the HEPA filter housing unit to be "10,000 cfm at -15" H_2O" and of the prefilter housing unit to be "1000 cfm at -15" H_2O." The reported normal configuration of the ventilation system results in a flow rate of 27,000 cfm total, which is approximately 6750 cfm per train. This would still be well in excess of the 1000 cfm capacity marked on the prefilter housings.*

"Use at overcapacity will reduce the effectiveness of the HEPA filters and lead to a loss of confinement. Data from 1990 indicate that this may have happened during the week of October 10, 1990. Stack monitoring results show that for five weeks the weekly concentration of Pu and Am isotopes was approximately 10X the Derived Concentration Guide (DCG)."

Response:

A. Prefilter Capacity:

The prefilter was designed for an air flow rate capacity of 10,000 cfm with a nominal flow of 8000 cfm. Each housing contains a single array of six filters (two wide by three high) and each filter has an air flow rating of 1667 cfm at 420 FPM maximum face velocity. This design was performed by Ellis & Watts company under contract no. WDW-XVV-581721. The references below identify the air flow rate capacity for each prefilter housing as 10,000 cfm. Per telecon with G. A. Johnston, a Project B-459 engineer, the nameplate on each prefilter housing was mislabeled when the nameplate was engraved. This was noticed, but not considered important at the time and no Non-Conformance Report was filed.

1. Caprio, G. T., 1987, Procurement Specification B-459-P3 for Disposable Prefilter Housing Project B-459 "T" Plant Exhaust Filter System Upgrade. (Document No: 2943B/0527A, 2310.105 to Singh Bath, December, 1987, WHC, Richland, Washington), SCM Consultants, Inc. Kennewick, Washington.

2. DR Whitworth, 1988, Prefilter Housing - T Plant Exhaust Filter System Upgrade, Marking/Identification. (Document No. K0323-06, to WHC Data Management) Ellis & Watts, Cincinnati, Ohio 45244

3. DR Whitworth, 1988, Prefilter Housing - T Plant Exhaust System Upgrade. (Document No. K0323-01, to WHC Data Management) Ellis & Watts, Cincinnati, Ohio 45244

B. HEPA Filter Capacity:

The HEPA filters were designed for an air flow rate capacity of 10,000 cfm for each bank (2 stages in series for each bank). Each stage has 9 filter elements (three wide by three high). According to records, the normal total air discharge into the four banks (trains) ranges from 22,000 cfm to 30,000

cfm but the volume of air through each bank is not equal. For example, on 10-2-92, the test data shows that Bank #1 had a flow of 4353 cfm and Bank #4 had a flow of 6494 cfm. Other data shows that at high exhaust flow rates (greater than 36,000 cfm) one or two banks had a flow of more than 10,000 cfm (see Figures 1 & 2). The butterfly valves for each bank are adjusted by the Ventilation/Balance team during filter testing, but the flow into each bank does not remain equal after a few days of operation. This can create overcapacity flow in one or two banks when the 291-T-1 stack exhaust system is operating near the designed maximum flow capacity.

Recommendation:

A. Prefilter Capacity:

Relabel or create new nameplates for each housing with the correct prefilter flow rate capacity (10,000 cfm). (see Original Plate Identification, Figure 3.)

B. HEPA Filter Capacity:

1. HEPAs are operated at less than 90% of the designed flow capacity.

   According to historical data, no individual filter stage exceeded the maximum flow capacity (10,000 cfm) when the total air discharge to the 291-T-1 stack was less than 90% of the maximum total design flow rate (40,000 cfm). Therefore, if the system is kept at a total flow rate of less than 36,000 cfm, there should be no problem. Otherwise, there are two alternate solutions for operating the exhaust system with the total discharge exceeding 36,000 cfm.

2. HEPAs are operated at no more than 100% of the designed flow capacity.

   This recommendation guarantees that no bank exceeds the flow capacity as long as the total system discharge does not exceed 40,000 cfm. Modify the butterfly valves from manual control to automatic control and add flow elements to each bank that will provide a feedback signal to control the butterfly valves. This will ensure that the four banks have the same flow rate and guarantee no bank exceeds its flow capacity.

3. HEPAs are operated at more than 40,000 cfm.

Increase the capacity of the four filter banks (prefilter and HEPA filters). Each bank should have a maximum design flow rate 10% greater than the maximum air discharge rate.

4.2 EFA-F02

Finding: 1. "The measurement site being used for determination of velocity and volumetric flow rate for the roof stack 296-T-13, is approximately one stack diameter downstream from a right angle turn with a change from a rectangular filter housing to a 67 inch diameter circular duct, and less than one foot upstream from the fan unit housing. A review of the applicable literature indicates that disturbed flow is probable at the location used. No errors with the actual flow rate measurements were observed except site selection."

Response:

In the present configuration, there is no measurement site between the filter and fan housings that meets the criteria of 40 CFR 60, Appendix A, Method 2. The distance between the filter housing and the fan unit is ten feet, which is only 1.5 duct diameters. The stack above the fan unit is only ten feet high, which is two and a half equivalent diameters in length.

Nonetheless, 40 CFR 60, Appendix A, Method 2, allows deviation from the standard procedure if the measurement site meets the criteria of section 2.5 of Method 1, 40 CFR 60, Appendix A. This requires an extensive test of the measurement site using directional probes to determine the pitch and yaw angles of the gas flow. The site is considered acceptable if the gas flow meets the acceptance criteria.

Recommendation:

Our primary recommendation is to extend the roof exhaust stack and install a permanent flow element. This would provide an easy means of determining stack velocity and flow rate and would meet the requirements of 40 CFR 60.

An alternate recommendation is to perform the testing to determine if the present sampling site meets the criteria of 40 CFR 60, Appendix A, Method 1, section 2.5. This requires an extensive test of the measurement site using directional probes to determine the pitch and yaw angles of the gas flow. The site would be considered acceptable if the gas flow met the acceptance criteria.

A last resort solution to meet the site location requirements of 40 CFR 60, Appendix A, Method 2, would be to relocate the fan unit further away from the filter housing.

Finding: 2. "It was not apparent that the system was designed to achieve uniform mixing under the observed test conditions, or that such a test was performed for each bank's injection port."

