Florida Department of Environmental Regulation

Twin Towers Office Bldg. ● 2600 Blair Stone Road ● Tallahassee, Florida 32399-2400

Lawton Chiles, Governor

Carol M. Browner, Secretary

December 22, 1992

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. James A. Waters
Group Vice President
Waste Management of North America
500 Cyprus Creek Road, Suite 300
Ft. Lauderdale, Florida 33309

Dear Mr. Waters:

Re: File No. **AC**13-218495
     Medley Landfill Flare

This letter is in response to the comments made in Ms. Charlene
Pisatowski's letter dated December 4, 1992, written to Mr. Thomas
Cascio, referencing our request for additional information. Our
review of the document reveals the following items still need
further clarification:

1. Output Gas Flow from Well System

    The data you provided concerning estimated gas flow for the 48
    well system into the flare reveals that you expect an average
    of 37.6 cubic feet per minute (cfm) flow per well. Multiplying
    this rate times the 48 well total equates to 1805 cfm for the
    system as it exists today. However, the estimate provided in
    your APPLICATION TO OPERATE/CONSTRUCT AIR POLLUTION SOURCES,
    received September 1, 1992, is 3140 cfm. We assume this higher
    figure is the upper limit of all wells eventually installed.
    We also note that Specific Condition No. 22 of your solid waste
    permit sets the value at 1026 cfm. Please clarify these
    apparent inconsistencies.

2. Gas Flow from Flare

    · It is our understanding that you used a factor of 22.1
      multiplied by the methane input flow rate to compute the
      flare output emission volumetric gas flow rate. The methane
      input value was derived by assuming that 60% of the gas into
      the flare system consisted of methane. It appears that the
      remaining 40% was not accounted for in the analysis.

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• Ms. Pisatowski indicated via telephone that it is her interpretation that the 40% in question, composed mainly of CO_2, will pass through the flare system with no chemical modification, and is thus irrelevant to the discussion. This statement appears to be in conflict with the response in your Company's letter of October 21, 1992 that stated:

"The 22.1 cfm gas flow rate was calculated with the total landfill gas constituents, including methane, **carbon dioxide**, and **hydrogen sulfide**." (Emphasis added.)

Please clarify this point.

• The computation on page 2 of the Attachment to the APPLICATION utilizes a flare stack inside diameter of 16 inches, not 14 inches, resulting in an apparent erroneous gas exit velocity calculation. Please indicate if this is correct.

• The table at the bottom of page 4 of the Attachment to the APPLICATION lists the following volume percentages of gas pollutant output from the flare:

NOx = .004%
CO = .015
CH_4 = .002

Please provide a reference and all computations justifying these estimates.

• It appears that the formula specified on the middle of Attachment 2 to the December 4th letter referenced above contains a typographical error and should read:

3210 SCFM * [460 + 120] / 520 = 3580 ACFM

Please indicate if this is the case.

Enclosed with this letter is a typed representation of the handwritten material you submitted as the Attachment to your original APPLICATION. Please review this document for accuracy and indicate any changes or modifications based on the response to our above concerns.

We will continue processing your permit application when we receive a response to the above items. If you have any questions on this

matter, please contact Thomas Cascio at 904-488-1344 or write to me at the above address.

Sincerely,

John C. Brown, Jr., P.E.
Administrator
Air Permitting and Standards

JCB/TC/plm

cc: S. Brooks, SED
    E. Anderson, DERM
    H. Bush, Jr., P.E.
    T. Cascio, BAR
    M. Yon, BS&HW
    W. Hanks, BAR
    C. Pisatowski, Central Disposal

GENERAL DESCRIPTION

Landfill gas consists of: CH_4, methane, 60%

                          CO_2 40%

                          H_2S .0004%

Gas flow rate is estimated at 3140 scfm.

Gas emission exit velocity from stack = 496 fps, computed (648.54 fps ? Error in computation?).

This analysis assumes a constant maximum landfill gas flow rate.

Information required for the enclosed flare unit:

1. Maximum landfill gas flow rate = 3140 ft^3/min. standard, theoretical rate.

2. Maximum concentration of methane in the landfill gas = 60% (0.6).

3. Design basis for the flue gas flow = 22.1 ft^3/min (actual), per 1 ft^3/min of methane (standard).

4. Inside diameter of the flare = 14 inches.

First, calculate the methane input flow rate:

    0.6 * 3140 ft3/min standard = 1884 ft^3/min methane standard.

Second, calculate the flare gas emission flow rate:

    (22.1 ft^3/min actual)/(1 ft^3/min methane standard) * 1884 ft^3 methane standard = 41,636.4 ft^3/min actual gas emission volumetric flow rate.

Third, calculate the cross-sectional area of the flare:
    Area = pi * radius^2 = pi * (7)^2 = 153.86 in^2 = 1.07 ft^2.

Finally, calculate the gas exit velocity:

    (41,636.4 ft^3/min)/(1.07 ft^2 * 60 sec/min) = 648.54 ft/sec^2

Average molecular weight of landfill gas -- basis 100 (lb. mol) of landfill gas.

Component	Mole Percent	Molecular Weight	Pounds	Wt.%
CH_4	60.	16.041	962.46	36.3
CO_2	35.	44.01	1542.35	58.2
O_2	1.	32.00	32.00	1.2
N_2	4.	28.016	112.06	4.2
H_2S*	.0004	34.076	.014	.000005
Totals:	100.0004		2648.884	99.900005

*Separate calculations made for combustion of H_2S to SO_2.

Assuming standard conditions (60° F, 30 in. Hg):

Density of H_2S = .0911 lbm/ft3
Density of SO_2 = .1733 lbm/ft3

Gas flow rate = 41,636 ft^3/hr.

Hydrogen Sulfide volume flow rate:
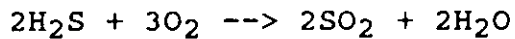
41,636 ft^3/hr * (.000004) = .1665 ft3/hr

Convert volume flow rate to mass flow rate using density:

(.1665 ft^3/hr)*(.0911 lbm/ft3) = .0152 lbm/hr H_2S.

Convert mass flow rate to mole flow rate using molecular weight:

(.0152 lbm/hr)/(34.076 lbm/lb mol) = .00045 lb mol/hr H_2S.

Using the stoichiometric combustion reaction:

$$2H_2S + 3O_2 \longrightarrow 2SO_2 + 2H_2O$$

We determine that every 2 (lbmol) of H_2S converts to 2 (lbmol) of SO_2, therefore:

.0004 (lbmol/hr) H_2S = .0004 (lbmol/hr) SO_2

Now convert mole flow rate to mass flow rate:
(.0004 (lbmol/hr))*(64.060 (lbm/lbmol)
      = .023 (lbm/hr) SO_2 emissions.

The average molecular weight of landfill gas is:
2646.88 lb/100 lbmol = 26.47 lb/lbmol

actual emissions = potential (1-efficiency)

gas emission flow rate =   41,636.4 ft^3/min actual, or
                       = 2,498,184.0 ft^3/hr actual

COMPONENT	VOLUME %	DENSITY	EMISSIONS (lbm/hr)
CO_2	7.0	.1170	(.07)*(.1170)*(2,498,184)= 20,460.0
H_2O	10.0	.0476	(.10)*(.0476)*(2,498,184)= 11,891.0
N_2	73.0	.0744	(.73)*(.0744)*(2,498,184)=135,681.0
O_2	10.0	.0846	(.10)*(.0846)*(2,498,184)= 21,135.0
NO_X	0.004	.0769	(.00004)*(.0769)*(2,498,184)= 7.7
CO	0.015	.0740	(.00015)*(.0740)*(2,498,184)= 27.7
CH_4	0.002	.0424	(.00020)*(.0424)*(2,498,184)= 21.2

SO_2 (see page 2)   .0004

TOTALS   100.021%

COMPUTATIONS IN TONS PER YEAR:

CO_2	20,460.0	*	4.38 =	89,614.8	TPY
H_2O	11,891.0	*	4.38 =	52,082.58	
N_2	135,681.0	*	4.38 =	594,282.78	
O_2	21,135.0	*	4.38 =	92,571.3	
NO_X	7.7	*	4.38 =	33.73	
CO	27.7	*	4.38 =	121.33	
CH_4	21.2	*	4.38 =	92.86	
SO_2	.0004	*	4.38 =	.0018	

● **SENDER: Complete items 1, 2, 3 and 4.**

Put your address in the "RETURN TO" space on the reverse side. Failure to do this will prevent this card from being returned to you. The return receipt fee will provide you the name of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for service(s) requested.

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2. ☐ Restricted Delivery.

3. Article Addressed to: James A. Waters
Waste Mgmt of N. america
500 Cypress Creek Rd
Ft. Lauderdale, Fl 33309

4. Type of Service:		Article Number
☑ Registered ☐ Insured		P062 921 940
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☐ Express Mail		

Always obtain signature of addressee or agent and **DATE DELIVERED.**

5. Signature – Addressee
X _Natalie Seafrick_

6. Signature – Agent
X

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Receipt for Certified Mail

UNITED STATES POSTAL SERVICE

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Sent to James A. Waters	
Street and No. Waste Mgmt of N. Amer.	
P.O., State and ZIP Code Ft. Lauderdale, Fl	
Postage	$
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Restricted Delivery Fee	
Return Receipt Showing to Whom & Date Delivered	
Return Receipt Showing to Whom, Date, and Addressee's Address	
TOTAL Postage & Fees	$
Postmark or Date 12-22-92	
AC 13-218495	

Medley Landfill and Recycling Center
9350 N.W. 89th Avenue
Medley, Florida 33178
305/883-7670

A Waste Management Company

December 15, 1992

Mr. Thomas Cascio
Department of Environmental Regulation
Air Quality
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Re: File #AC13-218495
       Medley Landfill Flare

Dear Mr. Cascio:

Thank you for contacting me on December 16, 1992 informing me of the final approval status of the Air Source Permit for the Medley Landfill Flare.   I understand that the final permit will be issued shortly.

In the conversation, you requested further clarification of the gas emission flow rate.   You were concerned over the 60% methane input flow rate and where the remaining 40% is accounted for in the calculations.

The gas emmisions flow rate is calculated using the combustible percentage of the landfill gas only as well as the amount of oxygen required for complete combustion. The remaining 40% constituent is carbon dioxide not involved in the combustion.

The carbon dioxide emission is calculated assuming a 40% concentration upon emmission as it is not combusted during the process.

I trust this addresses your concerns. Please notify me as soon as possible if you require additional information as we would like to begin operation of the landfill gas collection system.

Sincerely,

Charlene Pisatowski
Staff Engineer

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DEC 2 1 1992

Division of Air
Resources Management

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December 4, 1992

Mr. Thomas Cascio
Department of Environmental Regulation
Air Quality
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, FL   32399-2400

RE: File #AC13-218495
       Medley Landfill Flare

Dear Mr. Cascio:

This is in response to Mr. John C. Brown's letter dated November 13, 1992 requesting additional information in the Medley Landfill Gas Flare at the Medley Landfill in Medley, Florida.

The letter noted 6 items requiring further detail. This response will address the items sequentially:

1. NUMBER OF GAS WELLS

The number of wells to be installed is limited to the capacity of the flare. The flare has been overdesigned to account for all future well installations. The proposed future number of wells is based on the permitted landfill footprint, approximately 150 acres. There is approximately 1 well installed per acre.

2. GAS FLOW

Please see attached Table 1 indicating gas flow and gas compensation per well taken at the Central Sanitary Landfill in Pompano Beach, Florida. As the gas collection system at Medley, Florida is not yet operational, the data at Central has been submitted to verify the actual gas flows. The original estimate of 10 scfm was submitted for the system on free flow, i.e., with no applied vacuum. When the system is operational, the flows will be as indicated on Table 1.

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Please note the flows vary widely, from 0 cfm to 225 cfm with some flows reading at 0 cfm due to the flows being so low they did not register on the pressure reading instrument. The attached Table 1 also indicated the gas quality/gas flow functinal relationship.

3. MONITORING OF GAS FLOW FROM EACH WELL AND FLARE

The instrument to be used to measure gas flow to the flare is a Dwyer Magnehellic Gauge. This is a pressure-measuring device used to measure the differential pressure across a 6-inch orifice plate. The differential pressure is used in a calculation described on Attachment I to calculate gas flow. The flows measurements will be made manually. The min/max measurement range for the instrument is 0 to 100 inches of water column. The blower manufacturer indicates a capacity of 35 inches of water column. Therefore, the instrumentation is adequate to handle the capacity of the system.