Response:

The roof exhaust stack filter housing consists of three filter stages in series; one prefilter stage and two HEPA filter stages. The inlet to the filter housing is ten 30" x 48" openings through the top of building 221-T (no inlet duct). The outlet is a 67 inch diameter circular duct. ASME N510, Sections 9 and 10 state in part, "If the housing has more than one HEPA filter stage in series, a separate challenge-injection port is required for each stage, and separate air-aerosol mixing test is required for each injection port and filter stage.... If the system contains a second stage of HEPA filters requiring leak testing, DOP must be injected at a point between the two HEPA filter stages in order to introduce sufficient aerosol to the second stage for a valid test". An inspection of the 296-T-13 filter housing unit showed that there are three sample ports on the east side of the filter housing. The first sample port is located upstream of the prefilter, the second sample port is located between the first and second HEPA filter stages, and the third sample port is located downstream of the second HEPA filter stage. A field inspection revealed that these ports do not extend beyond the walls of the filter housing. These sample ports do not meet the requirements of ASME N510.

Recommendations:

Install permanent or removable injection and sampling manifolds in the filter housing per ASME N510 as follows (see Figures 4 & 5):

- Install a manifold with fifty-seven nozzles at the first sample port. This would be used as the injection manifold for DOP testing the first HEPA stage.

- Separate the prefilter stage and the first HEPA stage to allow clearance for a single sample line to be used as a single upstream sample port for the first stage HEPA filter.

- Install sampling and injection manifolds between the two HEPA stages. Both manifolds would have multiple nozzles. One would be used for the first HEPA stage DOP sample and the other for the second HEPA stage DOP injection. The space between the two HEPA filter stages may not be sufficient for personnel entry when the two manifolds are installed. If that is the case, then the filter system must be tested by using a remotely controlled traverse. This would require more personnel and could be personnel exposure and contamination control problem for testing since there are fifty-seven filters elements in each stage.

- Install a sample manifold with ten nozzles into the outlet duct about six feet from the filter housing (see Figure 4). Alternately, install a multiple nozzle sample manifold at the third sample port to be used for the second HEPA stage DOP sample (see Figure 5).

NOTE: It should be noted that permanent manifold installations are highly recommended in order to obtain better repeatability of test results and to eliminate the need to enter housings which will decrease personnel radiation exposure.

Finding: 3. "The concentration downstream was determined. Given the observed test method, it would not be physically possible to determine upstream concentrations. It was concluded that the test as performed would not detect a leak at or near the design efficiency of 99.97% per filter bank."

Response:

We agree with this finding.

Recommendations:

See the recommendation for Finding 2 above.

Finding: 4. "The single point downstream sample point was approximately two feet (0.6 m) upstream of the system fan. There did not appear to be a sample manifold.

Response:

We agree with this finding.

Recommendations:

See the recommendation for Finding 2 above.

Finding: 5. "The downstream sample line length, if minimized, would have been less than 20 feet (6.1 m). The length of sample line, as noted during the appraisal, was in excess of 50 feet. There was no upstream sample line, although the downstream sample line was connected to the "UPSTREAM" sample port, as previously noted. The duration of each of the two samples appeared to be less than that required to draw sample through the entire length of the sample line. This would negate any positive measurement due to the inability of the challenge aerosol to reach the instrument.

Response:

After the date of this finding (July '91), ECN 161393 relocated the sample lines and corrected the labelling of the sample ports.

Recommendations:

None required.

Finding: 6. "Two readings did not appear to be sufficient to verify repeatability within the specified range."

Response:

We agree with this finding.

Recommendations:

The modification of the testing injection/sample ports as mentioned in the recommendation for Finding 2 should allow easier testing and provide repeatable results.

Finding: 7. "The test was performed by testing both banks simultaneously from downstream of the second bank, with challenge aerosol injected upstream of each bank. This would not be a test of individual banks."

Response:

We agree with this finding.

Recommendations:

The modification of the testing injection/sample ports as mentioned in the recommendation for Finding 2 will provide access for testing each bank separately.

4.3 EFA-F03

Finding: *"For the reported normal configuration, the canyon stack sampler at 291-T-1 samples under isokinetic conditions."*

Discussion: *"According to the data provided by a Health Physics (HP) engineer, the stack linear flow rate is 814 linear feet/min (lfm) (4.2 m/s), and the sample probe velocity is 813 lfm (4.2 m/s).*

"This flow rate is for the reported normal configuration with total system volumetric flow at approximately 27,000 cfm (12.7 m^3/s). However, review of logs for operation of the ventilation system indicates that the system is often operated in other flow configurations. For example, the system operated at 27,000 cfm for only about 20 weeks in 1990. The remaining 32 weeks the system operated at other velocities, primarily at approximately 15,000 cfm (2.3 m/s) and 39,000 cfm (5.7 m/s), although other velocities/flow rates were used. The differences are sufficient to create nonisokinetic conditions.

"Effluents are sampled using a 47 mm particulate filter. The sample flow rate is approximately 2 cfm. When the flow rate was checked during the audit for 291-T-1 it read 2.2 cfm. When other flow rates are used, i.e. two fans are on line or damper settings are changed, there is no indication that any adjustment is made on the flow of the record sampler. Isokinetic conditions would therefore not be maintained when this occurs. Sample records indicate stack flow varies widely over the year. There is no automatic feedback method for sample flow adjustment as is recommended in DOE EH-0173T, and a review of records of the monitor for 291-T-1 indicates that flow is maintained constant between 1.6 and 2.0 cfm, resulting in variability greater than the 10% recommended for the accuracy of flow measurements."

Response:

According to the 291-T-1 log books:

Date	Flow rate (cfm)	
10-2-92	22182	
8-7-92	22345	
5-19-92	42025	(Maximum)
2-14-92	26650	
8-14-91	42000	
8-14-91	37013	
9-17-90	14943	(Minimum)

3-29-90 36212

The sample probe nozzle is located approximately 50 feet downstream from the fan unit in a circular duct of radius 39 inches (cross-sectional area of 33.18 ft^2). Therefore, the sample velocity at this section was:

Maximum 1266.46 lfm = 6.43 m/s,
Median 858.39 lfm = 4.36 m/s, (3)
Minimum 450.32 lfm = 2.29 m/s

Referencing H-2-93414, *Stack Monitor Probe Assembly 291-T-1*, and CEO-014168, the sampling manifold contains ten nozzles, each with an inside radius of 0.1525 inches, and has an extraction flow volume rate of 6.2 cfm. Therefore, the extraction velocity for each nozzle is:

$$V = \frac{\text{sampling flow rate}}{\text{\# of nozzles x cross-sectional area of each nozzle}}$$

$$V = \frac{6.2 \text{ cfm} * 144 \text{ in}^2/\text{ft}^2}{10 * 0.1525 \text{ in}^2 * 3.1416}$$

V = 1221.98 lfm = 6.21 m/s (4)

This is not consistent with Finding EFA-F03, which states that "the sample probe velocity is 813 lfm". However, the minimum stack flow rate is 450.42 lfm. This implies that the 291-T-1 main stack is operated at super-isokinetic conditions during system operation at minimum flow. The ratio of sample velocity to minimum stack velocity is 1221.98/450.42 which equals 2.71 (271% error). This does not meet the requirement of WHC-CM-7-5, Part D, Rev. 1. Sec. 7.3, which requires that sampling be near isokinetic (+/-20%).

Recommendations:

The flow rate of the main stack, 291-T-1, is not constant (Fig. 2). Therefore, the sample vacuum system requires modification for a variable flow rate. The sample system must be designed for sample velocities ranging from 450 lfm to 1260 lfm. A flow measuring device would provide a feedback signal to control the sample flow to keep it isokinetic (Fig. 6,7). In addition, the sample manifold must be redesigned to match

the range of stack flow rates and the location of each nozzle must meet the requirements of ANSI N13.1.

Finding: *"The 296-T-13 Building roof exhaust is currently sampled at only 35% of stack flow."*

Discussion: *"The 296-T-13 Building roof exhaust is a HEPA filtered exhaust system, flowing at a nominal rate of 37,750 cfm and with a capacity of 70,000 cfm. One prefilter and two HEPA filters in series are used for filtration.*

"The roof stack sample line appears to have a single extraction point. The duct has a cross-sectional area of approximately 13 ft^2 (1.3 m^2). According to (ANSI/ASME) N13.1-1969, Appendix A, a rectangular stacks of 2 to 25 square feet area should have between 6 and 12 extraction points. Also, according to calculations based on flow measurements and on available plant diagrams, the stack flow is at 2716 lfm and the record sampler samples at 954 lfm. This is not near isokinetic and the correction factors found in ANSI/ASME N13.1 Table C1 for nonisokinetic corrections do not extend this far. The WHC-CM-7-5, Part D, Rev. 1, Sec. 7.3 requirement is for +/-20% of isokinetic. The current probe samples at only 35% of stack flow (a -185% error)."

Response:

According to the T-Plant 296-T-13 log books:

Date	Flow rate (cfm)	
9-30-92	36157	
8-07-92	31995	(Minimum)
5-19-92	36561	
2-20-92	32136	
2-20-92	37174	
2-20-92	36375	
1-03-91	32999	
9-17-90	39560	(Maximum)

The sample probe monitoring location is in a square duct approximately 43" square (cross-section area 12.84 ft^2). The calculated stack velocity is:

Maximum 3080.99 lfm = 15.65 m/s,
Median 2786.41 lfm = 14.16 m/s, (1)
Minimum 2491.82 lfm = 12.66 m/s

According to H-2-91149, *Probe Assembly 296-T-13 Stack Sampler/Monitor*, there are two nozzles for sampling. Each has a 0.323" inside diameter and the designed extraction rate is 3 cfm. The sample velocity is calculated by the following formula:

$$V = \frac{\text{sampling flow rate}}{\text{\# of nozzles x cross-sectional area of each nozzle}}$$

$$V = \frac{3.0 \text{ cfm} * 144 \text{ in}^2/\text{ft}^2}{0.1615 \text{ in}^2 * 3.1416}$$

V = 5272.16 lfm = 26.78 m/s (2)

According to equation (2) the velocity of the gas entering the sampling nozzle is 5272.16 lfm. Finding No. EFA-F03 states "the record sampler samples at 954 lfm" and that the average velocity of the airstream being sampled at the extraction point was 2754.67 lfm. This implies that the roof exhaust system operated at super-isokinetic conditions. The ratio of sample velocity to stack velocity 5272.16/2754.67 = 1.91 (191 % error) This does not meet the requirement of WHC-CM-7-5, Part D, Rev. 1. Sec. 7.3 that the sampling rate be near isokinetic (+/-20%).

Recommendations:

Assuming that the roof stack can be extended to twenty feet tall, install a flow element at twelve feet downstream of the fan and relocate the sample port to fifteen feet downstream from the fan. Also, the two single nozzles must be redesigned to a multiple nozzle configuration consisting of at least six nozzles such that each nozzle has an extraction rate of 27.86 lfm.

5.0 OBSERVATION

Observation: EFA-OB06

There is no accountability for measurements of stack flow rates or volumes required for determining the degree of isokinetic sampling and the total effluent discharges from the record stacks at the T Plant. Up to the final week of the appraisal, no T Plant personnel could be identified who currently performed these measurements (as required quarterly by Airflow Capacity and

Distribution Tests Maintenance Procedure 7-GN-56, Rev. 1, 12-8-89). A single hand written calculation of 291-T-1 stack measurements and isokinetic conditions was delivered on the final day of the appraisal. This calculation was correctly performed. An engineer from Ventilation and Balance (V&B) stated they no longer keep current records of measurements, but they still send data to T Plant. No personnel at T Plant were identified as being responsible for making and recording these measurements, although it was determined that informally a set of flow measurements for 291-T-1 is kept by a T plant engineer.

Recommendations:

There is a flow meter mounted on the 56" duct that is located inside a radiological control area. Currently no one is responsible for keeping track of the flow rate. The options are to either add a data acquisition system for real time tracking and reporting of stack flow or to add the flow reading to the "General Daily Surveillance Log T-Plant Facilities" in Section A.1: "Total flow rate _____LFM/_____CFM". Then Operations personnel who perform the daily surveillance would record the data and send it weekly to the cognizant engineer for analysis as needed.