The Magnehellic is calibrated with a water column.

4. FLARE OPERATING TEMPERATURE

There is no procedure or method to actually control the flare operating temperature. A minimum BTU value, however, will be maintained of 300 BTU or greater. Per 40 CFR 60.18, Section 3, a minimum BTU of 200 or greater is required for non-assisted flares. (Please see Attachment 2 for a copy of these regulations.) The temperature is directly correlated to the BTU value. The flare manufacturer indicates the flare temperature to be at 1400 degrees if methane concentration is greater than 20% methane, i.e. 200 BTU's. The exact temperature will be known upon start-up of the system.

A Fuji Electronic MicroController will be used to monitor the temperature. This is a programmable device to monitor temperature utilizing K-type thermocouples with a range up to 2200 degrees Fahrenheit.

5. SOLID WASTE PERMIT NO. SC13-179974

Please see Attachment 3 for a copy of the above permit as well as specific condition No. 22.

6. GAS FLOWS AND EXIT VELOCITY

Please see Attachments 1 and 2 for calculations used to measure gas flows and exit velocities.

It would be greatly appreciated if you could expedite your review process, as it is imperative to operate the gas collection system for odor control and gas migration at the Medley Landfill.

Please call me at (305) 977-9551 Ext. 15, should you have any questions or concerns.

Sincerely,

Charlene Pisatowski
Staff Engineer

CP/dt
cc: Mike Berg
     Harvey Bush
     Jim Barrett
     Stephanie Brooks (SE District FDER)
     E. Anderson (DERM)
     Jack Bratcher

C9Y)

Please note the flows vary widely, from 0 cfm to 225 cfm with some flows reading at 0 cfm due to the flows being so low they did not register on the pressure reading instrument. The attached Table 1 also indicated the gas quality/gas flow functinal relationship.

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4.   FLARE OPERATING TEMPERATURE

There is no procedure or method to actually control the flare operating temperature. A minimum BTU value, however, will be maintained of 300 BTU or greater. Per 40 CFR 60.18, Section 3, a minimum BTU of 200 or greater is required for non-assisted flares. (Please see Attachment 2 for a copy of these regulations.) The temperature is directly correlated to the BTU value. The flare manufacturer indicates the flare temperature to be at 1400 degrees if methane concentration is greater than 20% methane, i.e. 200 BTU's. The exact temperature will be known upon start-up of the system.

A Fuji Electronic MicroController will be used to monitor the temperature. This is a programmable device to monitor temperature utilizing K-type thermocouples with a range up to 2200 degrees Fahrenheit.

5.   SOLID WASTE PERMIT NO. SC13-179974

Please see Attachment 3 for a copy of the above permit as well as specific condition No. 22.   *Plant Specifics: 48 wells*

Flow Rate = 1026 CFPM

6.   GAS FLOWS AND EXIT VELOCITY

Please see Attachments 1 and 2 for calculations used to measure gas flows and exit velocities.

TABLE 1

GAS RECOVERY FACILITY WELLFIELD TUNING LOG

SITE: CDSL

PERSONNEL: MATT WELLS

TABLE 1

DATE	TIME	WELL #	O/P (in)	GAS TEMP. (°F)	Ph ("wc)	Pw ("wc)	DP ("wc)	GAS FLOW (cfm)	%O2	% N2 (AIR)	%CH4	INLET VAC. ("wc)
890727	1300	129			-8.0	-8.0	0.90	169	0.09	0.31	54.9	23
890727	1300	141			-7.2	-3.9	0.80	160	0.12	0.33	55.8	23
890727	1300	29			-13.0	-3.0	0.02	25	0.20	0.33	58.2	23
890727	1300	137			-11.0	-7.4	0.24	87	0.10	0.29	56.9	23
890727	1300	134			-11.0	-2.7	0.09	53	0.59	8.60	50.5	23
890727	1300	133			-11.0	-1.7	0.13	64	0.20	6.20	50.8	23
890727	1300	135			-8.0	-6.2	0.25	89	0.17	1.90	54.6	23
890727	1300	140			-11.0	-3.2	0.26	91	0.24	4.60	53.6	23
890727	1300	143			-13.0	-1.9	0.09	53	0.11	0.26	56.3	23
890727	1300	142			-12.0	-5.4	0.45	119	0.17	4.80	53.2	23
890727	1300	139			-12.0	-7.1	0.02	25	0.24	0.69	56.7	23
890727	1300	31				-2.1	0.03	31	0.16	0.74	57.5	23
890727	1300	27			-12.0	-2.6	0.01	18	0.05	0.10	56.9	23
890727	1300	30			-12.0	-2.7	0.01	18	0.05	0.09	57.0	23
890728	0830	29						0	0.17	0.27	58.5	
890728	0830	137						0	0.15	0.24	57.0	
890728	0830	143						0	0.17	0.28	56.1	
890728	0830	139						0	0.34	0.87	56.8	
890728	0830	31						0	0.11	2.30	55.9	
890728	0830	27						0	0.14	0.22	57.6	
890728	0830	30						0	0.13	0.18	57.5	
890728	0830	144			-14.0	-1.7	0.01	18	0.10	0.28	56.5	
890728	1330	145			-14.0	-0.3	0.00	0	0.10	0.31	56.0	
890728	1330	147			-11.0	-3.6	0.03	31	0.12	1.40	55.9	
890728	1330	150			-13.0	-1.6	0.01	18	0.11	0.26	56.6	
890728	1330	102			-11.0	-0.2	0.02	25	0.11	0.42	55.7	
890728	1330	105			-9.0	-5.6	0.24	87	0.11	0.49	55.5	
890728	1330	108			-11.0	-0.1	0.00	0	0.13	0.30	55.9	
890728	1330	106			-10.0	0.2	0.00	0	0.13	0.38	55.6	
890728	1330	152			-10.0	-1.2	0.11	59	0.18	3.50	53.7	
890731	0930	144			-16.0	-3.4	0.24	86	0.12	0.29	56.2	
890731	0930	145			-16.0	-2.4	0.02	25	0.74	8.10	50.1	
890731	0930	147			-16.0	-6.6	0.04	35	0.23	4.60	53.0	
890731	0930	150			-16.0	-5.6	0.02	25	0.15	0.30	56.5	
890731	0930	102			-16.0	-3.2	0.39	110	0.21	2.50	54.5	
890731	0930	106			-16.0	-1.8	0.12	61	0.21	5.70	52.0	
890731	0930	152			-16.0	-2.8	0.17	73	0.33	8.80	49.6	
890731	0930	31						0	0.11	5.10	53.5	
890731	0930	142						0	0.38	9.00	49.9	
890731	0930	143						0	0.07	0.18	56.0	
890731	1100	140						0	0.44	9.30	49.8	
890731	1100	139						0	0.20	0.68	56.0	
890731	1100	137						0	0.12	0.19	56.6	
890731	1100	134						0	0.13	2.80	54.1	

GAS RECOVERY FACILITY WELLFIELD TUNING LOG

SITE: CDSL

PERSONNEL: MATT WELLS

DATE	TIME	WELL #	O/P (in)	GAS TEMP. (°F)	Ph (°wc)	Pw (°wc)	DP (°wc)	GAS FLOW (cfm)	%O2	% N2 (AIR)	%CH4	INLET VAC. (°wc)
890731	1100	133						0	0.19	7.50	49.9	
890731	1100	135							0.14	2.50	53.6	
890801	0530	29							0.09	0.14	57.8	
89C801	0530	146			-9	-5.0	1.20	195	0.29	0.71	56.0	
890801	0530	141			-12	-8.0	0.12	61	0.23	0.32	56.5	
P^^801	0530	136			-10	-10.0	0.08	50	0.13	0.22	55.7	
L .01	0530	151			-12	-10.0	0.45	119	0.17	0.36	56.0	
890801	0530	153			-14	-14.0	0.30	97	0.17	0.25	56.5	
890801	0530	103			0	4.5	0.00	0	0.18	0.24	56.8	
890801	0530	104			2.6	2.6	0.00	0	0.13	0.18	57.1	
890801	0530	129			-12	-11.0	0.15	69	0.12	0.51	54.6	
890801	0530	128			-6	-6.0	0.12	62	0.20	0.32	56.1	
890801	0530	130			0.06	0.0	0.00	0	0.12	0.20	55.7	
890801	0530	127			-6.6	-5.0	0.40	113	0.22	0.45	54.9	
890801	0530	125			-10	-6.0	0.80	159	0.12	1.80	51.0	
890801	0730	124			-2.8	-2.4	0.10	57	0.16	2.10	51.8	
890801	0730	121				-7.0	0.50	126	0.37	3.00	47.9	
890801	0730	119			-12	-10.0	0.70	148	0.19	2.10	54.5	
890801	1100	27			-16	-7.0	0.01	18	0.03	0.20	56.6	
890801	1100	131			15	-2.0	0.10	58	0.23	7.20	50.0	
890801	1100	126			-9	-5.5	0.25	89	0.25	7.20	49.6	
890801	1100	122			-10	-6.0	0.84	163	0.21	9.40	50.0	
890801	1100	19			-10	-10.0	0.00	0	0.09	0.20	57.4	
890801	1100	20			-4	-2.0	0.72	152	0.23	7.90	50.8	
890801	1100	18			-15	-15.0	0.10	56	0.14	0.70	57.0	
890801	1100	22			-15	-15.0	0.00	0	0.16	0.26	57.1	
890801	1100	21			-16	-15.0	0.05	39	4.70	17.50	45.1	
890801	1100	24			-16	-15.0	0.00	0	0.14	0.23	56.5	
890801	1100	25			-16	-0.7	0.00	0	0.18	0.26	58.0	
890801	1100	26			-16	0.0	0.00	0	6.30	16.20	51.1	
890801	1100	14			-16	-14.0	0.00	0	0.02	0.06	56.5	
.01	1100	5			-21	0.0	0.00	0	0.33	0.59	65.3	
890801	1100	7			-20	-3.2	0.22	82	0.29	3.90	56.1	
890801	0730	120			-6.8	-2.5	1.20	196	0.28	8.60	47.6	
890801	0730	118			-12	-3.0	0.26	90	0.32	15.00	44.6	
890801	0730	117			-20	-0.5	0.01	18	0.19	3.90	52.2	
890801	0730	114			-8	-2.0	0.20	80	0.19	6.00	51.2	
890801	0730	113			-20	-1.3	0.03	30	0.13	1.00	55.4	
890801	0730	111			-20	-2.8	0.01	18	16.30	60.50	12.5	
890801	0730	110			-20	-2.0	0.10	56	0.14	0.25	56.1	
890801	0730	109			-20	0.0	0.00	0	0.20	0.33	55.3	
890801	0730	107			-20	0.0	0.00	0	0.26	0.42	56.0	
890801	0730	108			-20	-2.0	0.04	35	0.18	1.60	55.0	
890801	0730	105			-17	-12.0	0.60	137	0.18	1.40	54.7	

GAS RECOVERY FACILITY WELLFIELD TUNING LOG

SITE: COSL

PERSONNEL: MATT WELLS

DATE	TIME	WELL #	O/P (in)	GAS TEMP. (°F)	Ph ("wc)	Pw ("wc)	DP ("wc)	GAS FLOW (cfm)	%O2	% N2 (AIR)	%CH4	INLET VAC. ("wc)
890801	0730	123			-9	-3.4	1.60	225	0.28	9.00	48.9	
890801	0730	106			-19	-0.6	0.00	0	0.19	4.90	52.4	
890801	0730	101			-20	0.0	0.00	0	0.13	0.26	58.2	
890801	0730	102			-20	-3.0	0.50	124	0.12	1.30	55.1	
890801	0915	152			-19	-0.3	0.00	0	0.19	3.10	54.8	
P^^801	0915	150			-20	-0.7	0.00	0	0.10	0.20	56.3	
\ .01	0915	147			-16	-6.2	0.04	35	0.27	4.00	53.4	
890801	0915	145			-17	-0.4	0.20	79	·0.51	4.90	52.3	
890801	0915	144			-16	-3.6	0.00	0	0.19	0.30	56.4	
890801	0915	143			-16	-4.0	0.18	75	0.17	0.30	56.0	
890801	0915	142			-14	-8.0	0.48	123	0.26	8.40	50.8	
890801	0915	140			-15	-4.0	0.35	105	0.62	9.80	49.5	
890801	0915	139			-16	-12.0	0.04	35	0.36	1.00	56.4	
890801	0915	137			-14	-13.0	0.28	94	0.14	0.21	56.6	
890801	0915	135			-11	-8.0	0.34	104	1.30	6.60	50.3	
890801	0915	138			-16	-16.0	0.00	0	0.17	0.26	56.4	
890801	0915	134			-16	-1.4	0.56	132	0.18	3.10	53.9	
890801	0915	133			-16	-1.4	0.06	43	0.19	7.20	49.9	
890901	0915	132			-16	-15.0	0.01	18	0.09	0.20	56.8	
890801	1230	115			-20	-12.0	0.15	68	0.13	0.23	58.0	
890801	1230	116			-20	-0.4	0.01	18	0.14	0.88	55.2	
890801	1230	8			-21	-4.0	0.12	61	0.15	0.30	57.9	
890801	1230	9			-16	-7.4	0.50	125	0.14	2.30	55.5	
890801	1230	10			-16	-0.8	0.03	31	0.12	0.24	58.2	
890801	1230	12			-16	1.7	0.15	68	0.16	0.34	58.7	
890801	1230	11			-16	-0.4	0.01	18	0.17	0.31	57.5	
890801	1230	13			-16	-3.2	0.20	79	0.09	0.20	57.0	
690801	1230	23			-15	0.0	0.00	0	0.17	0.29	57.0	
890801	1230	15			-15	-3.5	0.02	25	0.17	0.27	57.4	
890801	1230	16			-14	-13.0	0.16	71	1.30	5.40	54.8	
890801	1230	17			-14	-12.0	0.10	56	0.18	0.27	58.1	
`01	1230	6			-8	-8.0	0.02	25	0.55	5.00	51.6	
6y0801	1230	3			-20	0.0	0.00	0	0.05	0.18	58.0	
890801	1230	2			-20	-0.6	0.07	46	0.06	0.18	57.4	
890801	1430	1			-20	-2.0	0.06	43	0.10	0.21	57.0	
890801	1430	154			-18	-3.0	0.02	25	0.06	0.17	57.0	
890801	1430	37			-22	-8.0	0.04	35	0.55	7.10	51.5	
890601	1430	43			-24	-2.0	0.01	17	0.34	3.90	54.0	
890801	1430	149			-20	-7.4	0.00	0	1.20	22.00	41.0	
890801	1430	45			-22	-5.0	0.02	25	0.15	0.27	56.5	
890801	1430	44			-24	-6.8	0.10	55	0.13	0.33	56.5	
890801	1430	148			-19	-17.0	0.01	18	6.00	24.60	38.7	
890801	1430	41			-22	-3.0	0.00	0	0.10	0.20	56.4	
890801	1430	42			-21	-8.0	0.00	0	0.11	0.22	56.5	

GAS RECOVERY FACILITY WELLFIELD TUNING LOG

SITE: CDSL

PERSONNEL: MATT WELLS

DATE	TIME	WELL #	O/P (in)	GAS TEMP. (°F)	Ph ('wc)	Pw ('wc)	DP ('wc)	GAS FLOW (cfm)	%O2	% N2 (AIR)	%CH4	INLET VAC. ('wc)
890801	1430	40			-20	-5.4	0.02	25	0.10	0.19	56.5	
890801	1430	39			-22	-20.0	0.02	25	0.23	0.64	56.2	
890801	1430	38			-22	-3.6	0.06	43	0.14	2.40	54.9	
890801	1430	36			-10	-4.0	0.05	40	0.06	0.15	56.0	
890801	1430	35			-10	-0.6	0.00	0	0.19	1.00	56.0	
P^^901	1530	33			-16	-4.0	0.04	35	0.09	2.00	56.8	
∟ .01	1530	31			-16	-2.8	0.03	31	0.17	5.60	53.4	
ε90801	1530	34			-8	0.0	0.00	0	0.20	0.41	60.9	
890801	1530	32			-16	-4.0	0.00	0	0.08	0.18	57.2	
890801	1530	29			-16	-8.0	0.02	25	0.08	0.20	57.9	
890801	1530	28			-16	-16.0	0.01	18	3.00	11.90	49.6	
890801	1530	30			-16	-6.0	0.01	18	0.12	0.28	57.2	
890801	1530	155			14	3.0	0.00	0				
890801	1530	112						0				
890802	1100	118			-18	-0.4	0.05	39	0.19	7.6	50.7	
890802	1100	149						0	1.00	6.4	57.7	
890802	1100	148						0	3.90	17.7	43.8	
890802	1100	111			-19	-1.2	0.00	0	15.40	57.9	15.0	
890802	1100	123			-16	0.0	0.00	0	0.14	6.4	50.9	
890802	1100	120			-16	0.1	v.00	0	0.09	1.6	55.2	

TABLE 1

GAS RECOVERY FACILITY WELLFIELD TUNING LOG

SITE: CDSL

PERSONNEL: MATT WELLS

TABLE 1

DATE	TIME	WELL #	O/P (in)	GAS TEMP. (°F)	Ph (°wc)	Pw (°wc)	DP (°wc)	GAS FLOW (cfm)	%O2	% N2 (AIR)	%CH4	INLET VAC. (°wc)
890727	1300	129			-8.0	-8.0	0.90	169	0.09	0.31	54.9	23
890727	1300	141			-7.2	-3.9	0.80	160	0.12	0.33	55.8	23
890727	1300	29			-13.0	-3.0	0.02	25	0.20	0.33	58.2	23
890727	1300	137			-11.0	-7.4	0.24	87	0.10	0.29	56.9	23
890727	1300	134			-11.0	-2.7	0.09	53	0.59	8.60	50.5	23
8^^727	1300	133			-11.0	-1.7	0.13	64	0.20	6.20	50.8	23
(27	1300	135			-8.0	-6.2	0.25	89	0.17	1.90	54.6	23
890727	1300	140			-11.0	-3.2	0.26	91	0.24	4.60	53.6	23
890727	1300	143			-13.0	-1.9	0.09	53	0.11	0.26	56.3	23
890727	1300	142			-12.0	-5.4	0.45	119	0.17	4.80	53.2	23
890727	1300	139			-12.0	-7.1	0.02	25	0.24	0.69	56.7	23
890727	1300	31				-2.1	0.03	31	0.16	0.74	57.5	23
890727	1300	27			-12.0	-2.6	0.01	18	0.05	0.10	56.9	23
890727	1300	30			-12.0	-2.7	0.01	18	0.05	0.09	57.0	23
890728	0830	29						0	0.17	0.27	58.5	
890728	0830	137						0	0.15	0.24	57.0	
890728	0830	143						0	0.17	0.28	56.1	
890728	0830	139						0	0.34	0.87	56.8	
890728	0830	31						0	0.11	2.30	55.9	
890728	0830	27						0	0.14	0.22	57.6	
890728	0830	30						0	0.13	0.18	57.5	
890728	0830	144			-14.0	-1.7	0.01	18	0.10	0.28	56.5	
890728	1330	145			-14.0	-0.3	0.00	0	0.10	0.31	56.0	
890728	1330	147			-11.0	-3.6	0.03	31	0.12	1.40	55.9	
890728	1330	150			-13.0	-1.6	0.01	18	0.11	0.26	56.6	
890728	1330	102			-11.0	-0.2	0.02	25	0.11	0.42	55.7	
890728	1330	105			-9.0	-5.6	0.24	87	0.11	0.49	55.5	
890728	1330	108			-11.0	-0.1	0.00	0	0.13	0.30	55.9	
890728	1330	106			-10.0	0.2	0.00	0	0.13	0.38	55.6	
890728	1330	152			-10.0	-1.2	0.11	59	0.18	3.50	53.7	
890731	0930	144			-16.0	-3.4	0.24	86	0.12	0.29	56.2	
' 31	0930	145			-16.0	-2.4	0.02	25	0.74	8.10	50.1	
8/v/31	0930	147			-16.0	-6.6	0.04	35	0.23	4.60	53.0	
890731	0930	150			-16.0	-5.6	0.02	25	0.15	0.30	56.5	
890731	0930	102			-16.0	-3.2	0.39	110	0.21	2.50	54.5	
890731	0930	106			-16.0	-1.8	0.12	61	0.21	5.70	52.0	
890731	0930	152			-16.0	-2.8	0.17	73	0.33	8.80	49.6	
890731	0930	31						0	0.11	5.10	53.5	
890731	0930	142						0	0.38	9.00	49.9	
890731	0930	143						0	0.07	0.18	56.0	
890731	1100	140						0	0.44	9.30	49.8	
890731	1100	139						0	0.20	0.68	56.0	
890731	1100	137						0	0.12	0.19	56.6	
890731	1100	134						0	0.13	2.80	54.1	

GAS RECOVERY FACILITY WELLFIELD TUNING LOG

SITE: CDSL

PERSONNEL: MATT WELLS

DATE	TIME	WELL #	O/P (in)	GAS TEMP. (°F)	Ph ("wc)	Pw ("wc)	DP ("wc)	GAS FLOW (cfm)	%O2	% N2 (AIR)	%CH4	INLET VAC. ("wc)
890731	1100	133						0	0.19	7.50	49.9	
890731	1100	135							0.14	2.50	53.6	
890801	0530	29							0.09	0.14	57.8	
890801	0530	146			-9	-5.0	1.20	195	0.29	0.71	56.0	
890801	0530	141			-12	-8.0	0.12	61	0.23	0.32	56.5	
890801	0530	136			-10	-10.0	0.08	50	0.13	0.22	55.7	
890801	0530	151			-12	-10.0	0.45	119	0.17	0.36	56.0	
890801	0530	153			-14	-14.0	0.30	97	0.17	0.25	56.5	
890801	0530	103			0	4.5	0.00	0	0.18	0.24	56.8	
890801	0530	104			2.6	2.6	0.00	0	0.13	0.18	57.1	
890801	0530	129			-12	-11.0	0.15	69	0.12	0.51	54.6	
890801	0530	128			-6	-6.0	0.12	62	0.20	0.32	56.1	
890801	0530	130			0.06	0.0	0.00	0	0.12	0.20	55.7	
890801	0530	127			-6.6	-5.0	0.40	113	0.22	0.45	54.9	
890801	0530	125			-10	-6.0	0.80	159	0.12	1.80	51.0	
890801	0730	124			-2.8	-2.4	0.10	57	0.16	2.10	51.8	
890801	0730	121				-7.0	0.50	126	0.37	3.00	47.9	
890801	0730	119			-12	-10.0	0.70	148	0.19	2.10	54.5	
890801	1100	27			-16	-7.0	0.01	18	0.03	0.20	56.6	
890801	1100	131			15	-2.0	0.10	58	0.23	7.20	50.0	
890801	1100	126			-9	-5.5	0.25	89	0.25	7.20	49.6	
890801	1100	122			-10	-6.0	0.84	163	0.21	9.40	50.0	
890801	1100	19			-10	-10.0	0.00	0	0.09	0.20	57.4	
890801	1100	20			-4	-2.0	0.72	152	0.23	7.90	50.8	
890801	1100	18			-15	-15.0	0.10	56	0.14	0.70	57.0	
890801	1100	22			-15	-15.0	0.00	0	0.16	0.26	57.1	
890801	1100	21			-16	-15.0	0.05	39	4.70	17.50	45.1	
890801	1100	24			-16	-15.0	0.00	0	0.14	0.23	56.5	
890801	1100	25			-16	-0.7	0.00	0	0.18	0.26	58.0	
890801	1100	26			-16	0.0	0.00	0	6.30	16.20	51.1	
890801	1100	14			-16	-14.0	0.00	0	0.02	0.06	56.5	
890801	1100	5			-21	0.0	0.00	0	0.33	0.59	65.3	
890801	1100	7			-20	-3.2	0.22	82	0.29	3.90	56.1	
890801	0730	120			-6.8	-2.5	1.20	196	0.28	8.60	47.6	
890801	0730	118			-12	-3.0	0.26	90	0.32	15.00	44.6	
890801	0730	117			-20	-0.5	0.01	18	0.19	3.90	52.2	
890801	0730	114			-8	-2.0	0.20	80	0.19	6.00	51.2	
890801	0730	113			-20	-1.3	0.03	30	0.13	1.00	55.4	
890801	0730	111			-20	-2.8	0.01	18	16.30	60.50	12.5	
890801	0730	110			-20	-2.0	0.10	56	0.14	0.25	56.1	
890801	0730	109			-20	0.0	0.00	0	0.20	0.33	55.3	
890801	0730	107			-20	0.0	0.00	0	0.26	0.42	56.0	
890801	0730	108			-20	-2.0	0.04	35	0.18	1.60	55.0	
890801	0730	105			-17	-12.0	0.60	137	0.18	1.40	54.7	