6.0 OTHER CONSIDERATIONS:

Engineering-Science Inc. has been contracted to perform a study of reconfiguring the 291-T-1 fans from series to parallel operation with a variable speed control. The maximum flow rate of a parallel configuration may exceed the current filter housing capacities. Based on *T Plant Ventilation Upgrade - Engineering Study*, SD-459-ES-001, the filter system was designed to operate at 40,000 cfm and can be expanded to 80,000 cfm. If the filter system is expanded to 80,000 cfm, then the roof exhaust system may no longer be required. Furthermore, there exists space for a third fan: the ductwork could be modified to operate three fans in parallel. The third fan could be used for backup in case either of the other fans fail (see Figure 7).

7.0 SUMMARY OF RECOMMENDATIONS

7.1 291-T-1 Main Stack

- Change fan configuration from series to parallel with variable speed control so that the maximum flow rate will not exceed the total filter housing capacity.

- Add automatic controls to the butterfly valves on the individual filter banks to provide balanced airflow.
- Relabel or create new nameplates for each prefilter housing with the correct prefilter flow rate capacity.
- Upgrade the sample vacuum system to a variable flow rate system proportional to stack flow. Redesign the sampling manifold to match the new system.

7.2 296-T-13 Roof Stack

- Install a flow element in the exhaust stack to measure the velocity and volumetric flow rates.
- Redesign the sampling manifold to provide an isokinetic sample.
- Install permanent or removable sampling manifolds inside the filter housing to meet the requirements of ASME N510 for filter testing.
- Discontinue the operation of this system if it is no longer needed.

8.0 REFERENCES

ASME, 1989, *Nuclear Power Plant Air-Cleaning Units and Components*, ASME Standard N509-1989, The American Society of Mechanical Engineers, New York, New York.

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Fig. 1: 291-T-1, INDIVIDUAL BANK AIR FLOW

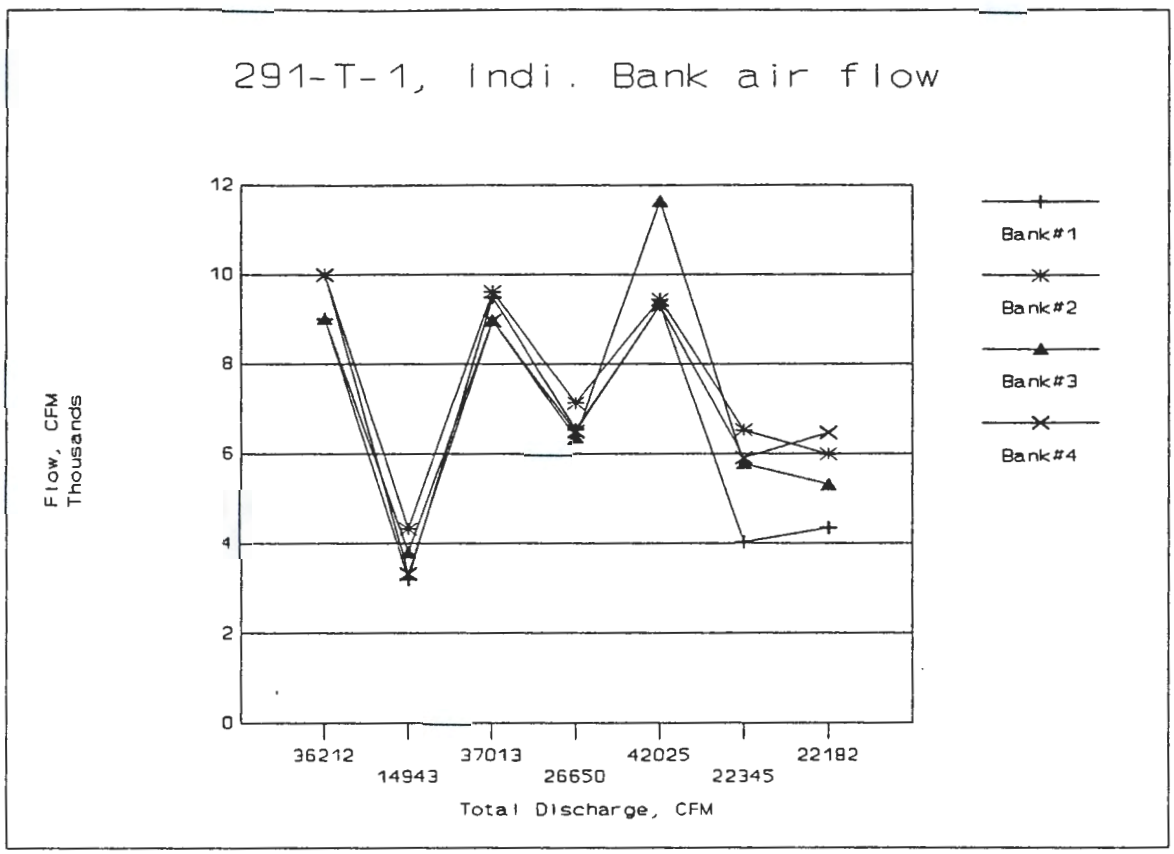
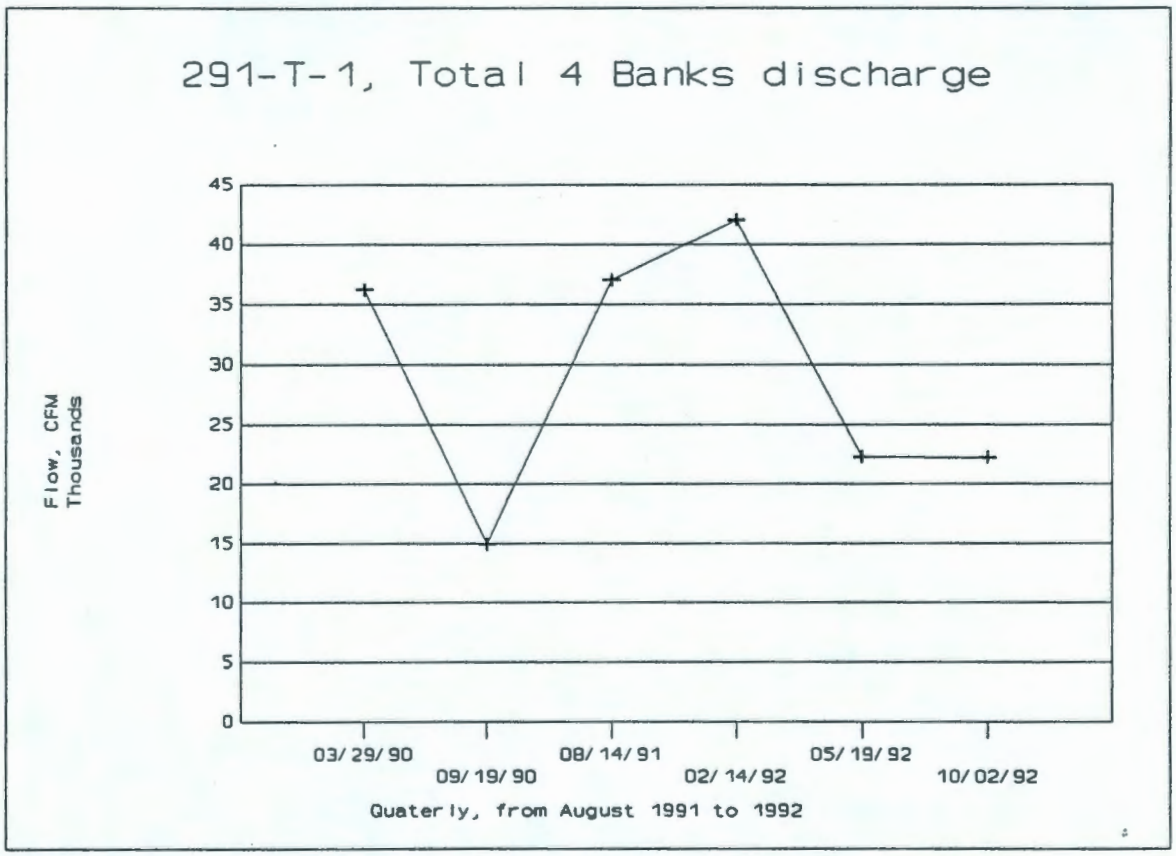