GAS RECOVERY FACILITY WELLFIELD TUNING LOG

SITE: CDSL

PERSONNEL: MATT WELLS

DATE	TIME	WELL #	O/P (in)	GAS TEMP. (°F)	Ph ("wc)	Pw ("wc)	DP ("wc)	GAS FLOW (cfm)	%O2	% N2 (AIR)	%CH4	INLET VAC. ("wc)
890801	0730	123			-9	-3.4	1.60	225	0.28	9.00	48.9	
890801	0730	106			-19	-0.6	0.00	0	0.19	4.90	52.4	
890801	0730	101			-20	0.0	0.00	0	0.13	0.26	58.2	
890801	0730	102			-20	-3.0	0.50	124	0.12	1.30	55.1	
890801	0915	152			-19	-0.3	0.00	0	0.19	3.10	54.8	
P^^801	0915	150			-20	-0.7	0.00	0	0.10	0.20	56.3	
ι .01	0915	147			-16	-6.2	0.04	35	0.27	4.00	53.4	
890801	0915	145			-17	-0.4	0.20	79	0.51	4.90	52.3	
890801	0915	144			-16	-3.6	0.00	0	0.19	0.30	56.4	
890801	0915	143	\		-16	-4.0	0.18	75	0.17	0.30	56.0	
890801	0915	142			-14	-8.0	0.48	123	0.26	8.40	50.8	
890801	0915	140			-15	-4.0	0.35	105	0.62	9.80	49.5	
890801	0915	139			-16	-12.0	0.04	35	0.36	1.00	56.4	
890801	0915	137			-14	-13.0	0.28	94	0.14	0.21	56.6	
890801	0915	135			-11	-8.0	0.34	104	1.30	6.60	50.3	
890801	0915	138			-16	-16.0	0.00	0	0.17	0.26	56.4	
890801	0915	134			-16	-1.4	0.56	132	0.18	3.10	53.9	
890801	0915	133			-16	-1.4	0.06	43	0.19	7.20	49.9	
890801	0915	132			-16	-15.0	0.01	18	0.09	0.20	56.8	
890801	1230	115			-20	-12.0	0.15	68	0.13	0.23	58.0	
890801	1230	116			-20	-0.4	0.01	18	0.14	0.88	55.2	
890801	1230	8			-21	-4.0	0.12	61	0.15	0.30	57.9	
890801	1230	9			-16	-7.4	0.50	125	0.14	2.30	55.5	
890801	1230	10			-16	-0.8	0.03	31	0.12	0.24	58.2	
890801	1230	12			-16	1.7	0.15	68	0.16	0.34	58.7	
890801	1230	11			-16	-0.4	0.01	18	0.17	0.31	57.5	
890801	1230	13			-16	-3.2	0.20	79	0.09	0.20	57.0	
890801	1230	23			-15	0.0	0.00	0	0.17	0.29	57.0	
890801	1230	15			-15	-3.5	0.02	25	0.17	0.27	57.4	
890801	1230	16			-14	-13.0	0.16	71	1.30	5.40	54.8	
890801	1230	17			-14	-12.0	0.10	56	0.18	0.27	58.1	
.01	1230	6			-8	-8.0	0.02	25	0.55	5.00	51.6	
89u801	1230	3			-20	0.0	0.00	0	0.05	0.18	58.0	
890801	1230	2			-20	-0.6	0.07	46	0.06	0.18	57.4	
890801	1430	1			-20	-2.0	0.06	43	0.10	0.21	57.0	
890801	1430	154			-18	-3.0	0.02	25	0.06	0.17	57.0	
890801	1430	37			-22	-8.0	0.04	35	0.55	7.10	51.5	
890801	1430	43			-24	-2.0	0.01	17	0.34	3.90	54.0	
890801	1430	149			-20	-7.4	0.00	0	1.20	22.00	41.0	
890801	1430	45			-22	-5.0	0.02	25	0.15	0.27	56.5	
890801	1430	44			-24	-6.8	0.10	55	0.13	0.33	56.5	
890801	1430	148			-19	-17.0	0.01	18	6.00	24.60	38.7	
890801	1430	41			-22	-3.0	0.00	0	0.10	0.20	56.4	
890801	1430	42			-21	-8.0	0.00	0	0.11	0.22	56.5	

GAS RECOVERY FACILITY WELLFIELD TUNING LOG

SITE: CDSL

PERSONNEL: MATT WELLS

DATE	TIME	WELL #	O/P (in)	GAS TEMP. (°F)	Ph ("wc)	Pw ("wc)	DP ("wc)	GAS FLOW (cfm)	%O2	% N2 (AIR)	%CH4	INLET VAC. ("wc)
890801	1430	40			-20	-5.4	0.02	25	0.10	0.19	56.5	
890801	1430	39			-22	-20.0	0.02	25	0.23	0.64	56.2	
890801	1430	38			-22	-3.6	0.06	43	0.14	2.40	54.9	
890801	1430	36			-10	-4.0	0.05	40	0.06	0.15	56.0	
890801	1430	35			-10	-0.6	0.00	0	0.19	1.00	56.0	
8^^801	1530	33			-16	-4.0	0.04	35	0.09	2.00	56.8	
٬ ,01	1530	31			-16	-2.8	0.03	31	0.17	5.60	53.4	
890801	1530	34			-8	0.0	0.00	0	0.20	0.41	60.9	
890801	1530	32			-16	-4.0	0.00	0	0.08	0.18	57.2	
890801	1530	29			-16	-8.0	0.02	25	0.08	0.20	57.9	
890801	1530	28			-16	-16.0	0.01	18	3.00	11.90	49.6	
890801	1530	30			-16	-6.0	0.01	18	0.12	0.28	57.2	
890801	1530	155			14	3.0	0.00	0				
890801	1530	112						0				
890802	1100	118			-18	-0.4	0.05	39	0.19	7.6	50.7	
890802	1100	149						0	1.00	6.4	57.7	
890802	1100	148						0	3.90	17.7	43.8	
890802	1100	111			-19	-1.2	0.00	0	15.40	57.9	15.0	
890802	1100	123			-16	0.0	0.00	0	0.14	6.4	50.9	
890802	1100	120			-16	0.1	v.00	0	0.09	1.6	55.2	

ATTACHMENT 1

ERICAN · NATIONAL · STANDARD

ORIFICE METERING

OF NATURAL GAS

AND OTHER RELATED HYDROCARBON FLUIDS

31SI	American National Standards Institute	ANSI/API 2530
A&A	American Gas Association	Report No. 3
ID	American Petroleum Institute	API 2530
GPA	Gas Processors Association	GPA 8185-85

Gas

Amer. ...... -

Gas Assoc.

Q_m = mass flow rate in lbm per hour (see Equations 53, 55, and 57).	—	3600
Q_v = volume flow rate in cubic feet per hour (see Equations 54, 56, and 58).	—	3600
d = orifice diameter in millimeters.	10^{-3}	--
d = orifice diameter in inches.	—	1/144
P_b = pounds per square inch absolute.	—	1/144
P_h = pounds per square inch absolute.	—	12
ΔP = inches of water at 60° Fahrenheit.	—	$\left[\dfrac{62.3663}{12}\right]^{0.5}$

The pressure exerted by one inch of water at 60° Fahrenheit is defined as $\frac{1}{12}$ of the force that 1 cubic foot of water having a density of 62.3663 lbm per cubic foot exerts on an area of 1 square foot when acted upon by the standard acceleration of free-fall, 32.17405 feet per second squared.

For example, to convert q_v in Equation 58 to Q_v,

Where:
  d = inches.
  P_b = pounds per square inch absolute.
  P_h = pounds per square inch absolute.
  ΔP = inches of water at 60° Fahrenheit.
  Q_v = cubic feet per hour.

Then:
  N_s' should be substituted for N_s in Equation 58.

Where:
  $N_s' = (N_s)(3600)(\frac{1}{144})(\frac{1}{144})(12)(\frac{62.3663}{12})^{0.5}$

6.3 EQUATIONS FOR VOLUME FLOW RATE OF GASES USING INCH-POUND UNITS AND CALCULATION FACTORS

Equation 58 can be expressed in a more familiar format through the inclusion of calculation factors. These factors (ratios) simply calculate the value of the various terms in the above equations individually. Since the factors have historically been developed in IP units, this approach is generally applicable only to IP units. The factors can be converted through the application of individual conversion factors to equivalent SI quantities. Under such circumstances, the results will be consistent with the other equations in this standard.

In the measurement of most gases, and especially natural gas, the general practice is to express the flow in cubic feet per hour at some specified reference or base condition of pressure and temperature. A convenient way of making this computation is to write another flow equation using the orifice flow constant C':

$$Q_v = C'[h_w P_f]^{0.5} \qquad (59)$$

Where:
  Q_v = volume flow rate in cubic feet per hour at base conditions.
  h_w = differential pressure in inches of water at 60°F.
  P_f = absolute static pressure in pounds per square inch absolute, use subscript 1 when the absolute static pressure is measured at the upstream orifice tap or subscript 2 when the absolute static pressure is measured at the downstream orifice tap.

and:

$$C' = F_b F_r Y F_{pb} F_{tb} F_{tf} F_{gr} F_{pv} \qquad (60)$$

Where:
  C' = orifice flow constant.
  F_b = basic orifice factor.
  F_r = Reynolds Number factor.

Y = expansion factor.
F_{pb} = pressure base factor.
F_{tb} = temperature base factor.
F_{tf} = flowing temperature factor.
F_{gr} = real gas relative density factor.
F_{pv} = supercompressibility factor.

6.4 ORIFICE FLOW CONSTANT

6.4.1 General

The orifice flow constant C' may be defined as the rate of flow of air as a real gas in cubic feet per hour, at base conditions, when the extension $(h_w P_f)^{0.5}$ equals one. It is called the "orifice flow constant" and should not be confused with the flow coefficient mentioned in Section 5. It is to be calculated by Equation 60.

NOTE: The sequence of multiplication shown in the above Equation 60 is not binding; however, in order to duplicate volumes determined by using this equation, the sequence of multiplication and the manner of rounding or truncation should be agreed upon and practiced.

The orifice flow constant C' as shown is slightly different than the one used in the past. The constant assumes that the measured values are absolute. Trim factors to compensate for the type of instrumentation used, the calibration methods, and elements of meter location are treated separately in Appendix E. When the instruments are not calibrated or read to absolute values, the trim factors may be applied as a multiplier to the flow constant C'.

6.4.2 Tables

The values of all the factors of C' defined in 6.3 are obtained from equations listed in 6.5 through 6.13. Tabular data is included in Appendix B as an alternative means of determining factor values. The tables may also be used to check calculated values.

6.5 BASIC ORIFICE FACTOR

6.5.1 Equation

The basic orifice factor F_b is calculated from the following equation:

$$F_b = 338.178\,d^2\,K_o \qquad (61)$$

The numeric constant combines several substitution values and unit multiplying factors. See 6.8 for details.

Equations for determining K_o are shown in 5.2.1.

The derivation is also shown in Section 5. It must be noted, however, that K_o in this equation is not the same K that appears in Equations 38 through 58. K_o is the specific value of K when the Reynolds Number is infinitely large.

Values of K_o may be calculated from Equations 9, 11, 12, and 13 for flange tap orifice meters and from Equations 10, 11, 12, and 14 for pipe tap orifice meters and tables prepared for values of F_b (flange) and F_b (pipe) for various values of D and d. The steps in the values of D and d may be so spaced as to make possible linear interpolation of intermediate values, although this is not the case with the tables in Appendix B.