Fig. 2: 291-T-1, TOTAL DISCHARGE, FROM 8/91 TO 10/1992



291-T-1, PREFILTER HOUSING, PLATE IDENTIFICATION

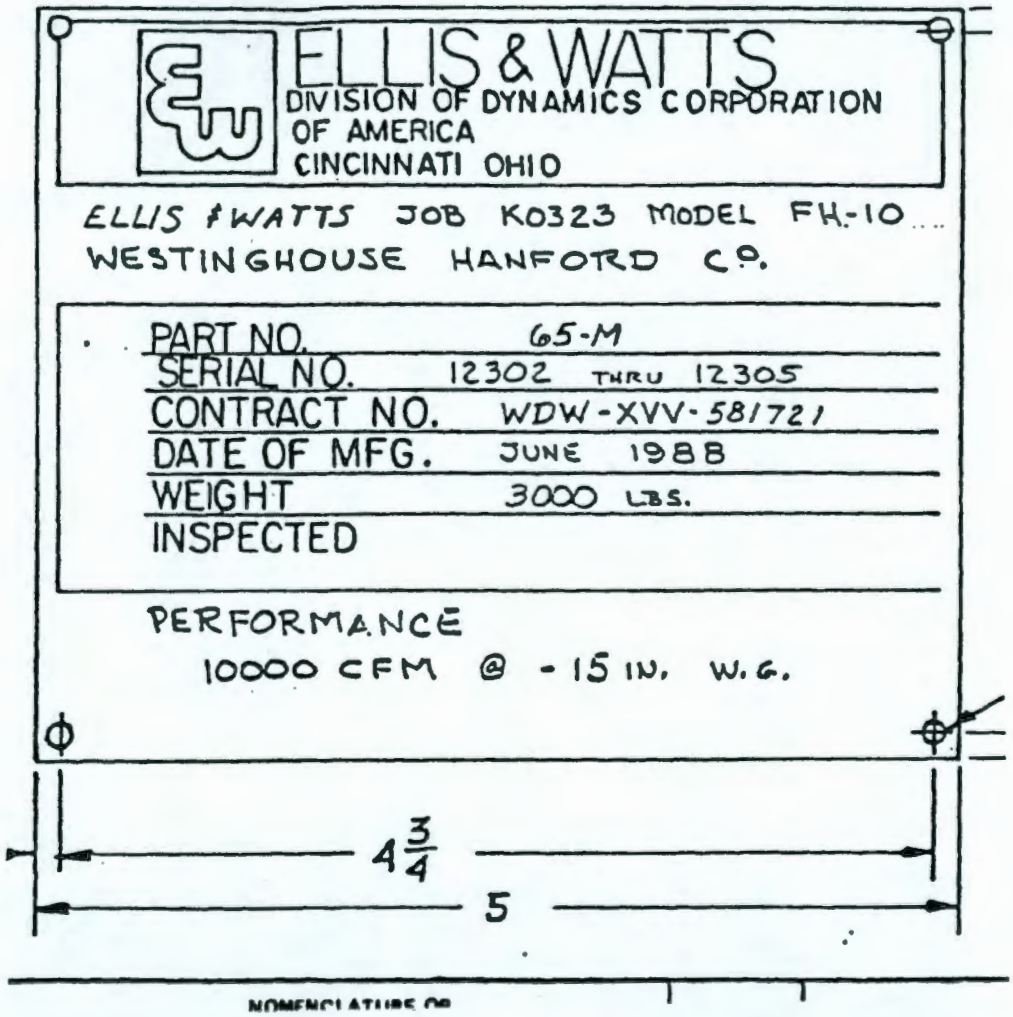
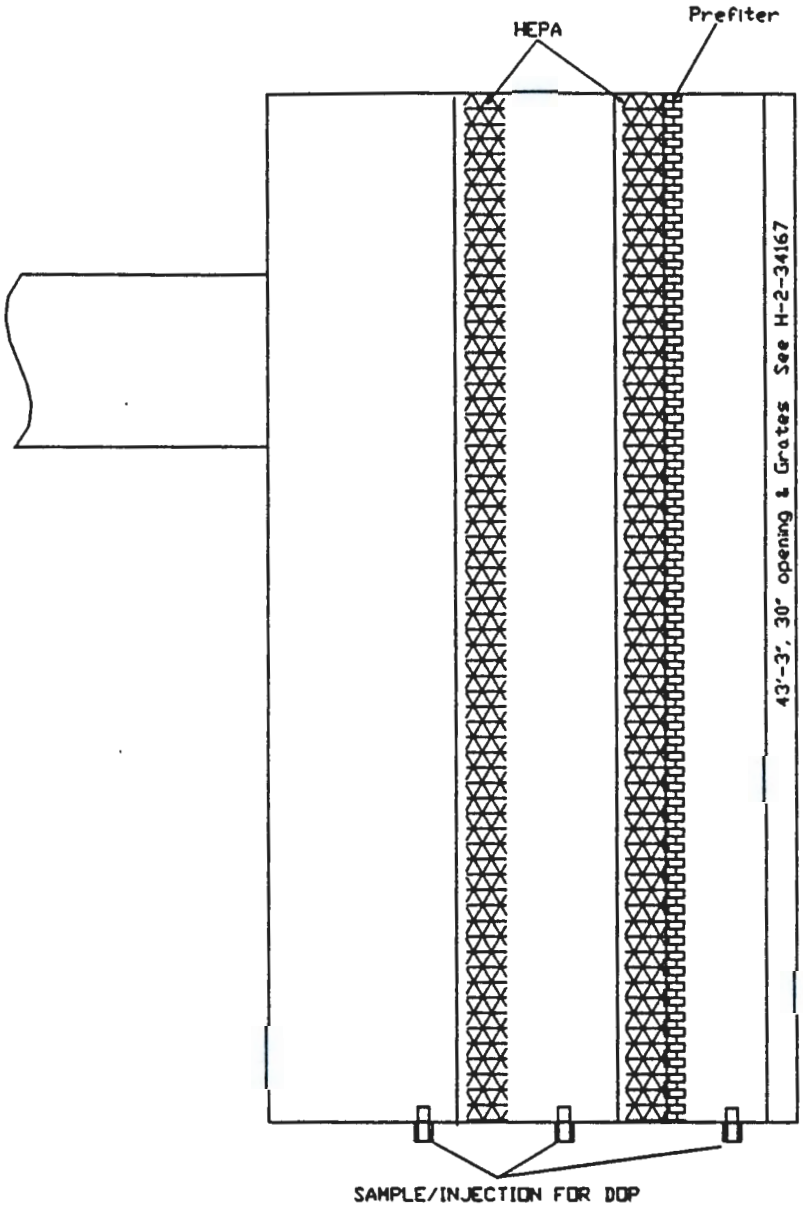
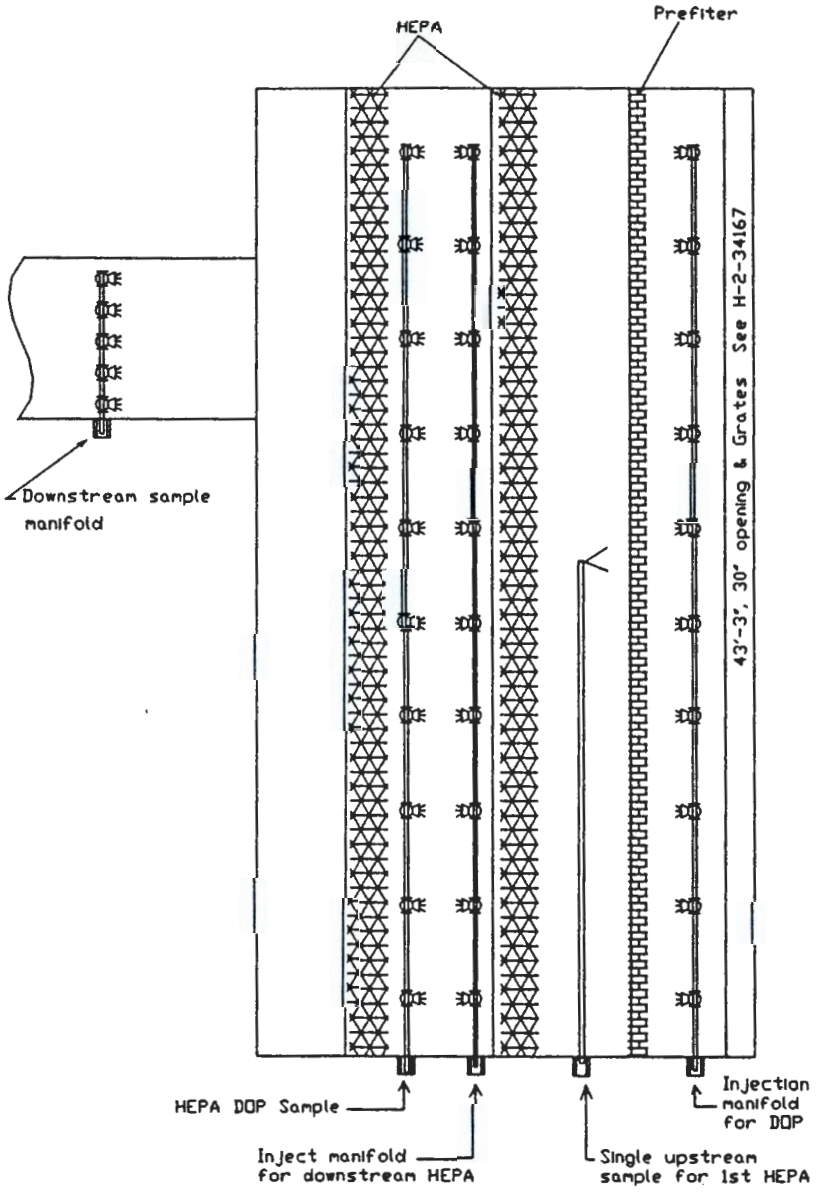


Figure #3

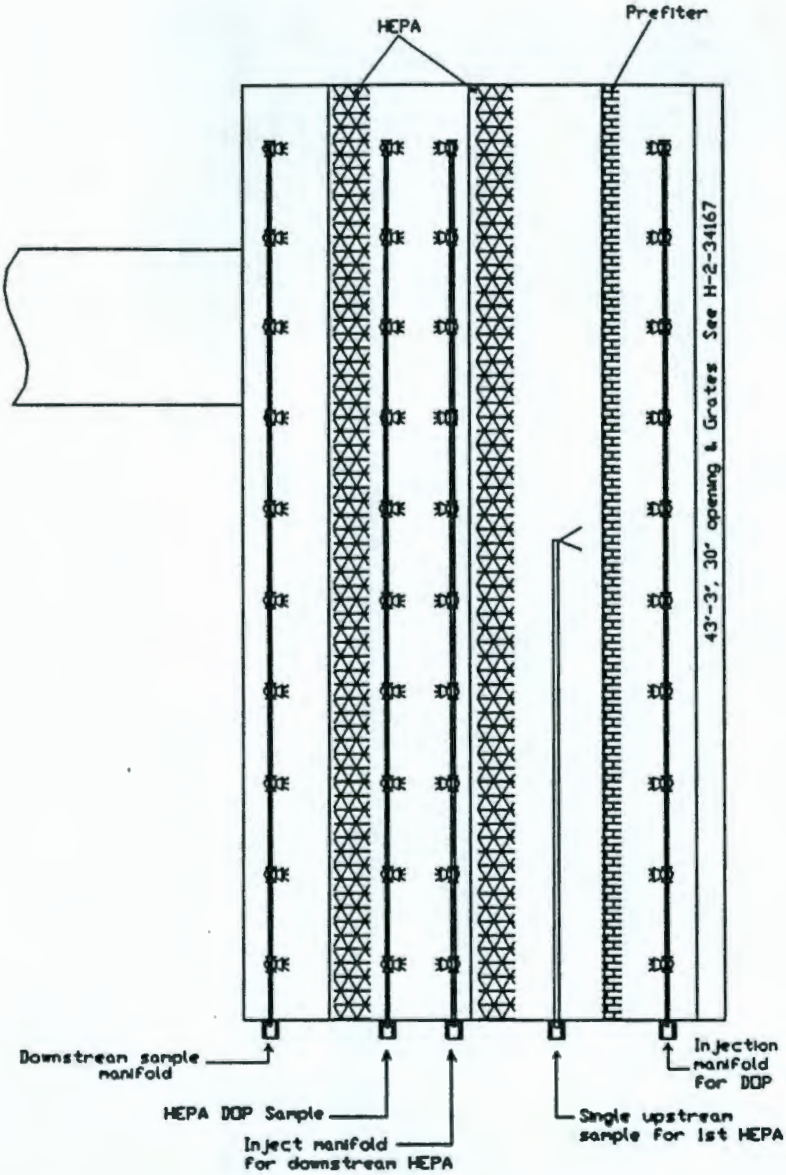


296-T-13, EXISTING filter housing sample ports



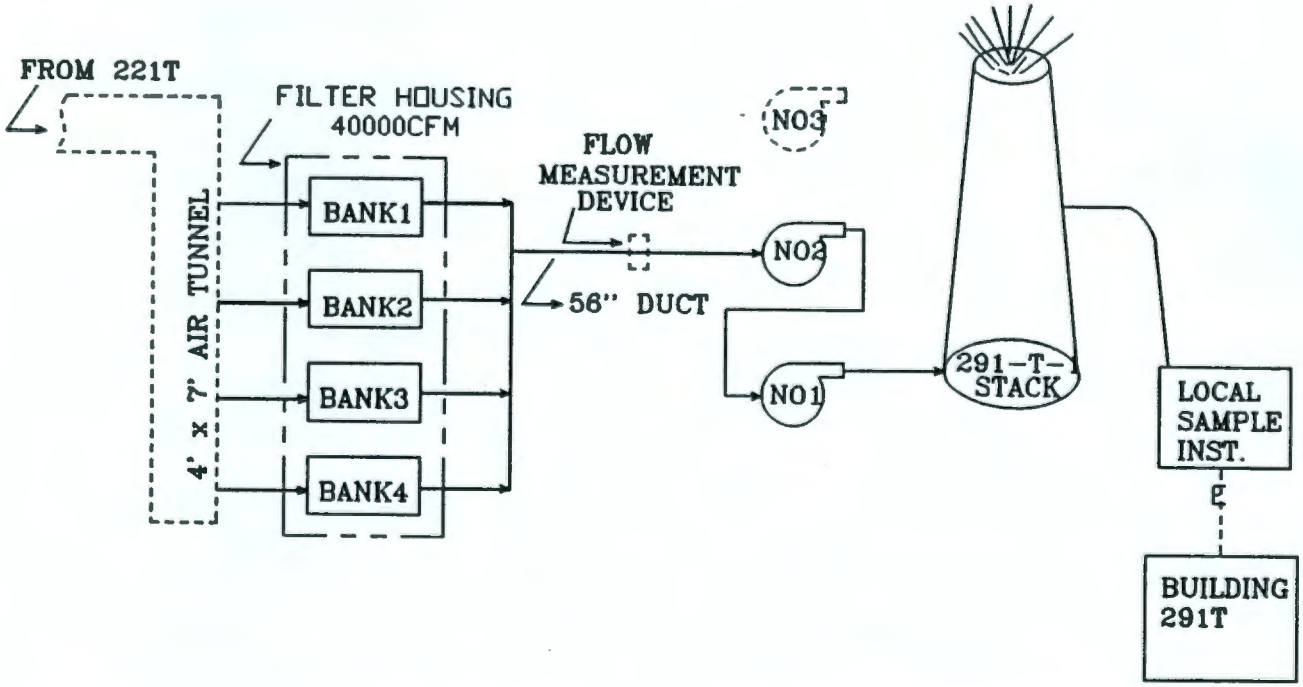
296-T-13, Method 1, filter housing sample/injection manifold