6.5.2 Tables

Values of F_b are shown in Table B1 for flange taps and C1 for pipe taps, in Appendixes B and C respectively, for some orifice and meter tube sizes. If the tables are to be used, the diameter of the meter tube must be within the limits specified in Figure 3.

6.6 REYNOLDS NUMBER FACTOR

6.6.1 Equation

The Reynolds Number factor F_r is introduced because in any actual case of metering, the Reynolds Number R_d will have a finite value; hence, the corresponding value of K will be somewhat greater than K_o. The Reynolds Number factor, F_r is defined as:

$$F_r = 1 + \frac{E}{R_d}$$
(62)

Thorefore, from Equation 15:

$$K = K_o F_r$$
(63)

Where:

R_d = the orifice bore Reynolds Number.

E = a function of meter tube and orifice diameters.

Equations for determining the values of R_d and E are shown in Section 5.

Tables B2 and C2 in Appendixes B and C may be utilized for determining the value of F_r for normal natural gas mixtures. Table D8 may be used for determining K in Equation 63. When the tables are used, the average extension at which the meter operates must be known in addition to the orifice and meter tube size. The value of $(h_w P_f)^{0.5}$ (extension) used in calculating the F_r factor from Table B2 or C2 may be based upon the meter record or estimated from knowledge of the average static pressure and the average differential pressure at which the meter may operate. This extension, it should be noted, is an index from which a factor is selected; it does not enter directly into the computation of the gas volume. An extension value, selected as suggested, will normally be sufficiently close to the average operating condition of the meter for selecting the proper value of F_r, especially since the variations in F_r corresponding to the values of the extension above and below the selected average will be compensating over any appreciable length of time. When the value of the extension is less than 5, the measurement is less precise.

6.6.2 Tables

Tables B2 and C2 in Appendixes B and C have been calculated using the following average values: viscosity, 0.0000069 pounds mass per foot-second; temperature, 60°F; and real gas relative density (specific gravity) 0.65, applying particularly to natural gas. If the fluid being metered has a viscosity, temperature, or real gas relative density (specific gravity) quite different from these, the value of F_r in Tables B2 and C2 may not be applicable. However, for variation in viscosity of from 0.0000059 to 0.0000079 pounds mass per foot-second, in temperatures from 30° to 90°F, or in real gas relative density (specific gravity) of from 0.55 to 0.75, the variations in the factor F_r would be well within the uncertainty limits stated in 7.

6.7 EXPANSION FACTOR

6.7.1 Equation

The expansion factor Y is a function of beta ratio, the ratio of differential pressure to static pressure and the ratio of specific heats (also called the isentropic exponent or the ratio of specific heat capacity). Equations for the determination of Y for either flange or pipe taps based upon upstream or downstream static pressure are found in 5.2.6.

6.7.2 Tables

Tabular data for the expansion factor Y is shown in Tables B3, B4, C3, or C4 in Appendixes B and C. The table selected is a function of the tap location from which the static pressure is taken. They are based upon a ratio of specific heats of 1.3. In the tables, the ratio h_w/P_f is an index from which the value of Y is selected, and may be based on the meter record, or estimated from the average absolute static pressure and the average differential pressure at which the meter may operate. The effects of operating variations from the "average" h_w/P_f would ordinarily be compensating.

6.7.3 Pipe Taps

With orifice meters using pipe taps, the variation from the mean estimated operating value of h_w/P_f used in the determination of the expansion factor Y will result in the greatest variation in the value of Y when the upstream static pressures are used. The use of downstream static pressure for this type of connection results in the least change in the value of Y due to changes in the values of the h_w/P_f ratio from the mean operating value.

NOTE: In use it may be found that a group of meters in the locality are operating under the same conditions and will have the same values for R and Y. If this is true, the flow constants in this group will be the same for all orifice plates of the same size and beta ratio. Likewise, for individual stations, the values of R and Y may be based upon estimated average static pressures and differential pressures.

6.8 BASE FLOW CONDITIONS INCLUDED IN THE ORIFICE FLOW CONSTANT

The orifice flow constant C' includes the fluid flowing conditions $P_b = 14.73$ pounds per square inch absolute, $T_b = 519.67°R$, $T_f = 519.67°R$ and $G_r = 1$ (exactly). To simplify the change of any one or all of these conditions, four numeric ratios are added to Equation 58. These ratios which have a value of 1 (exactly) are $14.73/14.73$, $519.67/519.67$, $[519.67/519.67]^{0.5}$, and $[1/1]^{0.5}$. One-half of each ratio is combined respectively with P_b, T_b, T_f, and G_r to form the factors $14.73/P_b$, $T_b/519.67$, $[519.67/T_f]^{0.5}$, and $[1/G_r]^{0.5}$. These factors are called F_{pb}, F_{tb}, F_{tf}, and F_{gr}, respectively. The remaining half of each ratio is combined with the numeric constant N_5 of Equation 58 and the multiplying factors in 6.2.5 to obtain the numeric constant given with the basic orifice factor in Equation 61. Including Equation 15 with the above, the following numeric equation is obtained:

$$Q_r = 3600 \cdot 46.0088 \cdot \frac{1}{144} \cdot \frac{12}{144} \cdot \frac{519.67}{14.73} \cdot \left[\frac{62.3663}{12 \cdot 519.67}\right]^{0.5} \cdot$$

$$K_o \cdot d^2 \cdot \left[1 + \frac{E}{R_d}\right] \cdot Y_1 \cdot \frac{14.73}{P_b} \cdot \frac{T_b}{519.67} \cdot$$

$$\left[\frac{519.67}{T_f} \cdot \frac{1}{G_r} \cdot \frac{Z_b}{Z_{f1}}\right]^{0.5} \cdot [h_w \cdot P_{f1}]^{0.5} \tag{64}$$

which reduces to the equivalent of Equation 59:

$$Q_v = F_b F_r Y F_{pb} F_{tb} F_{tf} F_{gr} F_{pv} [h_w P_{f1}]^{0.5} \tag{65}$$

6.9 PRESSURE BASE FACTOR

The pressure base factor F_{pb} is applied to change the base pressure from 14.73 pounds per square inch absolute, and is calculated by dividing 14.73 by the required

(contract) absolute base pressure. The use of this factor is equivalent to substituting the (contract) absolute base pressure in Equation 58 for P_b:

$$F_{pb} = \frac{14.73}{P_b}$$

(66)

Where:

P_b = the required (contract) base pressure, pounds per square inch absolute.

Values of F_{pb} are also shown in Table D1 in Appendix D.

6.10 TEMPERATURE BASE FACTOR

The temperature base factor F_{tb} is applied where the base temperature is other than 60°F and is calculated by dividing the required (contract) base temperature in degrees Rankine by 519.67°R. The use of this factor is equivalent to substituting the contract absolute temperature base for T_b in Equation 58:

$$F_{tb} = \frac{T_b}{519.67}$$

(67)

Where:

T_b = the required (contract) base temperature in degrees Rankine.

Values of F_{tb} are also shown in Table D2 in Appendix D.

6.11 FLOWING TEMPERATURE FACTOR

The flowing temperature factor F_{tf} is required to change from the assumed flowing temperature of 60°F to the actual flowing temperature T_f. F_{tf} is determined by dividing 519.67°R by the flowing temperature in degrees Rankine and taking the square root of the results. The use of this factor is equivalent to substituting the actual absolute flowing temperature in place of T_f in Equation 58:

$$F_{tf} = \left[\frac{519.67}{T_f} \right]^{0.5}$$

(68)

Where:

T_f = actual flowing temperature of the gas in degrees Rankine.

Values of F_{tf} are also shown in Table D3 in Appendix D.
The temperature utilized should be the actual flowing temperature of the gas.

6.12 REAL GAS RELATIVE DENSITY (SPECIFIC GRAVITY) FACTOR

The real gas relative density (specific gravity) factor F_{gr} is to be applied to change from a real gas relative density of 1.0 to the real gas relative density of the gas flowing, and is obtained by taking the square root of the ratio of 1 divided by the real gas relative density. The use of this factor is equivalent to substituting the real gas relative density for G_r in Equation 58:

$$F_{gr} = \left[\frac{1}{G_r} \right]^{0.5}$$

(69)

6.12.1 Real Gas Relative Density (Specific Gravity)

The real gas relative density (specific gravity) is defined as the ratio of the real gas density (specific gravity) of the gas to the real gas density (specific gravity) of dry air when both the pressure and temperature of the gas and air are at the defined base conditions. This may be determined by field measurement or by calculation.

Almost universally, the real gas relative density values used by the industry have been determined by relative density measurement made with gravity balances. The procedures have only required that the observations be adjusted so both the air and gas measurements reflected the same pressure and temperature. The fact that the temperature and pressures were not always at the base conditions has resulted in small variances in relative density determinations. Another small source of variance has been that atmospheric air has been used and its composition (also molecular weight and density) varies from place to place and time to time at any given location.

Where recording gravitometers are used and calibration is performed with reference gases, either "ideal" or "real" gas relative density can be obtained as the recorded relative density simply by the proper certification of the reference gas.

6.12.2 Ideal Gas Relative Density (Specific Gravity)

The ideal gas relative density (specific gravity) is the ratio of the molar mass of the gas to the molar mass of air and is calculated by Equation 26.

$$G_i = \frac{M_{r(gas)}}{M_{r(air)}} = \frac{M_{r(gas)}}{28.9625} \tag{26}$$

The relationship between ideal gas relative density (specific gravity) and the real gas relative density (specific gravity) is expressed as:

$$G_r = G_i \cdot \frac{P_{(gas)} \, T_{(air)} \, Z_{(air)}}{P_{(air)} \, T_{(gas)} \, Z_{(gas)}} \tag{70}$$

When both the gas and air sample densities are at the same base pressure and temperature, the equation reduces to:

$$G_r = \frac{G_i Z_{b(air)}}{Z_{b(gas)}} \tag{71}$$

The derivation of this relationship is shown in 5.3.3.

6.12.3 Tables

Tabular data for the real gas relative density (specific gravity) factor F_{gr} is shown in Table D4 in Appendix D. The tabular data is only applicable to real gas relative density (specific gravity). When the ideal gas relative density (specific gravity) is used, it must be converted through Equation 71 in order to use the tables.

6.13 SUPERCOMPRESSIBILITY FACTOR

6.13.1 General

The development of the general hydraulic flow equation involves the actual density of the fluid at the point of measurement. In the measurement of gas, this is generally determined by the flowing static pressure and temperature. To translate the calculated mass or volume at the flowing static pressure and temperature to base pressure and temperature, ideal gas laws are applied. All gases deviate from the ideal gas laws to a greater or lesser extent. This deviation is known as "compressibility" and is generally noted by the symbol Z.

6.13.2 Compressibility

In orifice meter measurement of gases, the effect of compressibility equates to the relationship $(1/Z)^{0.5}$. This has been termed the "supercompressibility" of the gas. The historic utilization of real gas relative density (specific gravity) (at base condi-

6.13.6 Base Compressibility

The value of Z_b or the compressibility at base conditions is required in Equations 41, 42, 43, 56, 57, and 58. Section 8.3 provides a means of calculating Z_b.

6.14 Adjustments for Instrument Calibration and Use

Other multiplying factors may be applied to the orifice flow constant C' as a function of the type of instrumentation applied, the methods of calibration or the meter environment or all of these.

Such calibration adjustments are beyond the scope of this standard but are discussed in Appendix E as a guide.

7 Uncertainty Limits

7.1 GENERAL

No two orifice meters can be built, except by accident, to give exactly the same readings when the same amount of gas is flowing. For this reason, uncertainties are necessary for the values of the constants given in this standard. For commercial work, the uncertainties must include some allowance for the pressure and temperature measuring devices as well as that for the orifice plate. The commercial accuracy will be somewhat less than the accuracy indicated by the tolerance given for the orifice flow constants.

Very exact duplication of orifice plates is not commercially possible; hence, two duplicate plates made, installed, and operated as nearly as practicable in accordance with the specifications given cannot be expected to have exactly the same discharge coefficient no matter how many times or how accurately they are tested. Uncertainties have to do with these practically unavoidable individual differences between ostensibly duplicate plates. They do not refer to accidental errors of observation, concerning which no general predictions are possible. The tables of coefficient factors given in this standard represent what the committee believes to be the most satisfactory average values now available. The uncertainties given in 5.2.3 estimate the range of departure from the average that may be anticipated in the case of individual meters constructed, installed, and operated in accordance with the specifications in this standard.

7.2 EXAMPLE

The statement "with flange taps and with a diameter ratio between 0.15 and 0.70, the uncertainty is 0.5 percent" means that if a meter with this diameter ratio is made and used in accordance with the specifications, its flow coefficient may be assumed to be within ± 0.5 percent of the value found from the table. This statement does not mean that any single test of the meter could, with any confidence, be expected to give a result within this range; it refers to the true value of the flow coefficient, which would be obtained if all the observations were perfect, and to which the average of a large number of tests is a closer and closer approximation as the number of tests is increased. If the example had been based on pipe taps, the tolerance would be a little greater than ±0.5 percent, as stated in Section 5, and may under certain conditions reach as high as ±0.75 percent.

It should be noted that the statement deals with the degree of deviation from some absolute value (the true value) of the flow coefficient. For example, the paragraph thus indicates that if the installation is made using flange taps in accordance with the previously outlined recommendations, a deviation of the coefficient from the true value of less than ±0.5 percent may be expected.

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tions) has required that the compressibility in this relationship be expressed as a ratio: $Z = Z_f/Z_b$.

6.13.3 Supercompressibility Factor

The supercompressibility factor may be calculated from the following equation:

$$F_{pv} = \left[\frac{Z_b}{Z_f} \right]^{0.5} \tag{72}$$

The American Gas Association's *Manual for the Determination of Supercompressibility Factors for Natural Gas*, December 1962 (Catalog No. L00304), is made a part of this standard and is referred to as the NX-19 Manual. It is also known as PAR Research Project NX-19, *Extension of Range of Supercompressibility Tables*, American Gas Association. The equations in that manual are the empirical method of evaluating supercompressibility factors for normal natural gas mixtures. The accuracy of determining the factors from the real gas relative density (specific gravity) method listed will be within the uncertainties of this standard if the relative density of 0.75 and diluent contents of 15 mole-percent nitrogen or 15 mole-percent carbon dioxide or both percentages are not exceeded. Alternative methods are given for use with gases having higher real gas relative density (specific gravity) or inert content or both. Compressibility tests may be used to establish the suitability of using the standard or an alternative method for gas mixtures beyond that described as "normal."

NOTE: Research has recently been completed that provides an expanded capability to calculate the supercompressibility factor. The results of this work have been evaluated, tested and accepted by the A.G.A. Transmission Measurement Committee. A user's manual is being produced under the title "A.G.A. Transmission Measurement Committee Report No. 8—Compressibility and Supercompressibility for Natural Gas and Other Hydrocarbon Gases." Upon publication of Report No. 8, the A.G.A. NX-19 manual will be prospectively withdrawn as a publication and superceded by A.G.A. Report No. 8.

6.13.4 Tables

Table D5 in Appendix D has been included as an abridged form of the F_{pv} table in the NX-19 Manual. This table is only applicable to a 0.6 specific gravity hydrocarbon gas. Only adjusted pressure and adjusted temperature can be used with Table D5 to obtain accurate values of F_{pv} for gases containing one or more of the following: carbon dioxide, nitrogen, or a specific gravity other than 0.6.
The adjusted pressure is calculated from

$$P_{adj} = \frac{156.47 P_f}{160.8 - 7.22 G_r + (M_c - 0.392 M_n)} \tag{73}$$

The adjusted temperature is calculated from

$$T_{adj} = \left[\frac{226.29 T_f}{99.15 + 211.9 G_r - (M_c + 1.681 M_n)} \right] - 459.67 \tag{74}$$

Where:

P_{adj} = adjusted pressure for supercompressibility factor equation—pounds per square inch gage.

P_f = static pressure—pounds per square inch gage.

T_{adj} = adjusted temperature for supercompressibility factor equation—degrees Fahrenheit.

T_f = temperature—degrees Rankine.

M_c = mol-percent carbon dioxide.

M_n = mol-percent nitrogen.

NOTE: The units shown here for equations 73 and 74 are for use with Table A13 and the F_{pv} table in NX-19 and are not consistent with the units used for these symbols elsewhere.

Pennsylvania Avenue NW., ~~i~~ington, DC 20037.

Method 209A, Total Residue Dried at ~~1~~5 °C, in *Standard Methods for the Ex-tion of Water and Wastewater*, 15th ~~e~~n, 1980, IBR approved February 25, ~~f~~or § 60.683(b).

The following material is avail- for purchase from the following ~~a~~ss: Underwriter's Laboratories, UL), 333 Pfingsten Road, North-~~n~~, IL 60062.

UL 103, Sixth Edition revised as of ~~Nove~~mber 3, 1986, Standard for Chimneys, ~~factor~~y-built, Residential Type and Build-~~ing Heat~~ating Appliance.

The following material is avail- for purchase from the following ~~a~~ss: West Coast Lumber Inspec- Bureau, 6980 SW. Barnes Road, ~~Portla~~nd, OR 97223.

West Coast Lumber Standard Grading No. 16, pages 5-21 and 90 and 91, Sep-~~tembe~~r 3, 1970, revised 1984.

The following material is avail- for purchase from the American ~~Societ~~y of Mechanical Engineers ~~(ASM~~E), 345 East 47th Street, New . NY 10017.

ASME QRO-1-1989, Standard ~~for th~~e Qualification and Certification ~~of Re~~source Recovery Facility Opera- ~~tors. I~~BR Approved for § 60.56a.

ASME PTC 4.1, Power Test ~~Code:~~ Test Code for Steam Generat-~~ing U~~nits (1972), IBR Approved for ~~§ 60.4~~6b and 60.58a(h).

ASME Interim Supplement 19.5 ~~on In~~struments and Apparatus; Appli-~~cation~~, Part II of Fluid Meters, 6th ~~editio~~n (1971), IBR Approved for ~~§ 60.5~~8a(h).

~~[48 FR~~ 3735, Jan. 27, 1983]

~~EDIT~~ORIAL NOTE: For FEDERAL REGISTER ci-~~tations~~ affecting § 60.17, see the List of CFR ~~Sectio~~ns Affected in the Finding Aids sec-~~tion of~~ this volume.

~~EFFE~~CTIVE DATE NOTE: At 56 FR 5506, Feb. ~~11, 19~~91, § 60.17 was amended by revising ~~paragr~~aph (h), effective Aug. 12, 1991. For ~~the co~~nvenience of the user, the superseded ~~text of~~ § 60.17(h) is set forth below.

Incorporations by reference.

• • • •

The ASME *Power Test Codes* 4.1, 8 ~~and~~ 1972, is available for purchase from

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the following address: The American Socie-ty of Mechanical Engineers, 22 Law Drive, Box 2350, Fairfield, NJ 07007-2350.

§ 60.18 General control device requirements.

(a) *Introduction.* This section contains requirements for control devices used to comply with applicable subparts of parts 60 and 61. The requirements are placed here for administrative convenience and only apply to facilities covered by subparts referring to this section.

(b) *Flares.* Paragraphs (c) through (f) apply to flares.

(c)(1) Flares shall be designed for and operated with no visible emissions as determined by the methods specified in paragraph (f), except for periods not to exceed a total of 5 minutes during any 2 consecutive hours.

(2) Flares shall be operated with a flame present at all times, as determined by the methods specified in paragraph (f).

(3) Flares shall be used only with the net heating value of the gas being combusted being 11.2 MJ/scm (300 Btu/scf) or greater if the flare is steam-assisted or air-assisted; or with the net heating value of the gas being combusted being 7.45 MJ/scm (200 Btu/scf) or greater if the flare is non-assisted. The net heating value of the gas being combusted shall be determined by the methods specified in paragraph (f).

(4)(i) Steam-assisted and nonassisted flares shall be designed for and operated with an exit velocity, as determined by the methods specified in paragraph (f)(4), less than 18.3 m/sec (60 ft/sec), except as provided in paragraphs (b)(4)(ii) and (iii).

(ii) Steam-assisted and nonassisted flares designed for and operated with an exit velocity, as determined by the methods specified in paragraph (f)(4), equal to or greater than 18.3 m/sec (60 ft/sec) but less than 122 m/sec (400 ft/sec) are allowed if the net heating value of the gas being combusted is greater than 37.3 MJ/scm (1,000 Btu/scf).

(iii) Steam-assisted and nonassisted flares designed for and operated with an exit velocity, as determined by the methods specified in paragraph (f)(4),

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less than the velocity, V_{max}, as determined by the method specified in paragraph (f)(5), and less than 122 m/sec (400 ft/sec) are allowed.

(5) Air-assisted flares shall be designed and operated with an exit velocity less than the velocity, V_{max}, as determined by the method specified in paragraph (f)(6).

(6) Flares used to comply with this section shall be steam-assisted, air-assisted, or nonassisted.

(d) Owners or operators of flares used to comply with the provisions of this subpart shall monitor these control devices to ensure that they are operated and maintained in conformance with their designs. Applicable subparts will provide provisions stating how owners or operators of flares shall monitor these control devices.

(e) Flares used to comply with provisions of this subpart shall be operated at all times when emissions may be vented to them.

(f)(1) Reference Method 22 shall be used to determine the compliance of flares with the visible emission provisions of this subpart. The observation period is 2 hours and shall be used according to Method 22.

(2) The presence of a flare pilot flame shall be monitored using a thermocouple or any other equivalent device to detect the presence of a flame.

(3) The net heating value of the gas being combusted in a flare shall be calculated using the following equation:

$$H_T = K \sum_{i=1}^{n} C_i H_i$$

where:

H_T = Net heating value of the sample, MJ/scm; where the net enthalpy per mole of offgas is based on combustion at 25 °C and 760 mm Hg, but the standard temperature for determining the volume corresponding to one mole is 20 °C;

$$K = \text{Constant},\ 1.740 \times 10^{-7}\ \left(\frac{1}{ppm}\right) \left(\frac{g\ mole}{scm}\right) \left(\frac{MJ}{kcal}\right)$$

where the standard temperature for $\left(\frac{g\ mole}{scm}\right)$ is 20°C;

C_i = Concentration of sample component i in ppm on a wet basis, as measured for organics by Reference Method 18 and measured for hydrogen and carbon monoxide by ASTM D1946-77 (Incorporated by reference as specified in § 60.17); and

H_i = Net heat of combustion of sample component i, kcal/g mole at 25 °C and 760 mm Hg. The heats of combustion may be determined using ASTM D2382-76 (incorporated by reference as specified in § 60.17) if published values are not available or cannot be calculated.

(4) The actual exit velocity of a flare shall be determined by dividing the volumetric flowrate (in units of standard temperature and pressure), as determined by Reference Methods 2, 2A, 2C, or 2D as appropriate; by the unobstructed (free) cross sectional area of the flare tip.

(5) The maximum permitted velocity, V_{max}, for flares complying with

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paragraph (c)(4)(iii) shall be determined by the following equation.

$$\text{Log}_{10}(V_{max}) = (H_T + 28.8)/31.7$$

V_{max} = Maximum permitted velocity, M/sec
28.8 = Constant
31.7 = Constant
H_T = The net heating value as determined in paragraph (f)(3).

(6) The maximum permitted velocity, V_{max}, for air-assisted flares shall be determined by the following equation.

$$V_{max} = 8.706 + 0.7084 (H_T)$$

V_{max} = Maximum permitted velocity, m/sec
8.706 = Constant
0.7084 = Constant
H_T = The net heating value as determined in paragraph (f)(3).

[51 FR 2701, Jan. 21, 1986]

the sampling surveys described in this paragraph shall be used to determine if detectable emissions exist.

4.3.3 Alternative Screening Procedure. A screening procedure based on the formation of bubbles in a soap solution that is sprayed on a potential leak source may be used for those sources that do not have continuously moving parts, that do not have surface temperatures greater than the boiling point or less than the freezing point of the soap solution, that do not have open areas to the atmosphere that the soap solution cannot bridge, or that do not exhibit evidence of liquid leakage. Sources that have these conditions present must be surveyed using the instrument techniques of 4.3.1 or 4.3.2.

Spray a soap solution over all potential leak sources. The soap solution may be a commercially available leak detection solution or may be prepared using concentrated detergent and water. A pressure sprayer or a squeeze bottle may be used to dispense the solution. Observe the potential leak sites to determine if any bubbles are formed. If no bubbles are observed, the source is presumed to have no detectable emissions or leaks as applicable. If any bubbles are observed, the instrument techniques of 4.3.1 or 4.3.2 shall be used to determine if a leak exists, or if the source has detectable emissions, as applicable.