Figure #4

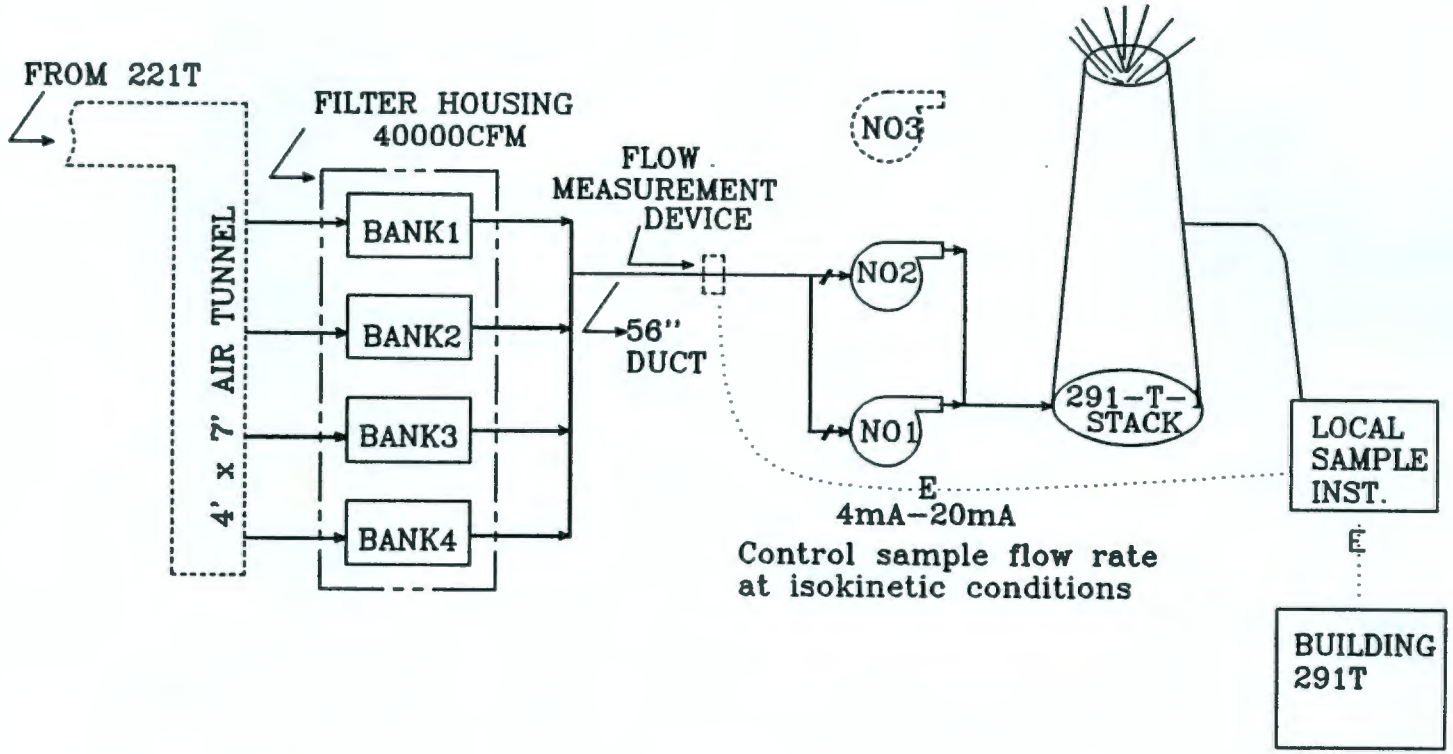


296-T-13: Method 2, filter housing sample/injection manifold

Figure #5

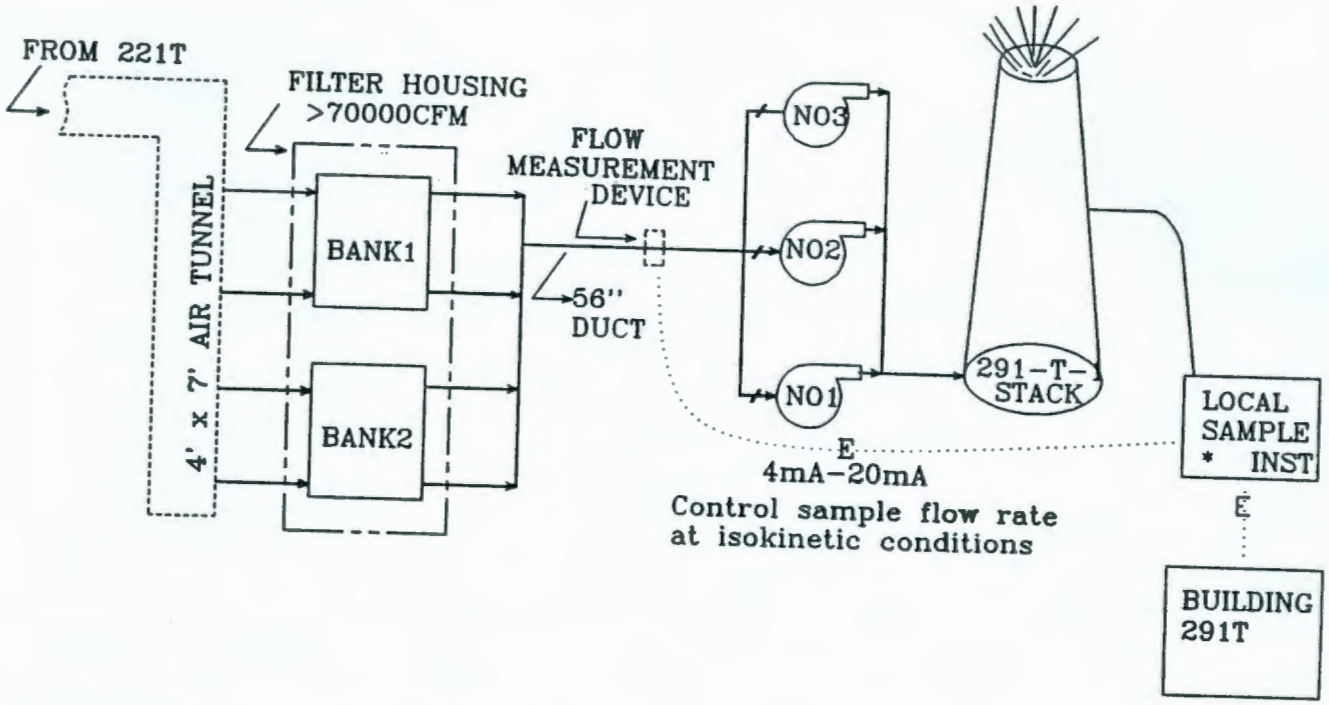


SCHEMATIC OF 291-T-1, EXHAUST STACK
EXISTING CONDITION.



SCHEMATIC OF 291-T-1, EXHAUST STACK
RECOMMENTDATION #1

Figure. 6:



SCHEMATIC OF 291-T-1, EXHAUST STACK
RECOMMENDATION #2

Figure #7

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