4.4 Instrument Evaluation Procedures. At the beginning of the instrument performance evaluation test, assemble and start up the instrument according to the manufacturer's instructions for recommended warmup period and preliminary adjustments.

4.4.1 Response Factor. Calibrate the instrument with the reference compound as specified in the applicable regulation. For each organic species that is to be measured during individual source surveys, obtain or prepare a known standard in air at a concentration of approximately 80 percent of the applicable leak definition unless limited by volatility or explosivity. In these cases, prepare a standard at 90 percent of the saturation concentration, or 70 percent of the lower explosive limit, respectively. Introduce this mixture to the analyzer and record the observed meter reading. Introduce zero air until a stable reading is obtained. Make a total of three measurements by alternating between the known mixture and zero air. Calculate the response factor for each repetition and the average response factor.

Alternatively, if response factors have been published for the compounds of interest for the instrument or detector type, the response factor determination is not required, and existing results may be referenced. Examples of published response factors for flame ionization and catalytic oxi-

dation detectors are included in Bibliography.

4.4.2 Calibration Precision. Make a total of three measurements by alternately using zero gas and the specified calibration gas. Record the meter readings. Calculate the average algebraic difference between the meter readings and the known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

4.4.3 Response Time. Introduce zero gas into the instrument sample probe. When the meter reading has stabilized, switch quickly to the specified calibration gas. Measure the time from switching to when 90 percent of the final stable reading is attained. Perform this test sequence three times and record the results. Calculate the average response time.

5. *Bibliography*

1. DuBose, D.A., and G.E. Harris. Response Factors of VOC Analyzers at a Meter Reading of 10,000 ppmv for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81-051. September 1981.

2. Brown, G.E., et al. Response Factors of VOC Analyzers Calibrated with Methane for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81-022. May 1981.

3. DuBose, D.A., et al. Response of Portable VOC Analyzers to Chemical Mixtures. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2-81-110. September 1981.

METHOD 22—VISUAL DETERMINATION OF FUGITIVE EMISSIONS FROM MATERIAL SOURCES AND SMOKE EMISSIONS FROM FLARES

1. *Introduction*

This method involves the visual determination of fugitive emissions, i.e., emissions not emitted directly from a process stack or duct. Fugitive emissions include emissions that (1) escape capture by process equipment exhaust hoods; (2) are emitted during material transfer; (3) are emitted from buildings housing material processing or handling equipment; and (4) are emitted directly from process equipment. This method is used also to determine visible smoke emissions from flares used for combustion of waste process materials.

This method determines the amount of time that any visible emissions occur during the observation period, i.e., the accumulated emission time. This method does not require that the opacity of emissions be determined.

Since this procedure requires only the determination of whether a visible emission occurs and does not require the determination of opacity levels, observer certification according to the procedures of Method 9 are not required. However, it is necessary that the observer is educated on the general procedures for determining the presence of visible emissions. As a minimum, the observer must be trained and knowledgeable regarding the effects on the visibility of emissions caused by background contrast, ambient lighting, observer position relative to lighting, wind, and the presence of uncombined water (condensing water vapor). This training is to be obtained from written materials found in Citations 1 and 2 of Bibliography or from the lecture portion of the Method 9 certification course.

2. *Applicability and Principle*

2.1 Applicability. This method applies to the determination of the frequency of fugitive emissions from stationary sources (located indoors or outdoors) when specified as the test method for determining compliance with new source performance standards.

This method also is applicable for the determination of the frequency of visible smoke emissions from flares.

2.2 Principle. Fugitive emissions produced during material processing, handling, and transfer operations or smoke emissions from flares are visually determined by an observer without the aid of instruments.

3. *Definitions*

3.1 Emission Frequency. Percentage of time that emissions are visible during the observation period.

3.2 Emission Time. Accumulated amount of time that emissions are visible during the observation period.

3.3 Fugitive Emissions. Pollutant generated by an affected facility which is not collected by a capture system and is released to the atmosphere.

3.4 Smoke Emissions. Pollutant generated by combustion in a flare and occurring immediately downstream of the flame. Smoke occurring within the flame, but not downstream of the flame, is not considered a smoke emission.

3.5 Observation Period. Accumulated time period during which observations are conducted, not to be less than the period specified in the applicable regulation.

4. *Equipment*

4.1 Stopwatches. Accumulative type with unit divisions of at least 0.5 seconds; two required.

4.2 Light Meter. Light meter capable of measuring illuminance in the 50- to 200-lux range; required for indoor observations only.

5. *Procedure*

5.1 Position. Survey the affected facility or building or structure housing the process to be observed and determine the locations of potential emissions. If the affected facility is located inside a building, determine an observation location that is consistent with the requirements of the applicable regulation (i.e., outside observation of emissions escaping the building/structure or inside observation of emissions directly emitted from the affected facility process unit). Then select a position that enables a clear view of the potential emission point(s) of the affected facility or of the building or structure housing the affected facility, as appropriate for the applicable subpart. A position at least 15 feet, but not more than 0.25 miles, from the emission source is recommended. For outdoor locations, select a position where the sun is not directly in the observer's eyes.

5.2 Field Records.

5.2.1 Outdoor Location. Record the following information on the field data sheet (Figure 22-1): company name, industry, process unit, observer's name, observer's affiliation, and date. Record also the estimated wind speed, wind direction, and sky condition. Sketch the process unit being observed and note the observer location relative to the source and the sun. Indicate the potential and actual emission points on the sketch.

5.2.2 Indoor Location. Record the following information on the field data sheet (Figure 22-2): company name, industry, process unit, observer's name, observer's affiliation, and date. Record as appropriate the type, location, and intensity of lighting on the data sheet. Sketch the process unit being observed and note observer location relative to the source. Indicate the potential and actual fugitive emission points on the sketch.

5.3 Indoor Lighting Requirements. For indoor locations, use a light meter to measure the level of illumination at a location as close to the emission source(s) as is feasible. An illumination of greater than 100 lux (10 foot candles) is considered necessary for proper application of this method.

5.4 Observations. Record the clock time when observations begin. Use one stopwatch to monitor the duration of the observation period; start this stopwatch when the observation period begins. If the observation period is divided into two or more segments by process shutdowns or observer rest breaks, stop the stopwatch when a break begins and restart it without resetting when the break ends. Stop the stopwatch at the end of the observation period. The accumulated time indicated by this stopwatch is the duration of the observation period. When the observation period is completed, record the clock time.

RLF: AIR POLLUTION - ITS ORIGIN + CONTROL

K. WARK AND C. WARNER   1976

Table 6-10 Uses of Thermal Oxidation for the Control of Hydrocarbons in Effluent Gas Streams

Adhesive tape curing	Packing house effluents
Brake lining ovens	Paint baking ovens
Coffee roasters	Plastic curing ovens
Core ovens	Printing presses
Cupola furnace stacks	Solvent degreasing
Fiberglass curing	Textile driers
Lithographing ovens	Varnish burn-off
Meat smokehouses	Varnish kettles
Metal coating ovens	Wire enameling

Source: D. W. Waid. "Afterburners for Control of Gaseous Hydrocarbons Odor. *Am. Inst. Chem. Engineers Symposium Series No. 137, 70, 1974.*

In general, combustion calculations for afterburners are made determine the quantity of additional fuel gas required to attain the desir exhaust gas temperature, the volume of combustion gases or exhaust ga generated and based upon that value, and the size of the combustio chamber required to provide the desired dwell or contact time. Illustrati examples of the calculations for direct incinerators appear in the literatu [11, 12]. The following example illustrates the required calculations e ploying tabular data presented in reference 12.

Example 6-6

A natural-gas-fired circular afterburner is to be designed to incinera the contaminants discharged from a meat smokehouse and th eliminate visible emissions and odor. The maximum rate of dischar is 1200 scf of gas at 170°F. (Note that the volume rate at 170 has been corrected to standard conditions of 60°F and 1 atm.) A sume that the contaminated gas has approximately the properties air, no heating value is assigned to the contaminants, and a tempe ture of 1200°F will eliminate the odors. (Refer to Figure 6-21.)

Solution

The mass flow rate of contaminated gas is

$$m_{gas} = \frac{(1200 \text{ scf/min})(60 \text{ min/hr})}{13.1 \text{ ft}^3 \text{ air/lb air}} = 5500 \text{ lb/hr}$$

The heat required to increase the temperature of the contaminate gas from 170° to 1200°F is determined from the enthalpy values air. From standard air tables the enthalpy at these two temperatu is 150.7 and 411.8 Btu/lb, respectively. Therefore, the first estim of the heat rate required is

$$Q = 5500(411.8 - 150.7) = 1,435,000 \text{ Btu/hr}$$

If we assume a heat loss of 10 percent of the preceding value from the afterburner, then the total heat required by the afterburner to attain a gas temperature of 1200°F is

$$Q_R = 1.1(1,435,000) = 1,580,000 \text{ Btu/hr}$$

Next, we determine the required quantity of natural gas.

Reference 12 offers a table that gives the available enthalpy for heating purposes when 1 ft³ of natural gas is burned with the theo- retical quantity of air to yield products at any desired temperature. From that table, we find that at 1200°F the excess enthalpy is 721.3 Btu/ft³ of natural gas. Thus the required volume rate of natural-gas fuel at 60°F is

$$\text{volume rate of natural gas} = \frac{1,580,000 \text{ Btu/hr}}{721.3 \text{ Btu/ft}^3} = 2190 \text{ ft}^3/\text{hr}$$

It is assumed that, on the average, 1 ft³ of natural gas requires 10.36 ft³ of air for stoichiometric or theoretical combustion. Hence the volume of products of combustion from 1 ft³ of natural gas is 11.36 ft³ at 60°F and 1 atm. The volume rate of the products of combustion is

$$\text{volume rate of products} = \frac{(2190 \text{ ft}^3/\text{hr})(11.36)(1660°R)}{(3600 \text{ s/hr})(520°R)}$$

$$= 22.1 \text{ ft}^3/\text{s}$$

To this must be added the volume flow rate of contaminated gas at 1200°F, which is

$$\text{volume rate of contaminated gas} = \frac{(1200 \text{ ft}^3/\text{min})(1660°R)}{(60 \text{ s/min})(520°R)}$$

$$= 63.8 \text{ ft}^3/\text{s}$$

In the afterburner, then,

$$\text{total volume flow rate} = 22.1 + 63.8 = 85.9 \text{ ft}^3/\text{s}$$

This value enables us to determine the throat diameter of the burner. Gas velocities in afterburner throat regions vary from 15 to 25 ft/s to promote mixing of combustion products and contaminated gases. If we assume a velocity of 20 ft/s, then

$$\text{throat diameter} = \frac{4(\text{volume rate})^{1/2}}{\pi(\text{velocity})} = \frac{4(85.9)^{1/2}}{\pi(20)} = 2.34 \text{ ft}$$

The combustion chamber diameter is determined by providing adequate

PROCEDURES FOR MODELING A FLARE

At certain types of industrial sources, flares are used to dispose of waste gases through combustion. As the gases are vented up a tall vertical pipe and then ignited at the top of the pipe, heat and other combustion products are released. Depending upon combustion efficiency, pollutant emissions may be important and dispersion modeling may be necessary.

Treatment of a flare as a point source is debatable in view of the differences between a flare and conventional combustion source. A recent study ("Observations of Plume Rise from Sour Gas Flares", Leahey and Davies, 1984), however, indicates that use of the standard Briggs plume rise formulas (i.e., 2/3 law) provides a good approximation of the plume rise from a flare. Consequently, it is reasonable to model flares as elevated point sources with appropriately chosen "stack" parameters. (Note, the stack exit parameters suggested by the Leahey and Davies study agree well with the parameters suggested by other approaches - e.g., see "User's Guide to the Texas Episodic Model", October 1979 and "Notes on Dispersion Modeling - Plume Rise of Flares", Trinity Consultants, 1984.)

The following steps are proposed for deriving the stack parameters for a flare:

STEP 1: Calculate the total heat release (H) of the flared gas based on the gas heat content and the gas consumption rate

STEP 2: Assume that 45% of H is released as sensible heat (Q_H)

$$Q_H(cal/sec) = 0.45 \times H(cal/sec)$$

STEP 3: Calculate the effective stack diameter using the following formula*

$$d_s(m) = 9.88 \times 10^{-4} \times \left[Q_H\right]^{1/2}$$

STEP 4: Final stack parameters for model input are as follows

h_s = height of flare stack
d_s = (calculated in STEP 3)
v_s = 20 m/sec
T_s = 1273 °K

---

*This formula was derived by combining two equations for the buoyancy flux parameter (i.e., $F = (gQ_H)/(\pi\rho c_p T_a)$ (Eq. 4.20, Briggs, 1969) and $F = gv_s(d^2/4)(1-T_a/T_s)$ (Turner, 1972)), solving for "d", and assuming $T_a = 293$ °K, $T_s = 1273$ °K, $v_s = 20$ m/sec, $\rho = 1205$ g/m^3, and $c_p = 0.24$ cal/g°K.

EXAMPLE FLARE CALCULATION

GIVEN: Process flare X burns the following gas mixture

	AMOUNT (#/HR)	HEAT CONTENT (cal/#)	HEAT RELEASE (cal/sec)
N_2	30.0	0	0
H_2S	67.9	1.6×10^6	30,180
Organics	126.0	3.9×10^6	136,500
			166,680

STEP 1: H = 166,680 cal/sec

STEP 2: Q_H = 0.45 x H = 75,000 cal/sec

STEP 3: $d_S = 9.88 \times 10^{-4} \times [Q_H]^{1/2} = 0.27$ m

STEP 4: Stack parameters are h_S=height of flare stack, d_S=0.27 m, v_S=20 m/sec, T_S=1273 °K

ATTACHMENT 2

LANDFILL GAS UTILITY FLARE STATION
MEDLEY GAS RECOVERY

Flare is designed in accordance with EPA criteria (40 CFR 60.18). Per EPA testing, flares designed and operated in accordance with the specified criteria will achieve a minimum of 98% destruction efficiency of total hydrocarbons.

For an optimum destruction efficiency, the gas exit velocity at the flare tip should be less than 60 ft./sec. with the net heating value of the gas being maintained at 200 BTU/SCF or greater.

- With a methane content of 40-60%, the net gas heating value would be between 404-607 BTU/SCF.

- Flare Tip and Tip Velocity:

  Assuming a tip temperature of 120 degrees Fahrenheit and a gas flow of 3210 SCFM (maximum design capacity for the flare).

  Flow corrected for 120 degrees Fahrenheit =

$$3210 \text{ SCFM} + \frac{460 + 120}{520} = 3580 \text{ ACFM}$$

$$\text{Flare Tip Velocity} = \frac{\text{Actual Flow}}{\text{Tip Cross-sectional area}}$$

$$= \frac{3580 \text{ ACFM}}{\frac{\pi * 14^2 \text{ in.}}{4 * 144 \text{ in}^2/\text{lb.}}} = 3348.8 \text{ FPM}$$

$$= \frac{3348.8 \text{ FPM}}{60 \text{ sec/min}} = 55.8 \text{ ft/sec} < 60 \text{ ft/sec}$$

Per EPA criteria, if the methane content is greater than 20% (200 BTU/SCF) and a gas tip velocity of less than 60 ft/sec, the flare will have a steady flame. Under these same conditions, the flare is expected to have a 98% total hydrocarbon destruction efficiency. Assuming a combustion temperature of 1400 degrees Fahrenheit.

LANDFILL GAS UTILITY FLARE STATION
MEDLEY GAS RECOVERY

Flare is designed in accordance with EPA criteria (40 CFR 60.18). Per EPA testing, flares designed and operated in accordance with the specified criteria will achieve a minimum of 98% destruction efficiency of total hydrocarbons.

For an optimum destruction efficiency, the gas exit velocity at the flare tip should be less than 60 ft./sec. with the net heating value of the gas being maintained at 200 BTU/SCF or greater.

- With a methane content of 40-60%, the net gas heating value would be between 404-607 BTU/SCF.

- Flare Tip and Tip Velocity:

  Assuming a tip temperature of 120 degrees Fahrenheit and a gas flow of 3210 SCFM (maximum design capacity for the flare).

  Flow corrected for 120 degrees Fahrenheit =

  $$3210 \text{ SCFM} \times \left(\frac{460 + 120}{520}\right) = 3580 \text{ ACFM} \qquad 3210\left(\frac{580}{520}\right) = 3580.$$

  $$\text{Flare Tip Velocity} = \frac{\text{Actual Flow}}{\text{Tip Cross-sectional area}}$$

  $$= \frac{3580 \text{ ACFM}}{\dfrac{\pi \cdot 14^2 \text{ in.}}{4 \cdot 144 \text{ in}^2/\text{lb.}}} = 3348.8 \text{ FPM}$$

  $$= \frac{3348.8 \text{ FPM}}{60 \text{ sec/min}} = 55.8 \text{ ft/sec} < 60 \text{ ft/sec}$$

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TO:
CHARLENE
PISATOWSKI

11-18-92

Tom,

Above person asked
about status of
Waste mgt. of NA
applic.

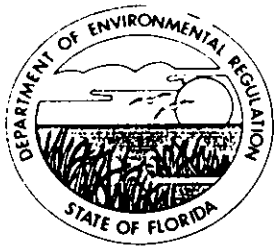I FAXED her a
copy of your
11-13-92 letter
and suggested she
call you Friday if
she needed clarification
on questions.

[signature]

MESSAGE CONFIRMATION

NOV-18-'92 WED 10:05

TERM ID: DIV OF AIR RES MGMT
TEL NO: 904-922-6979   P-9999

NO.	DATE	ST.TIME	TOTAL TIME	ID	DEPT CODE	OK	NG
572	11-18	10:04	00'01'23	3059730062	02	00	

Florida Department of Environmental Regulation

Twin Towers Office Bldg. ● 2600 Blair Stone Road ● Tallahassee, Florida 32399-2400

Lawton Chiles, Governor

Carol M. Browner, Secretary

November 13, 1992

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. James A. Waters
Group Vice President
Waste Management of North America
500 Cyprus Creek Road, Suite 300
Ft. Lauderdale, Florida 33309

Dear Mr. Waters:

Re: File No. AC13-218495
    Medley Landfill Flare

This letter is in response to Ms. Charlene Pisatowski's letter dated October 21, 1992. The review of this information reveals the following items need further clarification:

1. Number of Gas Wells

   We understand that 48 gas wells exist today. What is the yearly rate of gas well installation over the life of the landfill, and the maximum number? Please be advised that future gas well additions will require modification to any construction permit that has been issued.

2. Gas Flow

   You provided a range estimate on gas flow, however, we asked for maximum and average values per well. Is 10 scfm the maximum value? How was your estimate derived? Also, we need the details of the gas quality/gas flow functional relationship mentioned. This flow data, in conjunction with the number of wells information, are necessary to confirm that the selected flare is capable of handling the total gas flow.

3. Monitoring of Gas Flow from each Well and Flare

   Please provide a proposed make and model of the measurement device for monitoring gas flow. Will the measurements be automatically recorded? What is the min/max measurement range on the flow meter?

Recycled Paper
Printed with Soy Based Inks

4. Flare Operating Temperature

   You indicated that the flare operating temperature was included
   in the Specification Report from the flare manufacturer.
   Please give the page and paragraph reference. (We note that
   Appendix E, Flare Selection, of the Landfill Gas Management
   System Engineering Report you provided, includes as an item,
   Unit Design -- Operating Temperature: 1100-1600 degrees F.)
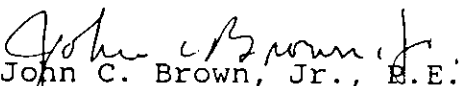   At what temperature will the flare be operated?

5. Solid Waste Permit No. SC13-179974

   The copy of the solid waste permit you provided did not include
   Specific Condition No. 22 (installation of the gas collection
   system). This condition was cited in your Company's August 22,
   1992, letter to Ms. S. Brooks of our West Palm Beach District
   Office. Please provide copies of the permit which includes
   Specific Condition No. 22.

6. Gas Flows and Exit Velocity Calculations

   Please provide a copy of all calculations, including formulas
   and input parameters.

Your permit application will continue to be processed when you
respond to the above items. If you have any questions, please
contact Tom Cascio at (904) 488-1344 or write to me at the above
address.

                                    Sincerely,

                                    John C. Brown, Jr., B.E.
                                    Administrator
                                    Air Permitting and Standards

JCB/TC/plm

cc: S. Brooks, SED
     E. Anderson, DERM
     H. Bush, Jr., P.E.
     T. Cascio, BAR
     M. Yon, BS&HW
     M. Baig, BAR
     W. Hanks, BAR

I also wish to receive the following services (for an extra fee):

1. ☐ Addressee's Address

2. ☐ Restricted Delivery

Consult postmaster for fee.

3. Article Addressed to:

Mr. James A. Waters DB
Group Vice President
Waste Management of No. America
500 Cyprus Creek Rd., Ste. 300
Ft. Lauderdale, FL 33309

4a. Article Number

P 062 922 008

4b. Service Type

☐ Registered   ☐ Insured
☒ Certified   ☐ COD
☐ Express Mail   ☐ Return Receipt for Merchandise

7. Date of Delivery 11-16-92

5. Signature (Addressee)

6. Signature (Agent)

8. Addressee's Address (Only if requested and fee is paid)

PS Form **3811**, November 1990   ☆U.S. GPO: 1991–287-068   **DOMESTIC RETURN RECEIPT**

P 062 922 008

Receipt for Certified Mail

UNITED STATES POSTAL SERVICE

No Insurance Coverage Provided
Do not use for International Mail
(See Reverse)

Sent to		
Mr. James A. Waters, Waste		
Street and No		Mgmt
500 Cyprus Creek Rd., Ste 300		
P.O., State and ZIP Code		
Ft. Lauderdale, FL 33309		
Postage	$	
Certified Fee		
Special Delivery Fee		
Restricted Delivery Fee		
Return Receipt Showing to Whom & Date Delivered		
Return Receipt Showing to Whom, Date, and Addressee's Address		
TOTAL Postage & Fees	$	
Postmark or Date		
Mailed: 11-13-92		
Permit: AC 13-218495		

PS Form **3800**, June 1991

I N T E R O F F I C E   M E M O R A N D U M

Date:	30-Oct-1992 12:51pm EST
From:	Tom Cascio TAL
	CASCIO_T
Dept:	Air Resources Managemen
Tel No:	904/488-1344
SUNCOM:	278-1344

TO: Tom Cascio   TAL   (CASCIO_T)

CC: Willard Hanks   TAL   (HANKS_W)

Subject: Medley Landfill Flare

CERTIFIED MAIL -- RETURN RECEIPT REQUESTED

Mr. James A. Waters
Group Vice President
Waste Management of North America
500 Cyprus Creek Road, Suite 300
Ft. Lauderdale, Florida 33309

Dear Mr. Waters:

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            Medley Landfill Flare

We are in receipt of Ms. Charlene Pisatowski's letter dated
October 21, 1992 on this subject, written in response to our
request for additional information. Our review of this document
reveals the following items still need further clarification:

1.   Number of Gas Wells.

We understand that 48 gas wells exist today. What is the yearly
rate of well installation over the life of the landfill, and the
maximum number?

2.   Gas Flow.

You provided a range estimate, however we asked for maximum and
average values per well. Also, we need the details of the gas
quality/gas flow functional relationship mentioned.

3.   Monitoring of Gas Flow from each Well and Flare.

Please provide a recommended make and model of the measurement
device described for this function. Will the measurement
recording be automated?

4. Flare Operating Temperature.

You indicated that this parameter was included in the Specification Report from the flare manufacturer. Please give the page and paragraph reference.

5. Solid Waste Permit No. SC13-179974.

The copy you provided did not include Specific Condition No. 22 (installation of the gas collection system). Please clarify this omission and forward this reference.

6. Gas Flows and Exit Velocity Calculations.

Please provide a copy of all formulas and input parameters used for the calculations.

We will resume processing your application after receipt of the requested information noted above. If you have questions on any of these items, please contact Preston Lewis or myself on 904-488-1344.

Sincerely,

C. H. Fancy, P. E.
Chief
Bureau of Air Regulation

cc: S. Brooks, SED
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